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ESSENTIAL PATENTS IN INDUSTRY STANDARDS: THE CASE OF UMTS

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We study the determinants of essential patents in industry standards. In particular, we assess the role of two main factors: the significance of the technological solution contained in the patent and the involvement of the applicant of the patent in the standardization process. To this end, we examine the case of UMTS one of the most successful standards in the area of mobile telecommunications. We compare the patents claimed essential for the UMTS standard with a group of randomly selected control patents covering the same time frame and technology classes. We establish that both the technological significance of the patent (measured using forward citations) and the applicant s involvement in the standardization process have a positive effect on the probability that a patent will be claimed as essential . On the basis of our findings, we offer policy recommendations.

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1. Introduction

With the advance of the network economy, standardisation has become one of the main processes that align technological development and implementation decisions by stakeholders. It acts as a coordination process that is key to firm strategies, determining which products interoperate with others, determining access to markets, and much more.

Standards have a fascinating and complex relation to Intellectual Property Rights (IPRs). Whereas standards aim at ensuring equal access for all stakeholders, IPRs grant temporary, exclusionary rights on the use of inventions. This tension may be particularly problematic in the case of essential patents, i.e. patents that are indispensible to produce a product or offer a service based on a standard. To prevent the situation in which standards cannot be implemented in practice due to the existence of patents covering inventions related with these essential components of the product or service in question, standards bodies have developed IPR policies that establish rules for their members with regard to the availability and conditions of licenses for essential patents. Most of these policies require the members to disclose ('declare') their essential patents.

Such disclosures may indicate technical value of the patent: the patented technology is chosen to become part of the standard by the virtue of its contribution to its technical performance, cost-effectiveness, etc. The technical content of standards is basically drawn up by the members of a standards body, this offers opportunities to influence the content of standards. As a consequence, essential patents may be brought into the standard (and subsequently declared to be essential) because of strategic reasons. After all, ownership of essential patents brings many advantages to its holder, such as licensing revenues, 'exchange chips' that open the door to attractive cross-licensing arrangements.

This paper examines to what degree patents are claimed to be essential in a standardisation process on the merit of their specific technological contribution, or as a result of strategic behaviour of their holders, or both. To do so, we perform an extensive analysis on a publicly available list of self-declared essential patents for the UMTS standard, the most successful technologies for mobile telephony worldwide.

2. Essential patents and industry standards

2.1 The standardisation process and the role of patents

Standards can come into existence in several ways. Sometimes, a single firm develops a set of technical specifications that becomes so successful that it gets to be seen as an industry standard. The firm in question might or might not allow other firms to make products or sell services based on its industry standard, by publicising the detailed specifications and/or granting licenses. In case the firm obtains a dominant market position, competition authorities may attempt to enforce this.

In the most common case, however, standards are the result of a negotiation process between two or more (independent) stakeholders. The explicit goal of this process is the creation of a standard that will be adopted by the stakeholders and/or other parties. Here, one may distinguish between formal standards bodies on the one hand, and consortia and fora on the other. Although various different definitions have been proposed in the literature, this paper will refer to formal standards bodies as those that are recognized as such by public authorities (for example, in Europe, Directive 98/34/EC designates CEN, CENELEC, and ETSI to be recognized regional standards bodies. Formal bodies must meet a number of criteria, including openness to participate, consensus-based decision-making/due process, open access to documentation, and IPR rules (Krechmer, 1996; Andersen, 2008). Consortia and fora might also meet these criteria, but may also choose not to do so. Depending on the exact context, firms may prefer one type of standard developing organisations over the other; therefore formal SDOs, consortia and fora (and the many sub-types one may distinguish here) may be seen as competing against each other on the same "market".

Although there were some early cases in which tensions between patents and standards had emerged (Bekkers & Liotard, 1999), this was not considered to be a major issue until the late 1980s. By that time, the first major clash took place, in the telecommunications sector, more specifically when the European Telecommunications Standards Institute (ETSI) developed GSM, a standard for mobile telephony. The clash took place against a background of liberalisation and privatisation in the European telecommunications sector, the so-called pro-patent era, and the disappearance of exclusive, long-term relations between network operators and their suppliers. This first clash has been extensively documented in the literature (Shurmer & Lea, 1995; Iversen, 1999, Wilkinson 1991, Bekkers, 2001) and may be considered as the beginning point for standard-setting bodies to develop specific rules on IPR ownership.

The most common way in which standard-developing organisations (SDOs) now deal with IPR is known as (F)RAND, an acronym that refers for the Fair, Reasonable and Non-discriminatory conditions that parties need to ensure for their licenses for essential patents. (F)RAND was pioneered by ETSI in the early 1990s (and revised and refined several times). By now, virtually all formal SDOs have adopted a (F)RAND policy, as well as many consortia and fora, though there are notable exceptions such as W3C, a body that requires all patents to be royalty-free (Bekkers & Seo, 2008).

In short, (F)RAND has the following basics: (1) Holders of IPR, member or not, will be rewarded in a suitable and fair manner; (2) Members will make a reasonable effort to inform the SDO of relevant IPRs of which they are aware. If they propose a technical design to the SDO they will also, in good faith, draw attention to IPRs that could become essential once that proposal is adopted; (3) If an essential IPR is identified, the SDO will request its holder, member or not, to make licenses available under (F)RAND terms; (4) Members can choose not to license an IPR; if they persevere the SDO will try to change the standard so it no longer draws upon that patent. If it does not succeed to do so, it will withdraw the standard or stop working on it. Note that although this policy does create rights for non-members (e.g. regarding the licensing conditions that members can impose), it cannot not create obligations for non-members as it does not have any legal relation to such third parties.

Usually, standards only define the interfaces between elements of a larger system, not the way these elements need to be made. This ensures a maximum incentive to innovate. In this context, it is important to note that the (F)RAND policy refers to 'essential patents'. These are patents that are so basic to the interfaces defined by the standard that it is impossible to design any device that complies with these interfaces without infringing the patent. If there are alternative ways to design something that complies with the standard (even when they are more expensive to implement), the patent in question is no longer essential.

Obviously, a particularly critical issue is how the requirement of Fair, Reasonable and Non-discriminatory conditions is to be interpreted. Does the licensing fee need to be reasonable from the perspective of the value of the patent, or reasonable given the total number of other patents that are essential to the standard and the total licensing fee that implementers can afford or want to afford? These questions are currently at stake in litigation between some of the firms in this market.[1]

2.2 Technological content as a determent of essentiality

In many cases, a standard must attain a number of different, often conflicting functional requirements. For example, in the area of telecommunications, a standard for mobile internet data services might aim to (1) offer a high data rate (speed), (2) in a large, continuous coverage area, (3) allowing the user to move with speeds up to 300 km/h, (4) consuming low power in order to optimize battery life, (5) requiring a minimum number of cell cites or antenna towers, (6) while being robust to noise and other types of interference and (7) at low costs for base stations and terminals. Clearly, certain technological solutions may be better suited at meeting one or more of these requirements than others, and given the high propensity to patent prevailing in many "high tech" sectors, it is very likely that many of these attractive technological solutions may be patented. Patented technologies may then be chosen to be included in a standard because of their attractiveness. In some cases, a patented technology may be the only feasible mean for realizing functional requirements of the standard in question. In other cases, the patented technology may not be the only solution but still be the best way to achieve the standard requirements, by offering a higher performance or making the implementations more cost-effective, etc.

If we assume that the intrinsic "quality" of a patented technological solution for the standard is the sole and only determinant of its inclusion in the standard (and that strategic

[1] Qualcomm has sued Nokia (as well as Broadcom) for patent infringement in the US and the UK, including a complaint with the U.S. International Trade Commission, while Nokia and five other entities have lodged a complaint against Qualcomm with the European Commission for excessive royalties (Fritchard, 2005). At base, the conflict begs the question of what 'fair, reasonable and non-discriminatory' FRAND actually means. In August 2006, Nokia in effect asked a Delaware court to define FRAND.

considerations as will be discussed below, do not play any role) then we can expect than essential patents are likely to be of higher quality than other patents, all other things being equal. Economists of innovation have attempted to assess the quality of patents using a number of characteristics of patents such as citations received, renewals, family size, opposition, etc. (van Zeebroeck, 2008 provides a detailed survey of this literature). So far, the number of forward citations (i.e., the citations received by a patent) is surely the most popular indicator of patent quality. Following the pioneering contributions of Carpenter et al. (1981) and Trajtenberg (1990), a number of studies have consistently established that forward citations are systematically correlated with the quality or the economic value or the industrial importance of patents (see for example, Albert et al., 1991; Sampat and Ziedonis, 2004; an exhaustive list of references is provided in van Zeebroeck, 2008). The intuition behind the use of forward citations as indicator of the quality of a patent is relatively straightforward: if a patent receives many citations this means that the technological solution outlined in the patent serves as a base for a large number of subsequent technological developments. Another somewhat related argument is that if a patent receives many citations this may also mean that it has been frequently used by patent examiners to reduce the scope of protection claimed by subsequent patents and this again points to the significance of the technological solution contained in the original patent (Van Zeebroeck, 2008, p. 5). For all these reasons, it seems reasonable to presume that the technological quality of a patent will be captured by the number of forward citations. If this is the case, then we can expect that essential patents will typically have a higher number of forward citations than non-essential patents. (In this context, we cannot fully rule out that some patents received cites as a result of being declared as essential.)

Several recent papers have indeed explored this hypothesis. Rysman & Simcoe (2007) conclude that patents declared as essential to SDOs are cited much more frequently than a set of control patents, and Layne-Farrar (2008) goes one step further by looking specifically at patenting taking place after the standard has been set, and concludes that also essential patents in this group are more valuable – i.e. receive more citations - than average patents.

2.3 Firm strategies and essential patents

Firms may try to have some of their own patents included in the standards as essential patents for reasons that may go beyond the specific "technological" contribution that these patents give to the standard. There are several incentives for this. Essential patents are not only a potential source of significant revenue, but they are also ‘exchange chips’ that open the door to attractive cross-licensing agreements. As has been shown for the GSM case, ownership of essential patents can be crucial for market entry (Bekkers, Duysters & Verspagen, 2002). Although (F)RAND policies now generally prevent patent owners to systematically block others from the market, those market players that do not own any essential patents are usually not in a very enviable position.

To understand better how firms can employ strategies in order to get essential patents it is useful to look in some more detail at the typical standardisation process at formal SDOs. The way in which the work on a new standard commences differs between SDOs, but often it is triggered by a proposal that is backed by a number of members. A set of requirements is defined in order to establish the mandate of the participants (usually employees of member firms) that are going to make the standard (often called “Terms of Reference”). Subsequently, one or more Technical Committees are established in order to develop draft specifications for the standard. Members can decide to actively participate in these committees (by sending their representatives to the meetings, or even by providing the chairman) and thus take an active part in deciding what the exact technological content of the standard will be. Although higher bodies in the standards bodies (such as a General Assembly or a Technical Assembly, depending on the SDO) will still need to vote on the acceptance of a standard, the real technical inclusion process – including dictions to include patented technologies - takes place in the technical committees. In exceptional cases, major design decisions might be taken to a higher level, but once these decisions are taken, the detailed work goes back to the Technical Committee. In these committees, discussions and negotiations are going on about the exact definition of the standard, and therefore the exact set of technologies the standard is drawing on. In a continuous process, participants in these meetings propose all sorts of solutions and technologies in order to draft a standard that meets the set of requirements. If firms suggest technologies for which they know that these are covered by IPR - in particularly their own IPR - they are obliged to disclose this information. On the basis of the pursuit of consensus (which does not mean all need to agree but usually is defined as the absence of persistent resistance), the committee makes decisions on whether to include suggested technologies. Contrary to what is often thought, most SDOs only rarely resort to formal voting procedures (that often require majority voting or 70% majority voting). Most technology decisions are taken as a part of social processes in relatively small groups, where the participants usually know and respect each other very well and quite often see each other as friends. The benefits that firms derive from the social network created by cooperation in the standard has been found to be one of the strongest determinants of the willingness of firms to contribute to standards by participating in technical committees (Bar & Leiponen, 2008). In such a context, there might be a tendency to accept others to bring in their patented technologies, as long as you are allowed to do the same thing. In this way, the interest of all parties – or at least, of all the participants – is catered for.

This 'technology inclusion' process give firms a number of opportunities to drive patents into a standard. Once the standard is established, firms may adopt a diverse set of further strategies for exploiting these patents and obtaining access to others' parties patents, where necessary. While this paper does not aim to go very deeply into that, it is worth noting that this process often involves the creation of larger portfolios of both essential and non-essential patents (where the value of some of the latter is often greatly overlooked), cross licensing involving essential, non-essential, and sometimes even patents for entirely different products), agreements on future patents, etc. Some of the strategies at the extreme end of the spectrum, such as patent ambush or 'holdup' have received considerable attention in the literature (see, for instance, Farrell et al, 2007). Some have also claimed that firms massively 'over-claim', i.e. unjustly declaring patents to be essential (Goodman & Myers, 2005).

2.4 Research question and our approach

The two preceding sections have outlined two basic determinants that may matter for making a patent "essential" for a standard, namely: 1) the intrinsic quality of the technological solution contained in the patent, 2) strategic bargaining of firms that may aim to have some of their patents considered essential, regardless of their specific quality. This paper aims at providing a detailed assessment of the role played by these two types of determinants. In order to do so, we analyze a set of patents that has been declared by their holders as being essential to the UMTS standard for mobile telephony / telecommunications. In order to identify the determinants affecting the probability will be claimed as essential, we have constructed a set of (non-essential) control patents that mirrors our essential patents in both technical subject and distribution over time. Following

Hedge, Mowery & Graham (2007), who have applied this approach to study the determinants of the decisions of firms of whether to apply for a continuation patent, we use a binomial logit model for assessing the determinants of essentiality declaration decisions.

3. Data

3.1 The case of UMTS

The UMTS standard is a third-generation (3G) standard for mobile telecommunications. It was designed as a successor to the successful, second-generation GSM standard. In addition to lowering the costs per call in comparison with earlier systems, UMTS was also designed to support multimedia mobile phones that can accommodate web-based applications and offer phone-based audio and video facilities. This required not only much higher transmission speeds than in earlier generations, but also much more flexibility: different users might require totally different speeds, and the speeds demanded by a given user may change a lot over time. To meet these requirements, new radio technologies had to be developed.

The first research and standardisation activities for UMTS commenced in the early 1990s, even before the first commercial GSM network was launched. Several research programmes funded by the European Commission studied suitable radio technologies, and one of this (in its last stage known as FRAMES FMA2) became the basis for what eventually became UMTS (for a more elaborate discussion, see Bekkers & West (2009). However, the 3G developments were largely ignored by GSM operators, who were focusing on increasing subscribers of their existing 2G systems (Garrard, 1998, p. 478). In 1997, Japan, whose first- and second generation standards never had any success outside its domestic market and whose manufactures had only a minimal role in supplying GSM products, attempted to leapfrog the other world regions by swiftly deciding upon a 3G standard and contracting both Japanese and other manufacturers to build test systems. In fact, the Japanese standards body ARIB specified a technology for this that was largely based on the outcome of the European FMA2 research programme. Not long after, Europe woke up, and its standards body ETSI decided (after some very controversial meetings) to select the same technology. Together with the Japanese ARIB and a number of other telecom standards bodies from other countries, the 3GPP partnership project was created to ensure that all participating standards bodies would adopt the same technology. The resulting standard is known as UMTS in Europe, as W-CDMA in most other areas of the world, and also as FOMA (Freedom of Mobile Multimedia Access) in Japan. (In the latter case, the technology is just employed on its own, while in most other areas of the world it is integrated into GSM networks.) UMTS is the most successful 3G standard, but not the only one. One competing technology is called cdma2000. It provides full backward compatibility with the second-generation cdmaOne standard, and for that reason it is mostly implemented in countries that implement this predecessor, particularly South-Korea and the United States (Seo, 2008). Its overall success, however, is limited. A third competitor is Time Division Synchronous Code Division Multiple Access (TD-SCDMA), developed in China with the help of some international companies like Siemens. The future success of this standard is unclear, and is likely to be limited to China itself at best.

For various reasons, UMTS is a particularly attractive case for assessing the determinants of essential patents in industry standards. First of all, it is a standard with a major economic relevance. The worldwide market for mobile telephony amounts to approx. 4 billion subscribers, of which 88% use GSM/UMTS phones (Informa, 2008 and GSM Association, 2009). The World Bank gives an estimate of global telecommunications spending of about 2.5% of global GDP percent in 1990 (Insight Research Corporation, 2009). Although not all of these phones yet support UMTS, their share in Europe is already around 70% and growing quickly (IDATE, 2007). Secondly, UMTS is an attractive case because in order to meet the design requirements, it included a number of radical technological solutions, representing a new technological trajectory in the area of telecommunications. Finally, and possibly most importantly, there is a large and complete database available of firms declarations indicating which of their own patents they consider essential to UMTS, and this database is publicly available. The availability of this type of data is a relatively rare occurrence in this field. For all these reasons, the UMTS case seems an almost ideal test bed for assessing the determinants of essential patents.

3.2 Data sources

In this study we use the latest available dataset containing all patents declared by their owners as essential to the UMTS standard. A database of all these declaration is made on-line by ETSI[2]; we have retrieved the relevant declaration in March 2008. These declarations are sent to ETSI by its individual members. As a matter of principle, ETSI does not have a role to judge these claims. In other words, there is no assessment of the "essential" nature of the content of these patents for UMTS technology. The database contains information on the patent owner, patent title, patent and application number, the (part) of the standard the patent related to, and the country of registration. However, the data and particularly the consistency of its format, leaves much to be desired (ETSI has currently embarked on a program to improve that). Since ETSI does not check this database on errors or duplicates, an extensive cleaning and sorting procedure is necessary to prepare the database for this study. The database we used was updated by ETSI in March 2008, and it contains 18,738 patents. 7,090 patents are essential to standards that are not relevant for our research, for example GSM, so the selection of essential patents is restricted to only those patents belonging to the projects related with UMTS. Withdrawn and inactive patents (88 in total) have been deleted from the selection.

The US patent application numbers from the ETSI database were matched with the list containing patent numbers from the NBER database (Hall et al., 2002). In this way it was possible to retrieve the patent information included in the NBER database (inventor, applicant, title, primary USPTO class, citations, etc.) The ETSI dataset contains patents registered in different countries and patent offices, but in this study we only use the USPTO patents. The reason for this choice is that for US patent citations are probably more representative of the quality of the patent, because in the US system, an applicant has a legal obligation to cite all relevant patents and prior knowledge (duty of candor). If a patent applicant fails to cite relevant patents, it can be sued and forced to pay fines. In Europe patent citation is more or less voluntary. An applicant cannot be punished for not citing relevant patents. (Criscuolo & Verspagen, 2005). As mentioned above, a number of studies such as Carpenter et al. (1981), Trajtenberg (1990) and Albert et al. (1991) have established that forward citations may be regarded as a valid proxy for the quality of patents in the US case.

In order to compare essential UMTS patents with non-essential patents we constructed a control set of comparable patents that are not claimed to be essential to UMTS. These are retrieved from the NBER US Patent Citations Data File. The original NBER (National Bureau of

[2] An on-line version of the ETSI IPR database can be found at http://webapp.etsi.org/ipr/.

Economic Research) data file comprises detailed information on almost three million U.S. patents granted between January 1963 and December 1999 and all citations made to these patents between 1975 and 1999 (over 16 million). (Hall et al, 2002). In this study we use an updated version of the NBER data file constructed by Bart Verspagen (see Fontana et. al., 2009 for another study employing this update version). This version contains patents granted up to the year 2003, including citations pairs. In order to make the non-essential patents comparable to the essential patents we have established a number of requirements the random selection queries procedures must satisfy. First, the patents in the control dataset should not occur in the list of essential UMTS patents, since we do not want any essential patents in the control dataset.[3] Second, the control dataset must contain the same proportions of patent classes as the set of essential UMTS patents (only patent classes, in which at least 3% a share of the essential patents is classified, are used to construct the control datasets). This ensures that essential UMTS patents are compared with a control set of non-essential patents covering the same technical fields. Table 1 shows the patent classes with shares higher than 3% of the essential patents group, and shows also the distribution of the essential and non- essential patent sets over different classes.

Table 1 classes for essential IPR (USPTO)

Primary Class Number	Primary Class Title	# patents in Primary Class	# essential patents in dataset (%)	# non-essential patents dataset (%)
370	Multiplex Communication	20831	225 (30%)	3194 (33%)
455	Telecommunications	18340	193 (26%)	2716 (29%)
375	Pulse or digital communications	16863	144 (19%)	2045 (21%)
704	Data processing: speech signal processing, linguistics, language translation, and audio compression/decompression	6197	48 (7%)	679 (7%)
714	Error detection/correction and Fault detection/recovery	13842	33 (4%)	469 (5%)
342	Communications: directive radio wave systems and devices (e.g., radar, radio navigation)	12434	32 (4%)	459 (5%)
Other Primary Classes	-	n/a	77 (10%)	0 (0%)
		88507	752 (100%)	9562 (100%)

Finally, the essential and non-essential patent set must cover the same time-periods. Since the oldest essential patents are from the year 1979, so the patents in the control dataset are from the period 1979-2003. This does not mean that the distribution of the patents over these periods is exactly the same for the control dataset and the dataset with essential patents. In fact, we expect the essential patents to have a later average application year, because UMTS technologies are relatively new.

[3] We should note that, since information on essential patents is scarce and incomplete, we cannot prevent that some essential non-UMTS patents (i.e., patents that are essential for other standards will be included in the control dataset. In other words, it may be that our control group will contain some patents that have been deemed as essential for other standards (for example GSM). This problem should not introduce a major bias in our results since the random query procedure has been applied to a very large patent population. A reasonable upper-bound estimate of essential patents for mobile telecom patents not claimed for UMTS is abound 2000 patents. Thus, we have an average upper bound probability of about 2% (2000/88507) that a patent in our control set would have been claimed essential in a non-UMTS standard.

Following these procedures, we have selected roughly 10.000 non-essential telecom patents. Our variable of interest is constructed as a dummy distinguishing essential from non-essential patents (0 = non-essential, 1 = essential). Appendix A contains a table with a complete list of variables names and their description. The variables provide information about application number, the patent owner (company code and company name), patent title, patent classification, patent application, issue and publication year, forward citations. The forward citations variable plays a key-role in this study, as it represents our indicator of the technological importance of each patent (Hedge et al, 2007). As mentioned in the previous section, we follow an established line of research relying on a number of studies that have established the existence of a positive correlation between forward citations and the technological importance. With technological importance we mean the value of the technological solution described in the patent for the technological field in question. We should note that the number of forward citations is not a good measure of technological importance when comparing patents of different ages. Clearly, older patents had more opportunities of receiving citations than younger patents, so they will typically have a higher number of forward citations than younger patents. This problem is aggravated by possible changes in patent and citation practices over time which may have repercussions on the number of forward citations (Hall et al. 2002, pp. 434-437). In order to deal with this issue we have carried out a "fixed-effect" adjustment of the number of forward citations by dividing the number of forward citations of each individual patent with the average number of forward citations of patents of the same application year. In this way, we have constructed an indicator of technological importance that can be used for comparing patents of different ages (Hall et. al. 2002, pp. 437-441). At this stage we have also decided to restrict our analysis to patents up to the year 2000, in order to further minimize problems related with the truncation of the forward citations of the most recent patents.

Further we have matched the applicant names of our patent data-set with the names of companies in the Compustat data-bank.[4] Our original patent data-set contained 2718 different companies names as applicants. By means of an extensive manual research on a number of internet sources (such as the United States Securities and Exchange Commission website) and on Compustat we have retrieved information on ownership structure and we have assigned patents applied by "daughters" to their respective "mother" companies. In this way we have reduced our applicant set to 1850 different companies. Concerning merger and acquisitions, we have taken 1999 as reference point: company that merged before that year were considered one company, company that merged after that year were two different companies in our data-set (at all events, this is not likely to affect our results in any major way) From Compustat and Company-Info we have then retrieved data on the yearly average number of employees, the average net-income and the average R&D expenditures over the period 1997-2001 for the companies included in our applicant set.

In order to capture the strategic involvement of companies in the standardisation we have constructed two additional variables. The first variable measuring strategic involvement is the voting weight in the standardisation process. Voting weights are assigned to companies in relation to the contribution fees to ETSI. In turn, these are based on declarations of the telecommunication-related revenues of companies. Voting weights are assigned in units and they may range from 1 to 45. Appendix C contains a table with contributing fees and voting weights in ETSI. The second variable we use here is a proxy for the involvement of firms in the standardisation process. Here, we use the number of work items within 3GPP supported

[4] For details on the contents of these two data-banks see respectively, http://www.compustat.com and http://company.info/help

by a given firm. This data has been collected by Bar & Leiponen (2008), who also describe the underlying 3GPP procedures with project coordination groups, technical specification groups, working groups, and work items. Of the over 300 firms that were 3GPP members in 2000, only 58 supported one or more work items, giving this variable a good spread. To sum-up, at the end of our efforts of data construction we have a data-set containing 10,314 USPTO patents, including 752 essential UMTS patents. For each of these patents we have proxies for its quality (captured by the adjusted number of forward citations) and for the strategic involvement of the patent owner in the standardisation process as captured by voting weights within ETSI or by the number of work items supported. Concerning the applicants, we have 1850 firms in our dataset, while the essential patents are owned by 50 firms.

3.3 Descriptive statistics

Table 2 shows the descriptive statistics for the most important variables. Essential is the binary variable that distinguishes essential from non-essential patents. The mean is obviously relatively low, because the dataset contains roughly ten times as many non-essential patents as essential patents. Firms that are not an ETSI member have 0 voting weight within ETSI whereas the maximum voting weight is 45. The maximum number of 3GPP work items supported by a firm is 34 (Ericsson), while the minimum is zero. Ericsson is also the company with the highest net income. Most patents have 0 forward citations, while USPTO patent 5103459 is the patent with the highest number of forward citations (617) . This essential patent is owned by Qualcomm and the title is "System and Method for Generating Signal Waveforms in a CDMA Cellular Telephone System". A perusal of the patent reveals that this is likely to be the key technology for CDMA. Qualcomm is also the firm with the most essential patents (208). The highest value for the fixed effect adjustment of forward citations of an individual patent by division with the yearly average is 70 (variable AdjCitations).

Table 2 Descriptive statistics

Variable name	#observations	Minimum	Maximum	Mean
Essential	10311	0	1	0,07
AdjCitations	10311	0	70	1,00
ApplicationYear	10311	1979	2002	1994,70
TotalPatents	10311	1	53595	14989,50
TechnologicalConcentration	10155	0	1	0,10
VotingWeight	10311	0	45	12,41
WorkItemsSupports	10311	0	34	7,48
NetIncome	7692	-1632	11622	2025,50
R&DExpense	7529	1	25472	3758,06
Employees (x1000)	5824	0	468	123,22
PatentCitationsIncoming	10311	0	617	9,44
EssentialPatents	10311	0	208	24,02
FirmCitationRatio2000	10275	0	70	1,02

Figure 1 shows the 12 firms with the highest number of essential UMTS patents. The US-based, technology-only firm Qualcomm owns 208 essential UMTS patents, which is more than 25% of all patents declared to the standard. Qualcomm is the developer of Code Division Multiple Access (CDMA). The implementation of a W-CDMA air interface in the UMTS standard accounts for Qualcomm's high number of essential patents (Bekkers & West, 2009b).

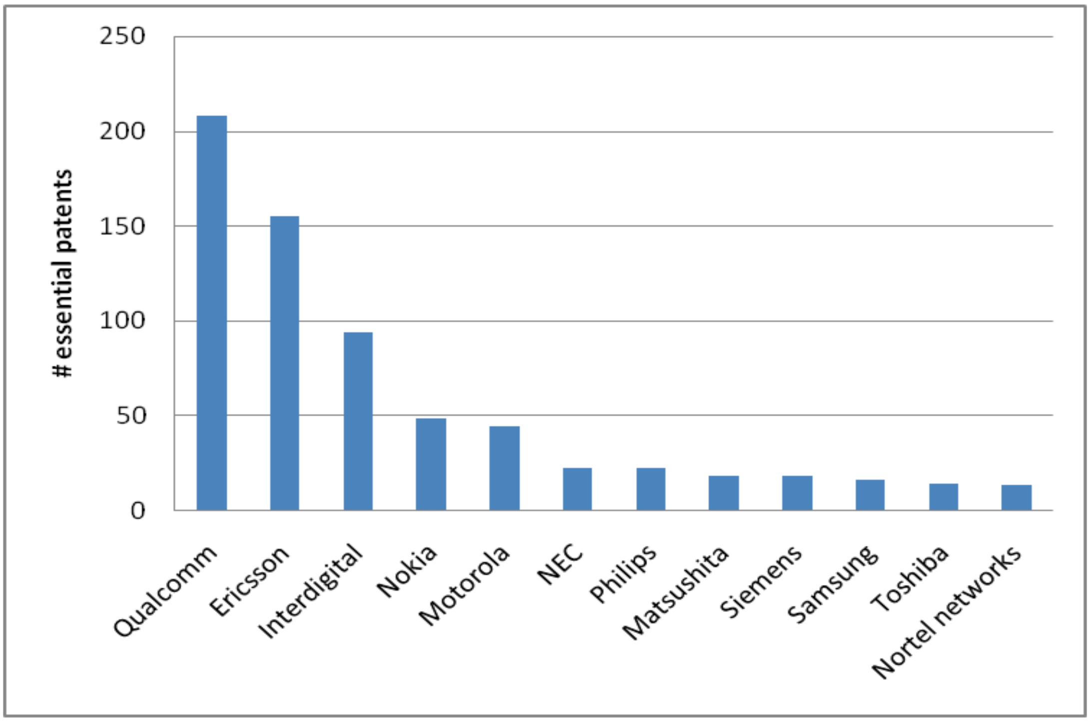

Figure 1 Essential UMTS patent owners

The Swedish company Ericsson is on the second place with 155 patents. Its core business moved from the production of mobile phones in the 1990s to the development and production of the cellular infrastructure. The third place (94 patents) is held by Interdigital, another US-based technology-only firm. Interdigital sells and licenses its patented technologies to other firms in the telecom industry. The global market leader in producing cell phones, Nokia, is on the fourth place with 48 essential patents.

Figure 2 shows the timing of patent applications for the five firms owning the highest number of essential UMTS patents. The series of Qualcomm has an early peak, which may be related with the period of the development of CDMA, which is the predecessor of the underlying air interface for UMTS.

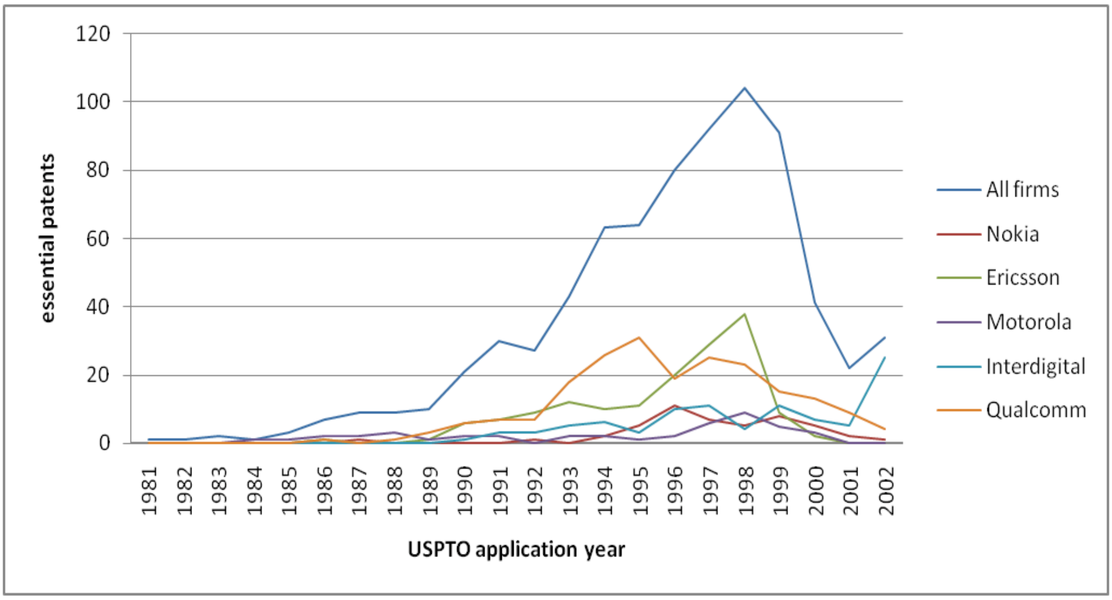

Figure 2 Timing of essential patents by telecom market leaders

Table 3 compares the technological importance of the firms' portfolio of essential patents with that of non-essential patents. The technological importance of the firm patent portfolio has been computed as the average of the "fixed-effect" adjusted number of forward citations of the patents belonging to the firm portfolio. Table 3 considers four different periods and contains the 14 firms with most essential UMTS patents. The hypothesis that the technological importance of a firm's essential patent portfolio is higher than its non-essential patent portfolio is confirmed by these figures. Most of the average essential patent portfolios have an average citation ratio higher than 1, while this value is lower than 1 for most of the non-essential patent portfolios. Siemens is the only firm for which the technological importance of its essential patents is lower than 1 (which means that its essential patents have less forward citations than the yearly average). Siemens' essential UMTS patents have an average citation ratio of 0.84. This might suggest that Siemens has used a suspicious patenting strategy, concerning its UMTS patents, claiming as essential patents of below average quality. However, we should notice that table 3 indicates that also Siemens' non-essential patents are of lower importance as well. Another explanation for Siemens' low importance of essential UMTS patents might be that Siemens was one of the firms that focused on the development of TD-SCDMA. Siemens, together with Alcatel, tried to convince ETSI to choose TD-SCDMA as the underlying air interface for the UMTS standard. So ETSI's choice for the competing W-CDMA technology in 1999 might be a reason for Siemens' low importance of essential UMTS patents.

Table 3: Average technological importance of the firm patent portfolio (USPTO patents)

	Essential UMTS patents				**Non-essential telecom patents**			
Company name	**1986-1990**	**1991-1995**	**1996-2001**	**all**	**1986-1990**	**1991-1995**	**1996-2001**	**All**
Qualcomm	10,27	3,01	2,98	3,21	-	1,36	1,38	1,32
Nokia	3,14	1,15	1,28	1,21	1,74	1,00	1,05	1,05
Ericsson	1,64	1,93	2,28	2,14	1,45	1,28	1,00	1,05
Interdigital	4,44	1,77	1,35	1,46	-	0,79	0,46	0,59
Siemens	-	0,67	0,84	0,84	0,33	0,52	0,60	0,56
Motorola	4,25	1,62	1,29	2,25	1,10	0,79	0,95	0,94
Samsung	-	0,79	1,80	1,74	0,27	0,83	0,56	0,57
Philips	3,96	0,41	0,51	1,62	0,71	0,49	0,54	0,55
NEC	3,90	0,43	2,76	2,31	0,66	0,59	0,43	0,56
Alcatel	-	1,18	1,14	1,15	0,67	0,62	0,69	0,66
NTT	-	-	-	-	1,09	0,96	1,30	1,11
Nortel	-	0,76	3,10	2,71	1,09	1,15	1,12	1,12
Matsushita	-	1,36	0,98	1,09	0,77	0,67	0,63	0,65
Toshiba	0,89	0,56	0,00	0,71	0,54	0,77	0,96	0,80

Table 4 reports a preliminary assessment of the differences between the samples of essential and non-essential patents. Since our variables of interest (in particular the adjusted forward citations) are skewed and not normally distributed we use a non parametric Mann-Whitney test. Table 4 compares the adjusted number of forward citations, our proxy for the technological importance of the patent and the WorkItemsSupported and the VotingWeight within ETSI, our proxies for the influence of a specific firm in the standardisation process, for essential and non-essential patents. Interestingly enough, the Mann-Whitney tests in table 4, seem to indicate that essential patents are characterized by a significantly higher number of adjusted forward citations, and *at the same time,* are also owned by companies with higher voting weights or supporting more work items within ETSI. In other words, this preliminary evidence suggests that both the intrinsic quality of the patent and strategic considerations by companies do play a role as determinants of essential patents.

Table 4: Mann-Whitney test for differences between essential vs. non-essential patents

Variable name	mean rank non-essential patents	mean rank essential patents	Asymp. Sig. (2-tailed)
AdjCitations	5017	6919	0,000
WorkItemsSupported	4975	7461	0,000
VotingWeight	4965	7588	0,000

3.4 Multivariate Analysis

In this section we probe further into the possible determinants of essential patents estimating a number of logit regression models. Our dependent variable is the dummy Essential which is 1 when the patent is essential and 0 when the patent is non-essential. Table 5 contains the results of eight regression models, having the binary variable Essential as the dependent variable. AdjCitation and WorkItemsSupported are the key explanatory variables in this regression exercise, since we want to assess the influence of technological importance and firm strategies respectively on the essentiality of a patent. The other independent variables are included as control variables. The coefficients for both AdjCitation and VotingWeight are significant at 1% level in all regression models. Although the results show some small differences in the coefficients of the explanatory variables, overall the estimated coefficients remain stable across the different specifications. Table 5 shows a coefficient of about 0.16 for AdjCitation. If we compute the odds ratios this implies that a one-unit increase of AdjCitation, leads to a 17% increase in probability of the patent being claimed essential odds for Essential to be 1. Note that an increase of AdjCitation from 1 to 2 means that the patent is cited twice as much as the average of all patents of the same publication year.

For the other explanatory variable in Table 4, WorkItemsSupported, we also find a significant and positive influence on the dependent variable Essential. The coefficient is stable with value of around 0.06, which implies that the odds for Essential (j= 1) will increase with 6% for a unit increase of WorkItemsSupported. This indicates that essential patents are more often owned by firms that are supporting more work items in the standardizing process, compared to non-essential patents.

Table 5 Logit Regressions (Dependent variable: Essential)

	1 (j=1)	2 (j=1)	3 (j=1)	4 (j=1)	5 (j=1)	6 (j=1)	7 (j=1)	8 (j=1)

AdjCitation	0,177 [0,018]**	0,161 [0,015]**	0,155 [0,014]**	0,158 [0,014]**	0,159 [0,014]**	0,169 [0,014]**	0,161 [0,014]**	
WorkItemsSupported	0,090 [0,009]**	0,048 [0,005]**	0,060 [0,004]**	0,059 [0,004]**	0,058 [0,003]**	0,056 [0,003]**		0,054 [0,003]**
NetIncome	0,000 [0,000]**	0,000 [0,000]						
Employees	0,004 [0,002]*							
HHI	7,368 [0,733]**	8,085 [0,606]*	2,693 [0,338]**	3,232 [0,299]**				
TotalPatents	0,000 [0,000]*	0,000 [0,000]	0,000 [0,000]**		0,000 [0,000]**			
Asia	-2,075 [0,287]**	-0,319 [0,168]	-0,302 [0,142]*	-0,424 [0,135]**				
Europe	0,285 [0,164]	0,018 [0,156]	-0,169 [0,121]	-0,177 [0,119]				
ApplicationYear	0,035 [0,014]*	0,004 [0,011]	0,017 [0,010]		0,023 [0,010]*			
R&DExpense	-0,001 [0,000]**							
Constant	-72,386 [27,120]**	-12,105 [22,494]	-37,333 [20,600]	-3,646 [0,091]**	-48,708 [20,227]*	-3,412 [0,066]**	-2,763 [0,045]**	-3,171 [0,060]**
Number of observations	5480	7518	9549	9549	9550	9550	9550	9550
Model Chi square	646,931	713,220	626,537	612,208	564,010	482,889	151,142	329,436
Model df	10	8	7	5	4	2	1	1
Model significance	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Loglikelihood	2555,579	3692,507	4333,412	4347,741	4396,089	4477,000	4808,957	4630,663
Nagelkerke R square	0,252	0,204	0,157	0,153	0,142	0,122	0,039	0,084
*significant at 5% **significant at 1%								

Next to the explanatory variables, some of the control variables seem to have significant influence on the dependent variable. The Herfindahl-like index is computed over the technological classes of the owner of the patent and it is used here as a proxy for the technological diversity of firms, has significant and positive influence on Essential. This indicates essential patents are much more often owned by firms whose patent portfolio is technologically concentrated, compared to non-essential patents. Net income, the number of employees, the number of patents and R&D expense has significantly no influence. So the size of the company does not seem to matter.

Table 6 Logit Regressions (Dependent variable Essential)

	1 (j=1)	2 (j=1)	3 (j=1)	4 (j=1)	5 (j=1)	6 (j=1)	7 (j=1)	8 (j=1)
CitationRatio	0,139 [0,019]**	0,143 [0,016]**	0,141 [0,014]**	0,145 [0,014]**	0,155 [0,014]**	0,165 [0,014]**	0,161 [0,014]**	
VotingWeight	0,092	0,089	0,089	0,089	0,051	0,052		0,051

	[0,006]**	[0,005]**	[0,005]**	[0,005]**	[0,002]**	[0,002]**		[0,002]**
NetIncome	0,000 [0,000]**	0,000 [0,000]						
Employees	0,007 [0,001]**							
HHI	12,421 [0,929]**	11,559 [0,800]**	4,333 [0,378]**	4,800 [0,340]**				
TotalPatents	0,000 [0,000]	0,000 [0,000]	0,000 [0,000]**		0,000 [0,000]**			
Asia	-1,152 [0,269]**	0,439 [0,186]*	0,436 [0,159]**	0,315 [0,152]**				
Europe	-1,556 [0,196]**	-1,635 [0,188]	-1,441 [0,143]**	-1,451 [0,142]*				
ApplicationYear	0,013 [0,014]	-0,009 [0,012]	0,006 [0,011]		0,019 [0,010]			
R&DExpense	0,000 [0,000]**							
Constant	-31,171 [28,641]	12,764 [24,141]	-15,501 [21,893]	-4,687 [0,136]**	-40,412 [20,891]	-3,788 [0,078]**	-2,763 [0,045]**	-3,548 [,072]**
Number of observations	5480	7518	9549	9549	9550	9550	9550	9550
Model Chi square	823,407	980,489	925,358	916,968	738,174	674,411	151,142	531,681
Model df	10	8	7	5	4	2	1	1
Model significance	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Loglikelihood	2379,104	3425,239	4034,590	4042,981	4221,925	4285,687	4808,957	4428,418
Nagelkerke R square	0,315	0,276	0,228	0,226	0,184	0,168	0,039	0,134
*significant at 5% **significant at 1%								

Table 6 presents 8 regression models with the explanatory variables AdjCitation and VotingWeight. In this case we use VotingWeight as a proxy of the strategic determinant of essential patents. The coefficients of AdjCitation are fully in line with those estimated in the models of table 5. VotingWeight has also a significant and positive influence on Essential. However, the estimate of the coefficient does not appear to be stable across specifications. This is probably caused by some multicollinearity between VotingWeight, R&DExpense and the dummy variable Europe (for Europe based firms). Overall we have an estimated coefficient of 0.05 for this explanatory variable. This implies that a one-unit change in VotingWeight, leads to a 5% increase of the odds of Essential (j=1). So also the firms' voting weight in ETSI is related to the essentiality of their patents for the UMTS standard.

4. Conclusion and discussion

The question of what makes companies claim that their patents are essential for a technical standard is a fascinating one. If this is a result of the technical merits of the patented technology (attributing value to the standard, such as increased performance, better cost effectiveness, etc.), there should be no concern. However, if patents are claimed to be essential as a result of the strategic behaviour of the participants in standards bodies, but have no merit in themselves, we have a different story. It can be argued that this would be undesirable from the public perspective and incompatible with the fundamentals of standards. It would unnecessarily hamper access to standards and create barriers to their use and adoption and it would increase the costs. While reliable data on actual IPR costs are hard to find in the public domain, several sources report 'multiple-digit' fees. For GSM, the predecessor of UMTS, the director of the European public Telecommunications Network Operators' association (ETNO) revealed that that royalty fees make up to 29% of the costs of GSM handset (Taaffe, 2000). Some industry analysis claim that "Estimates for cumulative royalties for WCDMA are between 25% to 30% and the mobile industry could spend US$80-100 billion on WCDMA-IP-royalty payments up to 2017" (Poropudas, 2006). Although these are likely to be upper bound estimates (and also those parties that are involved in cross-licensing agreement will pay less), these numbers illustrate the substantial sums of money involved and the possible burden they are for a market if they do not provide technical merit.

Our study on the determinants of essential patent claims shows that in the UMTS case the reality is on neither of the two extremes. While these findings are in line with several other studies, that provided evidence for the existence both effects. To the best of our knowledge, this is the first study that studies both effects simultaneously.

Assuming that forward citations do reveal patent value, we conclude that technical merit is a significant determinant of claims of essentiality. We find a positive, significant and robust relation, and looking at the data itself we indeed observe sets of patents that have a higher than average value while its owner (Qualcomm) was not actively participating in the standards body in question at the time the technology was decided upon.[5] These patents obviously became essential because of their technical merit. (In fact, most of the different UMTS candidate technologies put forward in 1999 relied on that same technology, see Bekkers (2001) for a detailed account.) If we take the patents of Qualcomm out of our database, we see that the influence of the technical importance of patents on essentiality becomes smaller, while at the same time the remaining firms show an even stronger strategic behaviour. So Qualcomm's patents are of high technical importance, and this firm is not behaving strategically in the standard setting process.

Assuming that the voting weight that a firm has in the standards body, and the actual involvement in the standards drafting process (captured by registered 'work item support'), are both proxies of the opportunities for involvement and influencing the content of the standard, we conclude that strategic involvement is also a significant determinant of claims for essential items. Being an active member helps to get more essential patents, regardless their technical quality.

Of course, our analysis is based on a single case-study of a specific technology. An obvious direction of further research would be to replicate this type of analysis for other standardization processes. In this way it would be possible to check to what extent our findings may be generalized.

Our work has some policy implications. Although it would be an ungrounded claim that IPR claims are solely the result of strategic gaming, participants still do systematically influence the content of the standard in the direction of their own patented technologies, valuable or not. Although it would be hard to imagine a world where such things do not take place at all,

[5] In the 1990s, a European subsidiary of Qualcomm was member of ETSI, but it is clear that this cannot be prepared in any way with the influence that the large participant in ETSI had.

it may be argued that on the basis of welfare effects, society would benefit from a process with more feedback loops, where the technical inclusion of certain (patented) technologies in standards is part of a conscious and well-considered process. Such inclusions currently take place in relatively small technical groups where it is likely (and maybe unavoidable) that 'kind turns' take place – if you allow me to move a trivial patent in, I will allow you to do the same thing. SDO's, as well as other stakeholders (such as the public authorities that recognise these bodies) would do well to study the technical inclusion processes and consider redesigns, for instance by introducing new incentives and safeguards. Also voluntary ex-ante licensing, a process in which IPR holders can choose to reveal their licensing conditions before the technology gets included, may help to promote more conscious technological inclusion discussions. A more far-reaching policy would be that for each known IPR to be included, a formal assessment is performed about the alternatives and their relative costs and benefits (including non-patented alternatives).

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Appendix A Variables

Essential	Dummy variable: 1= essential patent, 0 = non-essential patent
adjCitationRatio	Total of citations received by patent, divided by average of received citations of all patents from same year
ApplicationYear	Year of patent application at USPTO
Primaryclass	Patent classification USPTO
NorthAmerica	Dummy variable: 1 = Canada, United States
Europe	Dummy variable: 1 = all European countries including Israel
Asia	Dummy variable: 1 = Asian countries
TotalPatents	Total number of patents per firm
EssentialPatents	Number of unique essential patents in EPO list and USPTO list (EPO plus USPTO minus EPO-USPTO equivalents)
VotingWeight	Firm's voting weight in ETSI
HighVotingWeight	Dummy for firms with highest voting weight (voting weight = 45)
WorkItemsSupported	Number of work items supported by firms in 3GPP meetings, 2000-2003
TechnologicalConcentration	Normalised Herfindahl Index (values between 0 and 1), measuring firm's patent distribution over patent classes
FirmCitationRatio_all	Firm's average patent citation ratio for all patents in USPTO list up to application year 2000
FirmCitationRatio_essential	Firm's average patent citation ratio for essential patents in USPTO list up to application year 2000
FirmCitationRatio_non-essential	Firm's average patent citation ratio for non-essential patents in USPTO list up to application year 2000
Employees	Firm's average number of employees in the period 1997-2001, x1000 employees, according to Compustat database
NetIncome	Firm's average net income in the period 1997-2001, x$100.000 according to Compustat database
R&DExpense	Firm's average R&D expense in the period 1997-2001, x$1000 according to Compustat database

Appendix B Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Essential**	1													
2	*AdjCitation*	0.152**	1												
3	*VotingWeight*	0.249**	0.042**	1											
4	*HighVotingWeight*	0.148**	0.009	0.825**	1										
5	*WorkItemSupports*	0.208**	0.024*	0.782**	0.663**	1									
6	ApplicationYear	0.071**	-0.012	0.117**	0.09**	0.103**	1								
7	Europe	0.097**	-0.030	0.613**	0.748**	0.445**	0.011	1							
8	Asia	-0.097**	-0.079**	-0.275**	-0.237**	-0.168**	-0.016	-0.309**	1						
9	NorthAmerica	0.005	0.095**	-0.262**	-0.408**	-0.218**	0.006	-0.552**	-0.62**	1					
10	TotalPatents	-0.066**	-0.06**	0.132**	-0.017	0.114**	-0.075**	0.032**	0.355**	-0.336**	1				
11	HHI	0.081**	0.050**	-0.109**	-0.003	-0.091**	0.117**	-0.005	-0.239**	0.213**	-0.427**	1			
12	Employees	-0.166**	-0.074**	0.025	0.018	0.132**	-0.128**	0.097**	0.157**	-0.206**	0.773**	-0.498**	1		

13	NetIncome	0.097**	0.039**	0.452**	0.609**	0.480**	0.029**	0.540**	-0.336**	-0.157**	0.075**	0.104**	0.466**	1	
14	R&D-Expense	0.141**	0.039**	0.609**	0.667**	0.689**	0.105**	0.586**	-0.306**	-0.222**	-0.079**	0.149**	0.634**	0.806**	1

Appendix C ETSI Annual Contribution Fees

Electronics Communications Related Turn Over (ECRT) (Euro)	Voting weight (‘units’)	Annual contribution fee (Euro)
SMEs, user and trade associations, additional membership	1	6.000
Micro-Enterprises	1	3.000
Universities, public research bodies and not-for-profit user associations	1	2.000
Up to 135 million	2	9.380
136 to 200 million	3	12.760
201 to 450 million	6	22.900
451 to 700 million	9	33.040
701 to 1,350 million	13	46.560
1351 to 2,000 million	18	63.460
2,001 to 3,500 million	24	83.740
3,501 to 5,000 million	30	104.020
5,001 to 8,000 million	37	127.680
Above 8000 million	45	154.720

Source: ETSI website, 2008