Patent Pools and Patent Inflation

An empirical analysis of contemporary patent pools

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Abstract

Patent pools combine patents to be licensed out under a single contract. This may increase transparency, reduce transaction costs, avoid costly infringement litigation and reduce royalty rates. For this reason, an increasing number of patent pools have been created for patents that are essential to technological standards. Little is known however on the effects of patent pools on the incentives to file and declare essential patents. We investigate how patenting around technological standards and the number of patents declared essential has been affected by the increasing number of patent pools since 1997. Using data from a comprehensive sample of ICT standards released between 1992 and 2009, we show that periods around pool creation are characterized by exceptionally high levels of patenting and high declaration rates. In the case of standards released after 1999, when the possibility of pool creation was already established, patenting peaks prior to pool creation, and takes place earlier than for comparable standards. These findings are consistent with the theoretical analysis of the effects of expected pool creation on patenting incentives. In the case of earlier standards, patenting peaks immediately after pool creation, highlighting a reaction to the exogenous policy change establishing a more permissive approach towards pools. While this evidence indicates a positive effect of patent pools on the incentives to file and declare essential patents, the overall effect of pools on the inflation of essential patents around standards seems to have been limited.

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1. 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. Obtaining such a blocking power over a standard may increase the commercial value of a patent for its holder (Rysman and Simcoe, 2009, Bekkers et al., 2002). Standardization thus generates additional incentives for firms to file more patents (Layne-Farrar, 2008, Bekkers et al., 2012), or to adjust their patent files to ongoing standardization (Berger et al., 2012). The increasing number of patents around standardization thereby evolves to become a challenge for standard development and implementation (Shapiro, 2001).

In order to deal with these challenges, standardizing firms have come up with mechanisms to coordinate their strategies with respect to Intellectual Property Rights (IPRs). Patent pools are the most important of these mechanisms (Shapiro, 2001). Pools combine IPR to be licensed under a single contract. This increases transparency, reduces coordination costs and avoids costly infringement litigation. As long as pools only include patents that are complementary and necessary for implementing a standard, they furthermore reduce royalty rates for users of the standard by eliminating wasteful multiple marginalization (Lerner & Tirole, 2004). Based upon these arguments, patent pools are generally believed to increase *ex post* economic efficiency, and antitrust guidelines have adopted a permissive policy stance towards patent pools including only complementary patents.

The effect of patent pools on the incentives to innovate is however subject to debate. Simcoe (2005) argues that the spreading practice to create patent pools for technological standards is one of the driving factors of the increasing number of essential patents. This claim is supported both by the theoretical literature, predicting a positive effect of pools on innovation incentives, as well as by practitioner reports (Peters, 2012) and case studies evidencing the importance of opportunistic patenting in view of patent pools (Nagaoka et al., 2009, Baron and Delcamp, 2012). Recent empirical research (Lampe and Moser, 2012; Joshi and Nerkar, 2011) however suggests that patent pool creation was followed by a decline in related patenting. These findings however only describe a decline in follow-on innovation, once a number of existing patents were bundled into a pool (the *ex post* innovation effects). The effect of patent pools on the incentives to file patents to be included into this pool (the *ex ante* innovation effects) have so far not been subject to a thorough empirical analysis.

We will investigate *ex ante* effects of patent pools on innovation and evaluate whether policy changes facilitating the creation of more than 50 ICT patent pools have increased incentives to file standard-essential patents. We collect data on 60,000 declarations of essential patents to more than 700 ICT standards. We will describe the growth in the number of patent declarations over the past twenty years, and discuss to what extent the increasing number of patent pools is likely to have contributed to this evolution.

We then analyze on the standard and firm level whether the creation of the individual patent pools can be related to unusual peaks in the levels of patent declaration and patent files. We build up a comprehensive database of 7 million patents that are technologically close to declared essential patents, filed by over 150 companies contributing proprietary technology to the specific standard. We relate patenting and patent declarations to 700 standards and technical specification and 28 patent pools. We especially describe the baseline timing of patenting and declaration with respect to the development of technology standards. We can then analyze whether there is an unusual change in the extent of patenting before or after the launch of patent pools. We distinguish between expected and unexpected patent pools using the favorable business review of patent pools from 1997 to 1999 as an exogenous policy change. Firms investing in R&D related to standards released after this policy change were able to integrate the new policy environment in their expectations of the returns on essential patents. We will analyze how the timing of patenting and patent declaration around pools differs for pools created before and after policy change. Furthermore, we describe how the timing of patenting differs from standards related to a (foreseeable) patent pool with respect to other standards which are otherwise comparable but not subject to patent pools.

We find evidence for a positive effect of patent pools on patenting and the number of patent declarations. The effect of patent pools depends upon whether the pool creation was expected or came as a surprise to innovating firms. For instance, the periods before pool creation are characterized by high numbers of patent files in the subsample of standards released later than 1999. There is no such relationship in the sample of standards released earlier then 2000. Furthermore, we find that companies entering a patent pool increase their level of patenting with respect to companies contributing to the same standard, but staying outside the pool. The overall effect of patent pools on the number of essential patents seems however to be limited. The recent surge in the number of essential patents was mainly driven by standards for which pools were not an option.

2. Review of the Literature

The theoretical literature on patent pools generally predicts a positive effect on the incentives to invest in related R&D (Lerner and Tirole, 2004; Aoki and Schiff, 2007). Dequiedt and Versaevel (2012) analyze the dynamic incentives for R&D in view of a patent pool. In their model, patent pools increase innovation incentives, and especially induce patent races preceding the launch of the pool. Llanes and Trento (2009) analyze the impact of patent pools on follow up innovation. Patent pools efficiently reduce the royalty stacking problem, thus reducing the negative effect of patent protection on follow-up innovation.

Recent empirical advances however rather point to a negative effect of patent pools on innovation and patenting. In a study of the sewing machine patent pool in the 19th century, Lampe and Moser (2010) find that this pool had a positive effect on the number of subsequent patent files by insiders and outsiders. Nevertheless, the authors show that the effect on innovation is negative, as measured by indicators of real technical progress. There is thus apparently evidence of an increased patent propensity which does not translate into an increased innovation effort. In a more recent study of patent pools in the 1930s, Lampe and Moser (2012) find that most of these pools had a negative effect on subsequent patenting in the field. In the only existing study of the effects of contemporary ICT patent pools, Joshi and Nerkar (2011) find that the creation of the DVD patent pools was followed by a decline in patenting in related technical fields by pool licensors and licensees.

It is difficult to confront the empirical evidence with empirical predictions from the recent theoretical literature because of the heterogeneity of research settings. The expected effects depend upon whether the pools are allowed to include substitutable patents or not. Evidence on historical patent pools is thus only in a very limited sense applicable to contemporary patent pools.

The empirical papers measure the effects of patent pools upon measures of technological progress (Lampe and Moser, 2010) or patenting (Lampe and Moser, 2012; Joshi and Nerkar, 2011), while the theoretical papers typically focus upon related R&D efforts (Lerner and Tirole, 2004; Dequiedt and Versaevel, 2012; Llanes and Trento, 2009). Several of the empirical papers use patents to indicate R&D efforts or innovation. The number of patents however indicates innovation or R&D effort only under the condition that the pool has no effect on patent propensity and on the efficiency of R&D investment. Given the impact of patent pools on the return structure of patents, particularly the first assumption seems overly strong. Layne-Farrar and Lerner (2011) for instance highlight that holders of the most valuable patents often refrain from joining patent pools, because large numbers of insignificant patents included in pools water down the return on significant inventions. Evidence on effects of patent pools on patent counts should therefore only cautiously be interpreted as indicating an effect on innovation.

Furthermore, the empirical papers either measure the effects on patenting by pool members and licensees (Joshi and Nerkar, 2011), or on all firms in the field (Lampe and Moser, 2010, 2012). On theory side, some papers focus upon the incentives of potential pool members (Lerner and Tirole, 2004; Dequiedt and Versaevel, 2012), others concentrate on outside innovators using the technology licensed out through the pool as input (Llanes and Trento, 2009). While the comparison between pool members and outsiders is informative, it would be mistaken to interpret changes in the extent of patenting by members relative to outsiders as a measure of the overall effect of patent pools. Theoretical work clearly indicates that pool outsiders' innovation incentives are affected by patent pools (Llanes and Trento, 2009). Aoki and Nagaoka (2004) even stress that pool outsiders are the ones to benefit most from pool creation.[3] Furthermore, participation in a patent pool is endogenous to various factors that are likely to also have a direct influence on future R&D in the specific technology, such as vertical integration or R&D capacities.

Finally, most theoretical models consider the effects of expected pool creation, and even explicitly address effects on the level of innovation preceding the pool creation (Dequiedt and Versaevel, 2012). In contrast, all of the existing empirical work measures effects of patent pools in the time period following patent pool creation. This research setting requires that pool creation comes as a surprise to at least some firms. While arguably some pools have indeed been created in response to an exogenous policy change, it is implausible that significant effects on the incentives to file patents to be included into the pool can be measured with data from periods after pool creation. Indeed, contemporary ICT patent pools are restricted to include patents that are essential to precisely defined standards which are generally released several years before pool launch. An empirical researcher interested in the effects of contemporary patent pools on the incentives to file standard-essential patents needs to take into account the periods preceding the foreseeable creation of a patent pool, thereby testing empirical predictions of models of ex ante effects of pools, such as Lerner and Tirole (2004) and Dequiedt and Versaevel (2012).

[3] Lampe and Moser (2010) furthermore argue that pool outsiders reacted to the creation of a sewing machines patent pool by increased strategic patenting in order to counteract to the increased litigation capacity of pool members.

3. Descriptive Analysis

3.1 Patent declarations and standards

The aim of our analysis is to assess whether patent pools have contributed to the increasing number of essential patents for technological standards. In a first step, we identify the totality of declarations[4] of essential patents made from 1992 to 2010 to the main formal standard setting organizations (SSO) 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[5]. We identify 64,000 declarations of essential patents made by 150 companies. Our measure is based upon a count of declarations, and not a count of essential patents. The number of declarations is higher than the number of patents, because we also include so-called blanket declarations (a generic declaration that a company owns essential patents without specifying the patent number), and we count patents declared essential to various standards as multiple declarations.

These declarations are related to more than 700 standards and technical specifications. The PERINORM[6] database provides detailed bibliographic information on formal standards such as standard version updates, standard amendments, the number of pages, the technical classification and the year of release.

3.2 The policy change

While there have been many patent pools in very different technological areas until World War II (Lampe and Moser, 2012), stricter enforcement of competition law impeded any pool creation from the end of World War II until the 1990s (Gilbert, 2004). In 1997 and 1999, the European and American antitrust authorities however authorized a new model of patent pooling for two important standards[7], including several important safeguards against anti-competitive abuses. This major policy change significantly altered the expectations of standardizing firms regarding the likelihood of successful patent pool creation.

[4] 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 SSO.

[5] These SSOs account for a large part of the essential patents identified by Bekkers et al. (2011). The sample is however restricted to formal SSOs operating with comparable rules on Intellectual Property Rights, thus excluding important SSOs and consortia, such as the IETF.

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

[7] MPEG2 and DVD, see the business review letters: http://www.justice.gov/atr/public/busreview/2485.pdf, http://www.justice.gov/atr/public/busreview/215742.pdf.

Since this favorable business review, many other patent pools including very similar safeguards have been launched without meeting any resistance from antitrust authorities. *"The DOJ business review letters provide* ***a template*** *for patent pooling arrangements that should not run afoul of the antitrust laws. The letters embody a new thinking in economics and law and* ***contrast sharply*** *with early judicial opinions about the legality of patent pooling arrangements."* (Gilbert, 2004). It is thus reasonable to assume that companies working on a standard after the issuance of the business review letters had different expectations of the likelihood of pool creation than companies working on a standard before this policy change. These expectations in turn are likely to affect their patenting behavior. Simcoe (2005) notes that the policy change with respect to patent pools could be one of the explanatory factors of the increasing number of patents declared essential for technology standards.

3. 3 Patent pools and declarations of essential patents 1992 to 2010

We will first use our comprehensive database to describe the historical evolution of patent pools and the rate of patent declarations over the past 18 years. The most immediate effect of the policy change with respect to patent pools can be seen from figure 1: the rate at which new successful pool projects are created is steadily increasing. The increasing experience of companies with pools, the emergence of companies specializing in the administration of patent pools, initiatives by SSOs and standards consortia encouraging pool creation as well as the further clarification of the legal environment contributed to an increasing ease of pool creation.

Furthermore, we can compare the number of companies having joined the patent pool during the first four years after launch. We can see an increasing number of pools attracting a relatively large number of members. Nowadays, companies deciding upon the level of R&D investment for a future standard can integrate a non-negligible probability of successful pool creation into their calculations of the expected return on essential patents.

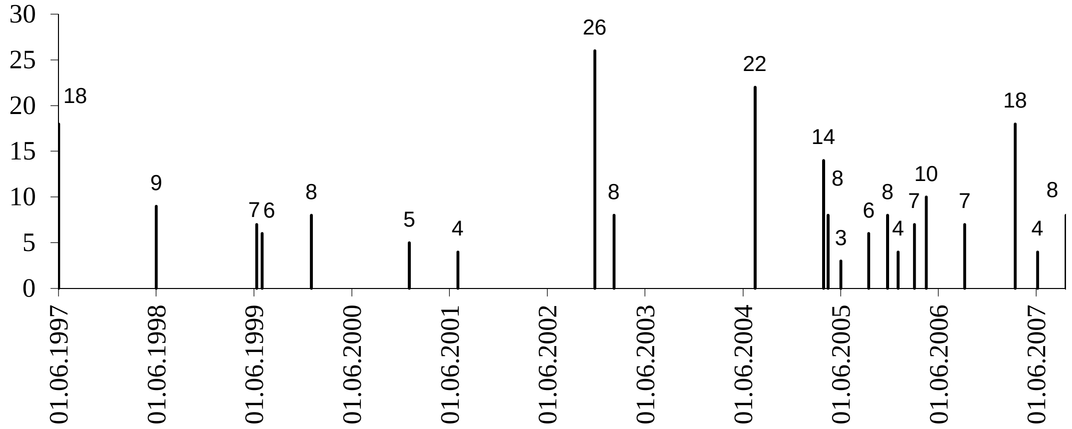

Figure 1 Pool creation and number of members after 4 years

In the following, we can use our declaration database, matched to individual standards, in order to analyze whether the increasingly widespread practice of pooling patents has affected the number of essential patents on new standards. First, our own data confirms a remarkable increase in the number of patent declarations beginning at the end of the 1990s (figure 2). These figures are however to a very large extent driven by declarations made to ETSI, and in particular related to 3G mobile communication standards (indeed, UMTS alone accounts for 11,000 declarations, 3GPP receives 15,000 declarations and AMR-WB 1,500 declarations). It can only be speculated to what extent the various attempts to create a large patent pool on 3G technology have fuelled this unprecedented level of patent declaration. It seems that the role of the (eventually failed) attempts to create important 3G patent pools have not been decisive for the huge number of essential patents on 3G standards[8]. Several of the most important holders of 3G patents have never aimed at joining a patent pool. Furthermore, patenting in this industry seems to be strongly driven by portfolio races between litigious rivals and by the presence of innovation specialists patenting aggressively, notably Qualcomm and InterDigital.

[8] As to practitioners and experts in the telecommunication industry only 8-9% of the GSM standard essential patents are pooled. Attempts by Sisvel and Via Licensing to form pools for LTE have yet not been successful even though there have been meetings to pool LTE patents since more than 2 years.

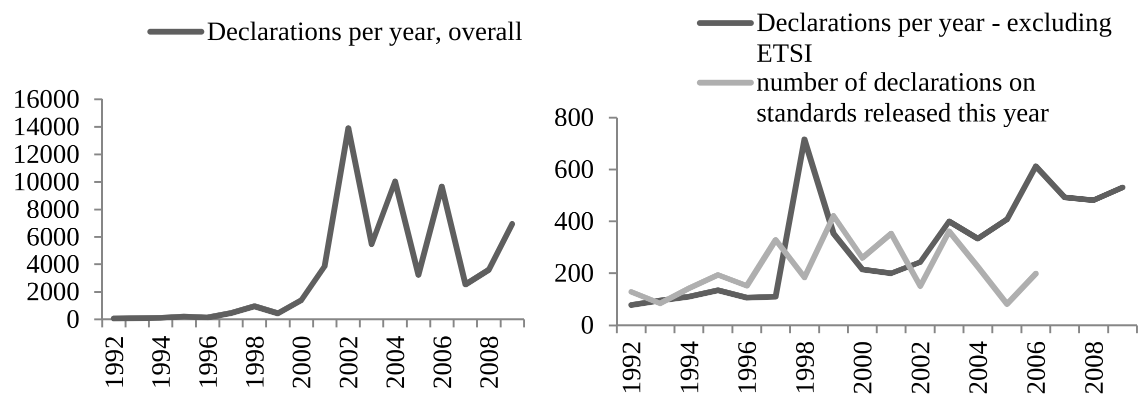

Figure 2 Declarations per year (whole sample left graph) Declarations per year and per year of release (excluding ETSI right graph)

Setting aside ETSI and the 3G mobile phone standards, we focus the analysis on ISO, IEC, ISO/IEC (JTC1), CENELEC, ITU and IEEE. These are standard bodies that, even though they account only for limited numbers of essential patents (compared to ETSI and IETF), are related to 24 out of the 48 pools in our database, including many of the most important ones. Concentrating on these standards, we can still see an increase in the number of declarations at the end of the 1990s (dark grey line in the right graph of Figure 2). The graph also exhibits a spike in the number of patent declarations in 1998. Possibly, this spike includes several declarations of essential patents made as an immediate reaction to the contemporaneous policy change. In order to analyze whether there was a lasting change in the levels of patenting related to new standards after this year, it is important to relate the number of declarations to the year of standard release. By comparing how many patent declarations standards receive in the first four years after release, we can see that standards issued after 1997 indeed include a higher number of essential patents, even though there is no obvious trend, and the numbers are in decline since 2003 (light grey line in the right graph of Figure 2)

We can go further in the analysis of these trends by comparing different types of standards in our sample. For instance, patent pools are a solution tailored to single large standards including many patents held by many different owners. In the following figure 3, we can however see that the increasing number of patent declarations on new standards is mainly driven by an increasing number of standards including patents.

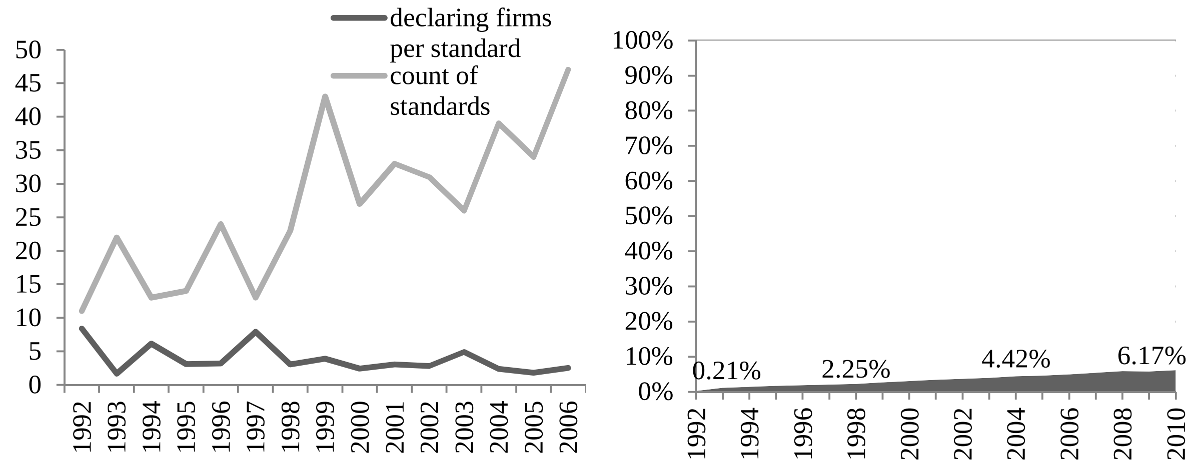

Figure 3 Number of declaring firms per standard and standards including essential patents released per year (excluding ETSI), the percentage of ICT standards with essential IPR (right graph)

The right graph reveals that an increasing share of the standards released by the SSOs in our sample receive at least one declaration of essential patents. At the same time, the average number of declaring firms per standard has decreased over this period.

This finding could indicate that the increasing number of patent declarations is driven by many small standards, for which pools are not really an option. We thus concentrate our analysis on standards including declarations by more than 4 firms. Analyzing this restricted sample, we find important numbers of patent declarations on standards released from 1997 to 2003, but no steady increase neither in the overall number of declarations on such standards, nor in the average number of declarations for each of these standards (figure 4).

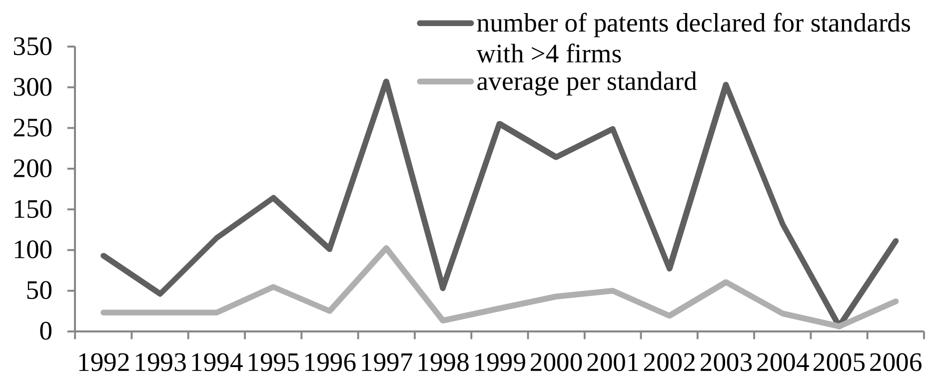

Figure 4 Number of patent declarations to standards receiving declarations from more than 4 firms, and average number of declarations for each of these standards (excluding ETSI)

The analysis of the trends in the number of patent declarations over the past twenty years indicates that the increasing number of patent declarations is on the one hand accountable to

3G mobile communication standards and on the other hand to a high number of standards including few essential patents. While this analysis suggests that patent pools have not been a main driver of the recent increase in the number of essential patents on standards, the analysis of the time trends does not allow concluding on the effect of patent pools on the incentives to file and declare essential patents. Indeed, the aggregate figures are affected not only by the policy change with respect to patent pools, but also by a strong variability in the rate of technological progress, by other policy changes with respect to disclosure obligations and reasonable royalty rates, and by a strong heterogeneity between standards released in different periods. In order to analyze the effect of patent pools on declarations and patenting, we will therefore proceed to an analysis on standard level, analyzing how patent pools affect the level and timing of patenting and declarations for each company and standard.

4. Patent Pools and Dynamics of Patenting

4.1 Methodological Approach

We will next analyze how the rate of patenting and declaring patents relevant for specific standards is affected by patent pools. The patents that are declared essential only constitute a share of the patents filed in view of technological standards. Indeed, very often rivaling firms develop competing technological solutions for the same problem of a standard. If only one of the proposed solutions is chosen for inclusion into the standard, the patents protecting the competing technologies are not essential patents, even though they have been filed as part of the technological development of the standard. In order to identify standard related patent files, we use the 7-digit IPC classification of the declared essential patents, and count the number of patents filed per year in the respective IPC classes. We use all ICT patents filed at the three major patent offices (USPTO, JPO and EPO) from 1992 to 2009 by the firms declaring at least one essential patent for the respective standard, using the PatStat database and the merging methods of Thoma et al. (2010). This merging yields 7 million patents filed by over 150 firms. To create our explained variable, we computed for each company-standard pair and year the number of priority patents filed in the relevant IPC classes for the standard of observation.[9]

[9] We further conduct tests of the technological position of standards as well as size measures to prove that our matching method reliably identifies standard-related patents. The method and the various tests have been presented at the Patent Statistics for Decision Makers Conference 2011 at the USPTO.

In a next step we identify 28 patent pools (including failed attempts to create a patent pool) and match these pools to the standards in our sample[10]. Matching pools with standards is straightforward, as pool administrators clearly display the technological standards that are covered by the patent pool license. 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 and Delcamp, 2012). Such a call, often made upon the initiative of a group of patent holders wishing to create a pool, seeks to identify and federate the remaining patent holders and to steer negotiations on licensing provisions. The call for patents thus indicates the time where the prospective pool creation becomes common knowledge. In the period preceding the call for patents, several companies can already negotiate on eventual pool creation, but at this stage there is still uncertainty on whether a patent pool will be launched. In addition to the launch of the pool, we identify the dates at which the companies joined the pools using internet archives and the history of news releases of the pool administrators (Baron and Delcamp, 2012).

We further create control variables such as a yearly count of all patent declarations on formal standards[11] and a patent count of all patents per year in the IPC classes “G” and “H”[12]. The latter two variables should account for technology shocks in the technical field and organizational changes in the SSOs. We also control for informal industry alliances arising around standardization. Consortia are matched to formal standards using liaison statements[13]. If an official liaison statement was not given, we conducted a more detailed analysis in order to identify the related standard. In total 21 different informal consortia could be related to 63 formal standards including essential patents.

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 patenting controlling for fixed effects of company-standard pairs, activities in standardization and exogenous technological shocks.

[10] The list of pools, the date of pool launch and the match of relevant standards is provided in Appendix 1.

[11] 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 numbers - were also counted as one declaration.

[12] “G” and “H” IPCs are technologies that can be connected to information and communication technologies. In our database of standard essential patents 95% of all patents are classified in in both or at least one of these IPC.

[13] A liaison implies an accreditation and a cooperative standardization development between the formal and informal standards bodies.

4.2 The counterfactual

In order to analyze the effects of patent pools, we need to compare the empirically observed patenting and declaration rate with the counterfactual rate that would have been observed for the same standard, the same company and the same year in the absence of a pool. The existing empirical literature on patent pools compares the levels observed after pool creation with the levels before pool creation, or with the hypothetical values which would be observed if these rates had continued to follow a general trend pre-existing to pool creation (Lampe and Moser, 2012), or if the patenting of pool members had evolved in a manner similar to the patenting of other firms (Lampe and Moser, 2012; Joshi and Nerkar, 2011).

We opt for a similar approach, especially tailored to the analysis of patent pools related to technological standards. The development of the essential technology for a standard does not follow a general trend, nor do patent files and patent declarations for different standards increase or decrease at the same time. Rather, we will show that the patenting and declaration rates follow an inverted U-shape over the development of the specific standard: the number of patent files related to technological standards increases up to the year of standard release and eventually declines, while the number of declarations culminates three years later. We will control for this baseline timing of patenting and declaration with respect to standardization by including a full set of standard age dummies. We furthermore control for different levels of investment in different standards with company-standard pair fixed effects.

In order to accurately estimate the baseline timing for standards related to patent pools, we estimate the baseline timing only over the subsample of standards for which at least some firms license out their patents through pools. This approach is warranted, if the standards licensed out through patent pools substantially differ from other standards. For instance, we expect that patent pools are concentrated on standards including many patents by many different firms, and that the development of these standards is more complex. Nevertheless, the estimated baseline timing is not completely unaffected by the creation of patent pools, even though different standards are affected by pool creation at different moments.

In a first robustness check, we thus estimate the baseline timing over the whole sample of standards including at least one declared essential patent. This yields a baseline timing which is unaffected by patent pools, but which is more prone to heterogeneity among standards. We therefore conduct a second robustness check on a sample of standards which are similar to standards licensed out through pools based upon observable characteristics. As can be seen in appendix 3, standards related to pools are updated more often and are significantly larger in terms of pages. These standards are much more often developed in connection with informal consortia, and they receive declarations of essential patents from a much higher number of firms. All these differences reflect the higher technological complexity and more important commercial stakes involved in these standards. Using these observable standard characteristics, we can construct a control sample of standards of comparable technological complexity and commercial importance (a detailed account of the sampling method based upon a PSM analysis is provided in appendix 4).

4.3 Patent declarations and standard dynamics

We wish to analyze how the pooling of patents affects the rates at which companies file and declare essential patents. Therefore we compare the level and timing of patenting and patent declarations between standards related to a patent pool and standards licensed out individually. We furthermore distinguish between standards released before and after the policy change with respect to patent pools.

As discussed, we have constructed two counts of standard-related patents: patent declarations and patent files in standard relevant IPC classes. We first analyze the timing of patenting and declaration with respect to standard development. Figure 5 compares the timing of our two measures around a standard release. In standardization, the release of the first standard version represents an important event. The first standard version specifies the core technological components that determine imminent standardization. Even though standards are regularly updated and may consequently progress in their technological scope beyond release, the first version often specifies a technical trajectory for ongoing development phases.

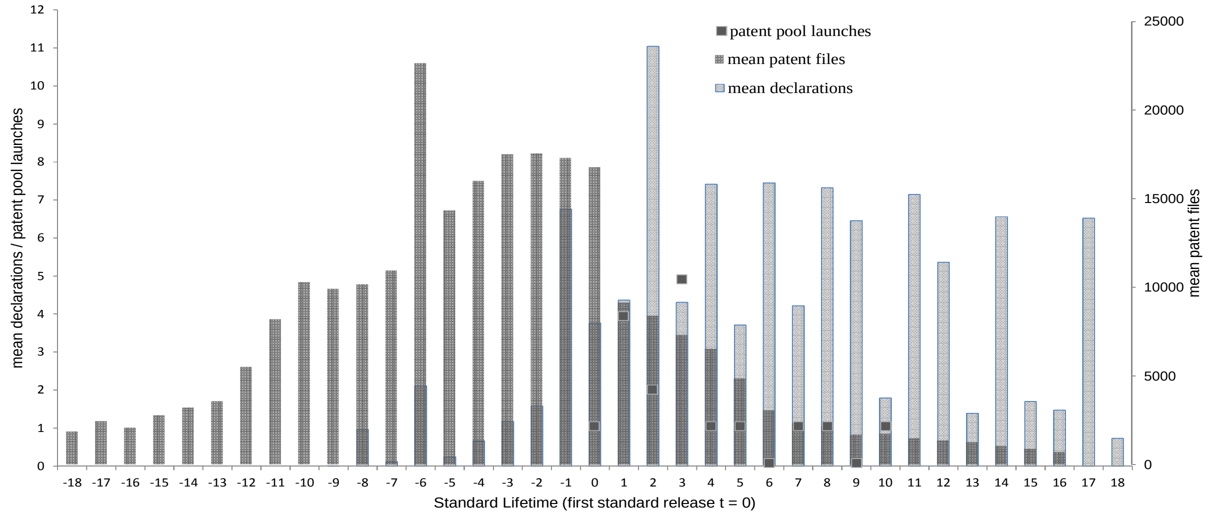

Figure 5 Patent files and Patent Declaration as to pool timing

The figure reveals the typical timing of patenting and patent declarations along the development of a technological standard. Most patents are filed during the four years preceding the first standard release, when the technological basis of the standard is under development. Most declarations are made after the first standard release. Furthermore the count of patent declarations is rather volatile and has a steeper peak around standard release compared to patent files. The graphical analysis shows that the patent count variable also measures some early R&D activities prior to standardization.

We next compare if firms' patent declaration timing differs when patents are pooled or not. In figure 6 we plot the mean patent declaration per firm over standard age. Both graphs show a peak of declaration around the year of standard release. This underlines our argument that the first version contains a major part of the standard's technology components. However, the figure also illustrates that standards related to pools exhibit an unusually high level of declarations in later periods. In comparison, standards without pools experience an almost steady decrease of patent declarations after release.

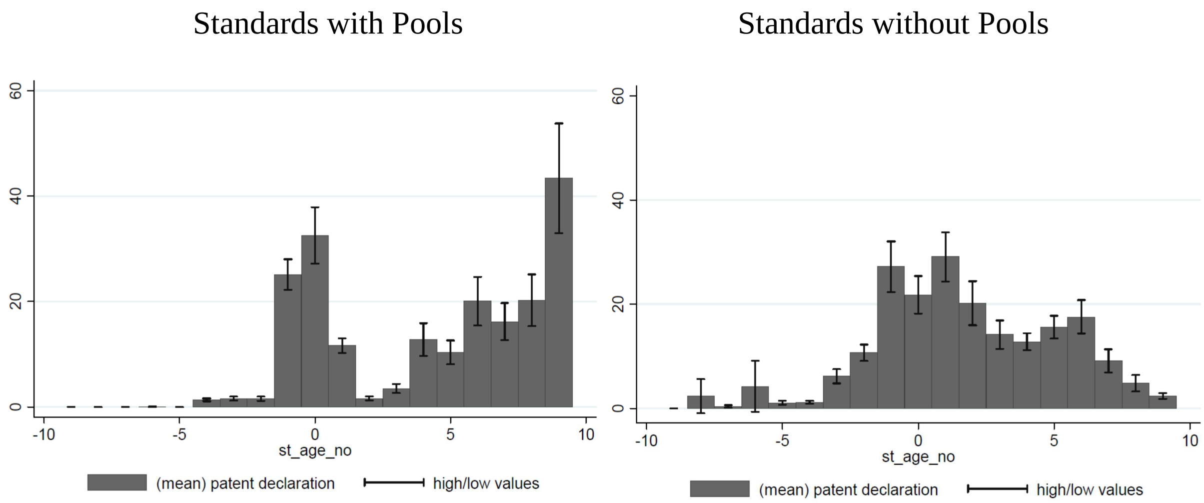

Figure 6 Patent declaration as to standardization timing if patents are pooled or not

In order to analyze whether the unusual peak in declarations well after standardization is related to pool creation, we turn to a panel data analysis. The unit of observation is a one year time span for each standard. We control for standard fixed effects, the baseline timing of declaration along standard development, for exogenous technology shocks and for standardization events (such as modifications or releases of new versions). We can then test whether the creation of a patent pool is related to an otherwise unexplained high level of patent declarations by introducing dummies for two-year periods around pool creation. We thus estimate the following poisson regression:

$$n_{S,Y} = \exp(\alpha_i PC_{S,Y+3} + \alpha_{ii} PC_{S,Y+1} + \alpha_{iii} PC_{S,Y-1} + \alpha_{iv} PC_{S,Y-3} + \theta S_S + \delta T_S + \eta S_{S,Y} + \zeta T_{S,Y} + \varepsilon_{S,Y})$$

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, S_S and T_S are time-invariant standard and technology characteristics, $S_{S,Y}$ and $T_{S,Y}$ are time variant standard and technology characteristics, and ε is an idiosyncratic error term. In the fixed effect specification, S_S and $T_S$are replaced by a standard fixed effect.

The full regression results can be consulted in appendix 2. The following figure 7 plots the estimated coefficients for the periods around pool creation. We can see that these periods exhibit significantly positive coefficients. The estimated coefficients are at the highest for the periods immediately preceding pool creation; and significantly decrease thereafter. This finding could indicate that preparations for pool creation trigger unusually high levels of the declaration rate well after standard release (indeed patent pools are usually launched several years after standard release). Alternatively, it could also indicate that patent pool creation is a reaction to periods of an unusual intensity of patent declarations.

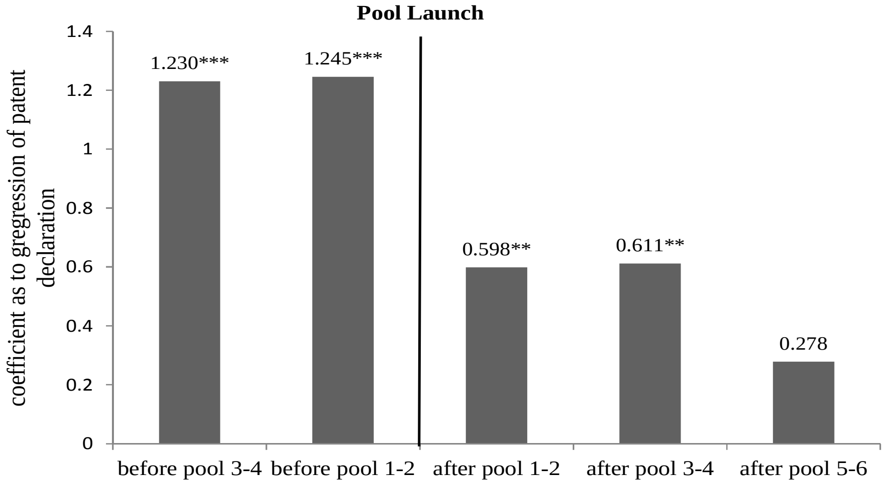

Figure 7 Coefficients on timing with respect to pool launch[14]

4.4 Patent pools and the timing of patenting

In a next step, we plot the evolution of our count of standard related patent files per firm standard pair over standard age. The timing of patenting refers to the date of patent publication. Again the two graphs in figure 8 illustrate that the timing of patenting differs when patent pools exist. Compared to the bell shaped distribution of patent files around the release of standards without pools, we observe an increase of patenting several years after the first release when the standard is related to a pool. Indeed most patent pools are formed several years after standard release. However, we have to be cautious in interpreting these shifts of patenting or patent declaration. On the one hand, we could argue that patent pool formation increases incentives to invest in R&D, leading to a peak in patent files that deviates from the normal timing of patenting around standard development. On the other hand, we could argue that patent pools are particularly formed for standards that are subject to ongoing technology development beyond standard release.

[14] ∗∗∗, ∗∗,and ∗ imply significance at the 99%, 95%, and 90% levels of confidence, respectively

Standards with Pools Standards without Pools

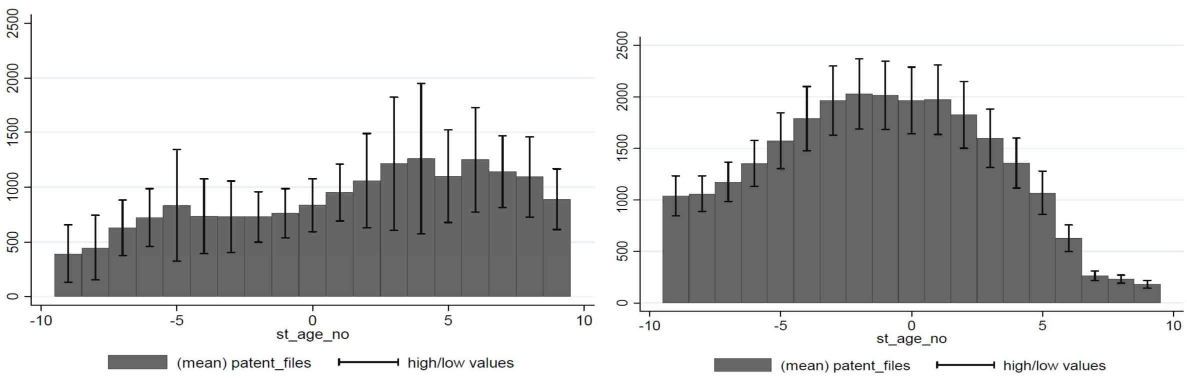

Figure 8 Patent files as to standardization timing if patents are pooled or not

Once again, we analyze whether the unusually high level of late patenting on standards related to patent pools can be connected to the timing of pool creation. We therefore graph patent files per company over time with respect to pool creation. We distinguish between pools for standards released before and after 1999.

Pools for standards released before 1999 Pools for standards released after 1999

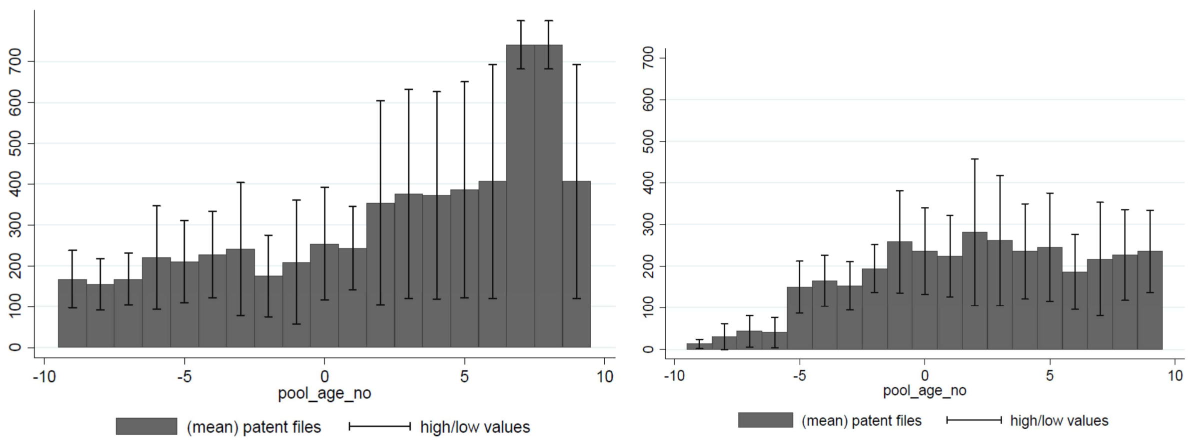

Figure 9 Patent files as to pool timing, standards released before and after 1999

Figure 9 illustrates patent files per firm as to pool timing for standards released before and after 1999. The graph for standards released after 1999 does not show clear evidence for a specific timing of patenting as to the creation of patent pools. We have discussed earlier that the business review of antitrust authorities ensured a legal certainty in periods after 1999. We have argued that for standards released after this date, the possibility of an eventual pool creation can be taken into account by the companies while investing in standard related R&D during the standard development phase. In comparison, for standards released before 1999, there is a strong peak in patent files well after the initial launch of a patent pool. These differences support our approach to distinguish between pools created for standards released before and after policy change. However, difference in the timing of patenting around pool creation between earlier and later standards could also be due to changes in the general dynamics of standardization, rather than the effects of a policy change on the expectations of pool creation. We therefore carry through a further analysis where we include a group of comparable control standards to account for generic changes in standard dynamics.

4.5 Patent pools and time shifts

We apply an additional analysis in order to examine the effects of expected pool creation. As we want to analyze the effect of a prospective pool launch on the overall timing of standard-related patenting, we need a counterfactual group of standards that are closely comparable with the analyzed standards in terms of technological complexity and commercial relevance, but are not licensed through a patent pool. As discussed, we have built up a control group of standards similar to standards related to pools based upon observable characteristics. These characteristics for instance account for the technological complexity and commercial stakes involved in the different standards (see appendix 4 for details).

We then compare the timing of patenting around standard development between the different groups of standards. We estimate the number of standard-related patent files by firm standard pair and year, controlling for fixed effects, persistent effects of transitory shocks, standard age dummies, and events affecting the standard and exogenous factors in the field. We test for the time-shifting effect of patent pools by including a linear standard age variable, which we interact with the dummy variable indicating that the standard is related to a pool. As in the previous analysis, we estimate this effect separately for standards issued before and after the policy shock[15] (results can be consulted in the appendix 5).

We estimate coefficients on the whole sample from 1992 to 2009. In order to avoid truncation of the observation period, we include for all standards only observations for the four years preceding and the four years following to standard release and restrict the sample to standards issued from 1995 to 2005 (results are robust to estimating the model over the full sample and the full observation period). We find that patent pools for standards released after the policy change are connected with patenting taking place earlier in the standard life-time.

[15] As we are now interested in effects of patent pools on R&D investment made early in the standard life time, we decided to divide the sample at a later date. For instance, we cannot expect that the policy change from 1997 to 1999 led to an earlier start of R&D investment for standards released in 2000. We somehow arbitrarily chose the release date of 2002 as a separating line, but within reasonable bounds the results are not sensitive to the precise date separating the samples.

We further conduct test of statistical differences for periods before and after the policy shock. The results reveal significant differences, ensuring that the time shift of patenting is specific to later standards.

4.6 Anticipation and reaction to pool creation

In order to confirm these descriptive findings, we apply econometric analysis to control for heterogeneity and isolate the pool timing effect. We use our panel of firm standard pairs over the timespan of 1992-2009. Thus we are able to make use of the baseline timing of standardization while testing for specific effects around the time when a pool is launched. All firms are observed over the whole period of time. Following our discussion of the importance of expectations, we distinguish between standards released before and after the policy change. We interact the pool dummies with a variable indicating whether the standard was released before or after 1999. We test the following specification:

$$st\ patents_{ijt} = \exp(\ \alpha_1\ st\ patents_{ijt-1} + \beta_1\ before\ pool\ active_{jt\ PL-3/4} * years\ later\ 1999_{\ j} + \beta_2\ before\ pool\ active_{jt\ PL-1/2} * years\ later\ 1999_{\ j} + \beta_3\ after\ pool\ active_{jt\ PL+1/2} * years\ later\ 1999_{\ j} + \beta_4\ after\ pool\ active_{jt\ PL+3/4} * years\ later\ 1999_{\ j} + \beta_5\ before\ pool\ active_{jt\ PL-3/4} * years\ earlier\ 2000_{\ j} + \beta_6\ before\ pool\ active_{jt\ PL-1/2} * years\ earlier\ 2000_{\ j} + \beta_7\ after\ pool\ active_{jt\ PL+1/2} * years\ earlier\ 2000_{\ j} + \beta_8\ after\ pool\ active_{jt\ PL+3/4} * years\ earlier\ 2000_{\ j} + \beta_9\ CT\ patent\ count_t + \beta_{10}\ standard\ activity_{jt-1} + c_t + \varepsilon\ )$$

Where we count st $patents_{ijt}$ filed by firm *i* that are relevant to standard *j* per year *t*, $before\ pool\ active_{jt\ PL+3/4}$ equals one 3 to 4 years before the pool launch *PL* for standard *j* in year *t*, $before\ pool\ active_{jt\ PL-1/2}$ equals one 1 to 2 years before the pool launch *PL* for standard *j* in year *t*, $after\ pool\ active_{jt\ PL+1/2}$ equals one 1 to 2 years after the pool launch *PL* for standard *j* in year *t*, $after\ pool\ active_{jt\ PL+3/4}$ equals one 3 to 4 years after the pool launch *PL* for standard *j* in year *t*, $years\ later\ 1999_{\ j}$ is a dummy variable that equals one if a standard *j* is released later than 1999, $years\ earlier\ 2000_{\ j}$ is a dummy variable that equals one if a standard *j* is released earlier then 2000, $CT\ patent\ count_t$ denotes all worldwide ICT patent files for each year *t*, $standard\ activity_{ijt-1}$ denotes version releases and amendments to standard *j* in year *t-1*, c_t are year dummies and ε is an idiosyncratic error term.

We restrict our standard firm pair panel to standards for which a pool has been created at some time, and further control for unobserved heterogeneity using fixed effects. Thus we rely on a sample of standards that is subject to a comparable pattern. Rather than accounting for pre-existing trends or supposing linear evolutions, we include a full set of standard age dummies to control for the bell shaped baseline pattern of patenting around standardization observed in the descriptive analysis. We furthermore control for particular events affecting the standard in question (including variables for standard upgrades) and for technological shocks in the wider technological field (including the overall number of ICT patents files in the categories G and H per year). We furthermore control for persistent effects including the lagged dependent variable as control variable. We use a poisson estimator with robust standard errors, and furthermore cluster standard errors by firms (clustering standard errors by standards instead does not alter the results). In models M1a-M1c we sequentially include our control variables of standard updates and lagged patent files to ensure independency from our main explanatory variables. In M2 we only use observations of member companies and thus reduce our sample from 242 to 93 group observations. In M3 we also include variables accounting for the timing of pool member entrance. This is due to the possibility that firms which are prospective pool members might react on both, the time when the pool is created and the time when they actually join the pool. All models show robust results for our main explanatory variables.

The results corroborate our methodology to distinguish between standards released before and after the policy change with respect to patent pools. Indeed, the link between patent pools and patenting is very different in the two different samples. For standards released earlier than 2000, we can observe that the creation of a patent pool is immediately followed by an unusually high level of patenting. This group of standards has been released at a time when the prospect of pool creation was still very uncertain. Pool creation became common practice after 1999, when these standards were already released. In comparison, we do not evidence any significant reaction to the creation of patent pools in the sample of standards issued later than 1999. However, our results indicate an anticipatory effect. Periods up to 4 years before pool launch have a significant positive effect for observations of contemporary pools later than 1999.

DV= patent_files	M1a	M1b	M1c	M2	M3
Variable	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)
3-4 y. before pool launch (later 1999)	0.122*** (0.027)	0.151*** (0.028)	0.149*** (0.027)	0.162*** (0.028)	0.145*** (0.033)
1-2 y. before pool launch (later 1999)	0.122*** (0.035)	0.136*** (0.029)	0.127*** (0.031)	0.114** (0.045)	0.152*** (0.037)
1-2 y. after pool launch (later 1999)	-0.006 (0.045)	0.043 (0.036)	0.027 (0.04)	0.122* (0.066)	0.050 (0.035)
3-4 y. after pool launch (later 1999)	-0.074* (0.044)	-0.076* (0.04)	-0.071* (0.041)	0.039 (0.064)	-0.056 (0.04)
3-4 y. before pool launch (earlier 2000)	0.071 (0.066)	0.078 (0.062)	0.090 (0.064)	0.024 (0.064)	0.188*** (0.056)
1-2 y. before pool launch (earlier 2000)	0.032 (0.083)	0.075 (0.062)	0.091 (0.063)	0.04 (0.068)	0.129* (0.068)
1-2 y. after pool launch (earlier 2000)	0.350*** (0.128)	0.330*** (0.12)	0.340*** (0.116)	0.468*** (0.109)	0.268*** (0.085)
3-4 y. after pool launch (earlier 2000)	0.159 (0.108)	-0.023 (0.056)	-0.019 (0.056)	0.055 (0.085)	-0.065* (0.037)
patent files in G and H [1]	0.011*** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.011*** (0.002)	0.010*** (0.002)
Lag1 patent files		0.076*** (0.011)	0.075*** (0.011)	0.071*** (0.012)	0.077*** (0.008)
Lag 1 standard upgrade			-0.022* (0.013)	-0.048*** (0.016)	-0.018 (0.013)
1-4 y. before pool entry (earlier 2000)					0.067 (0.047)
1-4 y. before pool entry (later 1999)					-0.065 (0.06)
1-2 y. after pool entry (earlier 2000)					0.175** (0.071)
3-4 y. after pool entry (earlier 2000)					0.232** (0.113)
1-2 y. after pool entry (later 1999)					-0.102* (0.059)
3-4 y. after pool entry (later 1999)					-0.028 (0.057)
Standard Year Dummies	Included	Included	Included	Included	Included
Observation	3,928	3,928	3,928	1,473	3,928
Groups	247	247	247	93	247
Log likelihood	-476,922	-446,830	-445,701	-190,429	-438,846

Note: All models are estimated using the conditional fixed-effects poisson estimator with robust clustered standard errors (reported in parentheses). Standard errors are robust to arbitrary heteroskedacity and allow for serial correlation through clustering by firm. ∗∗∗, ∗∗,and ∗ imply significance at the 99%, 95%, and 90% levels of confidence, respectively. [1]Coefficient multiplied by 1,000 to make effects visible.

Firms that declare patents to standards where a pool will be created may react to two events: first, the launch of the patent pool and second, the timing of joining the pool as a full member. In the last model we therefore also include the timing of joining a patent pool. In comparison to M1-M3 our last model differentiates the timing of two effects. The effects of the pool creation remain unchanged. In the timing of joining a pool firms show no reaction in periods before or after joining for periods later than 1999. In comparison, firms active in pools for standards released before 1999 show an incremental positive reaction immediately after joining the pool. This effect last for up to 4 years. However, for the latter sample of firm-standard pairs, the positive effect of pool creation is still slightly stronger compared to the effect of actually joining the pool.

4.7 Robustness

In our first models (M1-M3), we compared the observed rate of patenting with the baseline evolution of patenting over standard age estimated exclusively for standards which are licensed through patent pools. This makes sure that we work with a sample of comparable standards and reduces heterogeneity. However, the estimated baseline timing of patenting with respect to standard development is not unaffected by patent pools. In a first robustness check, we thus compare the timing of patenting for standards related to pools with the timing around standards where pools do not exists. We therefore make use of our whole sample of standards where at least one patent has been declared essential, consisting in 1,704 firm standard pairs. We estimate our third model (M1c) over the expanded sample (M4-1).

As discussed, standards where patent pools exist differ from other standards in technological characteristics and in the characteristics of the contributing firms. We gradually reduce our sample to better account for these differences. To account for differences in contributing firms, we identify firms which are technological outsiders with respect to other firms also contributing to the same standard. Indeed, firms may have a different patenting timing when they specialize on different technologies relevant for the standard. In order to limit this firm specific heterogeneity, we measure the technological difference between the essential patents declared by different firms using the overlap of IPC classes. In model M4-2, firms are dropped if their technological focus differs strongly from the average focus of other firms.

Another source of heterogeneity between firms is that different firms can be differently affected by specific technology or business cycles. Our sample covers 18 years during which markets and technology have changed in a volatile manner, with many technology-intensive firms disappearing during the internet crisis and new actors appearing. In order to obtain a sample of firms with a comparable overall evolution, we identify positive or negative shocks to the number of employees of firms (M4-3). We observe differences in one year periods, indicating mergers, acquisitions, restructuring etc. If this shock takes place after 2000, all observations after the shock are dropped for this firm, if the shock takes place earlier, we drop all previous observations. Firms with more than one shock are dropped altogether.

DV= patent_files	M4-1	M4-2	M4-3	M4-4	M4-5
Variable	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)
3-4 y. before pool launch (later 1999)	0.177*** (0.064)	0.177** (0.084)	0.159* (0.096)	0.057 (0.05)	0.166*** (0.045)
1-2 y. before pool launch (later 1999)	0.220*** (0.061)	0.209*** (0.076)	0.197** (0.092)	0.116* (0.065)	0.095** (0.046)
1-2 y. after pool launch (later 1999)	0.071 (0.052)	0.037 (0.061)	0.043 (0.078)	0.069 (0.074)	0.027 (0.041)
3-4 y. after pool launch (later 1999)	-0.186 (0.127)	-0.244** (0.119)	-0.233* (0.123)	-0.006 (0.087)	-0.061 (0.041)
3-4 y. before pool launch (earlier 2000)	-0.115** (0.055)	-0.084 (0.079)	-0.043 (0.067)	0.035 (0.077)	0.199*** (0.069)
1-2 y. before pool launch (earlier 2000)	-0.112* (0.067)	-0.047 (0.089)	-0.009 (0.085)	0.026 (0.1)	0.133 (0.081)
1-2 y. after pool launch (earlier 2000)	0.347* (0.184)	0.428** (0.185)	0.446*** (0.172)	0.452*** (0.148)	0.413*** (0.103)
3-4 y. after pool launch (earlier 2000)	-0.014 (0.055)	0.025 (0.074)	0.103 (0.102)	0.106* (0.063)	0.098 (0.104)
patent files in G and H [1]	0.009*** (0.001)	0.009*** (0.001)	0.008*** (0.001)	0.004*** (0.001)	0.008*** (0.001)
Lag 1 standard upgrade	-0.020 (0.013)	-0.031** (0.015)	-0.028** (0.011)	-0.042*** (0.01)	-0.033** (0.013)
Lag1 patent files	0.007*** (0.001)	0.006*** (0.001)	0.004*** (0.001)	0.007*** (0.001)	0.005*** (0.001)
Standard Age Dummy earlier 2000	0.001 (0.001)	0.001 (0.002)	0.002* (0.001)	0.005*** (0.002)	0.003* (0.001)
Sample restrictions	None	Tech outsider	Employee shock	PSM	Pool Exists
Standard Year Dummies	Included	Included	Included	Included	Included
Observation	27,147	19,560	13,197	6,675	2,521
Groups	1,704	1,227	972	482	171
Log likelihood[2]	- 25,596	- 13,682	- 7,310	- 2,185	-288

Note: All models are estimated using the conditional fixed-effects poisson estimator with robust clustered standard errors (reported in parentheses). Standard errors are robust to arbitrary heteroskedacity and allow for serial correlation through clustering by firm. ∗∗∗, ∗∗,and ∗ imply significance at the 99%, 95%, and 90% levels of confidence, respectively. [1]Coefficient multiplied by 1,000 to make effects visible. [2] values in thousand.

Heterogeneity among standards is also an important source of concern. We therefore make use of our database of comparable control standards (the sampling method is discussed in appendix 4). As to our sampling method, we exclude firm standard pairs that were not matched and estimate another model (M4-4). In our last model we again restrict our sample to standards where pools exists, retaining the restrictions with respect to technical outsiders and employee shocks. All models show robust results for both the anticipation effect before pool launch for standards released later than 1999, and the prompt reaction in periods after pool launch for standards released before 2000.

4.8 Discussion

We have highlighted unusually high levels of patent declaration and patenting around the time when a patent pool is launched. For instance, we have shown that standards related to a patent pool exhibit a peak in patent declarations well after standard release. The rate of patent declaration is especially high in the two years preceding pool launch. When changing our level of analysis to the firm standard level, we have furthermore shown that there is an unusually high level of standard related patenting in the periods around pool creation. In the case of standards released after the policy change with respect to patent pools, patenting takes place before pool creation, whereas in the case of standards released before the policy change, the unusually high level of patenting takes place in the periods immediately after the creation of a pool. Furthermore, companies increase their level of standard-related patenting after joining the pool. As compared with other standards, early standards related to a patent pool are characterized by a peak in patenting occurring several years after standard release. Later standards related to patent pools do not exhibit unusual peaks of late patenting and overall patenting takes place in earlier periods than for standards not related to a pool or for standards before the policy shock related to a pool.

In principle, finding a correlation between pool creation and periods of strong patenting and high rates of patent declaration is not necessarily evidence for a causal effect of patent pools. As patent pools are conceived a solution to the problems of large numbers of complementary patents, it is plausible that periods of unusually strong patenting or high declaration rates lead to launches of patent pools. This argumentation does however not explain why the creation of patent pools for standards released before the policy change is followed by an increase in patenting. In the case of these standards, pool creation can be considered as an unexpected response to a relatively exogenous policy change. While several companies initiated the project to create a pool before 1997, the favorable business review revealed new information on a more permissive policy stance. The direct increase in patenting as a reaction to pool creation, especially but not only by pool members, can therefore be interpreted as an immediate reaction to newly revealed information. The distinction between standards released before and after the policy change is indeed a crucial condition for interpreting our findings as evidence of causal effects of patent pools.

We have argued that the favorable business review of patent pools in 1997 and 1999 created a template for viable pool licensing schemes. Companies investing in R&D related to standards released after this policy change could take the creation of a possible patent pool into account. Due to the benefits of patent pools for holders of essential patents, the prospective creation of a patent pool is expected to induce companies to increase their efforts to obtain essential patents (Lerner and Tirole, 2004, Aoki and Schiff, 2008). Dequiedt and Versaevel (2012) expect that this induced effect takes place before the pool is actually created, and culminates in the periods immediately preceding the launch of the pool. This expectation is based upon the assumption that patent holders would prefer being among the founding members of a pool, rather than having to negotiate entry with incumbent members. This assumption finds empirical support in Baron and Delcamp (2012). Based upon this hypothesis, Dequiedt and Versaevel (2012) also predict that expected patent pool creation induces companies to overall anticipate their investment in related R&D. Our empirical findings are thus fully consistent with the predictions of the theoretical literature on the effects of prospective pool creation on ex-ante incentives to invest in related R&D and patenting.

It should however be stressed that our findings are limited by the fact that we do not directly observe firms' expectations with respect to future pool creation. We only observe actual pool creation on some standards, and assume that at least some firms expected pool creation for these standards with a higher likelihood than for other standards released at the same time. In future work, it should be analyzed whether our findings are robust if we explicitly model expectations as a function of observable standard characteristics in conjunction with learning about the conditions for successful pool creation.

5. Conclusion

In this article, we have analyzed whether the recent policy change with respect to patent pools has contributed to the increasing number of declarations of essential patents in ICT standardization. Indeed, we show that the policy change has altered expectations concerning the creation of a patent pool. We provide evidence that patent declaration as well as firm individual patenting show unusually high levels around the launch of a standard-related pool. There is an important difference between standards released before and after the policy change. While patenting is especially high before the pool is launched for the most recent standards, we find a direct effect right after pool creation for standards released before 1999. These findings indicate that companies were less able to anticipate pool formation before 1999, when patent pools were still subject to legal uncertainty. Today, patent pools are commonly accepted by antitrust authorities and several successful pools set an example for well-functioning mechanisms for pooling patents. Firms are thus able to include the possibility of a pool formation in their expectations of future returns on patents.

Our findings overall support the argument that patent pools have a positive effect on patenting. However, our analysis on the increasing number of patent declarations points out that patent pools have contributed very little to this increase. Most patent declarations are declared to standards that do not qualify for pooling patents. Still, policy makers should take into account that firms' incentives to patent may change due to a pool creation.

However, our analytical framework does not allow us to conclude whether this incremental patenting reflects an increase in substantial innovation or opportunistic patenting. The theoretical proposition that an increase in the expected value of patents leads to more R&D investment rests upon the assumption that firms cannot easily adapt their patent propensity. Given the importance of strategic patenting in the field of ICT standards, we would not be confident to interpret increases in the number of patents as evidence of an increase in substantial innovation. Further empirical research using outside measures of technological progress is required to analyze this question.

Furthermore, our research has pointed out that innovation measures need to take into account the role of expectations. We have made the case that in order to analyze substantial effects on innovation, researchers should focus upon the R&D investment incurred preceding expected or at least foreseeable patent pool creation. Our information on expectations concerning pool creation is however limited to the policy change. A challenge for future research is to better measure firms' expectations concerning pool creation, which may also depend upon pool experiences, market constellations, licensing strategies and implicit or explicit agreements between firms.

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Appendix

Appendix 1 Patent Pools Standard Match and Timing

Pool	Pool Launch	License Available	Standard
mp3	1992	1992	ISO/IEC11172-3
MPEG2	1997	during 1997	ISO/IEC13818-1/ITU-TH.220.0
DAB	1998	1998	ETS300401
G.729	1998	July 1999	G.729
G723.1	2000	from 2000	G.723.1
IEEE1394	2000	2000	IEEE1394
MPEG2AAC	2000	2000	ISO 13818-7 (MPEG2 AAC)
DVB-T	2001	during 2001	EN300744
MPEGAUDIO	2001	2001	ISO/IEC11172-3
MPEG4Audio	2002	2002	ISO/IEC14496-3
MPEG4Visual	2002	2002-11-25	ISO/IEC14496-2
MPEG4Systems	2003	2003-2-4	ISO/IEC 14496.1
AMR	2004	2004-2-24	AMR
AMR-WB+	2004	2004-10-4	AMR-WB+
AVC	2004	2004-7-15	ISO/IEC14496-10/ITUH.264
DRM	2005	2005-3-28	ETSI ES 201 980 V1.2.2 (2003-4); ETSI TS 101 968 V1.1.1 (2003-04); IEC 62272-1 Ed. 1
IEEE802.11	2005	2005-4-14	IEEE802.11/ISOIEC8802-11
UHFRFID	2005	2005	ISO/IEC18000-6
DVB-MHP	2006	2006-3-2	ETSI …
MPEG2Systems	2006	2006-4-16	ISO/IEC13818-1/ITU-TH.220.0
OCAP	2006	2007-6-5	.
NFC	2007	2007-6-5	ISO/IEC18092
VC1	2007	2007-3-14	.
G729.1	2008	2009-1-12	G.729.1
AGORA-C	2009	2009-8-5	ISO 17572-3
AMR-WB/G.722.2	2009	3Q 2009	G.722.2
CDMA-2000	2009	2009-6-10	CDMA Family: CDMA2000 1X, CDMA2000 1xEV-DO and Ultra Mobile Broadband (“UMB”)
G711.1	2009	beginning 2009	G.711.1

Appendix 2 Timing of patent declaration as to pool launch

DV = patent declaration Vaiable	Coef. (S.E.)
3-4 y. before pool launch	1.230*** (0.290)
1-2 y. before pool launch	1.245*** (0.276)
1-2 y. after pool launch	0.598** (0.300)
3-4 y. after pool launch	0.611** (0.293)
5-6 y. after pool launch	0.278 (0.332)
Version Release	0.090*** (0.140)
Amendment	0.220*** (0.042)
Standard Age	0.161*** (0.008)
Standard Age Square[1]	-0.001*** (0.001)
Standard Year Dummies	included
Observation	8,730
Groups	485
Log likelihood	-5,805

Notes: All models are estimated using the conditional fixed-effects poisson estimator, standard errors (reported in parentheses). ∗∗∗, ∗∗,and ∗ imply significance at the 99%, 95%, and 90% levels of confidence, respectively. [1]Coefficient multiplied by 100 to make effects visible.

Appendix 3 T-Test analysis t-tests of explanatory variables by standard with and without patent pools

Standard Updates						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	567	0.360	0.057	1.361	0.248	0.472
St. with Pool	17	3.647	0.818	3.372	1.914	5.381
t = -9.1848 Pr(|T| > |t|) = 0.0000						
Number Pages						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	567	89.280	7.504	178.681	74.541	104.019
St. with Pool	17	159.882	37.181	153.301	81.061	238.703
t = -1.6111 Pr(|T| > |t|) = 0.1077						
Accompanying Standards Consortia						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	568	0.132	0.022	0.526	0.089	0.175
St. with Pool	17	1.941	0.466	1.919	0.954	2.928
t = -12.0743 Pr(|T| > |t|) = 0.0000						
Declaring Companies						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95 %ConfInterval]	
St. without Pool	568	7.273	0.652	15.527	45.99	8.553
St. with Pool	17	55.882	18.521	76.366	16.61	95.146
t = -9.9426 Pr(|T| > |t|) = 0.0000						
NPE on Standard Dummy						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	568	0.276	0.019	0.448	0.240	0.313
St. with Pool	17	0.824	0.095	0.393	0.621	1.026
t = -4.9816 Pr(|T| > |t|) = 0.0000						
NPE Share (for Standards with NPEs)						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	157	0.296	0.019	.235	.259	0.334
St. with Pool	14	0.147	0.021	.077	.102	0.191
t = 2.3571 Pr(|T| > |t|) = 0.0196						
Gini Coefficient of Essential Patent Dispersion						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
St. without Pool	511	0.175	0.010	0.228	0.155	0.195
St. with Pool	17	0.267	0.048	0.199	0.165	0.369
t = -1.6484 Pr(|T| > |t|) = 0.0999						

Appendix 4 PSM Sampling for comparable standards

Our goal is to identify a comparable sample of standards that are licened individually to match it with partly pooled licensed standards. Propensity score matching (PSM) is a widely used approach to estimate causal treatment effects. We therefore apply a logit based propensity score matching algorithm to identify a common support region for both samples. In a first step we search for variables that explain the occurrence of pool formation. It is important to only use variables that are unaffected by the treatment (Heckman et al., 1999). We therfore only employ variables that are measured before pool formation. In particular we only estimate variables until two years after standard release to ensure a uniform measure among standards. In the literature it is argued that choosing to many variables might excaberate the support problem (Bryson et al., 2002). When including non-significant variables to explain the treatment, the propensity score estimates will not be biased but increase in their variance. As to Heckman et al. (1998) we therfore include all explanatory variables in our estimation and only keep variables when they are statistically significant and when they increase the prediction rates. Proceeding that way we dismiss standard characteristics such as the number of pages, the number of declaring companies, the number of essential patents and the gini coefficient of patent distribution. All of these variables did not significantly explain a pool formation and did not increase our prediction results. In comparison we found significant results for the occurrence of NPEs on standards, the existance of collaborating standards consortia and the number of standards updates (table 4).

DV= Pool Exists	Coef.	(SE)	z
Standard Updates	0.099*	(0.055)	1.81
Standard Consortia	0.259**	(0.114)	2.28
NPE Share	-4.188*	(2.257)	-1.86
Constant	-0.882	(0.444)	-1.99
Observations		102	
Pseudo R		0.3038	
Log likelihood		-27.091	

Table 4 Probit Regression

As to our t-test results more than 82% of the standards where we find a patent pool have at least one NPE that has declared essential patents on that same standard. We believe this to be an objective restriction to identify a comparable sample of standards. As discussed earlier, NPEs are an indicator of licensing profits from essential patents. Our PSM estimation is thus restricted to standards where at least one NPE declares essential patents and where the release of the standard has at least been three years ago. Table 4 shows that standards with consortia, with more updates but a lower NPE share explain the formation of pools. The latter results shows that the occurrence of NPEs is positivley connected while a higher share is negativly connected. Our former conducted t-test proved these results.

Figure 10 shows results of our PSM graph of treated (strandards with pools) and untreated (individually licensed standards) goups. We apply the nearest neighbor matching method where we identify matching partners of treated and untreated standards. We use a matching with replacement, where we allow matching an untreated standard observation more than once. This method is especially efficient when we have very different propensity scores as evidence in figure 10. Matching high with low values would result in bad matches. We overcome this problem by allowing replacement which on the other hand increases the variance of the estimator (Smith and Todd, 2005).

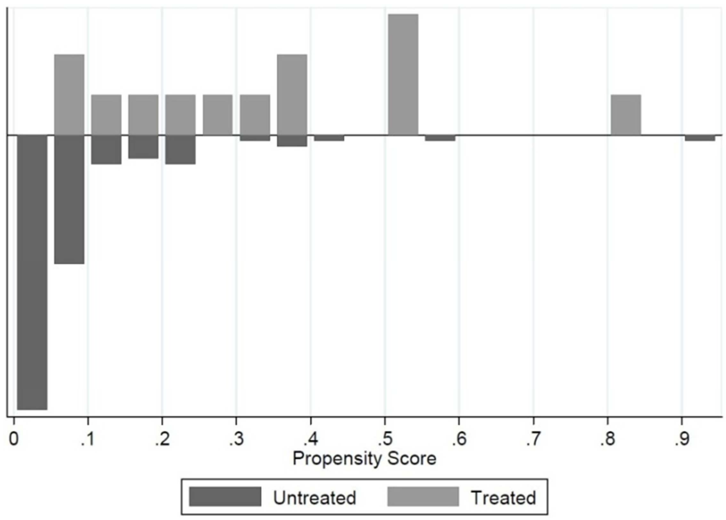

Figure 10 psm matching results

We also apply a maximum propensity score distance (caliper) but our neighbor matches remain the same. We conduct a sample statistic test after our propensity score matching. Table 5 shows that there is no remaining significant differences between characteristics of the standards in the two samples.

Variable	Sample	Mean: Treated	Mean: Control	% bias	% reduct bias	t-test: t	t-test: p>t
Standard	Unmatched	4.384	1.303	101		3.68	0.000
Updates	Matched	4.384	7.230	-93.3	7.6	-1.59	0.124
Standard	Unmatched	2.231	0.404	113.5		5.03	0.000
Consortia	Matched	2.231	1.231	62.1	45.2	1.23	0.230
NPE	Unmatched	0.139	0.271	-85.3		-2.28	0.025
Share	Matched	0.139	0.127	7.4	91.4	0.47	0.642

Table 5 Sample statistics, matched and unmatched samples

Appendix 5 Time shift analysis

DV= patent files	M5	M5-1	M5-2
Variable	Coef. (S.E.)	Coef. (S.E.)	Coef. (S.E.)
standard age before 2002	-0.009***	0.004*	0.005**
	(0.001)	(0.002)	(0.002)
standard age * pool exists before 2002	-0.001***	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
standard age after 2002	-0.006***	-0.006***	-0.005***
	(0.001)	(0.001)	(0.001)
standard age* pool exists after 2002	-0.004***	-0.003*	-0.003*
	(0.001)	(0.002)	(0.002)
patent files in G and H 1	0.011***	0.002	0.001
	(0.001)	(0.001)	(0.001)
Lag 1 standard Upgrade	-0.016	-0.006	-0.002
	(0.01)	(0.008)	(0.005)
Lag1 patent Files	0.001**	0.002***	0.001***
	(0.001)	(0.001)	(0.001)
Standard Year Dummies	Included	Included	Included
Added Restriction standard time and years	No restrictions	4 years bef. & aft. standard release	M5 restriction + 1995-2005
Observation	10,228	4,232	3,259
Groups	640	640	466
Log likelihood	-9,044,428	-2,107,350	-1,688,240

Note: All models are estimated using the conditional fixed-effects poisson estimator with robust clustered standard errors (reported in parentheses). Standard errors are robust to arbitrary heteroskedacity and allow for serial correlation through clustering by firm. ∗∗∗, ∗∗,and ∗ imply significance at the 99%, 95%, and 90% levels of confidence, respectively. [1]Coefficient multiplied by 1,000 to make effects visible.