Coordination mechanisms around ICT standardization projects: four empirical essays on patent pools and consortia

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Coordination mechanisms around ICT standardization projects:

Four empirical essays on patent pools and consortia

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“Statistics are like a drunk with a lampost: used more for support than illumination”

- Sir Winston Churchill

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Preface

In this dissertation, we present four empirical papers:

- **Research paper 1** :
  - Delcamp, H. "Essential Patents in Pools: Is Value Intrinsic or Induced?"
    - Revise and resubmit (2nd round), *Review of Industrial Organization*
    - Paper presented at:
      - 2010 European Academy for Standardization conference
- **Research paper 2** :
  - Delcamp, H. "Are patent pools a way to help patent owners enforce their rights?"
    - Paper presented at:
      - Sixth bi-annual Conference on The Economics of Intellectual Property, Software and the Internet, Toulouse School of Economics
      - 2010 Intertic Conference on Competition in High Tech Markets
- **Research paper 3** :
  - Baron, J., Delcamp, H. "The strategies of patent introduction into pools"
    - Paper presented at:
      - 2010 European Policy for Intellectual Property Conference
      - 2010 European Association for Research in Industrial Economics Conference
      - 2010 European Academy for Standardization Conference
- **Research paper 4** :
  - Delcamp, H., Leiponen, A. "Innovating standards through informal consortia: the case of wireless telecommunications"
    - Paper presented at:
      - 2011 National Bureau of Economic Research conference on Patents, Standards and Innovation
      - 2011 European Policy for Intellectual Property Conference
      - 2011 Intertic Conference on Innovation, Competition and the New Economy

Furthermore, my research work engendered other articles. These papers will not be presented in the body of this thesis as they are not wholly focused on the subject or due to their methodological aspect. However, these papers are available on demand:

- Baron, J., Delcamp, H. "The creation and growth of I.C.T. pools"
    - Under review, *Telecommunications policy*

- Baron, J., Delcamp, H. "Assessing Indicators of Patent Quality: Complex vs Discrete Technologies"
    - Forthcoming, *Scientometrics*
    - Paper presented at:
        - 2010 EPO Patent statistics for decision makers Conference

- Delcamp, H., Ménière, Y. "RAND, Reciprocity and cross-licensing"
    - Under review, *European Journal of Law and Economics*

Résumé

Cette thèse s'intéresse aux mécanismes de coordination créés autour des projets de standardisation technologique. Nous analysons plus particulièrement les standards technologiques développés dans les secteurs des technologies de l'information et de la communication (3G...) et deux types de mécanismes de coordination particuliers que sont les patents pools et les consortiums technologiques. Un patent pool est un regroupement de détenteurs de brevets visant à permettre la négociation d'une seule licence pour plusieurs brevets essentiels à l'implémentation d'un standard technologique. Un consortium est un regroupement d'entreprises, intéressés par le développement d'un standard commun, visant à discuter et promouvoir certaines spécifications technologiques en amont du processus officiel de standardisation. Les patent pools et les consortiums ont fait l'objet de nombreux travaux empiriques et théoriques. Ces travaux soulignent notamment le risque collusif existant au sein de ces organisations (Lerner and Tirole, 2004; Brenner, 2008) ou l'instabilité de ce type d'accord en raison du risque de free-riding (Aoki and Nagaoka, 2004; Brenner, 2009; Choi, 2010; Dequiedt & Verasevel, 2007; Lévèque and Ménière, 2011). Cependant, l'interaction entre ces organisations et l'innovation a été peu étudiée empiriquement. L'objectif de cette thèse est de combler ce manque en analysant l'impact de ces mécanismes de coordination sur les incitations à innover et les stratégies d'innovation des entreprises participantes. Il est essentiel d'apporter des résultats empiriques sur ces questions car l'impact de ces accords sur l'innovation pourrait justifier leur désirabilité sociale.

Cette thèse est constituée de quatre articles économétriques. Les principales conclusions de ces quatre articles sont présentées en début de chaque chapitre. En outre, notre travail de recherche a engendré trois autres articles en attente de publication. Ces articles ne sont toutefois pas présentés dans le corps de cette thèse en raison de leur aspect méthodologique. Ils sont cependant disponibles sur demande.

Introduction

1. Context

Standards are technical norms or requirements, such as GSM or UMTS, established and implemented collectively by several companies to enable interoperability between their components and products. Although standards exist in many sectors, they are especially frequent in Information and Communication Technology (hereafter ICT) industries, where interoperability is a fundamental requirement for successful communication. In the current context of convergence between IT and media industries, interoperability between all types of data formats and electronic devices matters more than ever. Indeed, agreeing on common specifications allows ICT firms to achieve interoperability between their products and economies of scale in their manufacturing – two powerful leverages to foster diffusion of innovations.

There are several ways to achieve interoperability. A dominant standard may be proprietary, privately owned and not officially approved by an independent standards body (i.e. iTunes, Windows, Skype…), but the most frequent modes of standardization consist of open standards that can be defined as not privately controlled with a publicly available repository. In ICT industries, such open standards have traditionally been defined cooperatively by industry players within Standard Setting Organizations (SSOs) such as the International Standards Organization (ISO), International Telecommunication Union (ITU) or European Telecommunications Standards Institute (ETSI).

During the last years, ICT standards have evolved from mere coordination on common specifications to the joint development of complex technology projects. For example, the third generation project (hereafter 3G) for mobile telecommunications includes different technologies mainly from the Universal Mobile Telecommunications System project (UMTS) and from the CDMA2000 project.

New generations of standards tend to embody more components and functionalities. For instance, wireless mobile telecommunication standards have evolved from analogical voice communication to comprehensive digital standards also allowing the transfer of video, email, photography, music, GPS or internet.

Furthermore, they embody an increasing number of patented elements. Rysman and Simcoe (2008) confirm this assertion with an analysis of a sample of 1664 intellectual property disclosures made over 34 years in four major SSOs[1]. The number of intellectual property disclosures increased from 1 in 1981 to 125 in 2004[2]. Besides the rising technical sophistication of standards, this trend is due to the use of patents for a broader set of strategic motives (Blind et al., 2006) and more aggressive patenting strategies of firms (Blind & Thumm, 2004; Simcoe et al., 2009) who seek to derive revenue from their patents incorporated in technological standards. As such, intellectual property rights thus represent a key strategic stake for companies involved in standard-setting activities.

Standards and patents were thus bound to meet, staging a clash between conflicting logics. On the one hand, standards are industry-wide public goods, developed by and for the industry players. To be widely adopted, they should be accessible to all at a minimal cost. On the other hand, patent law is meant to foster innovation by conferring inventors a temporary legal exclusivity. Its incentive power precisely lies in the profit innovators can derive from restricted access. These incentives are particularly high for patent holders participating in ICT standards as the downstream markets are characterized by demand-side economies of scale[3]

In order to overcome this opposition, industry players have designed new ways to develop standards and bring them to the market, thereby perpetuating the spirit of cooperation which is inherent to standard setting while preserving sufficient profit for innovators. In this respect, patent pools, which can be defined as ad hoc cooperative agreements in order to grant a single license for patents essential to the dissemination of a technology, are particularly interesting.

Patent pools have existed since the mid-19th century. The first known patent pool, the sewing machine combination, was created in 1856 (Lampe & Moser, 2010). However, patent pools became again a topic of interest in recent years, as they are particularly adapted to reduce problems especially prevalent in high tech sectors[4]. Thereby, whereas patent pools are not

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[1] the American National Standards Institute (ANSI), the Institute for Electrical and Electronic Engineers (IEEE), the Internet Engineering Task Force (IETF), and the International Telecommunications Union (ITU)

[2] This trend is also verified in Europe. For instance, the number of intellectual property rights declarations at ETSI rise from 33 in 2001 to 176 in 2010.

[3] A market with demand-side economies of scale or network effects is a market in which the value of a product or service increases with the number of users

[4] Such as the patent thicket problem that was first defined by Shapiro (2001) as a “dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology”

only created around a standardization process, one can observe a greater importance of these organizations around formal ICT standardization processes. It is now widely recognized, by both practitioners and antitrust authorities[5], that patent pools help to reduce the cost of royalty stacking.

Patent pools are playing an increasingly important role in the modern economy as they accompany the development of High-Tech sectors. BluRay or DVD players, smartphones or digital TV receivers all incorporate proprietary technology that is licensed through patent pools. For instance, Clarkson (2004) indicates that the value of products produced under pool licenses exceeds 100 billion US dollar per year on the US market.

This growing importance of both technological standards in the modern economy and intellectual property issues have made patent pools, particularly used around formal ICT standardization projects, a major subject of debates, controversies and research[6]. Patent pools are particularly attractive to study as they are a way to answer, at the same time, to two different objectives: conferring patent owners a temporary legal exclusivity while allowing a large diffusion of the technology by reducing the cost for the producers.

2. Justification

This thesis is mainly dedicated to patent pools. We chose to work more precisely on two questions: what are the main incentives for the different stakeholders to participate and what are the consequences of these arrangements on upstream markets for technologies especially on the patent holders' incentives to innovate.

The first question is fundamental as the theoretical literature on patent pools appears to be in contradiction with the recent success of patent pools, especially in ICT industries. Indeed, the theoretical literature predicts the instability of big patent pools due to the incentives for patent holders to free-ride (Aoki and Nagaoka, 2004; Brenner, 2009; Lévèque and Ménière, 2011). However, we can observe in practice an important number of patent pools with very little failure. For instance, Lerner, Strojwas and Tirole (2007) identify 125 patent pools, created from 1856 to 2001. Baron and Delcamp (2010) underline that the vast majority of pool launches, in their sample of 52 current ICT pools, were successful and reached the step of commercializing licenses.

[5] See for instance the MPEG 2 Business Review Letter issued by the U.S. Department Of Justice available at: http://www.justice.gov/atr/public/busreview/215742.pdf

[6] See for instance Gilbert (2004) for an historical review of judicial decisions and controversies on patent pools.

This difference between theory and practice appears particularly striking and prompted us to ask ourselves the existence of other incentives (not related to royalties) for patent holders to participate in pools. This questioning is at the center of the two first papers of this thesis.

In the first one, we analyze the quality of patents included in pools and highlight that pools are able to attract good quality patents. This finding is important as the free-riding problem is particularly important for holders of good quality essential patents that can more easily license their rights outside the pool and thus benefit from the pools' creation, without reducing their level of royalties. Consequently, many economists (Layne-Farrar & Lerner, 2010) suspect patent pools to include only low-quality patents and this could seriously call into question the usefulness of these agreements.

The second paper targets the impact of pools on litigation strategies. This question has been evoked in the literature (Gilbert, 2004) but this paper is the first, as far as we know, to question empirically the link between pools and litigations. The results are interesting as they point out incentives (related to the cost of the patents' enforcement) for patent holders to participate in pools that are not yet discussed in the theoretical literature, We especially underline that the number of litigations strongly increase after the patent's introduction in the pool and that this introduction effect vary according to the size, structure and nature of the patent holder and the pool.

We believe the second question, the impact of pools on upstream markets especially on incentives to innovate, is needed to complete the findings on the social advantages and drawbacks of patent pools and thus conclude on their desirability. Indeed, in spite of the growing number and importance of patent pools and thus available data, there is so far little research and very little empirical evidence on what their impacts on innovation are.

Patent pools have been widely studied in the economic literature but not their impacts on upstream markets. From a game theory point of view, the conflicting objectives between private and social interests in patent pools constitute an important field of research on coalition building issues (Aoki and Nagaoka, 2004; Brenner, 2009; Choi, 2010; Dequiedt & Verasevel, 2007; Lévèque and Ménière, 2011). On a related topic, there is also a substantial literature on the methods of royalty sharing within a standardization context (Swanson & Baumol, 2005; Layne-Farrar, Padilla & Schmalensee, 2007). This issue is obviously of major importance for the creation of a pool. For instance, the creation of a common pool for the DVD technology failed due to the inability of patent holders to agree on the royalty sharing rules. Layne-Farrar and Lerner (2010) are the first to analyze empirically the consequences of the royalty sharing rule chosen by a pool on the characteristics of the members.

From a competition economics standpoint, these arrangements are widely studied as they could be used as a price-fixing mechanism by introducing patents that are substitutes for each other (Lerner and Tirole, 2004; Brenner, 2008). For instance, the Federal Trade Commission charged Summit and VISX, two firms that controlled the market for laser eye surgery, with a price-fixing conspiracy for the creation of a pool through a shell entity named Pillar Point Partners.

Despite this important strand of literature, there is very little research dedicated to the link between pools and innovation. The choice to focus more specifically on the innovation aspect is based on several findings. We especially believe that the impact of patent pools on innovation could be significant and probably at least as policy-relevant as the questions of their consequences on licensing fees or competition.

Indeed, in practice, the overall patent licensing cost represents only a small share in the price of the final good. Most importantly, patent pools or other licensing agreements shape not only the structure of the downstream market, but also the upstream technology markets (incentives for patent holders to innovate…). and the circumstances under which technologies are developed and deployed. This question is of major importance to assess the global welfare effect of patent pools and is not yet fully integrated in the normative analysis of these organizations. This is due to the lack of research on the impact of pools on innovation issues. This thesis will attempt to partially fill this absence of research. In the third paper of this thesis, we will address this issue through a dynamic empirical analysis made possible by an important data work that we will present in section 3. We will especially highlight that incumbent members are able to introduce patents of different characteristics (narrower, more incremental and of poorer technological significance) than outsiders whishing to join the pool.

Our work on the impact of pools on upstream technology markets led us to question the presence of other cooperative agreements and their respective impact on innovation. The last part of this dissertation especially targets the complementary question of technological consortia. A technological consortium can be defined as an association of two or more firms[7] with the aim of pooling their Research and Development (hereafter R&D) resources for achieving a common technological project.

This complementary research is necessary to disentangle and emphasize the different effects of these two cooperative agreements (pools and consortia) on the orientation of R&D around a standardization project. The functioning and purposes of industry consortia are different from patent pools. However, their influence on the patent holders' incentives to innovate together with their growing importance around standardization projects in ICT fields

[7] Individuals or public organizations

justifies our interest. We especially investigate the impact of industry consortia on upstream markets especially on incentives to innovate and the orientation of R&D strategies.

From a more personal point of view, the centrality of patent pools and consortia at the interaction of two important issues, that are innovation and standardization, made these three years of thesis intellectually exciting and rich in research opportunities.

3. Methodology

The questions addressed in this thesis, as well as the positive standpoint adopted, naturally led us to use an empirical approach. Using a dynamic econometric approach is absolutely necessary to give new insights on these fact-based questions. This choice was reinforced by the recent increase in the number of public data sources available on patent pools and consortia that allow, by combination with more classical patent databases, to answer the majority of the questions presented above.

A key feature of this thesis is the addition of a dynamic outlook on pools and consortia. Indeed, using Internet Archives, we were able to observe the evolution of patent pools (the list of essential patents) and consortia over the full time-span since their creation. This dynamic viewpoint is important as the failure to analyze the timing of their activity with respect to R&D leads the existing theoretical research to fail to account for the effects of pools or consortia that are probably the most relevant, i.e. their effects on innovation strategies.

In order to investigate empirically these questions, we use specific information on the participation of firms to patent pools and consortia and combine these data with more classical databases on patents.

The first three empirical papers presented are mainly based on a database constituted using the websites of pools' administrators[8]. This database consists of U.S. essential patents, included in 8 different patent pools[9]. The patent numbers and the name of patent holders were retrieved using the lists available on the websites of the pools[10]. Using Internet Archives[11] we obtained this list of pool patents at different date over time. Comparing successive patent lists allowed us to identify the date of introduction. This database was completed with

[8] Such as MPEG LA or Sisvel
[9] DVD3C, DVD6C, MPEG2, MPEG4 Systems, MPEG4 Visuals, AVC H/264, IEEE 1394 and DVB-T
[10] www.mpegla.com (MPEG2, MPEG 4 Systems, MPEG4 Systems, AVC, IEEE 1394), www.dvd6cla.com (DVD6C), www.sisvel.com (dvb-t)
[11] www.archive.org

data on the nature and structure of the firm[12] and with information on the patents' characteristics[13]. We also obtained information on litigations involving these patents using the Stanford IP Litigation database.

In the second paper of this thesis, we develop a new indicator to analyze the technological focus of the patents filed by patent pool members. This indicator assesses the focus of a patent on a standard and is based upon the breadth of the essentiality claim. The patent essentiality reports indicate the standard sections for which each patent is essential. The summaries of these essentiality reports[14] indicate the sections and subsections of the standard document for which the respective patent is essential. This new indicator is a count of these sections and subsections corrected by the median of patents in the same pool. This indicator has been used to assess the patent's focus on the standard underlying the pool, controlling for the breadth and generality of the patent itself.

These three papers on patent pools are thus based on the same pivotal database regularly improved during my Ph.D thesis. These combinations of data represent an important part of this work and added value of this thesis. Indeed, the different formats used in the databases as well as the scattering of data across multiple sources required a large amount of data mining and standardization. This database is probably, at this time, one of the broadest and most complete databases on pool patents mixing data on patents' characteristics, information on the patent holders and the timing of introduction.

The econometric approaches used are quite homogeneous as we mainly use standard panel-data methods (fixed effects estimation) to control for time-invariant unobserved heterogeneity of members and patents.

The last paper presented in this thesis is based on the same type of database created using the websites of the consortia. This paper relies on a combination of data on consortium co-membership links between firms involved in the third-generation mobile standards and cross-citations of patents filed by these participants. We gathered data on 16 000 patents declared essential for the UMTS standard[15] and merged these data with information on citations[16] and on the identity of the cited patent holders[17]. Next, we created a database on consortium membership links between firms involved in the third-generation mobile standards. Similarly to the pool database, we used Internet Archive to obtain data on the memberships of the

[12] Size of the patent portfolio, number of employees, number of patents already included in the pool, vertical integration

[13] Using the NBER database, I obtained: The number of claims, forward and backward cites, patent generality, technological class, grant and application year

[14] Publicly available on the websites of the pools' administrators

[15] The projects included are : 3GPP, 3GPP release 7, 3GPP/AMR-WB+, UMTS, UMTS Release 5, UMTS Release 6, UMTS Release 7, UMTS Release 8, UMTS/CDMA

[16] using the NBER database

[17] Using the EPIP database available at: http://www.epip.eu/datacentre.php

patent holders (owners of the citing and the cited patents) in consortia in the ICT field from 2000 to 2005.

These databases are used to assess econometrically the effect of firms' participation in consortia on the convergence (cross-citations) of subsequent inventions. We then created different variables to capture the patent holder's general level of participation in ICT consortia from 2000 to 2005 and the direct connection between the holders of citing and cited patents during the year in which the citing patent was applied.

The main empirical issue in this paper is to disentangle the effects of participation in consortia from the technological centrality of the firm in formal standards development. Indeed, it can be argued that a patent is highly cited because of the patent holders' participation in consortia or because the patent is technologically central in the UMTS wireless system and then its holder participate in many consortia. In order to control for this problem, we use data on patent holders' participation in the formal standards-development organization (3GPP). We trace patent holders' activities in formal 3GPP committees[18] from 2000 to 2005 and create a variable that equals the number of unique connections to other firms through these committees. This variable allows us taking the centrality of the firm in formal standard setting into account and thus enables us to distinguish the direct effect of consortia on cross-citations.

In this last paper, we also explore whether a quasi-experiment, a merger of a set of industry consortia of mobile services, allows us to control for possible time-varying unobserved effects and estimate a differences-in-differences model. This method was developed to increase the robustness of the findings and to control for our main econometric concern in this research: innovations emerging during the period of analysis might make firms more likely to both attend consortia and cite patents held by the central participants.

As presented in this section, this thesis is constituted of four econometric papers with different findings on pools and consortia. The next section will present more precisely the results of the four papers and discuss their interest in the current context.

4. Main findings

This section presents in detail the econometric results of the four papers of this dissertation. We also emphasize their interest in the current context and controversies about patent pools and industry consortia. Regarding the methodology, two papers have been realized in collaboration with other academics (Aija Leiponen, Associate Professor at Cornell University

[18] Using the website http://www.3gpp.org/

and Justus Baron, Ph.D. student at Cerna Mines ParisTech). These collaborations have been very fruitful for my dissertation as they helped me to enhance my technical skills, to address new areas of research and to confront my ideas to other researchers working on the same topics.

⇨ *On the stability of patent pools and incentives to participate*

The main difficulty faced by patent pools, in practice, is to create sufficient incentives for patent owners of essential patents to participate. Indeed, even if efficient and beneficial for all interested parties, coalition building among patent holders to form a pool runs into free-riding problems. Patent holders have strong incentives not to participate in order to get a free ride by taking advantage of the opportunity to charge higher royalties for their patents. As pools cut down the number of firms licensing independently their essential technology, they allow each patent holder remaining outside to increase its profit. According to this reasoning, the most desirable position is that of being the only outsider to a pool made of all the other relevant patent holders (Aoki & Nagaoka, 2004; Lévèque & Ménière, 2011).

This pessimistic theoretical view appears to be in contradiction with the recent success of the pool business model. In fact, we observed an increasing number of pools especially in I.C.T. industries. For instance, Baron & Delcamp (2010) identify 52 pools in activity in I.C.T industries[19]. Therefore, a new strand of theoretical literature has emerged taking more seriously the dynamic features of patent pools and analyzing pool creation over time and with respect to patenting (Llanes & Trento, 2010).
The first two papers of our dissertation target this stability problem and the research gap between theory and empirical evidence.

In the first one, we point out that, contrary to prevalent expectations on the subject, patent pools are able to attract essential patents of high technological significance. This finding is important as it calls into question the real impact of the free-riding problem on the creation of patent pools. Indeed, due to this free-riding problem, many economists (Layne-Farrar & Lerner, 2010) suspect pools of including only low-quality patents. This paper seeks to inform this debate, by assessing empirically the value of patents included in pools. In order to do so, we disentangle the intrinsic value of the patents included from the induced value generated by this inclusion. Our results suggest that pool patents have a higher intrinsic value, at the time of introduction, than patents with similar characteristics not included in a pool. This result plays

[19] See Baron & Delcamp (2010), *The creation and growth of ICT pools* (paper not included in the body of this thesis)

an important role in the current debate about the pools and their economic efficiency. Indeed, it underlines that, contrary to what has been stated in the literature, patent holders do not use pools to license poor values' patents.

The second paper highlights that there exist incentives for patent holders, to participate to pools, which are not directly related to royalty sharing. We especially analyze two questions: the patent holders' incentives to litigate before and after introduction of their patents in the pool and the impact of this inclusion on the perceived characteristics of the patents by the courts. We emphasize that the number of litigations, with the patent holder as a plaintiff, strongly increases after the patents' introduction. We highlight a positive effect of the pools' size, as measured by the number of members, on this introduction effect. We argue that this effect could be due to a transmission of information and thus increases the likelihood that the infringement is detected by the patent owner. We also analyze other factors affecting the incentives to litigate such as the size of the firm and whether the patent holder is at the same time licensor and licensee of the pool.

To finish, we point out that the number of cases ended by settlement is higher after the patents' introduction in the pool. We argue that this effect could be generated by the impact of the essentiality evaluation, realized by a third party expert, on the uncertainty about the patent essentiality.

⇨ *On the impact of patent pools on innovation*

On the policy issues, economists globally agree that pools in their contemporary form decrease downstream licensing costs and increase consumer welfare. Nevertheless, the major part of this analysis neglects the dynamics of innovation and pool formation. Indeed, many patents are not only filed in expectation of a patent pool, but well after its creation[20]. The pools and their administrator thus play an increasingly important role in setting the framework and incentives for subsequent research and development.

The effect of patent pools on subsequent innovation is of great importance and has an impact on the total welfare effect of these organizations. However, this link between pools and innovation has so far not been treated empirically. This main question drives my third paper on patent pools. This paper is a joint work with Justus Baron (Ph.D. student at Cerna) in which we analyze the patterns of patent introduction into ICT pools, using data from major contemporary patent pools.

[20] See Baron & Delcamp (2010), *The creation and growth of ICT pools* (paper not included in the body of this thesis)

We analyze the impact of pool membership on the technological characteristics of patents that are introduced and highlight patterns of introduction providing sufficient evidence for an effect of pool membership on patenting strategies.

We stress that pool members are able to include narrower, more incremental and less significant patents than outsiders. We also provide a track to understand this result. Indeed, as measured by the new indicator presented in the methodology section, experienced pool members file patents that are more focused on the criteria of essentiality practiced by the pool.

This is one of the first results underlining the assumption that patent pools not only have an effect on the royalty level but also and more fundamentally on the underlying innovation. These empirical results are important because they point out a balance between pools' positive and negative effects. This paper stresses a potential negative effect, the incentives of pool members to file narrow patents and thus potentially increase the patent thicket problem. The interaction between these findings and the results of the first paper will be thoroughly discussed in section 5.

⇨ *On the impact of consortia on coordination of subsequent innovation*

Studying the impact of patent pools on the orientation of research and development led us to question the existence of other coordination cenacles around the standardization process. Formal SSOs are often perceived to be slow and bureaucratic. To accelerate the process, sub-groups of firms create less formal upstream alliances or consortia. These consortia may offer opportunities to simply discuss, test, or promote certain technologies, or they can be used to actually develop technical standards that will later on be submitted to formal SSOs for official approval. One can observe an increasing importance of such informal industry bodies in ICT fields. For instance, Leiponen (2008) highlights the existence of no less than 10 consortia directly related to the 3G project.

The effects of these consortia have been debated in policy circles but there is a scarcity of empirical evidence. Leiponen (2008) stresses that ICT firms' participation in such consortia facilitates influencing standard-setting outcomes, through change requests to ongoing specifications, in formal standard-setting organizations. However, there is no evidence to date about a possible effect of consortia on coordination regarding subsequent innovation.

The fourth paper of my dissertation analyzes the impact of cooperation in technology consortia, by ICT firms, on subsequent innovation. This research has been conducted in partnership with Aija Leiponen, Associate Professor at Cornell University and Imperial College Business School. This research provides the first empirical evidence of the effect of participation in consortia on the convergence of firms' innovation strategies. Our results emphasize the role of consortia in enabling the coordination of innovation. We find that co-membership of two firms in an informal technical consortium significantly increases the likelihood that they cite each other's patents in subsequent UMTS essential patents.

For managers, the results show that participation in a variety of technical consortia enables influencing not only standard specifications, as shown in earlier research (Leiponen, 2008), but also peers' innovation strategies.

5. Further comments on the link between pools and essential patents

This part is dedicated to a discussion of our results on patent pools, especially on the link between pools and patenting strategies. Our data work allowed us to obtain a complete database of pool patents coupling information on the characteristics of these patents, the identity of the holders and the timing of introduction. These data allowed me to accomplish two econometric papers, presented in this dissertation, on pool patents.

From a policy point of view, this work underlines some positive and negative effects of patent pools.

On the one hand, we underline, in a first paper, that pools are able to attract good quality patents and are not only used as a mechanism to bundle bad patents. This first finding is interesting for policymakers as it underlines that pools can be considered as an effective way to license patents with a real technological significance and thus help to effectively reduce the patent-thicket problem. It calls for a benevolent view on these agreements that are not, as sometimes stated in the literature, a way to bundle bad quality patents which could deteriorate the consumer welfare.

On the other hand, the third paper presented point out some negative effects of pools on patenting strategies of the members. Indeed, this article underscores that incumbent members are able to include narrower, more incremental and less significant patents than outsiders. We argue that these strategies are mainly generated by the existing incentives, for patent holders, to increase their number of patents in order to raise their share of licensing revenues. By diluting the returns on significant patents, these opportunistic patenting strategies around pools (by incumbent members) are particularly problematic. In fact, they affect the return on innovation and thus, in a long-term view, the incentives for outsiders to innovate. These opportunistic strategies also significantly increase the administrative costs of patenting without yielding additional innovation.

This third paper thus balances the results of our first paper and helps to refine the findings. Pools select patents that are, generally speaking, of higher technological significance than non pool patents presenting the same characteristics (technological class, application year....). Nevertheless, pools generate incentives leading to “patent races” between members and companies wishing to join, resulting in the inclusion of narrow, more incremental and less significant patents by incumbent members. Therefore, the selection of patents, at the time of introduction, allows pools to prevent the inclusion of bad quality patents but this selection is more severe for outsiders wishing to join than for incumbent members.

This “patenting race” significantly reduces the main interest of pools, which is to reduce the social costs of patent thicket. Pools could even aggravate the patent thicket problem by increasing the incentives for patent holders to multiply the number of patents very focused on the underlying standard but very narrow and of poor technological significance.

However, this advantage of incumbent members probably generates incentives for patent holders to join the pool promptly after its creation. Indeed, being one of the first members then becomes a clear advantage over competitors.

Résumé chapitre 1: Brevets essentiels inclus dans les pools: La valeur est-elle intrinsèque ou induite?

Cet article analyse empiriquement la valeur, mesurée par les citations futures, d'un ensemble de 1363 brevets essentiels inclus dans 9 pools différents. Nous constatons que les brevets inclus dans les pools reçoivent plus de citations que les brevets d'un groupe de contrôle présentant les mêmes caractéristiques (âge, classe technologique..) non inclus dans un pool. Nous analysons de manière approfondie cette différence pour savoir si les brevets sont plus cités au moment de l'introduction dans le pool ou si le pool a un impact positif sur le nombre de citations futures. Nous démontrons que les brevets inclus dans un pool sont plus cités au moment de l'introduction que les brevets du groupe de contrôle présentant les mêmes caractéristiques. Ce résultat est important en pratique car il souligne que les pools de brevets ne sont pas utilisés pour licencier des brevets de faible significativité technologique comme cela peut parfois être avancé dans la littérature. Cependant, cette différence ne provient pas uniquement de la capacité des pools à sélectionner des brevets de haute significativité technologique au moment de l'introduction. En effet, l'introduction dans le pool a un impact positif significatif sur le nombre de citations reçues par le brevet. L'introduction dans un pool tend donc également à augmenter la valeur des brevets.

Research paper 1: Essential patents in pools: Is value intrinsic or induced?

1. Introduction

Patent pools function as arrangements with the express aim of obtaining a single license for a package of patents belonging to different owners. Since the late 1990s, patent holders have used them chiefly to facilitate the adoption of technology standards embodying a large number of patented elements, such as the Digital Versatile Disc, or the MPEG video compression format. Indeed, pools provide a means of cutting the transaction costs of licensing. They also prevent excessive royalty stacking due to coordination failure between licensors[3].

Despite these advantages, the formation of patent pool often generates problems in practice. A patent holder may prefer to let the other ones form a pool, while keeping freedom to charge high royalties for its own patents (Aoki & Nagaoka, 2004). Against this background, many economists suspect pools of including only low-quality patents. Layne-Farrar & Lerner (2010) argue, for instance, "We might expect that firms with especially valuable contributions to a standard (say, in terms of crucial components for the standard) would opt out of the patent pool since they are more likely to be able to negotiate higher royalties for their patents undiluted by other less-valuable contributions."

This paper seeks to inform this debate, by assessing empirically the value of patents included in pools. Since many suppose pooling to facilitate licensing, one could expect patents to become more valuable once pooled. Accordingly, one must disentangle the intrinsic value of those patents included in a pool from the induced value generated by this inclusion.

The intrinsic value offers information about whether patents selected by pools were initially more or less valuable than similar patents not included in the pool. This question holds significance because it could call into question the usefulness of patent pools. Reasons exist that support the belief that these organizations, in some cases, may harm competition. Nevertheless, patent pools also offer economic advantages; however, if these organizations cannot attract the valuable contributions of a standard, this greatly reduces these advantages.

Second, the induced value effect may provide a better understanding of the incentives to join patent pools. The induced value effect has two different sources. It provides a means of assessing the reduction of the multiple marginalization problem engendered by the pools' creation and, therefore, the impact of the pool on the market of the standard. This effect not only benefits the pool members but also[21] the holders of essential patents not included in the pool. Other benefits, however, accrue only to the pool members. Pooling offers a way to cut transaction costs and, possibly to enhance strength of the patent[22].

Working with a pool database consisting of 1,363 patents from 9 pools and a control database of the same size formed with patents presenting the same characteristics (application year and technological class), we use the number of forward citations for a patent as a proxy of the patent's value. Next, we analyze whether patents incorporated in pools receive, on average, more citations. We identify the portions of patent citations that come from the intrinsic value effect (the pool selects patents with more citations), and the portions stemming from the induced value effect (a patent, having been introduced into a pool, sees an increase in the number of citations it receives). In order to accomplish this, we follow the method used by Rysman and Simcoe (2008) in a paper dedicated to the disclosure of patents within Standard Setting Organizations. We also ensure that our results are not subject to any endogeneity problem by using an alternative control database constituted with patents having the closest possible characteristics[23] to our sample, and control for the results' robustness using alternative methods[24].

Our results suggest that pool patents have a higher intrinsic value, at the time of introduction, than patents with similar characteristics not included in a pool. We also show that the creation of a pool increases the patent number of forward cites and induced value effect, and we analyze in detail what generates this effect. Although the induced value effect we find remains stronger than the intrinsic value effect, it does not appear uniformly across pools and seems chiefly driven by one of them: the 1394 pool.

We have organized the remainder of this paper as follows. Section 2 reviews the literature on essentiality and patents' value. Section 3 explains the data collection process and presents descriptive statistics. Section 4 deals with the intrinsic and induced value effect of the pool. Section 5 thoroughly analyzes both the intrinsic and induced value effect using data on the standardization process in order to test the robustness of the results.

[21] And probably even more.

[22] As the International Telecommunications Standards User Group (1998) stressed, "[…] when a patent is essential to a standard, it is converted into the equivalent of a 'master patent', even if it covers a relatively minor and unimportant innovation".

[23] same technological class and subclass

[24] Such as using data on the standardization process

2. Literature review: What is a standard and an essential patent?

Such formal or informal standardization bodies as consortia or standard developing organizations conduct the standardization.[25] The creation of a technological standard offers many advantages to the consumer. On one hand, standardization allows consumers to benefit *inter alia* from network effects. On the other hand, the creation of standards can also engender adverse effects such as reducing consumers' choices or enhancing a firm's control over a market.

An organization[26] commonly initiates the pool call for patents after the standards' definition (see Baron & Delcamp, 2010-2). The pool includes patents essential to the standardized technology and provides users the convenience of obtaining a single license for all patents in the pool. The literature generally identifies two main economic benefits of patent pools: reducing the transaction costs and avoiding the problem of multiple marginalization.

Nevertheless, patent pools may also carry perverse economic effects, including anticompetitive behaviors. On particular, one can use patent pools as a price-fixing mechanism by introducing patents that are substitutes for each other (Gilbert, 2004; Lerner & Tirole, 2004). Moreover, pools can foreclose competition by introducing a patent with a substitute and excluding another substitute. In this case, users could choose not to license the outside patent because the pool includes one of the substitutes. In order to avoid such behaviors, some authors (Lerner & Tirole, 2004; Lerner, Strojwas & Tirole, 2007; Quint, 2006) indicate that a pool must be formed solely of complementary essential patents and, therefore, one must allow patents to be licensed independently outside the pool. Brenner (2008) argues that compulsory individual licensing helps prevent anticompetitive behaviors only under certain assumptions. As a main criteria for success for compulsory individual licensing, patents included in pools should not have strong competition (strong substitutes) from outside patents; otherwise the incentives to create another pool remain too strong to ensure pool stability.

After the creation of a pool, a patent holder may choose whether to bring its patent to the pool. In practice, patent holders have little incentive to bring their patents to the pool, as they can maintain a high level of royalties while benefiting from the decline of the overall royalty rate engendered by the pools' creation (Aoki & Nagaoka, 2004; Lévèque & Ménière, 2010). Llanes and Trento (2010) underscore that downstream inventors have higher incentives not to participate. Layne-Farrar and Lerner (2010) test a couple of hypotheses on the incentives for

[25] defined as the creation of a common and documented repository to harmonize the activities of a sector

[26] Patent pools are constituted by patent holders or by pool administrators such as MPEG LA or Sisvel, whose principal business is the creation and administration of pools.

a firm to join a pool using a database of nine modern I.C.T. pools. They highlight how firms' business models affect participation. For instance, vertically integrated firms prove more likely to join a patent pool. Furthermore, firms having symmetric patent contributions remain more likely to accept a royalty sharing rule based on the number of patents held by the patent holder.

The only criterion for introducing a patent in a pool is essentiality. In order to introduce a patent into a pool, the patent must be essential to the standardized technology. Gilbert (2009) describes two main interpretations of the essentiality criteria. The definition of essentiality and the debates around it go beyond the scope of this paper; we present only the core definition. We consider essential any patent that has no close substitutes or substitutes so inferior that it makes them very distant alternatives.[27] In order to ensure the essentiality of the patents, pools usually have a third party evaluator—either an individual patent expert or a panel of experts—who verifies the claims of essentiality.[28]

In practice, one may find it difficult to identify precisely all the essential patents related to a technology. All pool patents are essential but all essential patents are not in the pool. As mentioned earlier, patent holders of essential patents are not force to participate and have little incentives to do so. This, of course, could reduce the advantage of this kind of organization, in particular if the patent holders who stay outside are those who have valuable contributions to the standard (Layne-Farrar & Lerner, 2010) and, therefore, justify a careful scrutiny of the intrinsic value effect. Another possible approach would be to use the lists of patents declared as essential in the Standard Setting Organizations (SSOs). Indeed, many SSOs[29] require their members to make public any patent that is potentially essential to a standard. However, these lists contain patents not truly essential to the standard,[30] and all patent holders do not disclose their patents in SSOs—so these lists are not exhaustive and may be partially wrong. The following figure summarizes the situation.

[27] The Department of Justice (DOJ), in the 1997 business review letter for the MPEG 2 patent pool, adopted this interpretation of essentiality: "There is no technical alternative to any of the portfolio patents within the standard."
[28] In some pools (such as MPEG 2 for instance), patent holders: "[…] need not consult the expert if they agree unanimously in good faith that a submitted patent is an essential patent or that a portfolio patent is not essential."
[29] For instance, the European Telecommunications Standard Institute
[30] For instance, the essentiality evaluation of Fairfield Resources on patents declared as essential to LTE and SAE underlines that around 50% of the families declared contain no essential or probably essential patent (see http://www.frlicense.com/LTE%20Final%20Report.pdf).

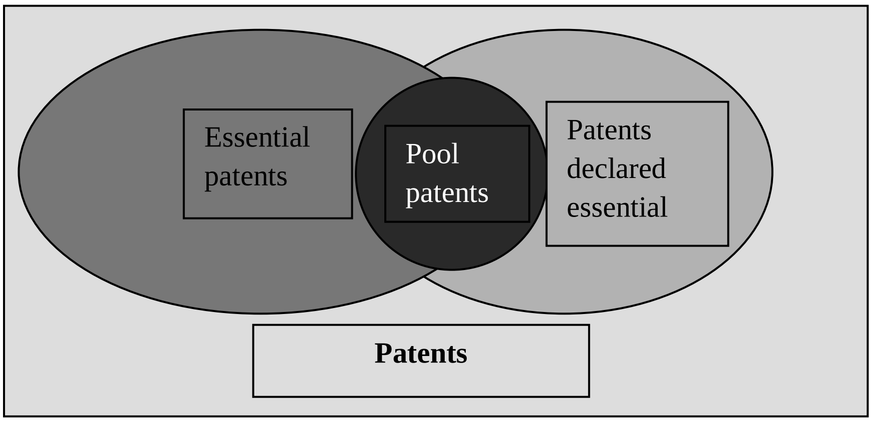

Figure 1. Dissociation pool patents, essential patents and patents declared as essential

In their article, Rysman and Simcoe (2008) studied the effect of patents' disclosure into SSOs. For their sample of essential patents, they use patents declared as essential. The authors underline that patents declared as essentials, receive more citations than other patents not disclosed in SSOs yet with the same characteristics (application year, citing year, and technology class). These patents also receive their citations later. This difference highlights not only that SSOs identify and endorse important technologies but also that the disclosure of a patent in an SSO significantly increases the number of citations. Rysman and Simcoe estimate that this marginal effect of disclosure accounts for roughly 20% of the difference in citation rates between SSO and control patents.

In this article, we focus on pool patents, comparing them to nonessential patents with the same characteristics. We also analyze the link between pool patents and SSO patents, comparing essential patents to patents declared as essential. For pool patents, the "induced value" effect serves as a means to capture the increase in the commercial value of the standard due to the pool's creation. Thus, although we use a similar method, we analyze a different underlying effect than that analyzed by Rysman and Simcoe (2008).

In order to assess the value of patents, we will use the patent's number of forward citations. This number constitutes one of the measures needed to assess the economic and technological significance of a patent. These citations allow the identification of the prior art for an invention. Therefore, patent offices carefully control these because they help define the scope of the claims of the patent.

For example, in their empirical assessment of patent pools, Layne-Farrar and Lerner (2010) use forward cites as an indicator of patent value. Rysman and Simcoe (2008), in their article dedicated to patents within SSOs, also use patent citations as an indicator of value. Harhoff et al. (1999) highlights a positive correlation between the number of citations and the subjective estimate of a patent's value determined by patent holders. Hall et al. (2005) demonstrate cited patents' stronger correlation with the patent holders' market value than not-cited patents. Using a sample of German patents, Giummo (2003) depicts how patents with more citations generate more royalties; therefore, he suggests that the citations could serve as an indicator of the economic value of patents. The literature proves the link between a patent's economic value and its number of cites.

3. The data

We work with 1,363 patents from nine pools, all of which publish their list of essential patents online and are managed by a pools' administrator.[31] Because these pools are all quite large and only partly reflect the average pool, this generates sample-selection bias. As previously indicated, pools are generally created and managed by companies holding patents or by specialized firms whose business is the management of pools such as MPEG LA and Sisvel. Using the website Internet Archives,[32] we obtained each patent's date of introduction into the pool,[33] As Baron and Delcamp (2010) show, one must take into account the exact date of introduction because a vast majority of pool patents are included after the pools' creation[34].

Table 1 presents the number of patents per pool[35]:

Pool name	Date of pool creation[36]	Number of patents	Number of American patents	Percentage of American patents in the pool
1394	1999	104	62	59.62%
ATSC	1997	50	31	62.00%
AVC	2004	311	60	19.29%
MPEG 4 SYSTEMS	1999	13	7	53.85%
MPEG 4 VISUAL	2004	366	123	33.61%
MPEG AUDIO	1999	102	15	14.71%
MPEG-2	1997	149	90	60.40%
MPEG-2 Systems	2006	27	19	70.37%
VC-1	2006	241	60	24.90%
Total		**1,363**	**467**	**34.26%**

Table 1. Pool patents

[31] MPEG LA, http://www.mpegla.com/index1.cfm or Sisvel, http://www.mpegla.com/index1.cfm
[32] www.archive.org
[33] Patent pool managers regularly update the lists of pool patents on their websites. Using Internet Archives and comparing current with previous lists allows the identification of the date when a patent is first listed in the pool.
[34] In our pool sample, 97 patents are founding patents. The average patent age at the time of introduction is 5,90 years for founding patents and 5,35 years for non-founding patents.
[35] The vast majority of the applications dates from the 1990s.
[36] Based on Geary B. (2009)

In order to obtain the number of citations for each patent, we use the 1976/2006 National Bureau of Economic Research (NBER) U.S. Patent Citation Database. Note that this operation creates an important selection bias (U.S. patents only) for our sample. Figure 2 presents the percentage of patents per technology class based on the U.S patent classes as of December 31, 1999.[37]

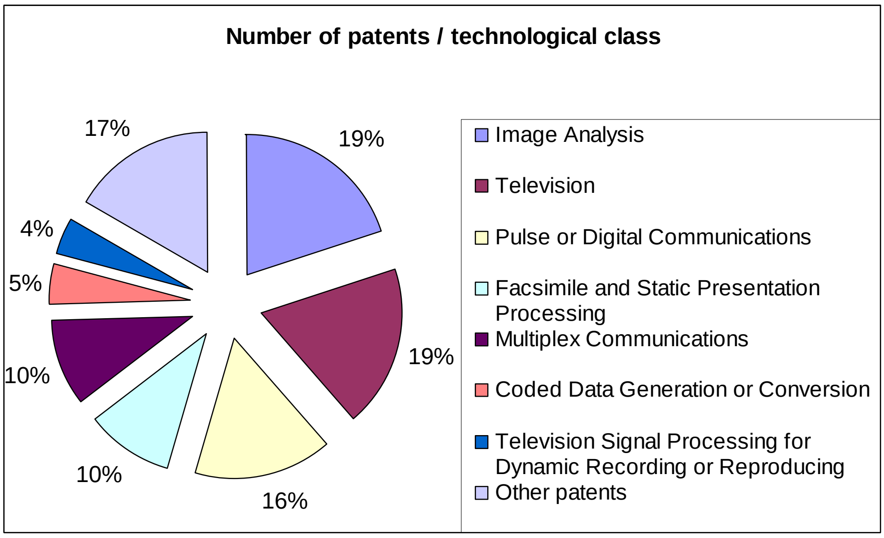

Figure 2. Number of patents per technological class

In order to analyze the pool patents, we created a control database with patents from the National Bureau of Economic Research (NBER) database that share the same characteristics (application year and technological class) as the pool patents. One must create a control database of patents that share the same characteristics because the number of cites could vary based on these characteristics (application year or cohort effect, technology class…). We also constitute a "matched control" sample based on a randomly selected one-to-one match (the joint distribution of application year and technology class is identical to that of the pool sample). The sample-matched control presents the same characteristics as the pool sample. This allows us to identify patents with characteristics close to those of the pool and, therefore, attribute the difference in citations to the pool. Table 2 presents the main characteristics of each sample. The sample "all controls" is constituted by all the patents with the same characteristics included in the 1976/2006 NBER U.S. patents database. The number of citations-corrected *allnscites* represents the patent's number of citations minus the citations made by the patent holder on its own patents.

[37] http://www.nber.org/patents/list_of_classes.txt

Data type	Patent pool sample	Patent pool sample without duplicates	Matched controls	All controls	NBER patents
Number of observations	467	383	382	135370	3209376
Mean Allcites	25.19	26.01	16.93	20.69	11.78
Standard Deviation Allcites	34.84	32.778	29.54	31.76	20.04
Min Allcites	0	0	0	0	0
Max Allcites	202.46	202.46	183.78	1185.26	2023.91
Mean Allnscites	21.46	22.01	15.64	19.06	10.95
Standard Deviation Allnscites	32.13	29.86	28.83	30.24	18.69
Min Allnscites	0	0	0	0	0
Max Allnscites	196.88	196.88	183.78	1185.26	1714.23
Application Year	1996.47	1996.73	1996.74	1996.5	1992.1
Age since grant	7.15	6.89	6.39	6.48	11.77
Cites/year	3.68	3.88	3.27	3.19	1.76
Number of claims	17.16	17.74	17.30	17.71	12.08

Table 2. Samples presentation

As Table 2 illustrates, pool patents seem to receive more citations than comparable patents from the control database. Pool patents have a higher average number of citations per year than do the matched control patents and, also, all the control patents. We check the number of claims, which also serves as an indicator of value. The data suggests that pool patents have a higher value than other NBER patents. However, although this ascertainment is useful, it is more interesting for our research to look more closely at the citation-age profile of the pool patents in order to discover whether these patents are usually cited earlier or later than the control patents.

To get an initial idea of the citation-age profile, we investigate the average citation age, conditional on patent age. Therefore, we employ the method developed by Mehta, Rysman, and Simcoe (2008) using a full set of patent applications, citing year and technology-class effect to control for various cofounding factors in order to generate predictions conditional on age and to obtain an average citation age for the control sample and the patent pool sample. The results, available on request, underscore that pool patents receive their cites later than control patents. The latter might indicate that an event that does not affect control patents— for example, the inclusion in a pool—triggers these citations.

4. The pool's effect

In this section, in order to differentiate between the intrinsic and the induced value effect, we analyze the link between citations and the pool. The preceding section suggests that pool patents receive more citations than control patents and receive their citations later; this situation can arise from several effects. The number of citations may increase because of the patent's introduction into a pool, or perhaps because the pool can select patents with a higher number of citations. This section addresses the following question: Are patents selected because they are more cited or are they more cited because they are selected?

In order to test our hypotheses, we work with two different methods, each of which provides detailed results. We base all regressions presented on a Poisson specification.[38] We also test, for each regression, a negative binomial specification; the results are similar and available on request.

In order to disentangle between the intrinsic and induced value effect, we must adopt a counterfactual approach. Of course, in our case, the counterfactual approach proves even more difficult because we do not have precise samples of essential patents not included in a pool[39]. Thus, in order to circumvent this difficulty, we use two different approaches. For the first, a panel approach, we use data on citations before the pools' creation to estimate the citation pattern after it. Controlling for any other patent characteristics using a fixed effect model should allow for the capturing of only the pools' marginal effect (induced value effect). In the other model, a cross-sectional approach (with the two control samples presented in Section 3), we estimate both a pool intrinsic value effect and the pools' marginal effect. Figure 3 depicts the levels of citations for the matched control sample and pool sample before introduction into the pool. This illustrates not only that pool patents receive more cites than control patents but also that the general trend, between the two samples, is close

[38] Data on citations are classical count data

[39] This is the reason why we use a meticulous approach to select the samples (and work with different control samples) and realize a couple of robustness analyses using data on the standardization process in section 5.

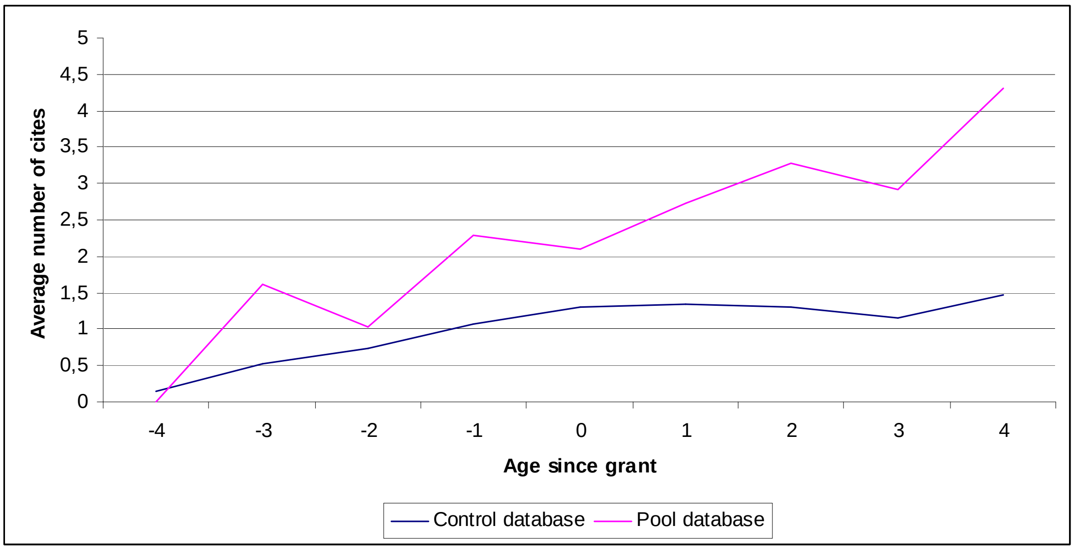

Figure 3. Citation age profile all pools

These two different approaches each have drawbacks. The first is a possible selection-bias problem. As explained in Section 3, patents in the pool are certainly not randomly assigned (from the sample of essential patents). Using a panel fixed-effect approach and, thus, comparing the citation pattern for pool patents before and after the pool's creation (taking into account any other intrinsic characteristics) should limit this selection-bias problem. Another possible problem is that we do not take into account a possible endogeneity of pool creation. Indeed, pools may be created only in technological subfields with a high expectation of importance (and, thus, a higher number of cites). It becomes impossible to perfectly account for this endogeneity problem because we do not have a sample of essential patents not included.

In order to control for endogeneity, we create a control database with patents having the same joint distribution of assignee type, application year, technological class, technological subclass, and HJT subcategory based on U.S. subclass[40]. This comprises the closest control sample that we can create (taking into account technological subclass) and should allow us to control, at least in part, for this endogeneity problem. The introduction in the pool remains the only difference we can identify between these two samples. The residual difference should come from this pool's effect (that we disentangle between intrinsic and induced value effect). Appendix 1 presents the results, which prove similar to the results (for the intrinsic and pre-introduction value effect) of the matched control sample.[41]

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[40] This control sample consists of 4,074 patents.

[41] In order to avoid further complications, and because the results are similar, we choose to present in the body of this paper the results using a control sample constituted of patents having the same application year and technological class.

To conclude, we note that both models have drawbacks; however, the joint approach, the stability of the results presented in the following subsections, and a couple of robustness tests using different control samples give us a measure of confidence in our findings on the intrinsic and induced value effect.

4.1 The pool's marginal effect

To study the value effect induced by the patents' introduction into the pool, we first use a method based on the pool sample. We work on a panel database of pool patents and control for the introduction into the pool through a dummy "patent pool introduction". In order to check for the possibility that patents have been made public before their introduction in the pool, we also control for a "pre-introduction" effect. One must control for the "pre-introduction" effect because there might be some discrepancies between the exact date of patent introduction into the pool and the update of the list of essential patents on the website. In order to establish that control, we created a dummy *pre-introduction_effect* for citations occurring two years prior to the effective introduction into the pool.

Next, we estimate a fixed-effect Poisson model with the number of forward citations at year y for a patent p as explained variable and controlling for the pools' effect,[42] pre-introduction effect, patent age effect,[43] and a possible truncation effect.[44] While the fixed effect specification allows us to control for the time-invariant unobserved heterogeneity of patents, we reduced the size of our sample by eliminating all patents cited only before or after introduction in the pool[45].

Table 3 presents the main results.

[42] Through a dummy that equals 1 after introduction in the pool.
[43] Age of the patent
[44] Using citing year effects
[45] In our case, the number of groups is 136 and the number of observations is 3265.

	Poisson Number of citations/year (N=3265)
Induced value effect	0.00544 (0.104)
Pre-Induced value effect	0.35014*** (0.071)
Patent age effect	0.18439*** (0.016)
Truncation effect	-0.50986*** (0.023)

Legend: * *p<0.05; ** p<0.01; *** p<0.001*. Robust standard error in parentheses.

Table 3. Panel fixed-effect approach

The induced value effect presents an insignificant parameter. Nonetheless, the pre-induced value effect with a parameter of 0.35014 is both positive and statistically significant. These two results suggest that the patent's introduction into the pool has an impact on the value of the patent. Indeed, the pre-introduction value effect is positive and significant, meaning that the introduction into the pool boosts the patent number of forward cites. However, the introduction effect is not significant; this may be due to some discrepancies between the dates of update of the websites[46] and the exact date of patent introduction into the pool. Thus, we can report that the introduction into the pool increases the value of the essential patent. In Section 5, we will deepen the analysis of the induced and pre-induced value effect using data on the standardization process. We dedicate the following subsection to a joint analysis of the intrinsic and induced value effect.

4.2 The intrinsic and induced value effects

The previous subsection reveals that the induced value effect is insignificant but that the pre-induced value effect is both positive and statistically significant. The patent's introduction into a pool has an impact on the patent's number of forward citations. This subsection analyzes both the intrinsic and induced value effects. In order to do so, we run a cross-sectional

[46] Available on www.archive.org.

regression with the entire sample, including both the pool and control patents.[47] To compare the two effects we introduce a dummy for the patent's presence in the pool. We also control for the application year, technological class, citing year, and age effects. This regression follows the method developed by Rysman and Simcoe (2008) in their paper dedicated to patent disclosure in SSOs.[48] We estimate the following Poisson regression on cross-sectional data:

$$Citations_{py} = \alpha_0 + \alpha_1 Pool\_participation + \alpha_2 After\_introduction + \alpha_3 Application\_year + \alpha_4 Technological\_class + \alpha_5 Age\_effect + \alpha_6 Citing\_year + \varepsilon_{py} \quad [1]$$

with:

$Citations_{py}$ = Number of citations for a patent p at year y

$Pool\_participation$ = Dummy that equals 1 if the patent is in a pool, 0 otherwise

$After\_poolcreation$ = Dummy that equals 1 after introduction

$Application\_year$ = Set of dummies for application year

$Technological\_class$ = Set of dummies for technological class

Age_effect = Patent age

$Citing\_year$ = Set of dummies for citing year

ε_{py} = Error term

[47] We also control that our results are not due to any problem in the matching procedure and run the same regression with a control database of all U.S. patents having the same application year and technological class as our pool patents (all control sample). The results are presented in column 3, Tables 4.

[48] For a complete description of patent variables having an impact on citations, see Hall, Jaffe, and Trajtenberg (2001).

Number of citations/year	(1) Matched control Sample (N=2695)	(2) Matched control Sample (N=2695)	(3) All control Sample (N=476358)
Intrinsic value effect	0.24567* (0.117)		0.07564* (0.045)
Induced value effect	-0.21324 (0.188)		-0.00892 (0.074)
Pre-Induced value effect	0.57839*** (0.160)		0.01316 (0.096)
Pre-Induced value effect 1394		0.92274*** (0.172)	
Pre-Induced value effect ATSC		-1.01956 (0.765)	
Pre-Induced value AVC		0.30609 (0.370)	
Pre-Induced value MPEG 4 systems		0.03122 (0.417)	
Pre-Induced value MPEG 4 visual		-0.32352 (0.363)	
Pre-Induced value MPEG 2		0.11921 (0.337)	
Application year effect	Y	Y	Y
Citing Year Effect	Y	Y	Y
Technology class effect	Y	Y	Y
Patent age effect	Y	Y	Y

Legend: * p<0.10; ** p<0.05; *** p<0.01. *Robust standard error clustered on patents in parentheses.*

Table 4. Cross-section approach, intrinsic and induced value effects

Results, presented in Table 4, show that the intrinsic value effect is positive and significant. Thus, patents selected by pools have a higher number of forward citations than do patents with the same characteristics not included in a pool. This result suggests that pools are able to attract valuable contributions—or good patents, in terms of technological significance. On the induced value effect, the result holds similar to the panel approach.[49] This result confirms our preceding finding: patent pools boost the number of forward cites, but the effect is not stable in the end. If we disentangle the pre-induced value effect by pools,[50] we can see in column 2 that this effect is due mainly to one pool: the 1394 pool.

In conclusion, it appears that patent pools can attract valuable contributions—patents that are highly cited. If we take into account a possible endogeneity problem in the pools' creation and use a control database of patents belonging to the same technological subclass, the result remains robust.[51] Our findings also suggest that the pre-induced value effect is around two times larger than the intrinsic value effect. However, the pre-induced value effect is due only to the 1394 pool, which has significant weight in our sample and might not be representative. The following section conducts a thorough analysis of these intrinsic and induced value effects to ensure that our results are robust.

5. Robustness of the intrinsic and induced value effects

The creation of patent pools follows the standardization of a technology. Thus, a patent is usually first disclosed in a Standard Setting Organization and is then introduced into a pool. Two interesting points can be refined with data on the standardization process. First, we must analyze the impact of the link between SSOs and patent pools on the number of citations. One could argue that the higher number of citations of pool patents results from the patent disclosure in the SSO.[52] The SSO disclosure effect could explain the intrinsic value effect of pools, using the assumption that pool patents are all previously disclosed in an SSO and then are subject to an increase in the number of their citations due to this disclosure.

In order to do that, we have to discuss the possibilities of linking pool and SSO patents. This link proves difficult to establish because SSO patent disclosures are often vague (the patent number or title is not always given, for instance). First, we link the database available online at www.ssopatents.org to our pool database. This allows us to identify 25 patents in our database previously disclosed in an SSO. We also control directly for the

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[49] The induced value effect is insignificant but the pre-induced value effect is positive and statistically significant. This result does not hold (the parameter is no more significant) if we take into account the sample "all control" but it is the only model of all the regressions run (Table 3 to 7) for which the pre-induced value effect is not statistically significant.
[50] Created before or in 2004 (see Table 1).
[51] Cf. Appendix 1
[52] Rysman and Simcoe (2008) show that the patent disclosure in an SSO increases the number of citations by between 35% and 40%.

AVC project if some patents are both pool and SSO patents. The results are surprising: only 29 American patents were disclosed in the SSO disclosure database and none of them included in the pool. The timing of the project explains this result in part.[53] In order to control for the link between pools and SSO patents given the difficulties explained above, we use the following method. We use a dummy for pool patents held by firms that make disclosures in the dedicated SSO, on the assumption that a firm cannot disclose only a part of its patent portfolio to an SSO.

Another problem could relate to the use of cites in a standardization context. Lampe and Moser (2009) show evidence of strategic patent files, highlighting that the creation of a pool increases the number of patent filings. Baron and Delcamp (2010) show that patents included after the pool' creation focus more on the standard than patents included at the creation. If the creation of a pool increases the number of patents filed in a given technological area, using the number of cites as an indicator of patent's value could be misleading. In this case, it would be quite normal to find a higher number of cites for pool patents than for non-pool patents of the same technological class. The difference herein could not be explained by a difference in value—but only by the increase in the number of patents filed and, therefore, by an increase in citations.

In order to manage this potential problem of cites, we run all our regressions both on all citations and on external cites. We define the number of external cites as the number of forward cites that are not self-cites or that do not come from patents in the same pool. Using external cites instead of the total number of cites (excluding self cites) serves to resolve the problem of citations in a standardization context.

The results of these robustness tests appear in Table 6, appendix 2. We use the same regression as in equation [1], adding a dummy for patents held by firms disclosing in the dedicated SSO.[54] In order to take into account a possible problem of cites in a standardisation context, we also use the overall number of forward citations and the number of external cites as a dependant variable. Results confirm the findings of section 4. The pool intrinsic value effect is still positive and significant when we take into account a possible effect of standardization on citations. The results of this regression confirm that, even if we control for the SSO effect, the pools are still able to select the most valuable patents in the field and that the intrinsic value effect is robust.

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[53] Indeed, out of 467 pool patents, 281 patents were applied before the year of the first standard definition. Out of these 281 patents, 168 were effectively granted before the first standard definition.
[54] With this method, we identified 229 patents (out of 417 in our pool sample) that may have been subject to a disclosure.

Second, it could be interesting to look more thoroughly at the induced value effect. This effect could be caused by an increase of the value due to the patent's introduction into the pool or to the disclosure of new information (existence) on the patent. Indeed, governments grant many patents each year, making it difficult to identify all patents related to a technology; the induced effect, thus, could only be due to the fact that the patent receives more scrutiny.

In order to do that, we create a variable *inducedvalue_ssopatents* to disentangle between these two effects. The idea behind this method is that, if the size of the induced value effect is different between patents that were already disclosed to an SSO and patents that just became public, the induced value parameter also captures the effect of disclosure of new information. Consequently, if the variable *inducedvalue_ssopatents* is not significant, this means that the induced value effect is not due to the disclosure of new information. We estimate the same Poisson regression as in equation 1 on a cross-sectional sample, adding the interaction variable *inducedvalue_ssopatents*. Table 7, Appendix 2 presents the results of these regressions.

As Table 7 illustrates, the previous results remain robust even if we take into account the possibility of disclosure of new information on the patent. The parameter of the variable *inducedvalue_ssopatents* is negative and significant. The latter means that there is a significant difference in the size of the induced value effect between patents already disclosed in an SSO, on the one hand, and patents that just became public with their introduction into the pool, on the other. The induced value effect captures, in part, a publicity effect. However, the *pre-induced_value* parameter remains positive and significant, thus the induced value effect still exists. This reinforces our interpretation of the induced value effect as not being due solely to the revelation of new information on the patent. Nevertheless, please keep in mind that this induced value effect is mainly due to the 1,394 pool and is not generalizable.

A possibility exists that our assumption that a firm cannot disclose only a part of its patent portfolio to an SSO, is wrong, altering our robustness analysis.[55] The creation of a pool might also have an impact on the patenting strategies (Baron & Delcamp, 2010), and then the induced value effect can not be fully explained by an increase in the commercial value of the patent.

[55] Especially, we could not affirm that the induced value effect is not due to the revelation of new information

6. Conclusion

In this article we compared the value of patents introduced into a pool to patents with the same characteristics (application year and technology class) not included in a pool. We successively analyzed the induced value effect of the introduction and then, simultaneously, the intrinsic and the induced value effects. We also discussed and analyzed the link between the marginal effect, based on the number of citations, of patents disclosed in an SSO and the pool intrinsic value effect.

Our results indicate not only that the patent's introduction into a pool increases the number of cites (induced value effect), but also that pools generally select patents with a higher number of citations (intrinsic value effect). The induced value effect proves to be larger than the intrinsic value effect on the number of citations. However, this induced value effect is mainly due to the 1394 pool. When we take into account the possible link between SSOs and patent pools, the results remain robust. Pool patents have a higher intrinsic value than patents with similar characteristics not included in a pool. Taking into account patents belonging to the same technological subclass as our pool patents as a control sample confirms these results

These results play an important role in the current debate about the pools and their economic efficiency. They reveal that—although the term of essentiality is not directly related to the patent value and, therefore, to the number of citations—patents selected by pools generally have a higher value than similar patents not introduced in a pool. The latter suggests that, contrary to what has been stated in the literature, patent holders do not use pools to license poor values' patents[56]. This finding holds particular importance for the debates on pools' efficiency by confirming that these organizations can attract valuable contributions and, therefore, that the advantages could outweigh the risks engender by a pool. Our result on the induced value could also help shed light on why, in practice, we observe the creation of pools, while the economic theory predicts the instability of these organizations. Indeed, other incentives—not linked to the royalty level—may encourage patent holders to participate in patent pools.

[56] See for instance, Layne-Farrar and Lerner (2010)

Chapitre 2 : Les pools permettent-ils aux détenteurs de brevets de faire respecter leurs droits ?

Cet article explore économétriquement le lien entre l'introduction d'un brevet dans un pool et les litiges impliquant ce brevet. L'article est basé, d'une part sur une base de données constituée de 1564 brevets américains inclus dans 8 différents pools et d'autre part sur une base de données contrôle constitué de brevets présentant des caractéristiques similaires. Nous étudions deux questions principales. Dans un premier temps, nous cherchons à savoir si l'introduction du brevet dans un pool aide le détenteur du brevet à faire appliquer ses droits. Notre analyse souligne différents facteurs qui aident les membres d'un pool à faire respecter leurs droits de propriété intellectuelle. Par exemple, nous soulignons un effet positif de la taille du pool, en nombre de membres, sur le nombre de litiges impliquant le brevet inclus dans le pool. Nous discutons l'hypothèse que ce résultat soit dû à une transmission d'informations entre membres qui augmenterait la probabilité que la violation soit détectée par le détenteur du brevet. Nous examinons d'autres facteurs impactant les incitations à déclencher un litige comme la taille de l'entreprise et l'intégration verticale du détenteur de brevet. Pour finir, nous étudions l'impact de l'introduction d'un brevet dans un pool sur l'incertitude liée à l'essentialité du brevet. Nous démontrons que l'introduction du brevet dans un pool, réduit l'incertitude liée à l'essentialité de ce brevet et donc in fine facilite la résolution du litige par accord amiable.

Research paper 2: Are patent pools a way to help patent owners enforce their rights?

1. Introduction

A patent pool is an agreement between patent owners in order to grant a single license for several patents. The economic literature underlines two main economic benefits of patent pools: a) by reducing the number of licenses for a potential licensee they help to reduce the overall transaction costs, and b) they eliminate or reduce the double marginalization problem.[57] In adapting the double marginalization concept to intellectual property, Shapiro (2001) indicated that the total amount of royalties that owners of complementary patents claim will be too high due to a lack of coordination. In the case of a standardized technology, this lack of coordination between owners of complementary patents could reduce the standards' diffusion. Patent pools, by allowing patent owners to coordinate their behaviors on royalties, may reduce or avoid this multiple marginalization problem.

In contrast to these benefits, these organizations can also have perverse economic effects. The main problem highlighted in the literature is the introduction of substitutable patents into the pool (Lerner and Tirole 2004), thereby reducing competition on the royalty level of these patents. Kato (2004) stresses that, under certain conditions, patent pools constituted of substitutable patents can also enhance consumer welfare. In order to avoid potentially perverse economic effects, Lerner and Tirole (2004) indicate that a pool should be both formed only of complementary patents and allow patent owners to license their patents independently. This compulsory individual licensing rule should eliminate pools constituted of substitutable patents, making them unstable. Brenner (2008) deepens the analysis of the compulsory individual licensing rule by underlining the fact that this rule is efficient only if the patent does not have strong competition (substitutes) outside the pool.

[57] The double marginalization problem was first defined by Cournot (1838) as: "the exercise of market power at successive vertical layers in a supply chain".

The main difficulty faced by patent pools, in practice, is to create sufficient incentives for patent owners of essential patents to participate. Indeed, patent holders have strong incentives to free ride by taking advantage of the opportunity to charge higher royalties for their patents by not participating in the pool (Aoki and Nagaoka 2004). If the pool does not necessarily allow for the maximization of licensing revenues, the patent holders may have additional incentives. Delcamp (2010) opens this field of research by underlining the idea that one advantage of the pool for patent owners could be to increase their patents' value.

The purpose of this paper is to analyze more precisely the usefulness of these organizations in helping patent owners enforce their intellectual property rights, which could act as a strong incentive for patent holders to use patent pools. Indeed, practitioners, such as patent holders or pool administrators, often mention this aspect, but it has not been studied in the literature. As far as could be ascertained, nobody has ever questioned the possible link between the patent introduction in the pool and litigations. For instance, it is possible to imagine that, because of its higher quality (Delcamp 2010), a pool patent would be subject to more litigation than a non-pool patent. It is also plausible to suggest that the patent's introduction into the pool changes the incentives for a patent holder to litigate.

In order to analyze these hypotheses, we use a database of 1564 U.S. patents in 8 pools. We use the litigation database created by the Stanford Law School, which contains data on more than 100,000 intellectual property cases. We link this data on litigations to data on the nature and structure of firms and patent pools. We show that pools with a higher number of members are more effective in helping patent holders enforce their rights. We also highlight the important role played by the concentration of patents in the pool. Thus, a pool with a large number of members but also a large number of patents is less effective in helping patent owners enforce their rights. We provide evidence suggesting that this phenomenon comes from a mutual observation between pool members. We also emphasize that the size and the structure of the firm, vertically integrated or not, have an impact on the incentives to litigate. Finally, we stress that a patent's introduction into a pool facilitates dispute resolution by settlement. This result is in line with the theoretical literature on the subject. Indeed, a patent's introduction into a pool reduces uncertainty regarding the outcome of the dispute. The patent enjoys, in this case, a presumption of essentiality to the standard, and the plaintiff only has to prove that their patent is legally valid.

The remainder of this paper is organized as follows. Section 2 presents some stylized facts on the subject of patent pools and patent litigations. Section 3 explains the collection process of the data. Section 4 provides some descriptive findings. Section 5 introduces our theoretical frameworks on the link between patent pools and litigations. Section 6 presents the empirical results.

2. What is a standardization process, an essential patent and an infringement?

One may define the creation of a standard as the creation of a common and documented repository to harmonize the activities of a technological sector. Either formal (such as standard developing organizations) or informal (such as consortia) standardization bodies may conduct standardization. The creation of pools helps the dissemination of technology by allowing users to sign only a single license for several patents. A patent holder may choose whether to bring its patent to the pool. In practice, patent holders have few incentives to participate due to the possibility of free-riding (taking advantage of the pools' creation by charging higher royalties without participating in it). Patent-holders or such pool administrators as MPEG LA or Sisvel, whose principal business is the creation and administration of pools, comprise the pools.

A patent has to be essential to the standard to be introduced in a pool. The exact definition of essentiality is still subject to debate (Gilbert, 2009). In this paper, and because the exact definition is of little importance to this research, we will use the technical essentiality definition that considers essential any patent that has no close substitutes or substitutes so inferior that makes them very distant alternatives. Nonetheless, it is difficult to identify precisely all the essential patents related to a technology. All pool patents are essential, but all essential patents are not in the pool. Indeed, a vast majority of essential patents are not included in a pool mainly due to the lack of incentives for patent-holder participation.

Pools usually have third-party experts that assess the essentiality of the patents before inclusion. If this expert considers the patent essential, it can be included in the pool. The third-party expert usually establishes a patent essentiality report identifying the part of the standard to which the patent proves essential[58]. One of our main hypotheses in this paper tests whether this essentiality evaluation by a patent expert reduces the uncertainty of the outcome of the dispute and, thus, facilitates the resolution by settlement.

[58] The essentiality reports are available online for all the pools managed by MPEG LA.

Simcoe, Graham, and Feldman (2009) study the effect of patent disclosure in Standard Setting Organizations (SSOs) on the number of litigations. They show a higher level of litigation for patents disclosed in SSOs than for other patents with the same characteristics. They indicate that this effect is more significant for smaller firms than for larger firms. In this article, we study pool patents consisting of not only patents declared essential but also essential patents not disclosed. We offer two main points to explain the strikingly small overlap between patents disclosed as essential in an SSO and real essential patents introduced in a pool. First, the evaluators do not typically assess patent essentiality before disclosure in an SSO and, subsequently, many patents disclosed turn out not to be truly essential in reality[59]. Moreover, some very large firms particularly active in the standardization field do not participate to patent pools (e.g., Qualcomm). In addition, the pool functioning rules (essentiality evaluation, patent holders discussion on royalties…) should have an impact on litigations that the patent disclosure in an SSO does not have.

One can define a patent infringement as the use and/or production of an invention or a technology, for which someone owns a patent, without obtaining permission from the patent holder. In most countries, patent holders generally can enforce patents via civil lawsuits[60] but some countries also have criminal procedures against infringement. In the case of a civil lawsuit, the patent holder will seek monetary compensation and the infringer can be liable for all or part of profits made from the use of the infringing technology as well as damages to compensate any harm suffered by the patent holder. In order to prove the infringement, the patent holder has to show a violation of at least one of the patent claims. However, in many states, the accused infringer can be liable for patent infringement even though the technology does not fit exactly in the field of a patent claim due to the "doctrine of equivalents."

A patent owner that would like to enforce its rights faces a major constraint when an accused infringer attempts to challenge the validity of the patent. Indeed, in the United States, the civil courts that consider these cases can—and often do—declare the patent invalid. The courts can declare a patent invalid if at least one of the patentability requirements has not been fulfilled. Although these requirements vary by country, such core requirements as utility, non-obviousness, or novelty apply almost everywhere.

Nevertheless, all patent infringements do not reach the level of judicial decision. Indeed, many conflicts are resolved by a bargaining between the possible infringer and the

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[59] For instance, the essentiality evaluation of Fairfield Resources on patents declared as essential to LTE and SAE emphasizes that around 50% of the families declared contain no essential or probably essential patent (see http://www.frlicense.com/LTE%20Final%20Report.pdf)

[60] Such as in the United States

patent holder. The economic literature on the subject identifies many reasons that could justify the refusal of a settlement by one of the parties. The first obvious answer: the patent holder and the possible infringer have different expectations on the outcome of the case. The economic literature (Meurer, 1989; Yildiz, 2004; Nalebuff, 1987; Lanjouw & Lerner, 1998; Priest & Klein, 1984; Cooter & Rubinfeld, 1989) also highlights two other reasons that could justify this choice, hidden information and positive litigation externalities. Lerner (2009) summarizes four points that increase the probability of a trial occurring:

- The likelihood that the offence is detected by the potential plaintiff;
- The size of the stakes under dispute;
- The uncertainty about the outcome of the controversy between the two parties; and
- The costs of settlement relative to that of trial.

In this paper, we address each of these points. In particular, we show that a pool with a higher number of members increases the likelihood that the offense will be detected by the potential plaintiff. We also illustrate the demand side using the number of forward cites to control for a demand increase after the patent's introduction in a pool. We underline the effect of the patent introduction on the uncertainty about the outcome of the controversy. We carefully analyze the impact of the structure and the size of the patent holder on the incentives to litigate.

3. Data

We use a database of 8 patent pools: DVD3C, DVD6C, MPEG2, MPEG4 Systems, MPEG4 Visuals, AVC H/264, IEEE 1394 and DVB-T. We retrieve the patent numbers and the name of patent holders from the lists available on the websites of the pools.[61] We collected the data during early 2010. These eight pools relate to Information and Communication Technologies (I.C.T.) and are the only I.C.T. pools that make their data publicly accessible. Some patents participate in several pools. We treat each of these patents, in different pools, as different observations.

Using Internet Archives,[62] we obtain the list of pool patents at different dates over time. Comparing successive patent lists allow us to identify the date of the patent's first

[61] www.mpegla.com (MPEG2, MPEG4 Systems, MPEG4 Systems, AVC, IEEE 1394), www.dvd6cla.com (DVD6C), www.sisvel.com (dvb-t)
[62] www.archive.org

appearance on the list. We label this the "date of introduction." Of course, there may be some discrepancies between this date of introduction and the real date of the patents' introduction in the pool.[63] This does not become a problem in our analysis because the updates occur on a regular basis. We complete this database with data on the nature and structure of the firm.[64] We match the 1,564 U.S. patents in our sample with the National Bureau of Economic Research (NBER) database and, thus, obtain a full range of information on the patents.[65] We complete the dataset using the website of the European Patent Office.[66] Therefore, we concentrate solely on U.S. patents because we do not have litigation data for other countries. Nonetheless, this choice remains consistent with pool patents because U.S. patents tend to be the first patent of the family included in a pool (Baron & Delcamp, 2010). Figure 1 presents the distribution of U.S. patents per pool. Figure 1 highlights the preponderant number of U.S. patents in the DVD 6C patent pool. Accordingly, we check that our results are robust when excluding the DVD pools[67].

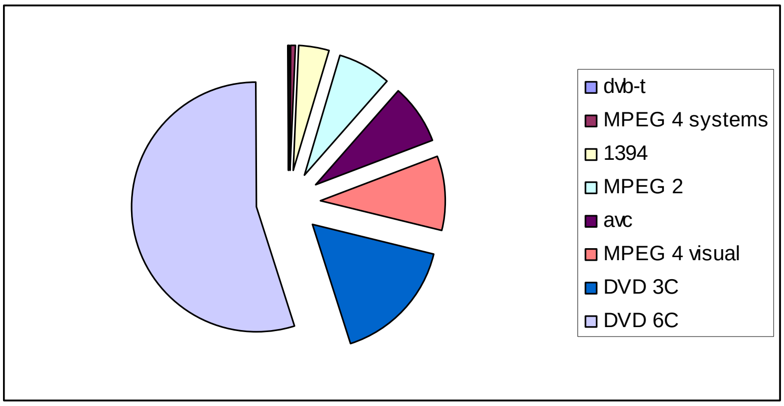

Figure 1. Number of patents / pool

Based on this pool database, we create a control database with patents presenting the same characteristics[68] and the same type of information as in our pool database. Previous papers have demonstrated the link between these characteristics and the number of

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[63] Due, for instance, to a late update of the websites.
[64] Size of the patent portfolio, number of employees, number of patents already included in the pool, vertical integration
[65] The number of claims, forward and backward cites (forward cites count the number of times a patent is cited by ulterior patents, backward cites count the number of previous patents cited by a patent), patent generality, technological class, grant and application year
[66] www.espacenet.com
[67] See the subsection dedicated to the robustness checks.
[68] Application year and type of assignee

patent litigations. Next, we match our databases to the Stanford IP litigation database[69] in order to obtain the number of litigations per patent. This database contains data on more than 100,000 intellectual property cases filed from January 2000 to the present. The lack of historical data pre-2000 could create a truncation problem for those patents granted before 2000. To control for this potential bias, we also run our regressions on patents granted during or after 2000 and for which we have all the history.[70] Since the truncation problem does not seem significant, in order not to reduce our sample, we presented the results for our entire sample in the body of the paper. Table 1 summarizes the main information for pool and non-pool patents.

	Patent pool sample	**Non Patent Pool sample**
Likelihood litigated	0.08	0.01
Mean number litigations / year	0.04	0.00
Mean cites	23.10	14.58
Mean forward cites	18.58	13.20
Number of claims	14.67	13.63
Mean family size	30.34	22.61
Generality index	0.33	0.31
Application Year	1997.82	1997.80
Age since grant	9.94	9.96

Table 1. Samples presentation

As Table 1 details, pool patents are more likely to be litigated than non-pool patents. Indeed, pool patents have about an 8% likelihood of litigation versus less than 1% for non-pool patents. Of note, this table also illustrates a significant difference between our samples on the traditional indicators of patents' quality (total number of cites, number of forward cites, number of claims, family size…).

First, our paper provides a descriptive analysis of the litigations in our sample. In order to do so, we conduct regressions on the likelihood of litigation and the number of litigations with indicators of patent quality as explanatory variables. We, therefore, revisit already

[69] www.lexmachina.org
[70] See the subsection dedicated to the robustness checks

existing results on our sample. The results, presented in Appendix 1, remain consistent with previous findings on the subject (Lanjouw & Schankerman, 2004; Lerner, 2009; Simcoe, Graham & Feldman, 2009). We confirm that the more-cited patents have a higher likelihood of litigation. All our indicators of patent quality (the number of forward cites, the number of claims, and the generality of the patent) also link to the number of litigations for a patent. These results confirm the previous findings on the subject using a new database on litigations (Stanford IP litigation database). These first results provide reassurance on both the method and the data contained in the database.

In the next section, we present some descriptive findings on the links between patents pools and litigations.

4. Descriptive findings on the link between patent pools and litigations

This section offers some descriptive findings on the interaction between patent pooling and litigations. We must address many questions, and, as such, we will treat each of them successively.

We first investigate whether pools are created, in larger part, to end patent disputes. Indeed, some authors (Shapiro, 2003) believe that the creation of a patent pool provides a way to end a dispute related to intellectual property. In this case, we should see a high number of litigations between pool members before the pools' creation. We will analyse this question in the first subsection. Next, we examine the question, "Why are pool patents more litigated?" Indeed, we highlight in the precedent section that pool patents have a higher likelihood of litigation. There are two ways to explain a potential difference between pool and non-pool patents; we present and investigate these explanations in the second subsection.

4.1 Are patent pools a way to end intellectual property disputes?

A first review of the link between litigations and pools brings up the issue of whether patent holders use patent pools to resolve previous disputes among themselves. For example, Shapiro (2003) asserts that: "Patent pools are another form of settling patent disputes." He uses the example of the pool involving patents for laser eye surgery formed by Summit Technologies and Visa. Each of these firms claimed that it held essential patents and both sued each other for infringement. The creation of the pool Pillar Point Partners was designed to end the dispute; however, the Federal Trade Commission finally forced it to dissolve. In order to answer this question, we carefully analyze litigations on the pools' founding patents. In this case, we define a founding patent as a patent included in a pool as of its creation[71]. In our pool sample, 13 patents that are litigated —at the same time—and a founding patent of a pool. Table 2 presents this detail.

Pool	Freq.	Date of pool creation
DVD 6C	4	1999
MPEG 4 systems	1	2003
Avc	8	2005
Total	**13**	

Table 2. Number of litigations, founding patents

In our litigation database, we carefully analyse each of the litigations that take place before the pools' creation. None of these litigations has opposed the patent holder and a future member of the pool. This does not verify the assumption that patent pools are created to end litigation between patent holders. Of course, this does not mean that this hypothesis is wrong, instead, it means that, given the data we have, we must reject it. It remains possible, for example, that pools are created to end conflicts that have not yet reached the litigation stage and which, therefore, do not appear in our database.

4.2 Are pool patents more litigated because they are of higher quality or is litigation due to a pool ex-post effect?

In the precedent section, we highlight that pool patents have a higher likelihood of being litigated. Two explanations support a potential difference in litigations between pool and non-pool patents. The first explanation contends that pool patents are more litigated because of their intrinsic quality. The notion that, due to the pool selection, pool patents do not have the same quality as non-pool patents having the same characteristics[72] supports this first explanation. In this case, it would be normal that pool patents have a

[71] For the dates of pool creation, see Geary B. (2009). Patent pools in high-tech industries. Intellectual Asset Management

[72] Technological class and assignee type

higher number of litigations, but this higher number would not come from any ex-post pool effect. This explanation is plausible because, as explained in the second section, pools carry a selection of the patents. Moreover, the technological classes to which our sample belongs hold many sleeping patents. This could, therefore, justify an important difference of intrinsic quality between pool and non-pool patents (see Delcamp, 2010).

In order to test this first explanation, we create a control database (presented in the data subsection) with patents having the same year of application and type of assignee. Indeed, previous papers highlight that both these variables have an impact on the patent number of litigations. Next, we perform a comparison of the two samples by performing the same (cross-sectional) regression as in the previous section, using a dummy variable for pool patents but adding indicators of patent quality as explanatory variables to control for possible different characteristics. We add a column (5) with a rare event logit model in order to account for the small amount of patents introduced in pools in the real population as compared to our sample. Indeed, econometric studies (Prentyce & Pyke, 1979; Scott & Wild, 1997) point out that, if the proportion of positive results in the sample is not comparable to the proportion of positive results in the real population, then logistic regression yields biased estimates. To control for this overestimation of the population of patents introduced in pools, we use the method of King and Zeng (2001) implemented in Stata by Tomz, King, and Zeng (2003).[73] Table 3 presents the results. They confirm our previous descriptive-statistic findings. Pool patents have a higher likelihood of being involved in litigation and have a higher number of litigations than non-pool patents having the same characteristics.

[73] The *relogit* command. Stata programs available at : http://www.jstatsoft.org/v08/i02

	(1) Logit		(2) Poisson		(3) Negative Binomial		(4) Tobit	(5) RE Logit
	DV= Dummy litigation		DV= Number of cases					DV= Dummy litigation
	Coef.	M. effect	Coef.	M. effect	Coef.	M. effect	Coef.	Coef.
Pool	3.510***	0.196***	2.555***	0.843***	3.122***	1.061***	18.894***	3.335***
	(0.635)	(0.022)	(0.825)	(0.168)	(0.417)	(0.203)	(3.179)	(0.630)
Log_	-0.134	-0.006	-0.049	-0.013	0.017	0.004	-0.589	-0.135
Cites	(0.125)	(0.005)	(0.114)	(0.031)	(0.155)	(0.038)	(0.867)	(0.125)
Log_	0.278	0 .012	0.715***	0.193***	0.305	0.076	2.718**	0.271
claims	(0.173)	(0.008)	(0.223)	(0.072)	(0.207)	(0.043)	(1.070)	(0.172)
Genindex	-0.853**	-0.037*	1.084**	0.292	1.608***	0.401	-1.799	-0.845*
	(0.353)	(0.016)	(0.443)	(0.187)	(0.593)	(0.247)	(2.731)	(0.351)
Control Grant Year	Y	Y	Y	Y	Y	Y	Y	Y
_cons	-32.252		160.136*		358.27***		320.974	-28.593
	(71.626)		(93.378)		(137.963)		(531.047)	(71.064)
Obs.	758		758		758			758
Chi2	39.64		28.4		225.05		93.42	
Prob> chi2	0		0		0		0	
Pseudo R2	0.1920		0.2211				0.0914	
Log lik.	-214.95		-1237.46		-452.21		-464.57	

Legend: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors in parentheses. Control database comprised of patents having the same application year and assignee type.

Table 3. Regressions results cross section litigated, pool and non-pool patents

This result requires further analysis to understand and identify the sources of this pool effect. To address this, a look at the distribution of litigations over time offers interesting information.

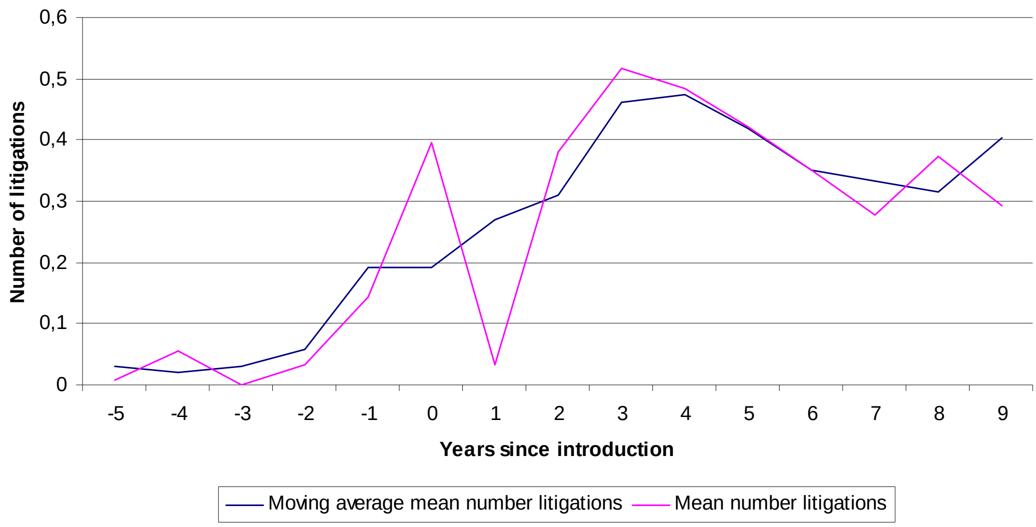

Figure 2. Mean number litigations / introduction in the pool

As Figure 2 illustrates, the number of litigations increases strongly after the introduction of the patent in a pool. This mean also appears peak three or four years after introduction and then decline.Note that the rise in litigations is almost immediate or even precedes the introduction by a few months. Our data collection process may create some discrepancies between the date of patent introduction in the pool and the update of the pools' website, which could explain this discrepancy. Table 3 and Figure 2 both seem to confirm our second explanation, that the pool has an ex-post effect on the number of litigations.

One can explain this introduction effect in two ways. First, the pool creation affects the demand side by increasing the opportunities for the patent owner to licence its patent (Delcamp, 2010). Second, the patent pools provide a means for patent holders to remain informed of potential infringement and, thus, affect the likelihood of the detection of the offense.

This next section presents our theoretical framework and hypotheses on the introduction effect and the effect of patent introduction into a pool on the outcome of the dispute.

5. Theoretical framework

This part presents our theoretical framework and both of our two different sets of hypotheses. The first set applies to the introduction effect: Why are pool patents more litigated after introduction into a pool? The second applies to the analysis of the case outcomes: Why does the patent essentiality evaluation have an impact on the outcome of the case?

5.1 Theory and hypotheses on the introduction effect

In this section, we base all of our hypotheses on the assumption that the patent holder is the plaintiff in the case. One explanation for the introduction effect could be that the number of litigations rises because a patent's introduction into the pool increases the market size of the patent. To control for this effect, we will use the number of forward cites that changes over time as an explanatory variable and allow taking into account this demand side effect (Simcoe, Graham, & Feldman, 2009).

If we control for this demand side effect, our main hypothesis is that the pool has an impact on the level of information. As confirmed by many pool members, patent enforcement assistance is one of the main advantages of a pool. Indeed, after introduction in the pool, other pool members help inform the patent holder about technologies that could infringe its patents. The patent-holder's level of information increases, and it can, therefore, more easily enforce its rights.

Hypothesis 1: The higher level of information about possible infringement available to pool members causes the introduction effect. Thus, controlling for the demand side effect, the introduction effect should remain positive.

Note that there may be several axioms of this hypothesis. The first would be that pool members voluntarily exchange information about the violation of intellectual property rights. The second, less restrictive, would be that patent holders remain informed through the actions of other pool members even when there is no voluntary exchange of information; for example, they can observe each other. In order to capture this effect, we create a variable that interacts the disclosure effect with the number of other patent holders in the pool at the time of patent introduction. In order to distinguish between these two axioms, we create another interaction variable that interacts the disclosure effect with the number of other patent holders and the number of patents in the pool at the time of patent introduction. Thus, if our second axiom is right, the parameter for the first interaction variable should be positive (the higher the number of pool members, the higher the introduction effect) and the second parameter negative (this effect is complicated by the number of patents in the pool, making it more difficult to observe the actions of other members).

Hypothesis 2: The introduction effect, explained by a higher level of information, results from a voluntary exchange of information or a mutual observation.

We also have several hypotheses on the structure and status of the firm. These hypotheses should affect the patent holders' incentive to litigate and, thus, also affect the size of the introduction effect. These hypotheses have been tested in previous research; this section aims simply to test these classical assumptions within a pool framework (using variables obtained through the firms' participation to the pool).

Regarding the size of the firm, several complementary effects can affect the litigation incentives for a patent holder. First, Simcoe, Graham, and Feldman (2009) show that the level of litigations increases more sharply for small firms after the patents' disclosure in an SSO. This could be due to a reputation externality effect, and it would, therefore, not be surprising that the reputation for "thougness" is more important for small than large firms. On the other hand, big firms could have more incentives to litigate because of lower litigation costs due to "learning-curve" effects (Lerner, 1995). In order to capture this reputation effect, we create two variables. The first one (*ppprior*) represents the number of patents already held by the patent holder in the pool and should allow capturing the reputation effect.

At the same time, we have to control for the overall size of the firm patent portfolio due to the learning-curve effect. To do so, we create a control variable, *portfolio_size,* to capture this learning-curve effect. In describing these reputation and learning-curve effects, the size of the firm patent portfolio becomes more important than the size of the firm measured by the number of employees. Therefore, in this paper, we will test our hypothesis using the size of the firm measured by the size of the patent portfolio. We also run the regressions using the size of the firm measured by the number of employees. The results are quite similar for either variable.[74]

[74] Results with the number of employees available on request

The risk of counter infringement serves as another effect that could affect litigation incentives. Practitioners often stress this counter infringement threat.[75] As a consequence, a firm that can be counter-attacked could have fewer incentives to litigate. In order to capture this counter-infringement risk, we create a variable, *vertical_integration,* for companies that are both licensors and licensees of the pool. Indeed, a firm that is vertically integrated (also licensee) can be more easily threatened. This lack of counter-infringement risk may often be emphasized for non-practising entities that cannot be threatened on the downstream market and are, thus, more inclined to litigate.

Hypothesis 3: The introduction effect varies according to the size, structure and status of the firm within the pool.

To summarize, the patent introduction in a pool may have an impact on the patent holder's level of information. Furthermore, the patent holder's incentives to litigate should vary according to its size, structure, and status. If the results verify these hypotheses, we should observe a positive introduction effect for pool patents controlling for the demand side effect. We should also be able to distinguish between the two axioms supporting this hypothesis using data from the pool number of members and number of patents. If the data verifies our hypotheses on the level of incentives, the introduction effect should vary according to the firm size, structure, and status. In order to capture these different effects, we create interaction variables between the introduction effect and the variables: *pool_size, firm_size, ppprior, patent_portfolio. firm_size_vertical integration.* The graph in Appendix 2 emphasizes the differences in the intensity of the introduction effect according to the firm size, the pool size, and the nature of the firm.

5.2 Theory and hypotheses on the outcomes of the disputes

Our main question, in this part, assesses why the patent introduction in a pool could have an impact on the outcome of the dispute. Lerner (2009) or Bessen and Meurer (2006) point out the importance of the uncertainty about the outcome of the controversy on the

[75] On this counter infringement risk, one of the pool administrator interviewed said: "Also there is a possibility that filing of an infringement action against company A may cause a serious problem, such as a counter patent infringement action against the company, that may cause a bigger damage to the member company."

equilibrium settlement/litigation. All of these papers follow the same direction, the closer the expectations on the outcome of the controversy, the higher the likelihood that the case is settled.

In this paper, we will test an hypothesis directly derived from this literature: the patent introduction in a pool should have an impact on the equilibrium settlement/litigation and, thus, increase the number of disputes that are ended with a settlement. This assumption appears quite logical, given the hypothesis presented above. Indeed, in a patent infringement case within a standardization framework, the court has to answer two questions: Is the patent valid? Is the patent infringed?

A patent that is introduced in a pool is reviewed by an external expert that evaluates its essentiality. Thus, the pool patents are necessarily essential to the technology and the introduction gives a presumption of essentiality to the patent. This presumption of essentiality gives at least a partial answer to the question: is the patent infringed? Therefore, the essentiality evaluation by a third party expert should decrease the level of uncertainty on the outcome of the dispute (the essentiality of the patent does not have to be assessed again if the patent is accepted in a pool).

Hypothesis 4: The patent essentiality evaluation by an expert, at the time of introduction, decreases the level of uncertainty on the outcome of the dispute and thus increases the likelihood of settlement.

6. Empirical results

This section presents the main empirical results on the hypotheses described above. We present, in the first subsection, the results of the introduction effect and, in a second subsection, the results on the outcomes of the disputes.

6.1 Results on the introduction effect

In this subsection, we only examine the litigations in which the patent holder is plaintiff, consistent with our hypotheses. The cases in which the patent holder is a defendant rarely occur after the patent introduction in the pool, and the results remain robust when we have the same analysis for the overall sample as shown in Appendix 4.

In order to test the hypotheses presented in the preceding section, the best method is using a panel database with fixed-effect count models grouped on patents (in order to only capture the change controlling for other variables such as the intrinsic quality). The test results presented in Appendix 8 (Table 13) confirm this fixed-effect approach. We introduce a dummy variable *(introduction_effect)* that equals 1 for all observations after introduction in a pool. We control for a timing trend (in litigations) using a fourth-order polynomial in calendar years and for a demand increase following the patent introduction in the pool through the number of forward cites at year N-1[76]

[76] This method was developed by Simcoe, Graham and Feldman in their 2009 paper

	(1) FE logit	(2) FE logit	(3) FE logit	(4) FE logit	(5) FE poisson	(6) FE poisson	(7) FE poisson	(8) FE poisson
		DV= Dummy litigation				DV= Number of cases with the patent holder as plaintiff		
Introduction effect	1.71975** (0.761)	3.70276** (1.648)	10.84063** (4.487)	13.77389** (5.412)	3.49540*** (0.987)	13.63207*** (3.359)	21.65224*** (5.51)	21.95810*** (5.441)
Number_other_member Introduction	-0.00485 (0.040)	0.02056 (0.044)	0.10603* (0.058)	0.14533** (0.066)	0.02380 (0.020)	0.16737*** (0.037)	-0.03254 (0.089)	-0.02372 (0.088)
Number_other_member2 Introduction							0.01179*** (0.004)	0.01150*** (0.004)
Othermembers_patents_Introduction			-0.00054** (0.000)	-0.0007*** (0.000)		-0.00077*** (0.000)	-0.00148*** (0 .000)	-0.00149*** (0 .000)
PPprior_introduction		-1.58017 (1.510)	-0.58744 (1.560)	-3.25562* (1.688)	-1.30864** (0.660)	-0.27678 (0.681)	-0.58256 (0.702)	-1.51384** (0.698)
Portfolio_size_introduction		0.00011 (0.000)	0.00038* (0.000)	0.00031 (0.000)	0.00011** (0.000)	0.00056*** (0.000)	-0.00185 (0.001)	-0.00172 (0.001)
Portfolio_size2_introduction							1.275e-07* (7.21e-09)	1.218e-07* (7.07e-08)
Portfolio_size_VI_introduction		-0.00002* (0.000)	-0.00009** (0.000)	-0.00012** (0.000)	-0.00002** (8.68e-06)	-0.00012*** (0.000)	-0.00013*** (0.000)	-0.00013*** (0.000)
Cites N-1				0.79004*** (0.230)				-1.63263*** (0.344)
Calendar year effect	0.00749 (0.026)	0.00068 (0.026)	0.00012 (0.027)	-0.1039*** (0.032)	0.01932 (0.012)	0.02058* (0.012)	0.02055 (0.013)	-0.00782 (0.012)
Chi2	43.65	49.91	58.33	117.68	90.31	75.58	59.94	84.46
Log lik.	-281.806	-269.322	-265.112	-235.435	-965.305	-944.152	-939.555	-843.995
Number of obs	1037	1003	1003	1003	1003	1003	1003	1003

Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses

Table 4. Regressions results fixed effect litigated, patent holder as plaintiff

The findings verify our first hypothesis, that the patent holder's level of information causes the introduction effect. Indeed, controlling for the demand side effect, the introduction effect is positive and significant—meaning that, for the same patent, the likelihood of litgation and the number of litigations increase after introduction in a pool.

The results on the number of members and the number of patents in the pool suggest that this effect is due, at least partially, to a mutual observation between members. In fact, the interaction variable between the introduction effect and the number of other members in the pool is positive and significant. This means that, *ceteris paribus*, the pools that have a higher number of members are more efficient in helping patent holders enforce their rights. If we accept the assumption that the number of pool members has a direct relationship to the level of information of the patent holder, this result is perfectly normal. The negative and significant parameter between this interaction variable and the number of patents in the pool at the time of introduction confirms that at least a part of this result is due to mutual observation and not to a voluntarily exchange of information between patent holders. Of course, there is a chance that this variable captures only a nonlinear relationship for the *number_othermember_introduction* variable. To control this effect, we included, in the last column, an interaction variable between the introduction effect and the number of other members in the pool squared.

On the incentives to litigate, our results confirm the reputation effect; smaller firms (firms that have fewer patents in the pool) pay more attention to their reputation for toughness and, thus, litigate more than firms holding an important number of patents in the pool. The results also verify the learning-curve effect because the parameter of the control variable *portfolio_size* is positive and significant. These two results are consistent with such previous research on the subject as Simcoe, Graham, and Feldman (2009), who emphasize the importance of the reputation effect for small firms, and Lerner (1995), who highlights the learning curve effect.

On the risk of counter infringement, the parameter for the variable *Portfolio_size_VerticalIntegration_introduction* is negative and significant—meaning that, controlling for the size of the firm, vertically integrated firms attack less than do pure research firms. Thus, the results shown in Table 4 confirm our hypothesis on the risk of counter infringement; also being a licensee of the pool negatively affects the incentives to litigate.

This section reviewed the empirical results on the introduction effect. The findings appear to verify our main hypotheses. The next section addresses the empirical results of the outcomes of the disputes.

6.2 *Results on the outcomes of the disputes*

This section tests our hypothesis that the introduction of a patent in a pool affects the equilibrium settlement/litigation. Please recall, our hypothesis seeks to test whether the expectations for the outcomes of the disputes are different before and after introduction in a pool. If our hypothesis is verified, the number of disputes ended by settlement should be higher after than before the patent introduction in a pool. Figure 4 (Appendix 9) presents some graphical evidence on the outcomes of the disputes for pool and non-pool patents.

Figure 4 suggests that the likelihood that the case ends with a settlement is higher when patents are pool patents. Of course, this difference could be due to intrinsic differences between pool and non-pool patents that could foster settlements in order to end disputes. These descriptive results remain consistent with our theory, presented above, that the patent introduction decreases the level of uncertainty and, thus, change the equilibrium settlement/litigation. We will confirm this result using econometrics methods.

In order to test this hypothesis, we first run a cross section regression with, as the dependant variable, the likelihood that the dispute is ended by settlement. Due to the small number of observations, we use a cross-section approach. We run this regression on all the litigated patents of our sample. We control for the age and quality[77] of the patents. The control database is comprised of patents having the same assignee and technological class. Last, we also use dummies to control for a possible court-fixed effect. Indeed, one could argue that the level of uncertainty will vary according to the court (some outcome are easier to predict). For the same reasons as in section 4.2, we also run a rare event logit regression to control the stability of our results. Table 5 presents the results:

[77] Using the number of forward cites and the generality index

	(1)		(2)		(3)	
	Probit		**Probit**		**Logit**	
	DV= Settlement dummy					
	Coef.	Marg. effect	Coef.	Marg. effect	Coef.	Marg. effect
Presence Pool	1.302* (0.557)	0.288*** (0.064)	1.493* (0.584)	0.281 (0.056)	2.591* (1.212)	0.270*** (0.059)
Log_ Cites	-0.292 (0.154)	-0.099 (0.052)	-0.399 (0.219)	-0.127 (0.069)	-0.681 (0.409)	-.0126 (0.075)
Generality			-0.241 (0.488)	-0.077 (0.156)	-0.342 (0.817)	-0.063 (0.152)
Control Grant Year	Y	Y	Y	Y	Y	Y
Dummy Court	Y	Y	Y	Y	Y	Y
_cons	-32.539 (70.170)		-7.103 (82.514)		1.017 (145.70)	
Obs.	139		139		139	
Wald chi2	21.20		17.04		14.89	
Prob > chi2	0.0035		0.0297		0.0614	
Pseudo R2	0.1275		0.1180		0.1162	
Log lik.	-76.363		-58.798		-58.923	

*Legend: * p<0.10; ** p<0.05; *** p<0.01. Robust standard errors in parentheses. Control database constituted with patents having the same application year and assignee type.*

Table 5. Regressions results cross section settlement, pool and non-pool patents

Table 5 confirms our previous descriptive findings. Everything else equal, pool patents have a higher likelihood to be involved in a dispute that will end with a settlement. These findings take into account the possible intrinsic differences between pool and non-pool patents, controlling for the number of forward cites, and patent generality. These results corroborate our fourth hypothesis: the patent essentiality evaluation decreases the level of uncertainty on the outcome of the dispute and, thus, increases the likelihood of settlement.

Due to the nature of our observations, the best econometric method to use, to emphasize this result, is a panel approach. Due to the results of the tests presented in Appendix 8 (Table 14), we chose a random-effect model. We control for the calendar year of the litigation, the quality of, and the age of the patent. Appendix 7 presents our results, because of the small number of observations. They confirm our previous findings, that the likelihood of a dispute ending by settlement increases after the patent's introduction into a pool.

6.3 Robustness tests

We base our regressions on the introduction effect on a fixed-effect Poisson model with a dependant variable that is the number of litigations (for a patent) per year or a fixed effect Logit model on the likelihood for a patent to be litigated in the year. Of course, we assume that the patent holder is the plaintiff; the previous results are based only on the cases in which the patent holder is plaintiff. We also present in Appendix 4 (Table 8) the results for the overall sample. The results closely follow those presented in Table 4. As explained in the data section, we control the robustness of our results excluding the DVD pools (results available in Appendix 6).

A truncation in the data may also affect our result. Indeed, we only have data on litigations filed after 2000. To take this into account, we run the same regressions on patents filed in or after the year 2000. The results, presented in Appendix 3 (Table 7), closely follow the results presented in Table 4.

These results clearly are sensitive to the unit of the variables. To avoid this problem, we run the same regressions using dummies to disentangle between small and large firms and pools. We present these results in Appendix 5. The results may also be sensitive to the age of the patent at the time of litigation (patents could be introduced in the pool at different ages). To overcome this difficulty, we run the same regression with interaction variables between the introduction effect and the age of the patent at the time of litigation. Appendix 5 (Table 10) summarizes our results. They also allow us to confirm the robustness of our findings. The results are even more significant using dummies and controlling for the age of the patent than in Table 4.

Patent litigation history could drive these results. Indeed, one could argue that patents, which already have a high number of litigations, have a higher likelihood of being litigated in the future. To take into account this effect, we run the regression with a dummy variable *already_litigated* that equals 1 for all observations after the first litigation. Appendix 5 (Table 10) also presents these results. Even if the parameter for this new variable is positive and significant—in other words, patents that already have a high number of litigations are more likely to be litigated again—our previous results remain robust. For all the regressions presented above, we also test that our results are robust to a fixed-effect, negative binomial model instead of a fixed-effect Poisson model. The results are available on request.

Last, as explained in the precedent subsection, we also use a panel approach to emphasize the result on the outcomes of the disputes. These random-effect model results, presented in Appendix 7, confirm the results of the cross-section model.

7. Conclusion

This paper analyzes the interplay between patent pools and litigations. We show that pool patents are more litigated than patents presenting the same characteristics but not included in a pool. This result could have two explanations: first, pool patents are more litigated before introduction or, second, the introduction of a patent into a pool increases the number of litigations. We demonstrate that the patent introduction into a pool greatly increases the number of litigations (or the likelihood that the patent is litigated) with the patent holder as plaintiff. One could explain this result by the greater ease a patent holder has to detect a potential infringement after introduction.

We present results that appear to verify this explanation for our sample, for example, the pool ex-post effect is higher for pools with a greater number of members. Using the patents' concentration in the pool, we argue that this effect should be due to mutual observation rather than an exchange of information.

Last, we demonstrate that the patent introduction into a pool has an impact on the outcome of the litigation by facilitating the resolution via settlement. Using the literature on patent litigations (Lerner, 2009; Bessen & Meurer, 2006), one can easily explain this result by a change in the expectations of the parties. Indeed, these expectations are closer, for the same patent, after introduction than before introduction; this due to the patent essentiality evaluation run by the pool.

These results are important and could help others understand the creation and stability of patent pools. Indeed, the theoretical literature on the subject emphasizes the free-riding problem and the difficulty of maintaining the stability of this type of organization. This paper, by highlighting that patent holders could have other incentives that those discussed in the literature, help fill, in at least in part, this lack of knowledge regarding patent holders' incentives to participate in these agreements.

Chapitre 3 : Les stratégies d'introduction de brevets dans les pools

Cet article explore économétriquement l'impact des patent pools sur les stratégies de dépôt de brevets. Nous conduisons une analyse sur 1337 brevets américains introduits dans 7 différents pools. Cette analyse souligne les différences de caractéristiques des brevets introduits par des entreprises déjà membres par rapport aux brevets introduits par de nouveaux participants. Nous démontrons que les entreprises déjà membres du pool sont capables d'introduire des brevets plus étroits, plus incrémentaux et de moindre significativité technologique que ceux introduits par les nouveaux participants. Ces résultats pourraient être expliqués par une asymétrie d'information entre les nouveaux et les anciens membres ou par une différence de pouvoir de négociation. Nos résultats démontrent notamment, par l'introduction d'un nouvel indicateur, que les entreprises déjà membres du pool sont capables de déposer des brevets plus centrés sur le critère d'essentialité pratiqué par le pool.

Research paper 3: The strategies of patent introduction into pools

1. Introduction

Patent pools are agreements between different patent holders to offer joint licenses for a bundle of patents. There have been patent pools since the early 19th Century, but since the successful launch of the MPEG2[78] and DVD patent pools in 1997 and 1999, pools have evolved with impressive speed. Today, patent pools are a phenomenon of increasing and undeniable importance in Information and Communication Technologies (ICT). Modern mobile phones, DVD or mp3 players, receivers for digital TV—all these high tech consumer goods use technology licensed from patent pools. The value of products produced under pool licenses and sold on the US market exceeds US $100 billion annually in 2004 (Clarkson, 2004).

Given the importance of patent pools, empirical analysis of the effects of pools on firm strategies is surprisingly scarce. This article analyzes the impact of pool creation on patenting strategies of pool members and outsiders. We investigate how patent pools affect the propensity to patent and the technological focus of firm R&D. We are thereby able to assess whether pools mitigate the effects of patent thickets or rather increase the adverse effects of strategic patenting on cumulative innovation.

We focus on patent pools in the field of technological standardization. While there have recently been important efforts to create patent pools in the fields of biotechnology and pharmaceuticals, most important patent pools are still related to technological standards. The importance of patent pools in ICT results from the fact that technological standards incorporate an increasing number of technologies protected by patents (Shapiro, 2001). Patent pools can play a beneficial role in standardized technologies. First, by bundling patents, they reduce the transaction costs by cutting down the number of licenses needed to comply with the standard. Second, pools reduce the multiple marginalization problem[79]. This problem arises when different firms have market power over complementary inputs (such

[78] MPEG2 is a data compression technology of moving pictures used in digital television, Internet streaming, DVDs among other uses.
[79] This problem was first analyzed by Cournot (1838) as "the exercise of market power at successive vertical layers in a supply chain".

as different patents necessary for complying with the same standard), and the firms fix prices independently of each other.

While there has been a fruitful stream of research on the impact of pools on downstream markets (e.g. Gilbert, 2004; Lerner & Tirole, 2004), much less attention has been spent on their potential upstream effects on innovation and patenting strategies. For instance, there is to date no empirical analysis of the patenting strategies of pool members and of companies wishing to join. The purpose of this paper is to fill this gap and to analyze the patterns of patent introduction into ICT patent pools, using data from major contemporary patent pools. We analyze the impact of pool membership on the technological characteristics of patents that are introduced. For instance, we compare the breadth and technological focus of patents introduced by incumbent pool members with those introduced by outsiders. We have produced a unique dataset on the timing of patent introduction into several of the most important pools that currently exist. Furthermore, we make use of technical documents to construct a novel indicator for the technological focus of a patent on the technology underlying the pool.

We highlight patterns of patent introduction providing sufficient evidence for an effect of pool membership on patenting strategies. We find that insiders introduce narrower and more incremental patents. We argue that this high propensity to patent allows these firms to capture an important part of the royalty income of the pool. These findings could indicate that insiders benefit from stronger bargaining power or better access to information than outsiders. We find arguments and empirical evidence especially for the latter explanation. Indeed, pool insiders and firms with a longstanding experience in a patent pool file patents that are more focused on the technology licensed out through the pool. While these findings provide evidence for opportunistic patent files induced by patent pool membership, we also find that patent pool membership increases the technological significance of patents controlling for patent breadth and generality.

The remainder of this paper is organized as follows. Section 2 presents a review of the economic literature on pools. Section 3 discusses main institutional features of contemporary ICT pools. Section 4 presents a quick overview of the novelty and interest of our data to establish new findings. Section 5 presents our main results on the differences between patents introduced into pools by firms according to their membership and experience in the pool. Section 6 highlights the importance of information asymmetry to understand how patents of different characteristics can be included. Our conclusion in section 7 discusses the implications of our findings for pool design and policy.

2. Theoretical background and empirical literature on patent pools

There is now a broad theoretical literature assessing the effects of patent pools on royalty rates and downstream markets (see for instance Gallini 2010, Gilbert & Katz 2006, Kato 2004). This literature generally stresses a positive welfare effect: patent pools have the potential to reduce the overall royalty rate by mitigating royalty stacking and transaction costs. But, in spite of their undeniable advantages, pools also have drawbacks. The main threat is the possibility that firms could use the pool for anticompetitive behaviors (Carlson, 1999). The literature particularly emphasizes the risk of introduction of substitutable patents, which would undermine competition between technologies (Gilbert, 2004; Lerner & Tirole, 2004).

There is also a smaller and more recent strand in the theoretical literature on the effects of patent pools on innovation incentives. Lerner and Tirole (2004) find that patent pools can induce socially wasteful excess innovation. LLanes and Trento (2010) also find that patent pools increase incentives to innovate, but in their model this increase is efficient, as it corrects for the negative effects of patents on sequential innovation. Dequiedt and Versaevel (2007) find a positive effect of prospective pool creation on innovation and patent files, as a patent is assumed to be more valuable to its owner when included into a pool. The recent empirical literature provides several justifications for this assumption. For instance, Delcamp (2010-1) shows that one advantage of the pool may be to increase the value of patents included. In another paper (Delcamp, 2010-2), the author shows that pools help patent holders enforcing their rights by increasing their level of information on possible infringement of the technology. Dequiedt and Versaevel (2007) nevertheless assume that companies willing to join an existing pool have to bargain their entry with incumbent pool members who extract the value added by the pool from the entrants. Their model thus predicts patent races until the launch of the pool, whereas innovation and patent files are on a low level during the existence of the patent pool.

Lampe and Moser (2010) verify this pattern of patent files empirically for the sewing machines patent pool in the 19th century. The number of patent applications both by pool members and outsiders was high before the creation of the pool, and dropped on a low level after pool creation. Nevertheless, the patent race in view of the pool creation did not yield significant technological progress on the technologies covered by the patent pool. Therefore, Lampe and Moser (2010) argue that the patent pool induced strategic patent files rather than innovation investments. Baron and Pohlmann (2010) find a similar result for contemporary ICT patent pools. They find that patent pools have a strong positive effect on the number of patents declared essential to the underlying standard in the periods before pool creation. This race of patent declaration does not induce an increase in standardization activity.

By contrast to the predictions of Dequiedt and Versaevel (2007) and the finding of Lampe and Moser (2010), Baron and Pohlmann (2010) find that patent pools have a positive and significant effect on patent declarations even after the pool is created. They argue that pool members continue to have stronger patenting incentives after patent pool creation than in the absence of a patent pool. This explanation is corroborated by descriptive results in Baron and Delcamp (2010). This description of the current patent pool landscape in ICT standardization reveals that generally more than half of the patents included into patent pools have been introduced after the pool creation. This result is confirmed for U.S. patents in our sample as it is shown in figure 2, appendix 1. Initial pool members account for the large majority of these late patent introductions. The descriptive analysis of patent pools provides furthermore further support for the suspicion that the strong patenting activity by pool members after patent pool creation does not reflect an increase in innovation investment. Indeed, Baron and Delcamp (2010) show that the scope and the technological significance of patents introduced into the pool strongly decreases over time.

Nagaoka (2009) provides a further analysis of the development and growth of patent pools over time. In order to do so, he examines three technological standards in information technology. The author underlines that the number of essential patents within pools increases significantly after the standard definition. He identifies three reasons to explain this increase over time: patents cover a number of different technology fields, there exists R&D competition and a firm can expand its patent portfolio by using continuation and other practices based on the priority dates of its earlier filed patent applications. He finds strong evidence for the hypothesis of a strategic increase of patent portfolios, as around 40% of the essential US patents for MPEG2 and DVD standards have been obtained by using these applications. The author also focuses on whether a firm already member of a pool can obtain more essential patents, using these practices. He concludes that firms with pioneering patents tend to have a smaller number of essential patents obtained through continuations.

Thus, there is evidence on an effect of patent pools on opportunistic patent strategies. These strategies induced by patent pools could increase the number of technologically insignificant or unnecessary patents on a standard. Gilbert (2009) argues that inclusion of such unnecessary patents into a patent pool should not lead to higher royalty rates and not represent a threat to consumer welfare. On the other hand, opportunistic patents reduce the return on technologically significant patents, as they dilute their share in the pool. Thereby they could reduce incentives to innovate and stifle the technological development of the standard.

Furthermore, opportunistic patent files potentially reduce the stability of patent pools and induce holders of valuable patents to refrain from joining the pool. For instance, Layne Farrar and Lerner (2010) find that holders of high quality patents are less inclined to join patent pools that redistribute royalty income according to the number of patents in the pool. In practice, the stability of patent pools is an important problem and many patent pools fail to emerge or to include all relevant patent holders. Indeed, Aoki and Nagaoka (2004) highlighted that patent holders have strong incentives not to participate to the pool. They thus can benefit from higher licensing fees for their patents due to the pools' creation. Llanes and Trento (2010) show that the incentives to stay outside a pool are particularly strong for downstream inventors. The effects of opportunistic patenting on the attractiveness of patent pools are therefore potentially severe.

The theoretical and empirical literature thus discusses possible causes and implications of the impact of patent pools on patenting strategies. In particular, there is evidence for an increased patent propensity. The theoretical analysis of the impact of pools on patent strategies highlights the different incentives of pool members and outsiders. Nevertheless, there is no direct empirical analysis of how patenting strategies are affected by patent pools. The aim of the present study is to fill this gap.

3. Stylized facts

In order to analyze the effects of patent pools on the incentives of pool members and outsiders to file and introduce patents, it is important to present two main features of the institutional setting of contemporary patent pools. These features are the rules on revenue sharing between patent pool members and rules governing the inclusion of patents into pools.

3.1 Revenue-sharing rules

Not all patent pools collect royalties. For example, the Bluetooth pool has a royalty-free licensing rule. In this case, introduction of patents into the pools is driven by non-monetary incentives, such as encouraging the implementation of the standard or access to the licensees' technology. However, all pools that collect royalties have rules on how these royalties are shared between members. There is no legal requirement stipulating a certain form of royalty sharing. Therefore members are free to agree on whatever rules they want. Layne-Farrar and Lerner (2010) identify two main types of sharing rules: numeric proportional rules and value added rules. Both rules provide important incentives to firms for increasing their share of patents in the pool.

The numeric proportional rule consists of dividing earnings based on the number of essential patents in the pool. All the pools administered by MPEG LA[80] use this revenue sharing rule (Layne-Farrar & Lerner, 2010). A variant of this rule is the revenue sharing rule of the MPEG 2 patent pool in which the calculation of the number of essential patents is weighted by country. The numeric proportional rule has a direct impact on the incentives to introduce large number of patents because each new patent increases the percentage of revenue allocated to its holder.

The value added rule exists in several variants. The first possibility is a negotiation that determines what share of revenue each contributor receives. The second possibility is a royalty sharing rule based on determinants such as the age of the patents, the number of claims, the number of times the patents are infringed, and the part of the standard these patents are essential for. In this case, the number of patents taken into account for the calculation of the share of revenue is weighted by some indicators of patent quality. One example of an application of the value added rule is the DVD 6C patent pool (Layne-Farrar & Lerner, 2010).

Even though the value added rule weights the number of patents by some indicators of patent quality, it still provides incentives to firms to increase their share of patents in the pool, even if the additions are of lower quality. The business review letter[81] of the DVD6C pool states: "The formula that will determine the royalty allocation is based on how many of each Licensor's 'essential' patents are infringed. Thus, although the formula weights the patent count with other factors, each Licensor will benefit monetarily from the exclusion of other Licensors' non-'essential' patents and accordingly has a strong incentive to encourage the expert to review other Licensors' patents critically, and to bring to the expert's attention any patents that have ceased to be 'essential.' ".

As all pools take the number of patents into account for determining the royalty shares of the members, it is straightforward why companies have incentives to introduce a high number of patents. On the other hand, it also becomes apparent that such strategies meet the resistance of other pool members, whose share in the pool would be diluted by opportunistic patents. It is the aim of our investigation to analyze how different firms manage to expand their share on the expense of others. As a further step, it is necessary to analyze how the rules of patent pools shape the incentives and possibilities of strategic inputs.

[80] MPEG Licensing Association is one of the currently most important pool administrators (together with Via Licensing and Sisvel). There are currently 8 patent pools administered by MPEG LA, including very important pools such as MPEG2. See Baron and Delcamp (2010) for a description of the business model of a pool administrator.

[81] Available at http://www.justice.gov/atr/public/busreview/2485.htm

3.2 The rules governing inclusion of patents into patent pools

In order to qualify for introduction into a pool, a patent has to be "essential" to the underlying standard. In order to ensure the essentiality of the patents, and thus the compliance of patents with the criteria adopted by the pool, patent pools usually have a third party evaluator (or expert, as the DVD6C pool letter states) that establishes essentiality reports[82]. The evaluator's work is to analyze the patent and to declare whether this patent is "essential" according to the criteria of essentiality defined by this particular pool. There are several points to highlight on this essentiality criteria.

First, the criteria of essentiality are not always exactly the same and may be endogenous: the definition of patent essentiality is a subject of debate, but two mains interpretations emerge from the literature and the decisions of competition authorities (Gilbert, 2009). The first one focuses on technical essentiality, meaning that there is no technological alternative to a patent. A second, broader definition includes criteria of economic feasibility. In this definition, patents are essential not because there is no technological alternative, but because the available technological alternative(s) is so costly that it is impossible to implement the standard in a way that is competitively priced without using the patent. In practice, pools have some discretion in defining their criteria of essentiality[83]. It is thus imaginable that the pool members choose the criteria of essentiality bearing in mind which criteria would best fit their patent portfolio. Furthermore, not all pools force members to consult the expert[84]. Finally, it is difficult to ascertain to what degree pool members can influence the outcome of the patent evaluation. Patent evaluators are appointed by the pool administrator and paid by the patent holders. In several cases of litigation, licensees have accused patent evaluators of being overly lax in their evaluation of allegedly essential patents.[85]

Most importantly, the criteria of the essentiality evaluation do not take into account the patent breadth or generality. Essential patents can still be of low technological or economic value. For instance, owners of an essential technology can often choose to protect it by one large or several narrow patents. Each of the numerous narrow patents may still be necessarily infringed by any implementation of the standard and therefore each separately complies with the criteria establishing essentiality in the respective pool.

[82] An example of a summary essentiality report is included in Appendix 3
[83] For instance, the MPEG 2 pool uses the technical essentiality criteria whereas the DVD 6C pool uses the economic feasibility criteria.
[84] For instance, the MPEG 2 pool stipulates: "The licensors are bound by the expert's opinion. However, they need not consult the expert if they agree unanimously in good faith that a submitted patent is an essential patent or that a portfolio patent is not essential"
[85] This claim is raised as patent misuse defence in many patent infringement cases, e.g. by disc replicator ODS in its litigation MPEGLA over the MPEG2 patent pool; Landgericht Düsseldorf Urteil vom 30. November 2006, Az. 4b O 346/05; V. b) cc)

We have thus discussed that essentiality evaluation by patent pool experts does not rule out the possibility of opportunistic patent introductions into pools. While the safeguards should be efficient in ruling out that substitutable or unrelated patents are included into the pool, the essentiality evaluation has no impact on the propensity to file patents on essential technology. For instance, holders of standard-essential technology can increase their number of patents by filing a high number of narrow patents, or by filing patents not only on fundamental, but also on very incremental inventions related to the standard. We will explicitly address these hypotheses in the remainder of this article.

4. Methodology

Even though some commentators suggest that pools may increase the number of low quality patents, to date no reliable evidence has been gathered. If the number and quality of essential patents is endogenous to pools, this does not necessarily imply that patents in pools are on average of lower quality than other patents. Besides the potentially negative incentive effect, one expects pools to have a positive selection effect: Patents essential to technological standards are generally found to be of higher quality than other patents, because Standard Setting Organizations (SSOs) tend to select the best technologies. As patents included in pools are by force of law required to be essential, included patents are expected to be of higher quality than the average patent. Delcamp (2010-1) finds evidence on this link between essentiality and quality of patents in pools.

The most straightforward way of assessing the patent introduction strategies would be to compare for each standard and each year which patents are introduced into the pool and which patents are not. Unfortunately, it is impossible to reliably identify those patents covering the same technology as the pool that are not included in the pool. Recently, databases of patents declared essential to SSOs have been used for these purposes (Layne-Farrar & Lerner, 2010), but the overlap between patents declared as essential and essential patents is small. For instance, many patents declared to be essential by their owner can be determined as not essential by an external evaluator[86], and there is no guarantee that all essential patents are correctly declared. This indicates that patent declaration databases do not reliably account for all relevant patents, which makes it impossible to distinguish between patents not presented to the pool by their owner and patents refused by the pool's patent evaluator.

[86] For instance, the essentiality evaluation of Fairfield Resources on patents declared as essential to LTE and SAE underlines that around 50% of the families declared contain no essential or probably essential patent (see http://www.frlicense.com/LTE%20Final%20Report.pdf)

Therefore, we concentrate on patents that have effectively been included into a pool and analyze patent quality with respect to the owners of the patent and the timing of their introduction. In particular, we analyze the effects of pools on patenting strategies by comparing patents introduced by firms that are already pool members and by outsiders. Furthermore, we compare patent introductions according to the experience of the firm in the pool, to the share of pool patents it holds, and to vertical integration. We label a firm as vertically integrated when it is licensor and licensee of the same patent pool.

4.1 Data

We have produced a unique database of 7 patent pools: DVD6C, MPEG2, MPEG4 Systems, MPEG4 Visuals, AVC H/264, IEEE 1394 and DVB-T[87]. These 7 major pools capture a big share of the commercial importance of patent pools in ICT. Restricting the analysis on ICT patent pools has the advantage that the institutional setting of the pools is very similar. As the first patent pools have undergone a rigorous and time-consuming screening by competition authorities, all later pools adopted an institutional framework sufficiently similar to the arrangements that had already been cleared as non-infringing.

The seven patent pools provide us with 8,046 patent observations. A few patents are included in several pools; for our purpose the same patent in different pools is treated as a separate patent observation each time it appears. Furthermore patents sometimes change the designation by which they are identified on patent lists (from application number to grant number) or are dropped (by expiry or retrieval of the holder). For these reasons the number of patent observations is higher than the number of patents currently included in the seven pools (8,046 observations for around 5,000 patents).

We retrieved the patent numbers and the name of patent holders from the lists available on the websites of the pools[88]. Using Internet Archives,[89] we checked when the patent first appeared on the list of pool patents. Patent pool managers regularly update the lists of pool patents on their websites. Like any other information on the site, these data are stored in Internet Archives. Comparing current lists with previous ones allows identifying the date when a patent is first listed as part of the pool. We call this the date of input. As the updating of sites may experience some delay or the update be retrieved from the Archives after some delay,

[87] DVD6C is one of the two patent pools licensing out patents essential for DVD specifications, MPEG2, MPEG4 Systems, MPEG4 Visuals and AVC H/264are patent pools including essential patents for coding standards issued by the Moving Pictures Expert Group, the IEEE 1394 patent pool covers wireless communication technology, and DVB-T is a patent pool for patents on Digital Video Broadcasting technology.

[88] www.mpegla.com (MPEG2, MPEG4 Systems, AVC, IEEE 1394), www.dvd6cla.com (DVD6C), www.sisvel.com (dvb-t)

[89] www.archive.org

the date we identify as date of input may differ from the actual date of introduction by as much as a couple of months. Nevertheless, our method reliably identifies the order in which patents are introduced into pools.

In order to compare only what is comparable; we restrict our analysis to the U.S. patents in our sample[90]. We match the 1,337 US patents with the National Bureau of Economic Research (NBER) database. By doing this, we obtain a full range of information on the patents, and especially the number of claims, forward and backward cites (forward cites count the number of times a patent is cited by ulterior patents, backward cites count the number of previous patents cited by a patent), patent generality, technological class, and grant and application year. In order to deal with truncation problems and missing observations, we completed the dataset using the web service of the European Patent Office[91]. Using these databases, we also retrieve the size of the patent family. The patent family is defined as the group of patents sharing the same priority number.

We collect four important dates for each patent: application date, grant date, date of pool creation and date of introduction into the pool. From these dates are drawn our age variables. Patent age is the difference between today and the grant date, and Input age is the age of the pool at the time a patent was introduced, defined as the difference between date of input and pool creation date.

4.2 Indicators

The main purpose of our paper is to analyze the impact of pools on the patenting strategies of the members. We are especially interested in assessing the effects of pools on patent propensity. Two patent indicators are particularly relevant for analyzing patent propensity. First, we use the number of claims, which is a common indicator of the patent breadth (Merges & Nelson 1990, Klemperer 1990). If due to higher patent propensity a holder of a technology decides to file more patents on the same number of inventions, this should be reflected in the fact that his patents are narrower, and therefore have fewer claims. Indeed, it is difficult to increase the number of valid claims on a technological invention, as the claim is a unit of legal significance that is difficult to manipulate, because it will be used to assess the validity and the possible infringement in case of litigation. On the other hand, it is possible to increase the number of patents by reducing the number of claims per patent (Merges & Nelson 1990). The second indicator for the patent propensity of technology holders we use is the generality index. Patent generality is defined as the dispersion of prior art over technology

[90] The U.S. patent is usually the first patent of a family to be introduced in a pool (Baron & Delcamp, 2010) and is also usually the patent upon which the essentiality evaluation is based

[91] www.espacenet.com

classes. If a patent cites prior art that is technologically very heterogeneous, it is more likely to protect a fundamental invention. By contrast, if a patent cites only prior art that is technologically very close, it is more likely to protect an incremental invention (Trajtenberg & al., 1997). Finally, we also use the family size to assess the value of a patent. Family size is a common indicator of patent private value (Putnam, 1996) as the costs of filing increase with the number of countries in which the innovation is protected.

In a next step, we want to analyze the technological focus of the patents filed by pool members. Indeed, if pools induce companies to file more patents with the only objective of introducing them into a pool, these strategies should be reflected by the fact that the patents of these companies are more focused on the technology covered by the pool. The generality index and other traditional patent indicators (such as the originality index) are unable to capture the relationship between a patent and a very precise technology such as a standard. Therefore we construct a novel indicator for the focus of a patent on a standard. This standard is based upon the breadth of the essentiality claim. As discussed earlier, the patent essentiality reports indicate the standard sections for which each patent is essential. Summaries of the essentiality reports carried through by independent patent experts are available on the pools' websites. These summaries indicate the sections and subsections of the standard document for which the respective patent is essential. We count these sections and subsections and correct by the median of patents in the same pool (respectively in the same licensing program for pools with several distinct licensing programs). Estimating the effects of patent pools on the breadth of the essentiality claim and controlling for the breadth and generality of the patent itself should give a good indication of the patent's focus on the standard underlying the pool.

Finally, we are also interested in analyzing the effect of pool membership on the technological significance of the patents filed by pool members. The most frequently used indicator of technological significance is the number of forward cites, which has been repeatedly found to indicate the value of the patent and the significance of the underlying technology (Harhoff & al. 1997, Hall, Jaffe & Trajtenberg 2001, Giummo 2003). Layne-Farrar and Lerner (2010) and Rysman and Simcoe (2008) use forward number of cites to analyze the quality of patents incorporated into standards and patent pools. Economists have thought about a potential bias resulting from citations a patent receives from patents of the same patent holder[92]. To exclude any bias and in line with most empirical research on patent quality, we exclude citations received by patents owned by the same firm.

A list of all the variables used in this paper with some descriptive statistics can be found in Appendix 2.

[92] Hall et al. (2001)

5. The impact of pool membership on patenting strategies

5.1 Hypotheses

The aim of this part is to examine if a pool creation changes firms' patenting strategies. For instance, we will analyze whether a patent pool induces firms to increase their patent propensity. As discussed, a higher propensity allows firms to reap more important shares of the pool royalty income. This strategy makes sense only when some firms are able to increase their patent propensity at the expense of others. For instance, we expect that insiders are more able to introduce numerous patents of low significance than outsiders. In order to address this hypothesis, we analyze differences in the characteristics of patents introduced by incumbent pool members and outsiders.

We can also refine the analysis and have a closer look at the patents' characteristics depending on the firm status and position within the pool. If pool membership has an impact on firms' patenting strategies, we expect that this effect is stronger for firms that have been in the pool for a longer time and that own more important shares of the patents in the pool.

A further hypothesis is that the patenting strategies could change if the firm is at the same time licensor and licensee (vertically integrated) of the pool. Licensees bear the cost of a higher patent propensity when it increases overall licensing costs or when it dissuades holders of significant essential patents from joining the pool. More generally, it has been found that the main motivation for manufacturing firms to join patent pools is to clear blocking positions and to facilitate access to technologies. This position could mitigate the incentives for a patent owner to increase the number of patents when he is at the same time a licensee of the pool.

Hypothesis 1: The characteristics of patents included should vary according to whether the patent holder is member of the pool, whether it is also licensee or held an important number of patents.

We will test the hypothesis of an increased patent propensity using three different patent characteristics. First, an increased patent propensity should result in narrower patents. Indeed, an essential technology can be protected by one or many essential patents. Patent holders have incentives to divide an essential technology in many essential patents if the sharing rules of royalties are at least partly based on the number of patents (cf. section 3). Furthermore, we expect that a high patent propensity leads firms to patent also very incremental inventions. We therefore expect that the patent generality decreases on average.

But at the same time, all the patents in the pool should have the same private value for the patent holder. In fact, after introduction into a pool, every patent gives a right to the same share of royalties (or almost the same if the pool adopted the value added rule). Thus, we should not observe any difference in the family size of the patent.

Hypothesis 2: The patent private value should be equal whatever the firm status with respect to the pool

Moreover, we also investigate if there are differences in the technological significance of the patents. We thus look if the number of forward cites differs according to the status of the patent owner. As patent citations are an exogenous indicator and can not result from a deliberate strategy by the owner, we present the results in the next section.

5.2 Results

We successively test our hypotheses regarding the number of claims, the generality and the family size of the patents. We run Poisson estimations on each indicator. We control for patent age, the time of patent introduction and for pool fixed effects. The results are presented in the following table (negative binomial results can be presented on request and go in the same direction).

	(1) Number claims	(2) Number claims	(3) Generality	(4) Generality	(5) Family size	(6) Family size
Outsiders	0.37528***	0.21096**	0.61934***	0.41313***	-0.16081	-0.38395
	(0,067)	(0,103)	(0,081)	(0,115)	(0,197)	(0,421)
PPprior		-0.202041		-0.93253*		0.00905*
		(0,270)		(0,502)		(0,005)
Seniority		0.00450**		0.00299		0.55282**
		(0,002)		(0,004)		(0,256)
Vertical Integration		-0.14928		-0.04930		-0.36693
		(0,116)		(0,162)		(0,263)
Patent Age	0.01811	0.02098**	-0.06992***	-0.06788***	0.20054***	0.20757***
	(0,011)	(0,010)	(0,011)	(0,011)	(0,034)	(0,037)
Age input	-0.00178	-0.00365**	-0.00869***	-0.01046***	-0.01460***	-0.01806***
	(0,001)	(0,002)	(0,002)	(0,003)	(0,005)	(0,006)
Dummy Pools	Y	Y	Y	Y	Y	Y
Dummy App. year	Y	Y	Y	Y	Y	Y
_cons	-33.9089	-38.979*	138.437***	134.6002***	-397.4718***	-411.9019***
	(22,263)	(20,943)	(22,918)	(22,849)	(67,657)	(73,613)
Obs.	1208	1208	707	707	698	698

*Regressions with robust standard errors in parentheses. Legend: * p<0.05; ** p<0.01; *** p<0.001.*

Table 1. Patent characteristics according to the status of the patent holder

Table 1 highlights two important results. First of all, we can underline that the pools grow by including over time increasingly narrow and incremental patents. We furthermore confirm Hypothesis 1 that patents brought by outsiders are broader and more general than patents brought by insiders. This result is verified for both the number of claims and the generality of the patent. Both findings concur that patent pools induce a higher patent propensity especially among pool members. Nevertheless, we do not find any significant incidence of vertical integration. Firms that are licensees of the pool do not introduce patents that are significantly different from patents introduced by other firms. Hypothesis 2 is also verified. Patents introduced by insiders or outsiders at the same time into the same pool do not differ in their family size. Patents brought by outsiders are thus less focused and more general, but of the same private commercial value than insider patents. This finding indicates that the opportunistic patenting strategies of pool members are profitable, as they allow achieving the same private value with a smaller and therefore arguably less expensive technological contribution.

This finding nevertheless calls for further investigation. If pool members introduce increasingly narrow and incremental patents into the pool, why would the other members accept these patents? Indeed, each introduction of new patent changes the repartition of royalties. Thus patent pool members should be particularly cautious when accepting new patent introductions. Yet, we have just shown that pool members are able to introduce numerous narrow and incremental patents. A further point is that if filing narrower and more incremental patents allows holders of essential technology increasing their share in the pool, it is not straightforward why outsiders would introduce less patents with broader claims and on more general inventions.

Furthermore, also a more detailed comparison of patents introduced by different types of insiders raises further need for investigation. On the one hand, pool members that hold bigger shares of the patents in the pools introduce even more incremental patents than the other pool members. On the other hand, companies that have been pool members for a long time introduce patents that are broader than the patents introduced by other pool members. Their patents also seem to have a significantly higher private value than patents introduced by other companies, as indicated by the bigger patent families. These results suggest that the experience of a company in a patent pool has an effect that does not necessarily go into the same direction as pool membership as such or as the share of the firm's patents in the pool.

The next section will thus investigate how being pool member affects a company's capacity to increase the number of patents and thus the share in royalty rates. In particular, we will analyze how the experience and the share of a firm in a patent pool affect the technological focus and significance of its patents.

6. Why do the characteristics of inputs differ according to the status of the patent holder?

6.1 Hypotheses

In the previous part we have seen that pool membership has an impact on firms' patenting strategies. Pool members are filing patents that are narrower and more incremental. This result is in line with earlier findings that pools induce a higher patent propensity around a technological standard (Baron & Pohlmann, 2010). There remains however an important issue to clarify. The fact that we find firm characteristics to be correlated with patent characteristics could be explained by two different sets of arguments. The first argues that some firms are able to introduce patents of different characteristics, narrower and less general, to the pool because they have greater bargaining power. These firms can induce a pool to accept a patent that it would have rejected if it was submitted by a firm with less bargaining power. The other argument would be that pool members present patents that at given patent scope and generality are more important for the standard and for the successive technological development. According to the first argument, pool membership thus induces a change in patent strategy because it improves the firm's bargaining power with respect to the patent pool. According to the second argument, pool membership induces a change in patent strategy because it improves the firm's capacity to file patents that are essential for technological standards or for successive research by other firms.

The greater ability of insiders to introduce less general and narrower patents could be explained by bargaining power. Patent pool administrators and patent evaluators are paid by pool members. It is reasonable to argue that they maximize the welfare of the pool members. Patents presented by outsiders are therefore only accepted if the value they add to the pool more than compensates pool members for the decrease of their share in pool income. Patents introduced by pool members modify shares of individual pool members, but do not reduce the number of joint shares of all members. Patents submitted by insiders should thus be accepted as soon as they add some value to the pool. Pool administrators could have a further incentive to reject patents presented by companies that are not yet pool members: accepting such patents means that their holders become pool members. If the pool increases, joint decision making becomes costlier and the risk of non-cooperative strategies increases. For both these reasons, at given patent quality and technological significance, a patent pool administrator could be expected to be more inclined to accept patents presented by pool members. This could explain our finding that outsiders introduce patents that are broader and less incremental on average.

By contrast to pool insiders, vertically integrated firms (in this context we mean patent holders that are also licensees of the same pool) may have weaker bargaining power. Licensees of a pool have an additional incentive to become pool members: being member of the pool allows them to participate in fixing the price of the license. Vertically integrated firms fix lower royalty rates in order to reduce their downstream production costs. For the other pool members, this shift away from the income-maximizing royalty rate is an additional cost. They will thus accept patents submitted by their licensees only if the value they add to the pool at least compensates for this cost.

We can also reasonably argue that the number of patents a patent holder already detained in the pool has an impact on its bargaining power. Thus firms with a higher number of patents in the pool should, if this bargaining power hypothesis is verified, be able to introduce patents of different characteristics.

Hypothesis 3: Pool members are able to introduce patents of different characteristics to the pool because they have greater bargaining power. They thus voluntarily increase their patenting propensity which leads to narrower and less general patents.

But there is another explanation that is alternative or complementary to the theory of bargaining power. This second explanation states that the acceptance of the patent by the pool is determined by the patent's essentiality and thus by the focus of the patent on the standard. Indeed, some firms could be more able to introduce patents of different characteristics into the pool not because they have stronger bargaining power, but rather because they are able to file patents that qualify for the pool at lower level of innovation efforts. According to this hypothesis, pool members thus introduce patents that at given patent generality and scope have a blocking power over broader parts of the standard and constitute prior art for a broader stream of successive research.

Hypothesis 4: Pool members are able to introduce patents of different characteristics because they present patents that are more focused on the standard

In order to disentangle between these two explanations, we will have a closer look at the significance of the patents for the standard and for successive research. The significance of an essential patent for the standard can be conceived as the share of the standard that necessarily relies upon the patent. We therefore retrieve from the essentiality reports (cf. section 3) of the pools the number of standard sections to which the patent is essential. We will use this number of standard sections as the first explained variable. The significance of a patent for successive research is generally measured by the number of times a patent is cited by successive patents. We therefore use the number of forward citations as second explained variable. The explanatory variables include characteristics of the firm with respect to the pool, such as a dummy for pool membership, the number of patents in the pool, the seniority in the pool or a dummy for vertical integration (is the firm at the same time licensor and licensee of the pool). In a second step, we include the patent characteristics, and for instance the generality and the scope of the patent, as control variables. Indeed, if our precedent hypotheses are verified, we should find that the scope of essentiality (sections of the standard infringing the patent) and significance for successive research (forward citations) vary according to the position of the firm with respect to the pool characteristics controlling for these patent characteristics. While we expect that broader and more general patents are generally more important for the standard and for successive research, we argue that pool membership increases the patent's importance at given scope and generality.

6.2 Results

We run successively Poisson estimates on each indicator (negative binomial results can be presented on request and go in the same direction).

	(1) Standard sections	(2) Standard sections	(3) Standard sections	(4) Standard sections	(5) Number of cites	(6) Number of cites	(7) Number of cites
Outsiders	-0.3652***	-0.2492*	-0.5122***	-0.4833***	0.2765**	0.1099	-0.0178
	(0,076)	(0,140)	(0,151)	(0,179)	(0.103)	(0.134)	(0.143)
PPprior			0.5761**	0.0427		0.5101	0.1711
			(0,252)	(0,338)		(0.400)	(0.421)
Seniority			0.0047**	0.0052**		0.0128***	0.0083**
			(0,002)	(0,002)		(0.003)	(0.003)
Vertical Integration			-0.0319	0.0711		-0.6001***	-0.2019
			(0,099)	(0,109)		(0.177)	(0.146)
Patent Age	-0.1038***	-0.0776***	-0.1004***	-0.0704***	-0.1059***	-0.1032***	-0.0744***
	(0,009)	(0,017)	(0,009)	(0,017)	(0.011)	(0.012)	(0.012)
age_input	0.0371***	0.0375***	0.0359***	0.0358***	-0.0081***	-0.0144***	-0.0079**
	(0,002)	(0,002)	(0,002)	(0,002)	(0.002)	(0.003)	(0.003)
Generality		-0.1155		-0.0590			0.4785***
		(0,205)		(0,206)			(0.134)
Number claims		-0.0034		-0.0038			0.0093***
		(0,003)		(0,003)			(0.002)
Dummy Pools	Y	Y	Y	Y	Y	Y	Y
Dummy App. year	Y	Y	Y	Y	Y	Y	Y
_cons	211.272***	158.803***	204.578***	143.899***	214.411***	209.695***	151.419***
	(19,438)	(33,205)	(19,690)	(35,700)	(22.723)	(22.905)	(24.636)
Obs.	1164	685	685	685	1229	1229	700

*Regressions with robust standard errors in parentheses. Legend: * p<0.05; ** p<0.01; *** p<0.001.*

Table 2. Patent focus and technological significance according to the status of the holder

Table 2 presents the results of our estimation of standard sections infringing the essential patents. We find broad support for the theory of information asymmetry. Indeed, firms that are already pool members introduce patents that are essential to much broader parts of the standard, even though patents presented by these firms are narrower and more incremental. Their patents are thus much more focused on the technology included into the standard. This result holds true controlling for patent characteristics or not. Furthermore, there are more concrete indications for a learning process. Indeed, the more time a company has been member of a pool, the broader are the parts of the standard covered by their patents (and the stronger is the focus of the patents on the standard). Firms that have a better understanding of the functioning of a pool are more able to produce patents that are more focused on the standard and that better meet the expectations of the pools' experts. We also can highlight that among all patents, i.e. those introduced by pool members and outsiders, the essentiality claim is broader the later the patent is introduced. It has already been found in the literature that firms adjust their patents in order to match technological standards (Köhler & al., 2009). In the drafting of patent claims, firms try to cover as many standard sections as possible. We now observe that pool members learn more quickly than outsider firms how to adjust their patents to the underlying standard, which could explain that they are able to introduce a higher number of narrow and incremental patents into the pool.

At the same time, the bargaining power theory does not seem to be verified. Indeed, all our explained variables that capture possible differences in firms' bargaining power (*ppprior* and *vertical_integration*) are not significant when controlling for patent characteristics. To conclude, we can thus say that our results allow disentangling between the two hypotheses. While, the information asymmetry seems to be confirmed by our results, the bargaining power theory does not seem realistic in light of the results on our sample.

Table 2 presents the same estimation on the number of forward citations. We can highlight that in contrast to our findings on standard sections, the number of forward citations significantly decreases when a patent is introduced late into a pool (Baron & Delcamp, 2010). This is probably due to the fact that patents are increasingly focused on the underlying standard, and therefore decreasingly relevant for research in the broader technological field. We also can underline that patents presented by pool members are less cited than patents presented by outsiders. This result was to be expected, taking into account the fact that pool members introduce narrower and more incremental patents. Nevertheless, controlling for patent scope and generality, patents presented by pool members are not less cited than patents presented by outsiders. To the contrary, the more time a company has been in a pool, the more its patents are cited at given scope and generality. We therefore conclude that pool membership increases firms' ability to file patents that are eventually found to be relevant for successive research. This further corroborates the hypothesis of a learning effect of pool membership.

7. Policy discussion and conclusion

This paper explores empirically the introduction of patents into pools. One of the main challenges for this investigation is that we do not have precise information on the selection process and cannot observe patents rejected by pool evaluators. To circumvent this problem, we compare patents included into the pool and investigate whether the characteristics of these patents vary according to the time of introduction or the status of the patent holder with respect to the pool.

First of all, we emphasize that firms that are already pool members introduce patents that are narrower and less general. The longer a company has been member to the pool, and the bigger the share of pool patents it owns, the narrower and the more incremental are the patents it introduces. We also produce evidence that the patenting strategies of these companies are more focused on the standard underlying the pool. It is thus reasonable to assume that these narrow and incremental patents are filed with the only objective to be included into the pool. On the one hand, these strategies of opportunistic patenting have an impact on the redistribution of royalty revenue inside the pool. On the other hand, our results do not necessarily imply that the consumer welfare will be affected. In fact, as the price of the pool license does generally not increase with the number of patents in the pool, these strategic inputs should not have any direct impact on the consumer. For instance Gilbert (2009) argues that if a patent pool contains at least one essential good quality patent, the introduction of trivial or non-essential patents does not increase royalty rates or deteriorate consumer welfare.

Nevertheless, consumers could be affected indirectly if pools are not able to attract the holders of good quality patents. Indeed, in this case, pools would not be able to reduce the multiple marginalization problem and consumers would have to bear the costs of licensing successive monopolies on complementary patents. This point has already been stressed in previous articles (Layne-Farrar & Lerner, 2010). Furthermore, on the long run, consumer welfare is reduced if pools reduce or skew innovation incentives. Indeed, by diluting the returns on significant patents, opportunistic patent strategies around patent pools also affect the return on innovation and thus the incentive to innovate. Moreover, this type of strategy is not socially optimal for patent holders. Indeed, if all patent holders adopt the same opportunistic behaviour and add patents in the same proportion, the revenue share of each of them should not evolve (because all members adopt the same behaviour) but the administrative costs of patenting rise without yielding additional innovation. For all these reasons, the opportunistic patent strategies we observe have the potential to seriously reduce the main interest of pools, which is to reduce the social costs of patent thickets. Indeed, we show that pools can even aggravate problems related to patent thickets.

In spite of these concerns, we also highlight a valuable learning effect for pool members. Firms that have been member of the pool for a longer time are more able to file patents that are technologically significant for subsequent research, controlling for the narrowness and generality of the patent. This is one of the first results underlining the importance of patent pools as a way to coordinate and orientate research. It thus gives credit to the assumption that these organizations not only have an effect on the royalty level but also and more fundamentally on the underlying innovation. This function is often claimed by the pool administrators. For instance, Sisvel ensures on its website[93] that one of its mission is to: "promote and guide innovation, and assist its partners in the development of intellectual property assets with market potential;"

These empirical results are important because they show how to strike a balance between patent pools' positive and negative effects on the underlying technology. As a negative effect, we can stress the incentive of pool members to file narrow patents and thus potentially increase the patent thicket problem. As a positive effect, we can underline that pools also are able to orientate innovation on fields that are technologically significant for subsequent research. Given the pros and cons highlighted above, we think that these results should be borne in mind especially by two groups: professionals responsible for the creation or administration of patent pools, and by public authorities.

Many important pools are in the process or about to be in the process of being created. An example is in the pharmaceutical sector where pools are promoted as a means to improve access to treatments against some of the major epidemics[94]. For this reason, the implications of the empirical results discussed here are particularly important.

[93] http://www.sisvel.com/english/aboutus/technicalexpertise, 07/12/2010

[94] For example, a pool was created to group the essential patents useful to struggle against AIDS. Information is available at: http://www.essentialinventions.org/

Chapitre 4 : Les stratégies d'introduction de brevets dans les pools

Dans ce dernier chapitre, nous conduisons une analyse empirique des effets des consortiums technologiques sur les stratégies de recherche et développement des participants. Notre analyse utilise des données de participation dans 32 consortiums entre 2000 et 2005 ainsi que les citations croisées des brevets déposés par les entreprises participantes. Cette recherche a été menée dans le contexte du système de télécommunication Wireless UMTS inclus dans le projet 3G. Nos résultats éclairent le rôle des consortiums technologiques dans la coordination des stratégies d'innovation des firmes participantes. Nous trouvons par exemple que la coparticipation de deux entreprises dans le même consortium augmente significativement la probabilité que les firmes se citent entre-elles dans leur dépôt de brevets ultérieurs liés à la 3G. Il apparaît donc qu'une partie importante du travail de coordination des projets de standardisation est réalisé au sein des consortiums.

Donc, d'un côté, les consortiums augmenteraient les incitations des entreprises à innover en permettant l'internalisation d'externalités d'innovation. D'un autre côté, ces résultats soulignent le rôle devenu prépondérant des consortiums dans le processus de standardisation technologique. Ce rôle prépondérant peut être considéré comme problématique dans la mesure où la participation à ces organisations n'est pas ouverte à tous et leurs travaux peu transparents. D'un point de vue pratique, cet article démontre que la participation d'une entreprise dans différents consortiums lui permet d'influencer non seulement les spécifications technologiques du standard mais également les stratégies d'innovation des autres membres.

Research paper 4: Innovating standards through informal consortia: The case of wireless telecommunications

1. Introduction

This paper examines the relationships between firms' participation in wireless telecommunications industry consortia and their subsequent innovations that become declared essential patents in the global UMTS standard for mobile communication. Compatibility standards are common technology norms that ensure interoperability between communication products and services[95]. Information and Communication Technology (ICT) standards in particular embody an increasing number of patented elements. In many ICT fields, particularly in telecommunications, standards have traditionally been defined cooperatively by governments or industry actors within formal Standard Setting Organizations[96] (SSOs). However, these formal SSOs are often perceived to be slow and bureaucratic, particularly when intellectual property rights have become part of the negotiation (Simcoe, forthcoming). For instance, the 3G wireless telecom standard studied here contains around 16000 essential patents and its development took most of a decade.

To accelerate the process, sub-groups of firms have increasingly begun to create less formal upstream alliances or consortia. These types of industry consortia offer opportunities to discuss, test, or promote certain technologies, or they can be used to actually develop new technical specifications that will subsequently be submitted to formal SSOs for official approval. The effects of these consortia have been debated in policy circles (e.g., Cargill, 2001) but there is little empirical evidence. Leiponen (2008) argues that ICT firms' participation in such consortia facilitates influencing formal standard-setting outcomes. However, there is no evidence to date about the implications of informal consortia for coordination of subsequent innovation. The purpose of this paper is to address this research gap and conduct an empirical analysis of the effects of ICT consortia on the coordination of R&D strategies of the participants.

This question of whether consortia facilitate coordination of subsequent innovations related to communication standards is interesting from both policy and managerial perspectives. From

[95] e.g., cell phones, DVD, internet protocols…
[96] Such as International Standard Organization, International Telecommunication Union, European Telecommunication Standard institute

a policy standpoint, our results should inform competition policies. The economic literature on the subject (Katz and Ordover, 1990; Jorde and Teece, 1990; and Choi, 1993) often considers these collaborative organizations as a potential threat to competition because of excessive market coordination. However, consortia can also be socially desirable if they reduce potential coordination problems around innovation. In this case, consortia might mitigate wasteful cost duplication and increase incentives to invest in R&D by internalizing potential externalities (d'Aspremont and Jacquemin, 1988). These arguments could lead competition authorities to adopt a supportive policy with respect to standardization consortia[97] as they are also a way to increase overall efforts of R&D.

However, our analyses regarding the coordination of innovation through consortia also shed new light on the processes through which communication standards are being created. Development of "open standards" through a process that is not truly accessible for all the interested parties may be viewed as problematic. To the degree that essential innovations that become incorporated in the formal standard are coordinated and agreed in informal and semi-private consortia, policymakers may find it worthwhile to better understand and provide rules of the game regarding meeting procedures, membership fees particularly for small firms, open access, and public release of relevant information.

From a strategic viewpoint, participation in standardization consortia could be a way for firms to promote their technologies and become central and hence powerful in the technological field. For instance, from a sociological perspective, Pfeffer (1981) suggests that consortium participation helps firms to access and control strategic knowledge. Nevertheless, there is to date little empirical evidence for this assertion. Our research aims to highlight strategies that firms may deploy in the wireless telecom field to influence innovation by others.

This paper utilizes a network- analytical approach and combines membership data from 32 ICT consortia to identify consortium network ties between firms involved in formal mobile communication standardization through Third Generation Partnership Project, or 3GPP, that is the formal international standard-setting organization driving the specification development for the Universal Mobile Telecommunication System, UMTS, which is one of the third-generation mobile communication systems. Additionally, we compile and analyze citations of 16000 essential patents filed by these firms in the 3GPP standardization process of UMTS . These data will be used to assess econometrically the effect of firms' participation in consortia on the convergence (cross-citations) of subsequent inventions. We also use a merger in the network of consortia as a natural experiment that, arguably, exogenously changed consortium connections of dozens of member firms to explore the robustness of our results.

[97] For instance, the same kind of approach adopted for patent pools those also present drawbacks in terms of competition and advantages in terms of innovation diffusion

Our empirical analysis demonstrates that the patent holder's involvement in consortia has an impact on the likelihood that their patents are cited by other consortium members in subsequent patents that are declared essential for the UMTS standard. This result is particularly strong for consortia that are formally allied with and thus directly related to 3GPP. The result is weaker but still positive and statistically significant for consortia that are not allied with 3GPP. However, this relationship is significant only for informal consortia and does not hold for more formal consortia such as other formal standard-setting organizations (e.g., regional SSOs). We also find that this coordination effect is more important for firms with lesser technological capabilities than for those with more substantial capabilities, and that the change in the network of consortia caused by the merger had an impact on the strength of this coordination effect. In other words, our key results are supported by the difference-in-differences analysis utilizing this source of exogenous variation.

Our results highlight consortia as a form of organization to coordinate innovation strategies related to communication standards. Consortia thus seem to enable sharing of knowledge and coordination of R&D. Policy and managerial implications of these findings are discussed in the last section. The remainder of this paper is organized as follows. Section 2 presents a literature review of R&D consortia and discusses the conceptual foundations of our research. Section 3 explains the data collection process and the empirical methodology. Section 4 presents our main empirical results and section 5 concludes.

2. Literature on research and development consortia and our targeted empirical contribution

Research and development consortia have been studied extensively in various strands of literature. The advantages and drawbacks of these organizations as well as their formation process and possible impact on future alliances are now relatively well understood. We will discuss the benefits and costs of participation as viewed in extant studies.

Scholars have found substantial positive effects of consortium participation on innovation by firms. For instance, an early stream of research analyzes R&D consortia from a theoretical standpoint and underlines financial incentives to participate therein. Katz (1986), Katz and Ordover (1990), d'Aspremont and Jacquemin (1988), among others, view consortia mainly as a way to share and reduce R&D expenses. These organizations are a way to realize scale economies among participants and to avoid project duplication. This stream of literature assumes symmetric contributions of consortia members in terms of R&D investments and competencies, and firms are assumed to manufacture substitutable products.

Complementary to this idea, another strand of literature discusses incentives to participate when firms do not have symmetric contributions (e.g., Kamien, Muller and Zang, 1992). Here, the main idea is that R&D investments create knowledge spillovers. Spillovers are positive externalities that enhance the social benefits of R&D investments but they lead to socially suboptimal investments because private incentives do not take spillovers into account. Consortia are a way to internalize these spillover effects. This potentially positive effect of consortia has led some economists to support public funding of these organizations (Romer and Griliches, 1993).

The notion of consortia as a way to internalize R&D externalities is in line with the resource-based view of the firm in strategic management. For instance Chung, Singh and Lee (1999) analyze investment banking firms' syndication in underwriting corporate stock offerings during the 1980s and point out that that the likelihood of investment banks' alliance formation is positively related to the complementarity of their capabilities. This approach considers a firm as a bundle of competencies. Firms' participation in consortia or other forms of cooperation can be viewed as a method to share skills and benefit from other members' competencies. This argument implies that diversity of members enhances consortium efficiency, because it increases the potential for spillovers and ultimately has a positive effect on the level of R&D expenditures in the field.

Two empirical papers confirm that R&D consortia lead to increased R&D investments. First, Branstetter and Sakakibara (1998) analyze a sample of Japanese consortia and find that the marginal effect of consortium participation is about two percent increase in total R&D spending and of between four and eight percent increase in patenting per R&D dollar (research productivity). In a subsequent paper, Sakakibara (2001) confirms an even more substantial effect of consortium participation on R&D expenses (around 9%) and also tests the hypothesis that diverse competencies of members enhance the efficiency of the consortium. The paper examines a sample of publicly sponsored Japanese consortia involving 213 firms over 13 years and confirms that consortium diversity is associated with greater R&D expenditure by participants.

An organization-theoretic literature points out that participation in R&D consortia is a way to obtain a strategic advantage over competitors. In this view, consortia are not necessarily formed to share costs or reduce potential market failure but to create competitive advantages over other competitors. Pfeffer (1981) proposes that consortium participation helps firms to access and control strategic knowledge. Aldrich et al. (1998) also argue that R&D consortia could be help to orientate research in the industry in a way that supports the firm's strategy. This hypothesis is supported empirically by Leiponen (2008) who examines consortia around the Third Generation Partnership Project (3GPP), a formal standards-development organization. This study finds that participation in R&D consortia significantly enhances firms' contributions to new standard specifications in 3GPP committees. Firms that are central in the consortium network are more able to ultimately influence the standard-setting outcome. From a social point of view, this result suggests that R&D consortia may also have adverse effects and are potentially a way to foreclose competition. This potential negative effect of consortia on competition (implicit collusion) was acknowledged in a series of papers[98] without causing significant reactions by competition authorities.

Finally, a set of studies identifies consortia as a way to signal strategies within the industry. In this framework (Rosenkopf, Metiu and Georges, 2001) consortium participation is a way to signal potential strengths to competitors or other actors of the technological field. In a longitudinal study of 87 cellular service providers and equipment manufacturers, the authors show that participation in technical committees help to identify potential alliance partners and opportunities for collaboration. The authors also find that the marginal effect of consortium participation on alliance formation is decreasing with the number of alliances already formed and varies according to interpersonal bonds. This importance of interpersonal bonds is also underlined by Dokko and Lorenkopf (2010). In this study of 186 firms over 7 years of participation in technical committees, the authors examine how job mobility of individuals affects firms' ability to influence others in a technical standards setting committee for U.S. wireless telecommunications. The authors point out that hiring individuals who are rich in social capital increases firms' power in technical standard-setting committees by increasing the hiring firm's social capital[99].

As described above, cooperative research arrangements can be very beneficial, but consortium participation may also be associated with risks and costs. First, firms have to support expenses such as travel and meeting costs or loss of productivity due to engineers' participation to the reunions. Sakakibara's (2001) empirical analysis of Japanese consortia and Hawkins' study of ICT consortia (1999) present empirical evidence that consortium participation engenders substantial costs. Hawkins' estimate of membership fees for a typical technology firm in mid-1990s was in the order of 1.5 million US dollars. This number does not include the travel and human resource costs of participation. Moreover, in the decade since, membership fees and the number of consortia have substantially increased.

Consortia can also represent an important risk of technology leakage. Sharing R&D knowledge in technical meetings with other participants that have sufficient skills to understand and absorb these competencies strongly increases the risks of imitation. Indeed,

[98] For instance Brodley (1990), Katz and Ordover (1990), Jorde and Teece (1990) and Choi (1993)
[99] In contrast, the loss of personnel does not affect a firm's social capital or influence over standards directly
but it does have an effect on firm social capital and influence contingent on changes in the firm's business strategy.

Kodama (1986) underlines that firms participating in consortia may create internal research groups just to absorb knowledge from consortium work.

Consortium participation may also reduce the set of potential appropriation strategies available to firms. For consortium members, secrecy is no longer an effective protection method and therefore member firms may need to follow alternative appropriation strategies and define which competencies can be shared and which ones protected according to the firm general strategy. This result is supported by empirical studies that analyze the means of protecting innovation in a cooperation context. For instance, Leiponen and Byma (2009) stress that small firms cooperating in innovation with horizontal partners (direct competitors) tend to prefer speed to market over secrecy or patents to protect their innovations.

To summarize, the extant literature on R&D consortia has identified many potential benefits and drawbacks of participation. However, systematic empirical evidence remains relatively scarce. The focus of our empirical work is on the hypothesis that consortia facilitate coordination of subsequent R&D. Aldrich et al. (1998) and Hawkins (1999) have previously discussed this idea. Hawkins argues that "[…]an international system has evolved in which communication and co-ordination is achieved primarily through inter-organisational alliances[…]". However, little systematic empirical evidence has been presented. Our paper targets this research gap by examining the role played by consortia as a vehicle for knowledge transfer and influence in the innovation context.

3. Data and Methods

The main research question that we empirically test in this paper is whether informal standardization bodies have facilitate the coordination of innovation strategies in terms of increasing the likelihood that a patent is cited by another consortium participant in a patent that is declared as essential for the wireless telecommunication system UMTS. We thus analyze whether the likelihood that a patent is cited depends on the position and centrality of the patent holder in the network of consortia during the year in which the citing patent was applied. We focus on citations by UMTS essential patents because we are interested in the ability of consortium participants to influence the set of technologies incorporated in the standard.

This paper relies on a combination of data on consortium co-membership links between firms involved in the third-generation mobile standards and cross-citations of patents filed by these participants. First of all, we gathered data on 16 000 patents declared essential for the UMTS standard[100]. We retrieved these data in October 2010 using the ETSI online patent database[101]. We then merged these data with information on citations using the 1976/2006 National Bureau of Economic Research database[102] and used the EPIP database to identify the patent holders of the cited patents[103]. Appendices 1 and 2 present some information about the timing of application and technological class of patents in our sample. As we can see, the citing patents are very concentrated in terms of technological class, whereas the cited patents are quite diverse. The cited patents were granted between 1976 and 2004 but the majority of them were granted in the late 1990s or early 2000s.

Next, we created a database on consortium membership links between firms involved in the third-generation mobile standards. This database is partly based on Leiponen (2008). Using the website Internet Archive, we obtained data on the memberships of the patent holders (owners of the citing and the cited patents) in consortia in the ICT field from 2000 to 2005. Some of these consortia are formally allied with 3GPP and others are unrelated or even directly competing with 3GPP. A list of these consortia is presented in Appendix 3.

As we have information on participation in consortia from 2000 to 2005, we will restrict our analysis of citing patents applied in this period. We organize our database around the cited patents over six years. This database consists of 1021 patents that were cited at least once by a UMTS essential patent. These patents were held by 44 different firms[104]. The database connects the cited patents with 1962 citing patents.

Our main dependent variable is a binary indicator for whether a patent was cited by a patent application that was subsequently declared as "essential" for the UMTS wireless telecommunication system developed in 3GPP. We focus on citing patents held by members of 3GPP. In robustness analyses we also utilize a binary indicator at the firm level: whether one firm was cited by another firm who is a member of 3GPP and whose patents became declared as essential for UMTS.

We use three different variables to capture firms' participation in informal standardization bodies (consortia). The first two measure the patent holder's general level of participation in consortia of the ICT field: the number of consortium memberships, (*total membership*) and the number of connections to peers from consortia (*consortium connections*). A consortium connection is formed if two firms meet at least one time in one of the consortia during the year. In network-analytical terms these are two-mode and one-mode degree centrality measures, respectively. The last variable (*co-membership*) captures the direct connection

[100] The projects included are : 3GPP, 3GPP release 7, 3GPP/AMR-WB+, UMTS, UMTS Release 5, UMTS Release 6, UMTS Release 7, UMTS Release 8, UMTS/CDMA

[101] Available at: http://ipr.etsi.org/

[102] Available at: http://www.nber.org/patents/

[103] Available at: http://www.epip.eu/datacentre.php

[104] A list of the patent holders of the cited patents is presented in appendix 4.

between two firms, i.e., between the holders of citing and cited patents during the year in which the citing patent was applied.

The main empirical issue is to disentangle the effects of participation in consortia and technological centrality of the firm in formal standards development. A patent can be highly cited because of the patent holders' participation in consortia or because the patent is technologically central in the UMTS wireless system being standardized within 3GPP, for which reason its holder may participate in many consortia. In order to control for this possibility, we use data on patent holders' participation in the formal standards-development organization (3GPP). We trace patent holders' activities in formal standards-development committees[105] from 2000 to 2005 and create a variable *3GPP connections* that equals the number of unique connections (one-mode degree centrality) to other firms through work-item committees. This variable allows us to take into account the centrality of the firm in formal standard setting and thus enables us to distinguish the effects of informal and formal standardization on cross-citations. Table 1 describes the main variables.

Variable	**Description**	**Mean**	**Std. D.**	**Min**	**Max**
Total membership	Number of cited firm's annual memberships (two-mode network degree) in consortia	8.27	6.96	0	24
Consortium connections	Number of cited firm's annual unique connections (one-mode network degree) through consortia	128.15	103.79	0	280
Co-membership	Dummy variable that equals 1 if the holder of the citing and the cited patent were in the same consortium during the year in which the citing patent was applied.	0.18	0.39	0	1
3GPP connections	Number of unique (one-mode degree) connections to other firms through 3GPP work-item committees	16.05	18.50	0	63
Age cited	Age of the cited patent (since the grant year)	3.61	5.34	- 4	29
Patent quality	Stock of forward cites at t-1	32.87	56.29	1	920

Table 1. Name and description of the main explanatory variables

We work with a panel database of patents cited by UMTS essential patents and estimate a fixed-effect logit model with the likelihood to be cited at year y for a patent p as the

[105] Using the website http://www.3gpp.org/

dependent variable. Table 2 presents descriptive statistics (for the cited patents) regarding the number of citations by other 3GPP members. As we do not use a count data model but estimate the likelihood to be cited for a patent at year y, Table 3 presents the number of times (years) our patents are cited over the six years of observation. The majority of our cited patents are not cited during the years we analyze. We also have a small number of patents that are cited every year from 2000 to 2005. These observations will be excluded in a fixed-effect logit model which significantly reduces our estimation sample[106].

	Mean	Std. Dev.	Min	Max
Total citations by other 3G members	2.97	7.24	0	79

Table 2. Number of citations by other 3GPP members

Number of years the patent is cited	Observations
0	657
1	78
2	102
3	76
4	48
5	49
6	13

Table 3. Number of years the patent is cited (2000-2005)

Our main explanatory variables measure consortium participation, and we control for the patent holder's centrality in 3GPP and the patent's quality and age. We thus estimate the following model:

$$\Pr(Citation_{py}) = \alpha_0 + \alpha_1 Consortium\_participation + \alpha_2 3GPP\_connections + \alpha_3 Patent\_quality + \alpha_4 Patent\_age + \varepsilon_{py} \quad [1]$$

$\Pr(Citation_{py})$ = Probability of firm being cited by another 3GPP participant in year y for patent p

Consortium participation = Participation in consortia of the holder of the cited patent, using the variables *total membership, consortium connections,* and *co-membership*

3GPP connections = Cited patent holder's centrality in formal standardization in 3GPP committees

[106] We also controlled that our results are not due to the patents that are cited only one time by other 3G participants, over the period, excluding these patents in one of our robustness tests. The results presented in the body of the paper remain robust even excluding these patents.

Patent age = Age of the patent

Patent quality = Patent stock of forward citations at year t-1

ε_{py} = Error term

Our primary estimation approach utilizes standard panel-data methods (fixed effects estimation) to control for time-invariant unobserved heterogeneity of firms and patents. We also disentangle the consortium participation effect according to the nature of the consortia and the size of the firm. As a fixed-effects estimation considerably reduces the number of observations, we also use a random-effects estimation taking into account the overall sample, using mean variables to control for intrinsic characteristics (Wooldridge, 2002, pp. 487-488, 679). This Chamberlain style procedure includes the means of the time-varying explanatory variables as additional regressors in the random-effects procedure, assuming that the permanent characteristics are normally distributed conditional on the explanatory variables. According to Wooldridge (2002), this method is less robust but more efficient than the conditional fixed-effects approach. The results are presented in appendix 6 and confirm the findings of the fixed-effects estimation.

We also explore whether a natural experiment occurring in the data allows us to isolate sufficient exogenous variation in the main explanatory variables to control for possible time-varying unobserved effects and estimate a differences-in-differences type model. Our concern is that innovations emerging during the period of study might make firms more likely to both attend consortia and cite their central members. This event is the merger of a set of industry consortia of mobile services that, we argue, exogenously shifted the consortium contacts of some but not all firms in our dataset. In late 2002, seven of the consortia in our database[107] merged to create the Open Mobile Alliance (OMA). OMA was formed by nearly 200 companies including mobile operators, device and network suppliers, information technology companies and content and service providers. Therefore we argue that individual firms were unlikely to have substantial influence in the merger. The stated reasons for the merger were increasing interactions and synergies between the technology fields of the seven component consortia: "The purpose of OMA is to address areas that previously fell outside the scope of any existing organizations, as well as streamline work that may have been previously duplicated by multiple organizations."[108] As a result of the merger, consortium connections of some firms increased and those of other firms decreased. We use this merger to estimate a diff-in-diff model and examine the robustness of our fixed-effects results.

[107] Wap Forum, Wireless Village, SyncML Initiative, MGIF, LIF, MWIF, and UMTS Forum.
[108] http://www.openmobilealliance.org/AboutOMA/FAQ.aspx, retrieved 8/2/2002.

4. Estimation results

We first run a fixed-effect model estimating the likelihood of a patent to be cited by a patent that was declared as essential for the UMTS standard, held by another consortium participant. We control for the age of the cited patent and its quality in terms of the stock of forward cites at time-1. The results of this model are presented in Table 4.

As we can see in Table 4, our three main explanatory variables all have statistically highly significant and positive effects on the likelihood to be cited by another consortium participant. Given the fact that our third explanatory variable, *co-membership*, presents a strong and very significant positive parameter, it is quite logical that our two other explanatory variables also have a positive impact. Marginal effects suggest that the total number of memberships has a stronger impact than the number of cited firm's annual unique connections (one-mode network degree) through consortia. One additional consortium membership increases the likelihood of citation by 1%, whereas an additional connection increases it by 0.02%. However, one needs to keep in mind that one additional membership tends to lead to dozens of new connections. Meanwhile, *co-membership* has the strongest positive marginal effect on the likelihood to be cited by other 3GPP members in subsequent innovations. If two firms are both members of the same consortium, the likelihood of citation goes up by 47%. We also find that the control variable patent age does not have a clear impact on the likelihood to be cited. In contrast, patent quality (stock of forward cites at year – 1) has a significant negative impact on the likelihood to be cited[109]. However, the random-effects estimation presented in appendix 5 attenuate this finding. Nevertheless, the role of patent quality in formal and highly cumulative standardization should probably be further investigated.

[109] We cannot exclude that this effect is due to some other unmeasured aspects of patents that relate to age not captured by our variable age.

	(1)		(2)		(3)	
	Coef. (SE)	**Marginal effect**	**Coef. (SE)**	**Marginal Effect**	**Coef. (SE)**	**Marginal effect**
Total memberships	0.143***	0.0108*				
	(0.019)	(0.005)				
Consortium connections			0.00218***	0.0002*		
			(0.0001)	(0.0001)		
Co-membership					3.364***	0.4666***
					(0.193)	(0.006)
3GPP connections	0.00840	0.0006	0.021***	0.0018*	-0.00245	-0.0006
	(0.006)	0.272	(0.005)	(0.0010)	(0.006)	(0.002)
Patent age	0.0256	0.0019	0.053	0.0044**	-0.111	-0.0276
	(0.065)	0.715	(0.065)	(0.0065)	(0.089)	(0.022)
Patent quality	-0.0896***	-0.007**	-0.087***	-0.0072	-0.085***	-0.0212***
	(0.011)	0.042	(0.011)	(0.0035)	(0.012)	(0.003)
Dummy 0/3/6/9	Y		Y		Y	
Observations	2154		2154		2154	
Number of groups	352		352		352	
Chi2	434.56		428.34		924.69	
Prob > chi2	0		0		0	
Log Likelihood	-596.312		-599.424		-351.251	

Legend: * p<.05; ** p<.01; *** p<.001
(* p<.10; ** p<.05; *** p<.01 for marginal effects)

Table 4. The effect of consortium participation on the likelihood of citation

Notes: Dependent variable is an indicator for whether a patent was cited by an essential patent applied in year y. Estimation method is logit with fixed effects at the patent level. Dummies 0/3/6/9 are nonlinear effects for patent age. Standard errors are in parentheses under the coefficients.

These results lend support for our main hypothesis. The patent holder involvement in the consortium network increases the likelihood that the patent is cited by other participants. Thus, participation in informal standardization bodies helps firms coordinate subsequent research.

Next, we refine the result by analyzing whether the nature and size of the consortium and the cited patent holder influence the result. We distinguish between different types of consortia (formal or informal) and their relationship with 3GPP (related or unrelated to 3GPP)[110]. Formal consortia actually draft and certify standard specifications whereas informal ones simply discuss and test technological alternatives. Consortia can also be formally allied with 3GPP or completely unrelated to 3GPP. We would expect consortia that are allied with 3GPP to provide more fruitful venues for influencing peers' innovation activities related to technologies that 3GPP standardizes. Also, we would expect informal consortia to be more

[110] See the data section.

conducive for influencing peers, because their fundamental purpose is usually to discuss and promote a set of technologies, hence these discussions can be more easily used to promote the members' technologies that might be utilized or built on in the standard-setting context of 3GPP.

We also examine the interaction effect of the technological resources of the patent holder using an interaction variable, *consortium connections*patent apps,* between *consortium connections* and the number of patents applied by the cited firm during the year. This variable allows us to assess the potential moderating impact of the (technological) size of the patent holder on the consortium participation effect. We expect that larger technology firms are more effective at translating consortium connections into opportunities to influence others' innovation activities[111]. These results are presented in Table 5.

[111] Appendix 7 gives an overview of these results for the main important patent holders (based on the number of citing patents).

	(1)		(2)		(3)	
	Coef. (SE)	**Marginal effect**	**Coef. (SE)**	**Marginal effect**	**Coef. (SE)**	**Marginal effect**
Informal consortium memberships	0.158*** (0.026)	0.0114* (0.006)				
Formal consortium memberships	0.0854 (0.048)	0.0061 (0.005)				
Related consortium memberships			0.267*** (0.046)	0.0216* (0.012)		
Unrelated consortium memberships			0.0843** (0.027)	0.0068* (0.004)		
Consortium connections					0.00278*** (0.0004)	0.0002* (0.0001)
Cons. connections* patent apps					-7.549e-07 (4.08e-07)	-5.59e-08 (0.000)
Patent apps					-0.00024 (0.0003)	-0.00001 (0.0002)
3GPP connections	0.00797 (0.006)	0.0006 (0.005)	0.0065 (0.006)	0.0005 (0.006)	0.0203*** (0.005)	0.0015 (0.0009)
Patent age	-0.00143 (0.064)	-0.0001 (0.005)	0.012 (0.066)	0.0010 (0.005)	0.0632 (0.067)	0.0047 (0.006)
Patent quality	-0.0879*** (0.011)	-0.0063 (0.003)	-0.089*** (0.011)	-0.0072 (0.004)	-0.0903*** (0.011)	-0.0067 (0.003)
Dummy 0/3/6/9	Y		Y		Y	
Observations	2154		2154		2154	
Number of groups	352		352		352	
LR chi2	427.34		443.35		410.89	
Prob > chi2	0		0		0	
Log Likelihood	-599.922		-591.919		-593.992	

Legend: * p<.05; ** p<.01; *** p<.001
(* p<.10; ** p<.05; *** p<.01 for marginal effects)

Table 5. Effects of different types of consortia and the moderating effect of technological resources

Notes: Dependent variable is an indicator for whether a patent was cited by an essential patent applied in year t. Estimation method is logit with fixed effects at the patent level. Dummy 0/3/6/9 are nonlinear effects for patent age.

Regarding the types of consortia, the results confirm expectations. Both the formality and relationship with 3GPP of the consortium moderate the participation effect. We can see in Table 5 that the participation effect is positive and significant for informal consortia but insignificant for the formal standardization organizations of our sample. The strategic and technological scope of the consortium also has an impact on the intensity of the effect. The consortium participation effect is much stronger for consortia that are directly related to 3GPP, and the difference is statistically significant at 0.01%. However, even though the coefficient is substantially lower, participation in unrelated consortia also has a positive and statistically significant impact on the likelihood to have a patent cited by peers in subsequent innovation.

Perhaps contrary to expectations, the greater the firm's technological innovativeness (patent applications), the lower the consortium participation effect on the likelihood to be cited in subsequent research by peers (this result is significant at 10%). We speculate that representatives of firms with large technology portfolios may have a less accurate understanding of the potential of individual patents for peers to build on. However, we plan to investigate the size/technological resource effect in more detail.

Finally, we use a natural experiment, a merger of seven consortia in 2002 to examine the robustness of our results. When MGIF, UMTS Forum, Wap Forum, Wireless Village, SyncML Initiative, LIF and MWIF merged to form Open Mobile Alliance, the consortium connections of the members of the seven consortia were exogenously shifted[112]. Using this exogenous event to identify the causal effect of consortium connections on patent citations, we dissect the participation effect according to the timing, the consortia affected by the merger, and their nature. The results are presented in Table 6.

[112] A list of the firms included in the control group, non-participant in one of the consortia concerned by the merger, is available in appendix 5

	(1)		(2)		(3)		(4)	
	Coef. (SE)	Marg. Effect	Coef. (SE)	Marg. Effect	Coef. (SE)	Marg. Effect	Coef. (SE)	Marg. Effect
CTO_OMA	0.0178*** (0.005)	0.0026 (0.002)	0.0183*** (0.005)	0.0023 (0.002)	0.0239*** (0.005)	0.0060*** (0.001)		
CTO_not_OMA	0.00041 (0.001)	0.0001 (0.001)	0.00027 (0.001)	0.00003 (0.0001)				
CTO_not_OMA _formal					-0.00042 (0.002)	-0.0001 (0.0004)		
CTO_not_OMA _informal					0.00810* (0.004)	0.0020** (0.0009)		
CTO_OMA_after	0.00911* (0.004)	0.0013 (0.001)	0.00941* (0.004)	0.0012 (0.001)	0.0151** (0.005)	0.0038*** (0.001)		
New_co_membership OMA							0.01117** (0.004)	0.0025*** (0.001)
Old_co_membership OMA							0.00428 (0.004)	0.0010 (0.0007)
Co_membership							5.05061*** (0.549)	0.7909*** (0.219)
Dummy_after	-3.538*** (0.357)	-0.4562 (0.288)	-3.720*** (0.374)	-0.4232 (0.294)	-4.0422*** (0.406)	-0.7537*** (0.112)	-0.9371*** (0.446)	-0.4323*** (0.137)
3GPP connections			-0.0149 (0.009)	-0.0018 (0.002)	-0.0148 (0.009)	-0.0037* (0.002)	0.00373 (0.012)	0.0009 (0.003)
Patent age	1.128*** (0.161)	0.1646 (0.143)	1.160*** (0.163)	0.1439 (0.137)	1.378*** (0.192)	0.3442*** (0.056)	0.84780*** (0.223)	0.1934** (0.087)
Patent quality	-0.177*** (0.020)	-0.0258 (0.020)	-0.179*** (0.020)	-0.0222 (0.019)	-0.184*** (0.021)	-0.0461*** (0.005)	-0.13989*** (0.026)	-0.0319* (0.019)
Dummy 0/3/6/9	Y		Y		Y		Y	
Number of obs	1731		1731		1731		2154	
Number of groups	338		338		338		352	
LR chi2	667.35		670.33		675.34		970.70	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Log Likelihood	-330.306		-328. 18		-326.314		-328.24092	

Legend: * p<.05; ** p<.01; *** p<.001
(* p<.10; ** p<.05; *** p<.01 for marginal effects)

Table 6. Impact of the OMA merger on subsequent citations

Notes: Dependent variable is an indicator for whether a patent was cited by an essential patent applied in year t. Estimation method is logit with fixed effects at the patent level. Dummy 0/3/6/9 are nonlinear effects for patent age.

The variable CTO_OMA has a strong positive and statistically significant effect on citations. OMA and the component consortia were thus probably central venues for discussing ongoing innovation. In fact, the effect of connections from other consortia (CTO_not_OMA) is insignificant. However, when we separate informal and formal other consortia (CTO_not_OMA_formal and CTO_not_OMA_informal) we retain the positive and statistically significant effect of informal non_OMA connections. The most important coefficient in table 6 is that on the variable CTO_OMA_after that measures the additional effect of OMA-related connections after the merger. This effect is significant at the 95% level of confidence in all specifications, but it is particularly strong (and significant at the 99% level) when the non_OMA effect is separately estimated for formal and informal consortia. In the last column we utilize the binary variable co-membership that measures the effects of two firms being members of the same consortium. Here, we separately estimate coefficients for new co-memberships due to the OMA merger and existing co-memberships from the affected consortia. These variables are not influenced by the number of consortium members. Again, we find that a new co-membership caused by the consortium merger triggered additional citations by the affected firms. This natural experiment is thus useful to examine the robustness of our results. Using the creation of OMA consortium as a source of exogenous variation, the change in the network of consortia caused by the merger had an impact on the strength of the coordination effect.

To conclude, our main hypothesis that consortia participation facilitates coordination of firms' research policies is supported. The result is robust independent of the method or the variable to capture the participation used. But the magnitude of the effect substantially depends on the nature of the consortium and (technological) size of the patent holder. The coordination effect is insignificant for formal consortia and strongly positive and statistically significant for informal ones. Additionally, the effect is much greater when consortia are technologically or strategically related to 3GPP but it remains significant when consortia are unrelated to 3GPP. The impact is also lower when the technological innovation capacity of the firm increases. Finally, we note that a merger in the consortium network had a significant positive impact on the magnitude of the coordination effect. Exogenous changes in consortium connections caused by the merger positively and statistically significantly influenced subsequent citations by peers.

5. Conclusion

This paper analyzes the impact of firms' participation in ICT consortia on the convergence of R&D strategies. In order to do that, we use data on participation in 32 ICT consortia and citations of essential patents filed by participants in the 3GPP standardization process. We also use a merger in the network of consortia as a quasi-experiment that exogenously changed consortium connections of members to explore the robustness of our results and refine our analysis.

Our empirical analysis underlines the impact of the patent holder's involvement in the consortium network on the likelihood to have its patents cited by other participants in subsequent research. The higher the patent holder involvement in the consortium network, the higher the likelihood to be cited by other contributors in subsequent patents that are declared essential for the UMTS standard. This result is stronger for consortia that are formally allied or directly related to 3GPP, whereas the result is weaker but still positive and statistically significant for consortia unrelated to 3GPP. Our findings suggest that informal consortia are an effective vehicle to coordinate standards-related research. Indeed, while participation in informal consortia has a positive and statistically significant impact on the likelihood to be cited by subsequent research, this result does not hold for more formal consortia such as other standard-setting organizations. To finish, we also stress that an exogenous change in the consortium network had an impact on the strength of this coordination effect. Thus, our main findings are confirmed by a difference-in-difference analysis using a merger in the network of consortia as a source of exogenous variation.

Our main result, that consortium participation facilitates coordination of firms' R&D activities lends support for an earlier literature on the effects of R&D cooperation on managing knowledge transfer between rivals. Thus, cooperation potentially improves incentives for R&D because it enables the internalization of knowledge-creation externalities. However, in the standard-setting context our findings also raise questions. Our results demonstrate that standardization is no longer practiced only in formal standard-setting organizations but also in informal upstream consortia.

First, transparency and openness of consortium activities is currently not ensured. Thus, it can be difficult for an entrant to understand who makes decisions about standardization, where, and through what process. Second, when standard setting is effectively distributed to dozens of consortia, each with substantial membership fees and frequent meeting schedules, participation can become prohibitively costly for smaller firms. Small firms tend to have few (if any) technical experts who are able to travel to standards meetings, and with dozens of potentially relevant consortia, this may simply not be possible. Finally, major firms have motivated consortia as a method of speeding up standards development. While this is an acceptable goal for any industry, the actual reason for accelerated outcomes from consortia may be exactly that smaller firms and those who disagree with industry leader(s) are not participating.

We suggest that these novel results potentially call for a rethinking of standard-setting policies. Innovation policymakers should no longer be interested only in formal standard-setting organizations but also pay attention to activities in informal upstream consortia in which much of the coordination work is actually done. Similarly, our results show that innovating firms that want to commercialize new products or technologies in network industries must design a standard-setting strategy that involves not only formal SSOs but also active participation and influencing peers within informal consortia.

Conclusion

This final section summarizes the main results of the four econometric papers presented. We derive general conclusions in light of the full set of studies presented in the dissertation. We focus the discussion on the policy implications of our findings and close with some possible directions for future research. From a policy point of view, this dissertation underlines some positive and negative effects that support a balanced portrayal of pools and consortia.

The first part of this Ph.D. dissertation targets the functioning of pools and try to understand why we, in practice, observe such a big numbers of pools whereas the theoretical literature predicts the instability of these agreements.

In the first paper, we highlight that pools are able to attract highly cited patents and are thus not only used as a mechanism to bundle patents of poor technological significance. Many authors[113] argue that good quality patents holders have little incentives to participate in pools. The results of this first paper prove that this assertion is not empirically verified. If patent pools are able to attract valuable contributions, this reinforces their usefulness to help disseminating the standardized product and lends credence to the idea that the positive effects of pools may outweigh their negative effects.

In the second paper, we point out that there exist incentives for patent holders, not related to royalties, to join these agreements. We especially analyze the impact of the patents' introduction in the pool on the cost of patents' enforcement. This finding should be useful to better understand the functioning of pools. It emphasizes new incentives (i.e. essentially the reduction of patents' enforcement cost) for patent holders to participate in pools and should help to understand the stability of these agreements in practice.

The second part of this dissertation analyzes the effects of two types of cooperative agreements around the standardization process, patent pools and consortia, on innovation.

The third paper presented underlines some negative effects of pools on the patenting strategies of its members. Our third paper proves that incumbent members are able to include narrower, more incremental and less significant patents than outsiders wishing to join. Despite the fact that pool patents are of better quality than non pool patents presenting

[113] For instance, Layne-Farrar & Lerner (2010) argue "We might expect that firms with especially valuable contributions to a standard (say, in terms of crucial components for the standard) would opt out of the patent pool since they are more likely to be able to negotiate higher royalties for their patents undiluted by other less-valuable contributions."

similar characteristics (first paper), there is a patenting race between members and outsiders that lead to the inclusion of narrower, more incremental and less significant patents by incumbent members. By diluting the returns on significant patents, opportunistic patent strategies around patent pools affect the return on innovation and thus the incentive to innovate. Moreover, this type of strategy is also questionable for patent holders. If all patent holders adopt this strategy and file patents of low technological significance in order to increase their share of licensing revenues, the share of each of them should not evolve (because all members adopt the same behaviour) but the administrative costs of patenting rise without yielding additional innovation. For all these reasons, these opportunistic patent strategies have the potential to seriously reduce the main interest of pools, which is to reduce the social cost of patent thickets. On the other hand, this difference between incumbent members and companies wishing to join, also gives incentives to join the pool promptly after its creation. Thus, this practical advantage of pool members over companies wishing to join is rather negative in a long-term perspective but certainly positive for the success of the pools' launch.

Our fourth and last paper emphasizes the role of consortia in enabling the coordination of innovation. We prove that co-membership of two firms in an informal technical consortium significantly increases the likelihood that they cite each other's patents in a subsequent research. On one hand, this finding points out that consortium may increase incentives to invest in R&D by internalizing potential innovation externalities and thus have a positive welfare effect. On the other hand, these results also call for a redefinition of innovation policies on standardization. Policymakers should no longer be interested only in formal standard-setting organizations but also pay attention to informal upstream consortia in which the real coordination work is actually taking place.

On the direction for future research, we are currently working on a couple of projects that should allow us to refine and expand the findings of the papers presented in this dissertation.

One of the main current obstacles for pools analysis is the absence of general databases of patents essential for a technological project. This problem was troublesome for our first article as the choice of the control sample was problematic. This lack of information on patent data around standardization processes has been underlined by other economists in the field[114] and some projects are being conducted to enable the provision of publicly standardized data on essential patents[115]. Our wish is to contribute to these projects by making all the databases we created for this dissertation available for future research. Furthermore, during our stay at the Imperial College in London, we have started to collaborate with a consulting firm which carries primarily patents assessment. We are currently working together to achieve a database of essential patents (patents assessed essential by this firm). This database, as a

[114] See for instance Bekkers, Catalini, Martinelli, Simcoe (2011)
[115] For instance, see the website www.ssopatents.org

“perfect” control sample of pool patents, should allow us to strongly increase the robustness of future findings and to launch new projects on the determinants of participation in pools.

The number of technical consortia strongly increased during the last years especially in ICT. This increasing importance of consortia calls for further research to better understand the drivers behind consortia’s creation and the incentives for firms to participate to these informal standardization bodies. Our fourth research paper confirms the main hypothesis on consortia, namely that these bodies are used by ICT. firms to coordinate subsequent innovations. However, it is important to gain a better understanding on the inside functioning of these bodies as it has an impact on the social welfare. Indeed, there are concerns that consortia could also be used as a way to foreclose competition around a standardization project. There are also doubts on the possibility for small and medium entities to effectively participate in these technical consortia and thus a risk of capture of standardization projects by a small number of dominant firms. As we underline that the coordination work is now mainly done in upstream consortia and not in formal Standard Developing Organizations anymore, this capture could be viewed as very problematic from a social point of view. It is thus necessary to bring along some empirical proof on the real activities and functioning of these consortia as well as the possibility for SME’s to effectively participate in these organizations. These projects are underway with Aija Leiponen with whom we decided to expand our database on consortia especially on European data.

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Appendix

Research Paper 1

Appendix 1 : Regression results, control sample taking into account technological subclass

	Poisson Number of citations/year (N=23771)
Intrinsic value effect	0.12581* (0.066)
Induced value effect	-0.28416 (0.186)
Pre-Induced value effect	0.18286* (0.108)
Induced value effect_SSO dummy	-1.06564*** (0.258)
Application year effect	Y
Citing year effect	Y
Technology class effect	Y
Patent age effect	Y

Legend: * p<0.10; ** p<0.05; *** p<0.01. *Robust standard error clustered on patents in parentheses.*

Table 5 : Cross-section approach, intrinsic and induced value effects

Appendix 2 : Robustness tests

Matched control sample (N=2695)	Poisson Number of citations/year (Allnscites)	Poisson Number of citations/year (external cites)
Intrinsic value effect	0.56638***	0.53856**
	(0.201)	(0.212)
Induced value effect	-0.12657	-0.09760
	(0.241)	(0.236)
Pre-Induced value effect	0.31147*	0.32065*
	(0.166)	(0.173)
Disclosure SSO dummy	-0.29605	-0.31461
	(0.188)	(0.202)
Application year effect	Y	Y
Citing Year effect	Y	Y
Technology class effect	Y	Y
Patent age effect	Y	Y

Legend: * p<0.10; ** p<0.05; *** p<0.01. *Robust standard error clustered on patents in parentheses.*

Table 6. Cross-section approach, robustness of the intrinsic value effect

Number of citations/year	Matched control sample (N=2695)
Intrinsic value effect	0.24802*
	(0.124)
Induced value effect	0.10184
	(0.216)
Pre-Induced value effect	0.57533***
	(0.160)
Induced value effect_SSO dummy	-0.52864**
	(0.243)
Application year effect	Y
Citing year effect	Y
Technology class effect	Y
Patent age effect	Y

Legend: * p<0.10; ** p<0.05; *** p<0.01. *Robust standard error clustered on patents in parentheses*

Table 7. Cross-section approach, robustness of the induced value effect

Appendix

Research Paper 2

Appendix 1 : Descriptive regressions litigations

	Probit	**Probit**	**Poisson**	**Poisson**
	DV= Litigation dummy		DV= Number of cases	
Log(forward cites)	0.12118*	0.19459**	0.32537*	0.35354**
	(0.062)	(0.073)	(0.137)	(0.135)
Generality	0.14038	-0.16067	2.00399***	1.92154***
	(0.175)	(0.230)	(0.401)	(0.498)
log(claims)	N/A	0.19664	N/A	0.63336*
		(0.107)		(0.253)
Assignee dummy	Y	Y	Y	Y
Technological class dummy	Y	Y	Y	Y
Control Grant Year	Y	Y	Y	Y
_cons	-2.168***	-2.779***	-3.432***	-5.262***
Number of obs	1060	608	1491	758
Legend: * p<0.05; ** p<0.01; *** p<0.001. Robust standard errors in parentheses.				

Table 6. Regressions results cross section litigated, patent quality

Appendix 2 : The introduction effect by size and structure of firms and pools

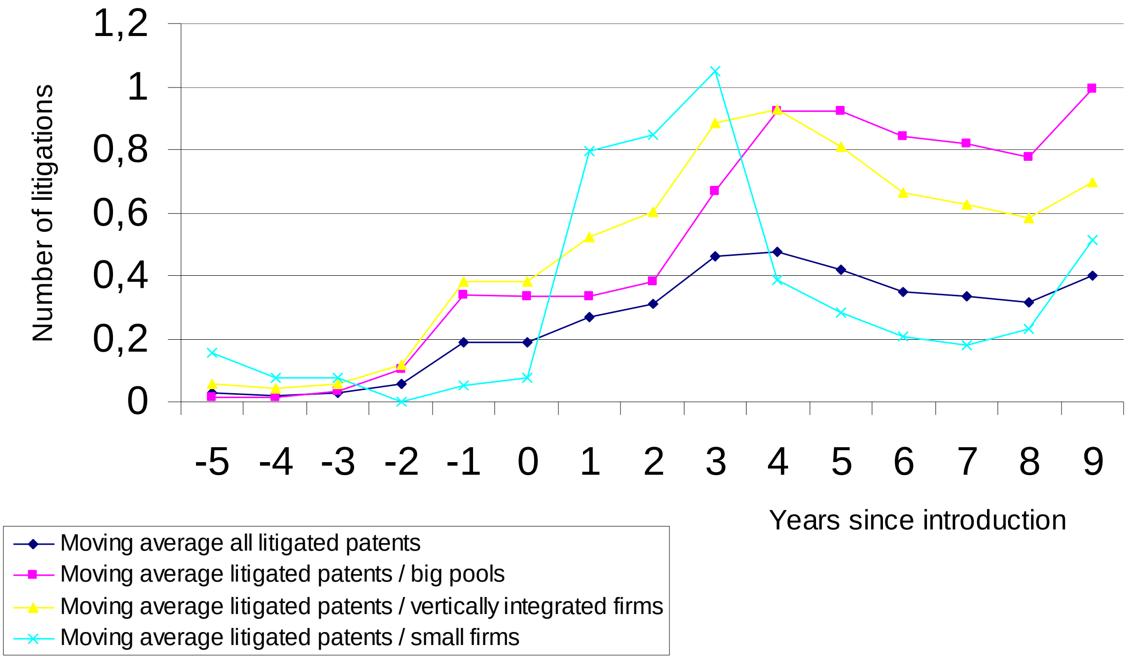

Figure 3. Introduction effect by pool and firm size

Appendix 3 : Results for patents granted after or in 2000

	Fixed effect logit	Fixed effect logit	Fixed effect poisson	Fixed effect poisson
	DV= Litigation dummy		DV= Number of cases with the patent holder as plaintiff	
Introduction effect	11.15359** (4.751)	12.56818** (5.046)	14.00882*** (3.887)	15.00070*** (3.866)
Number_ member_Introduction	0.08146 (0.123)	0.11631 (0.126)	0.21282*** (0.631)	0.23171*** (0.064)
Othersmemb_patents_Introduction	-0.00052** (0.000)	-0.00057** (0.000)	-0.00074*** (0.000)	-0.00078*** (0.000)
PPprior_introduction	0.10627 (4.295)	1.43219 (5.116)	-2.57095* (1.931)	-2.58399 (2.049)
Portfolio_size_introduction	0.00056* (0.000)	0.00046 (0.000)	0.00118*** (0.000)	0.00119*** (0.000)
Portfolio_size2_introduction	-7.265e-09 (1.26e-08)	-5.371e-09 (9.91e-09)	-1.889e-08** (8.76e-09)	-1.881e-08** (8.72e-09)
Portfolio_size_VI_introduction	-0.00009** (0.000)	-0.00010** (0.000)	-0.00013*** (0.000)	-0.00013*** (0.000)
Cites N-1		0.48499** (0.233)		0.39924*** (0.124)
Calendar year effect	-0.13771** (0.057)	-0.26212*** (0.073)	-0.12479*** (0.025)	-0.20730*** (0.029)
Number of obs	425	357	425	357

Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses

Table 7. Regressions results fixed effect panel, patents granted after or in 2000

Appendix 4 : Results, overall sample

	FE logit	FE logit	FE logit	FE logit	FE poisson	FE poisson	FE poisson
	DV= Litigation dummy				DV= Number of cases		
Introduction effect	1.54765**	3.91103**	7.36690**	8.74541**	3.91983***	10.70365***	14.95564***
	(0.728)	(1.666)	(3.085)	(3.731)	(0.997)	(2.785)	(4.302)
Number_other_member Introduction	0.00410 (0.039)	0.02708 (0.043)	0.05896 (0.048)	0.06495 (0.053)	0.03124 (0.020)	0.12621*** (0.032)	-0.04563 (0.088)
Number_other_member2 Introduction							0.00636** (0.003)
Number_othermembers_ numberpatents_Introduction			-0.00029** (0.000)	-0.00030* (0.001)		-0.00055*** (0.000)	-0.00065*** (0.000)
PPprior_introduction		-2.22683	-1.54347	-3.59714**	-1.67489**	-0.96166	-2.02418***
		(1.449)	(1.461)	(1.615)	(0.639)	(0.646)	(0.662)
Portfolio_size_introduction		0.00010	0.00034*	0.00035	0.00010*	0.00067***	0.00113***
		(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Portfolio_size2_introduction							-1.720e-08*
							(9.88e-09)
Portfolio_size_Vertical Integration_introduction		-0.00003* (0.000)	-0.00006* (0.000)	-0.00007* (0.000)	-0.00003** (8.52e-06)	-0.00010*** (0.000)	-0.00013*** (0.000)
Cites N-1				0.83050***			-1.31093***
				(0.231)			(0.216)
Calendar year effect	0.00383	-0.00076	-0.00118	-0.10973***	0.01624	0.01768	-0.01716
	(0.025)	(0.026)	(0.026)	(0.032)	(0.012)	(0.011)	(0.012)
Number of obs	1120	1088	1088	1087	1088	1088	1088

Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses

Table 8. Regressions results fixed effect litigated, overall sample

Appendix 5 : Results using dummies and controlling for the age of the patent

	FE logit	FE logit	FE poisson	FE poisson
	DV= Litigation dummy		DV= Number of cases with the patent holder as plaintiff	
Introduction effect	1.98244**	2.31237***	1.69388***	1.92227***
	(0.798)	(0.836)	(0.450)	(0.456)
Big_pool_Introduction	0.56502	0.65551	0.74237**	0.71377**
	(0.566)	(0.636)	(0.304)	(0.319)
Big_portfolio_Introduction	-0.78082	-1.15314	-0.29686	-0.69637
	(0.862)	(0.957)	(0.482)	(0.515)
PPprior_introduction	-2.65837*	-4.64015***	-1.83428***	-2.82617***
	(1.426)	(1.584)	(0.611)	(0.585)
Cites N-1		0.85453***		0.87594***
		(0.239)		(0.150)
Calendar year effect	0.012664	-0.09595***	0.03129***	-0.05399***
	(0.025)	(0.031)	(0.012)	(0.014)
Number of obs.	1122	1121	1122	1121
Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses				

Table 9. Regressions results fixed effect litigated, dummies

	FE logit	FE logit	FE logit	FE poisson	FE poisson	FE poisson
	DV= Litigation dummy			DV= Number of cases with the patent holder as plaintiff		
Introduction effect	1.57606***	2.81182***	1.57593***	1.81464***	1.90941***	1.54087***
	(0.393)	(0.747)	(0.428)	(0.222)	(0.222)	(0.222)
Big_pool_Introduction* Patent Age	0.08957**	0.03727	0.08651*	0.12787***	0.11969***	0.10854***
	(0.042)	(0.076)	(0.050)	(0.024)	(0.025)	(0.026)
Big_portfolio_Introduction* Patent Age	-0.08674*	-0.18456**	-0.11743**	-0.08667***	-0.09352***	-0.12072***
	(0.050)	(0.087)	(0.058)	(0.027)	(0.029)	(0.030)
PPprior_introduction* Patent Age	-0.25050**	-0.39427***	-0.38260***	-0.19552***	-0.22886***	-0.21091***
	(0.102)	(0.142)	(0.0120)	(0.040)	(0.039)	(0.039)
Cites N-1		-1.01148***	0.82462***		-1.30150***	0.79987***
		(0.358)	(0.233)		(0.217)	(0.143)
Dummy_already_litigated			0.02419			0.24937*
			(0.292)			(0.133)
Calendar year effect	0.04437	0.06252	-0.03319	0.02898	0.00581	-0.02361
	(0.043)	(0.071)	(0.048)	(0.025)	(0.026)	(0.026)
Number of obs	1037	828	1036	1037	1037	1036

Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses

Table 10. Regressions results fixed effect litigated, dummies and patent age

Appendix 6 : Results excluding DVD 3C and DVD 6C pools

	FE logit litigated	**FE poisson litigations**	**FE logit litigated**	**FE poisson Litigations**
	Results excluding DVD 3C		Results excluding DVD 6C	
Introduction effect	1.58233***	2.37226***	1.57593*	2.36112***
	(0.421)	(0.712)	(0.428)	(0.721)
Big_pool_Introduction* Patent Age	0.08651*	-0.03283	0.08651*	-0.03320
	(0.050)	(0.056)	(0.050)	(0.056)
Big_portfolio_Introduction* Patent Age	-0.11731**	-0.18665**	-0.11743**	-0.18628**
	(0.058)	(0.081)	(0.058)	(0.081)
PPprior_introduction* Patent Age	-0.38362***	-0.25925**	-0.38260***	-0.25746**
	(0.119)	(0.118)	(0.120)	(0.119)
Cites N-1	0.82546***	1.11446**	0.82462***	1.11254**
	(0.232)	(0.443)	(0.233)	(0.443)
Dummy_already_litigated	0.03182		0.02419	
	(0.344)		(0.292)	
Calendar year effect	-0.03183	0.17188**	-0.03319	0.16997**
	(0.045)	(0.076)	(0.048)	(0.079)
Number of obs	1036	798	1036	798

Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses

Table 11. Regressions results fixed effect litigated, excluding DVD pools

Appendix 7 : Settlement results using a panel approach

	RE logit	RE logit	RE logit	RE poisson	RE poisson	RE poisson
	DV= Settlement dummy			DV= Number of settlements		
Introduction effect	2.14909 (1.514)	1.85074 (1.365)	3.53464* (1.962)	2.16671** (0.995)	2.16705** (0.993)	2.04548** (0.998)
Log_Allnscites		-0.00411 (0.006)	-0.00020 (0.009)		-0.00306 (0.006)	-0.00341 (0.005)
Control Grant Year			Y			Y
Calendar year effect	-0.26980 (0.186)	-0.17185 (0.161)	-0.31725 (0.240)	-0.30775*** (0.097)	-0.29055*** (0.096)	-0.27926*** (0.097)
Number of obs	**113**	**108**	**108**	**113**	**108**	**108**

*Legend: * p<0.10; ** p<0.05; *** p<0.01. Standard errors in parentheses*

Table 12. Regressions results random effect settlement

<u>**Appendix 8 : Test results fixed/random effects**</u>

F Test Fixed Effect		Breusch and Pagan Lagrangian multiplier test random effects	
F :	1.8	Chi2 :	2.51
Prob > F :	0.0156	Prob > chi2 :	0.1131

Table 13. Results panel litigations

F Test Fixed Effect		Breusch and Pagan Lagrangian multiplier test random effects	
F :	0.89	Chi2 :	2.56
Prob > F :	0.6562	Prob > chi2 :	0.1094

Table 14. Results panel outcomes

Appendix 9 : Number of settlements, pool and non-pool patents

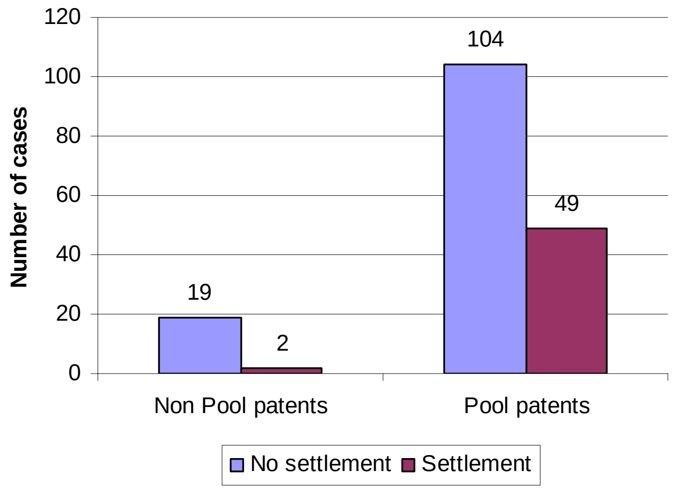

Figure 4. Settlement for pool and non-pool patents

Appendix

Research Paper 3

Appendix 1: Descriptive findings

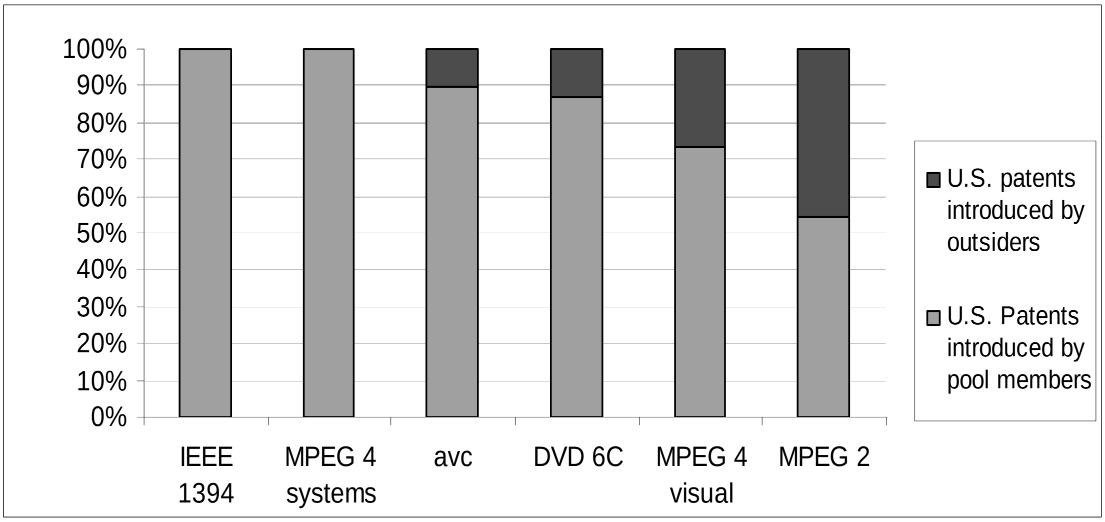

Figure 1. Introduction of U.S. patents insiders/outsiders

Appendix 2: Summary statistics

Variable	Description	Mean	Std. Deviation	Min	Max
Variables regarding patent					
Appyear	Year patent applied for	1998.226	3.959	1981	2006
Gyear	Year patent granted	2000.418	4.021	1983	2006
Nclass	U.S. patent technology class (3 digit)				
Allnscites	Total cites flow (truncation corrected) from other companies	17.916	29.404	0	251.33
Genindex	Generality of the patent (NBER U.S. database)	0.331	0.366	0	1
Claims	Number of claims for the patent	4.939	9.606	1	99
Family_size	Family size for the patent calculated from espacenet	30.371	83.237	1	700
External_cites	Cites received from patent not in the pool	20.5383	30.02179	0	270.47
Internal_cites	Cites received from patent not in the pool	2.567	6.579	0	88
Year_ disclosure_SSO	Disclosure year of the patent in the SSO	1998.821	3.601	1993	2007
Variables regarding the timing					
Age_input	Age of the input calculated from the pool creation date (in months)	40.261	29.522	0	139
Age_at_input	Patent age at the input date (in years)	5.441	2.919	0.199	19.25
Number_input	Chronological number of input into this pool	2.690	2.268	0	11
Age_at_creation	Age of the patent at the pool creation date (in years)	4.431	3.696	- 3.90	20.5
Variables regarding firms					
Ppprior	Number of patents previously in the pool held by the firm (Number of patents previously held by the firm in the pool / Number of patents previously in the pool)	0.136	0.141	0	0.7
Corpsize	Size of the company (based on ranking in Fortune 500 and Global2000 index)	0.001	0.002	0.001	0.042
Patent_portfolio	Size of the company patent portfolio (2009 U.S. patent application * number of patents espacenet)	10637.84	13956.52	0	50932
Variables regarding the patent essentiality					
Sections	Number of standard sections for which the patent is cited	4.236	2.913	1	24
Subsections	Number of standard subsections for which the patent is cited	13.884	10.839	1	88
Sections corrected	Number of standard sections for which the patent is cited / median number of standard sections	1.411	0.945	0.25	8.733
Subsections corrected	Number of standard subsections for which the patent is cited / median number of standard subsections	1.411	0.945	0.25	8.733
Focus_standard	Number of claims / Number of sections corrected	3.523	3.140	0.021	24

<u>**Appendix 3: Example of essentiality report for DVD 6C essential patents**</u>

SUMMARY REPORT OF ESSENTIAL DVD-ROM PLAYBACK PATENTS*

HITACHI ESSENTIAL DVD-ROM PLAYBACK PATENTS			
U.S. Patent Number	**Reported Counterpart(s)**	**Representative Claim(s) – (U.S.)**	**DVD-ROM Specification**
4,235,507	CA 1,109,961; FR 2,403,575; GB 2,006,461	6	**DVD-ROM, Part 1:** *Secs.:* 1.2, 2.3.2 *Pages:* PH-2, 12
5,586,108		12	**DVD-ROM, Part 1:** *Secs.:* 3.2.7, 3.2.8, 3.2.9 *Figs.:* 3.2.7-1, 3.2.8-1, 3.2.9-1 *Pages:* PH-47, 49, 50
5,768,298		19	**DVD-ROM, Part 1:** Secs.: 3.2, 3.2.1, 3.2.2, 3.2.7, 3.2.9 *Figs.:* 3.2-1, 3.2.1-1, 3.2.7-1, 3.2.9-1 *Pages:* PH-40, 41, 47, 50
5,966,721		16	**DVD-ROM, Part 1:** *Secs.:* 3, 3.1.3, 3.1.4, 3.4.1.3.1 (BP 4 to 15) *Figs.:* 3.1.4-1, 3.1.4-1(b) *Pages:* PH-37 to 39, 69
5,983,387	KR 239,236	2	**DVD-ROM, Part 1:** *Secs.:* 1.1, 2.1, 3.2.2, 3.2.9 *Annex:* L *Figs.:* 2.1-1, 3.2.1-1, 3.2.9-1, L-1 *Table:* 3.2.9-1 *Pages:* PH-1, 9, 40, 50, 51, PHX-22

* This report shows *illustrative* essential claims of each patent. Other patent claims also may be essential. Additionally, citations to the DVD specifications reflect one mapping of the representative claim to the DVD specifications. Other mappings of the representative claim or other claims in the patent to the DVD specifications may also be possible.

DVD-ROM PLAYBACK
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Appendix

Research Paper 4

Appendix 1: Description cited patents

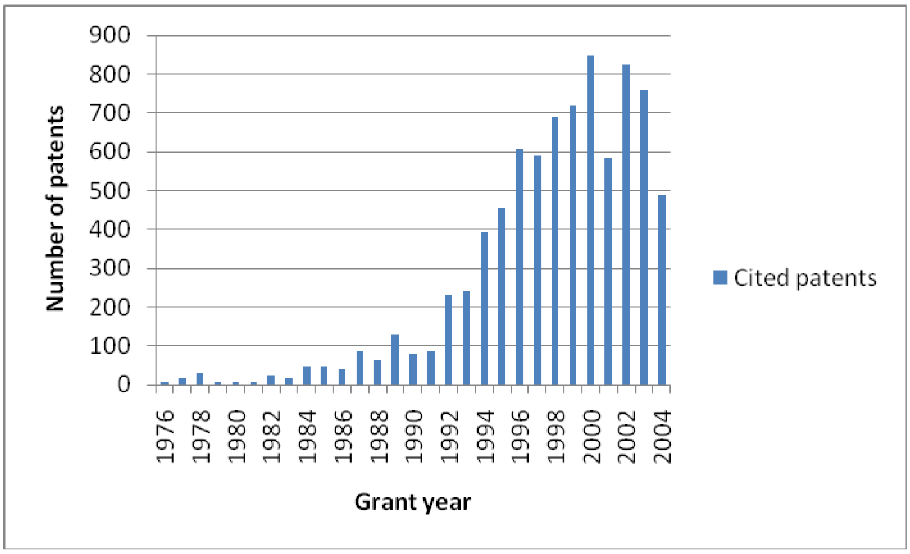


Figure 1. Grant year of the cited patents

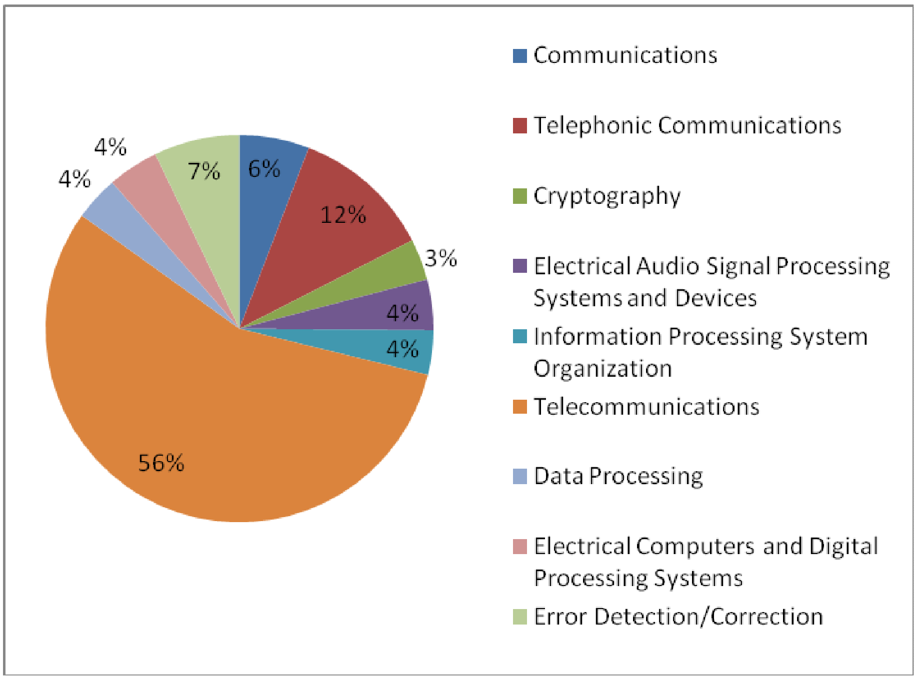


Figure 2. Technological class of the cited patents

Appendix 2 : Description citing patents

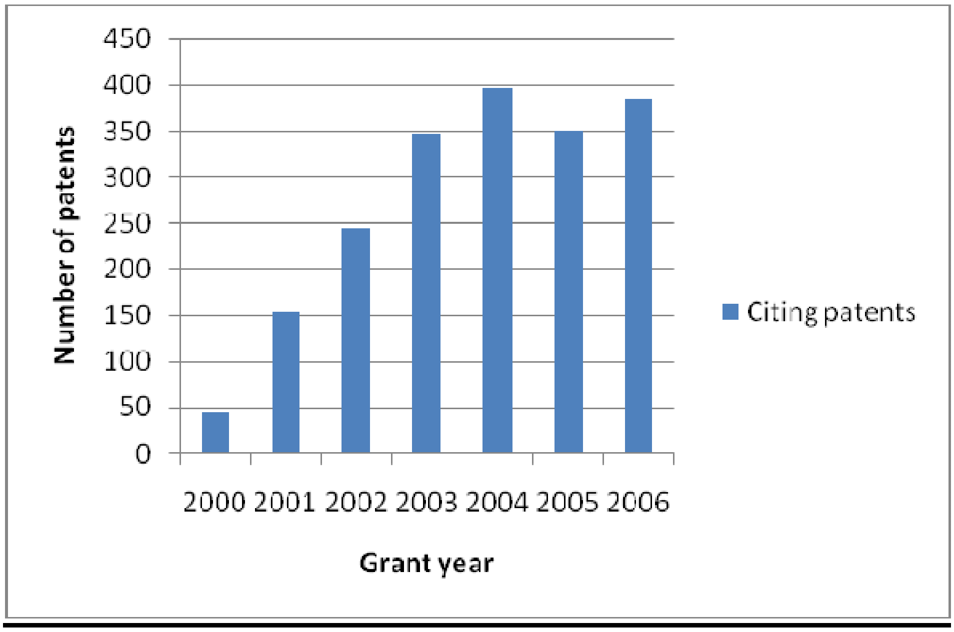


Figure 3. Grant year of the citing patents

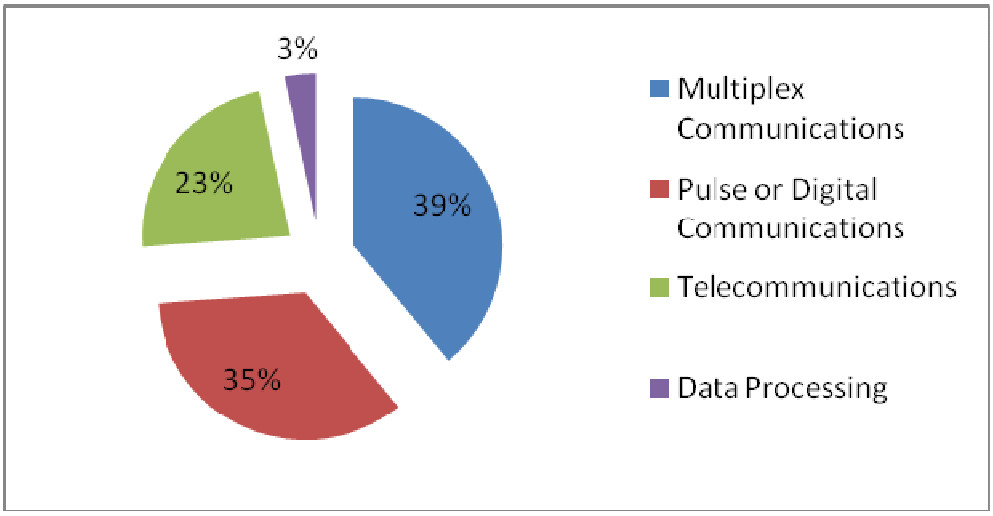


Figure 4. Technological class of the citing patents

Appendix 3 : List of consortia

Consortium Name	3GPP related	Affected by the OMA merger
MET	No	No
WLANA	No	No
SA Forum	No	No
ATIS	No	No
3G Americas	No	No
CDG	No	No
VoiceXML	No	No
IPv6 Forum	Yes	No
Hiperlan 2	No	No
WiFi Alliance	No	No
GSA	Yes	No
TTC	Yes	No
Bluetooth	No	No
GPP 2	No	No
UMTS Forum	Yes	Yes
T1	Yes	No
SyncML	No	Yes
TTA	No	No
UWCC	Yes	No
WAP Forum	No	Yes
Wireless Village	No	Yes
3GIP	No	No
ARIB	Yes	No
BWIF	No	No
CWTS	No	No
ETSI	Yes	No
GSM Association	Yes	No
MGIF	No	Yes
MWIF	No	Yes
OMA Alliance	No	No
Symbian	No	No
WECA	No	No

Appendix 4 : List of cited patent holders

id2_cited	Company Name
50020	Agere
50040	Alcatel
50100	ArrayComm
50120	AT&T Wireless
50180	Bell South
50220	BT (British Telecom)
50250	BULL S.A.
50360	Cisco Systems
50411	3Com
50421	Infineon Technology
50520	Ericsson
50580	France Telecom
50590	Fujitsu Limited
50630	Golden Bridge Technology
50640	Hewlett Packard
50670	Hughes Network
50710	ICO Global
50750	Intel
50760	InterDigital
50860	LG Electronics
50880	Lucent
50940	Matsushita
50950	Matra
51000	Microsoft
51010	Mitsubishi
51060	Motorola
51090	NEC
51130	Nokia
51140	Nortel Networks
51200	OKI Electrics
51280	Panasonic
51340	Qualcomm
51360	Racal Instruments
51400	Rogers Wireless
51440	Samsung
51490	Seiko Epson
51540	Sharp
51560	Siemens
51640	Sony
51880	Texas Instruments
51900	Thomson
51920	Toshiba

Appendix 5 : Control group for the OMA merger

Company Name
Hughes network
Agere
ArrayComm
BT (British Telecom)
Bull S.A.
Comneon
Golden Bridge technology
ICO Global
Matra
Racal Instruments
Rogers Wireless
Shanghai Be

Appendix 6 : Results using a random effects estimation

	(1)		(2)		(3)	
	Coef.	Odds	Coef.	Odds	Coef.	Odds
Total memberships	0.139***	1.149***				
	(0.018)	(0.021)				
Mean memberships	-0.215***	0.806***				
	(0.061)	(0.049)				
Consortium connection			0.002***	1.002***		
			(0.0002)	(0.0002)		
Mean consortium conn.			-0.002	0.998		
			(0.001)	(0.001)		
Co-membership					3.162***	23.610***
					(0.168)	(3.976)
Mean Co-membership					6.463***	640.071***
					(0.645)	(412.579)
3GPP connections	0.007	1.007	0.021***	1.021***	-0.002	0.998
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
Mean 3GPPconn.	-0.037	0.964	-0.081***	0.922***	-0.035***	0.965***
	(0.023)	(0.022)	(0.016)	(0.015)	(0.010)	(0.010)
Patent age	-0.109*	0.896*	-0.076	0.926	-0.039	0.962
	(0.053)	(0.048)	(0.053)	(0.049)	(0.064)	(0.062)
Mean patent age	0.305***	1.357***	0.276***	1.318***	0.199**	1.220***
	(0.052)	(0.070)	(0.051)	(0.068)	(0.062)	(0.075)
Patent quality	-0.068***	0.934***	-0.067***	0.935***	-0.074***	0.929***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
Mean patent quality	0.080***	1.083***	0.079***	1.082***	0.079***	1.082***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)

Dummy 0/3/6/9	Y	Y	Y
Observations	6276	6276	6276
Number of groups	1021	1021	1021
Chi2	418.96	421.75	539.77
Prob > chi2	0	0	0
Log Likelihood	-1554.269	-1558.675	-1142.618

Legend: * p<.05; ** p<.01; *** p<.001

Notes: Dependent variable is an indicator for whether a patent was cited by an essential patent applied in year t. Estimation method is logit with random effects. Dummy 0/3/6/9 are nonlinear effects for patent age. Means are computed at the cited patent level

Appendix 7 : Firm results using a fixed effects estimation

	Coef.	Std. Err.	Marg. Eff.	Coef.	Std. Err.	Marg. Eff.	Coef.	Std. Err.	Marg. Eff.	Coef.	Std. Err.	Marg. Eff.
co_membership	3.366***	0.194	0.172									
co_membership_Ericsson	10.498	956.892	0.975									
dummy_Ericsson	1.651	1.311	0.088									
co_membership				2.762***	0.252	0.170						
co_membership_Interdigital				-0.386	0.382	-0.012						
dummy_interdigital				3.379***	0.390	0.278						
co_membership							3.398***	0.197	0.176			
co_membership_Panasonic							-1.812*	1.101	0.254			
dummy_Panasonic							1.466	1.033	0.501			
co_membership										4.005***	0.251	0.387*
co_membership_Qualcomm										-2.931***	0.417	-0.055
dummy_Qualcomm										1.699***	0.364	0.139
3GPP connections		Y			Y			Y			Y	
Patent age and quality		Y			Y			Y			Y	
Dummy 0/3/6/9		Y			Y			Y			Y	
Number of obs		2154			2154			2154			2154	
Number of groups		352			352			352			352	
chi2		926.51			1059.89			927.52			976.76	
Log likelihood		-350.338			-283.651			-349.835			-325.211	

Legend: * p<.05; ** p<.01; *** p<.001 (* p<.10; ** p<.05; *** p<.01 for marginal effects)

Mécanismes de coordination autour des projets de standardisation ICT:

Quatre articles économétriques sur les patent pools et les consortiums technologiques

RESUME : Cette thèse s'intéresse à l'impact des mécanismes de coordination créés autour des projets de standardisation technologique sur l'innovation. Nous nous intéressons plus particulièrement aux standards technologiques développés dans les secteurs des technologies de l'information et de la communication (3G...) et à deux types de mécanismes de coordination particuliers que sont les patents pools et les consortiums technologiques. Cette thèse est constituée de quatre articles économétriques analysant l'impact des pools et consortiums sur les incitations à innover et les stratégies d'innovation des entreprises participantes.

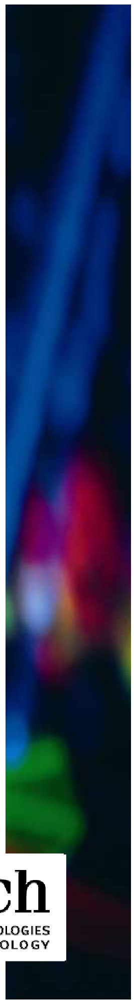
Mots clés : Patent pools, consortiums technologiques, standardisation, innovation

Coordination mechanisms around ICT standardization projects:

Four empirical essays on patent pools and consortia

ABSTRACT : This thesis focuses on the impact of coordination mechanisms, created around technological standards with a special focus on 3rd generation Information and Communication Technology, on innovation. We are particularly interested in two types of coordination mechanisms: patent pools and industry consortia. This thesis is comprised of four econometric papers analyzing the impact of consortia and patent pools on the incentives to innovate and innovation strategies of participating companies.

Keywords : Patent pools, R&D consortia, standardization, innovation



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