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## **Just-in-time inventions and the development of standards: How firms use opportunistic strategies to obtain standard-essential patents (SEPs)**

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### **Abstract**

Recent years have seen large-scale litigation of standard-essential patents. Such patents are particular because they are, by definition, indispensable to any company wishing to implement a technical standard. Firms that do not own such patents are prepared to spend billions of dollars purchasing them. It is an interesting question how firms obtain such patents in the first place, and to what degree this depends on those firms' standardization strategies. This paper presents an in-depth investigation on the standardization process of the successful W CDMA and LTE standards for mobile telecommunications. We studied the first 77 meetings where these standards took shape, covering a period of over 12 years, and identified the patenting behavior of each of the 939 individual participants attending these meetings, as well as the patenting behavior by non-participants, together resulting in over 14,000 patents for this technology. We observed a remarkable phenomenon that we call 'just-in-time-inventions': the patent intensity of about-to-be claimed essential patents is much higher during or just before these meetings than in other periods. At the same time, they are of considerably lower technical value ('merit?'). This suggests that the just-in-time inventions are only beneficial to their owners, whereas for the public they merely invoke unnecessary costs. Finally, we observed that the phenomenon of just-in-time inventions is highly concentrated among specific types of firms, above all vertically integrated ones, and the incumbent champions of the previous technology standard. We believe our findings have several implications for standard setting organizations and policy makers alike.

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### **Abstract**

Recent years have seen large-scale litigation of standard-essential patents. Such patents are particular because they are, by definition, indispensable to any company wishing to implement a technical standard. Firms that do not own such patents are prepared to spend billions of dollars purchasing them. It is an interesting question how firms obtain such patents in the first place, and to what degree this depends on those firms' standardization strategies. This paper presents an in-depth investigation on the standardization process of the successful W-CDMA and LTE standards for mobile telecommunications. We studied the first 77 meetings where these standards took shape, covering a period of over 12 years, and identified the patenting behavior of each of the 939 individual participants attending these meetings, as well as the patenting behavior by non-participants, together resulting in over 14,000 patents for this technology. We observed a remarkable phenomenon that we call *'just-in-time-inventions'*: the patent intensity of about-to-become claimed essential patents is much higher during or just before these meetings than in other periods. At the same time, they are of considerably lower technical value ('merit'). This suggests that the just-in-time inventions are only beneficial to their owners, whereas for the public they merely invoke unnecessary costs. Finally, we observed that the phenomenon of just-in-time inventions is highly concentrated among specific types of firms, above all vertically integrated ones, and the incumbent champions of the previous technology standard. We believe our findings have several implications for standard setting organizations and policy makers alike.

### **Introduction**

Recent years have witnessed an explosion of lawsuits about patents primarily built on standards: smartphones and mobile phones, tablets, personal computers, video consoles, and more. Many well-known companies like Apple, Samsung, Motorola, Nokia, Google, HTC, Microsoft, Kodak, and Research in Motion are involved. And this situation might be further exacerbated by the appearance of non-practicing entities (NPEs). Such companies are found to be particularly keen on acquiring patents in the above industries (Fischer et al., 2012). In these cases, a particularly important role is reserved for so-called Standard Essential Patents (SEPs), also simply referred to as essential patents. These patents are by definition required in order to implement a given standard. Consequently, any company implementing that standard will by definition infringe on such patents unless it has a licensing agreement with the patent owner. Because essential patents are particularly powerful and may give rise to abuse, such as refusal to license and hold-up pricing (Shapiro, 2001; Lemley et al., 2007), standard setting organizations created special regimes under which essential patent holders are requested to disclose these patents and commit themselves to license essential patents to any implementer of the standard on the basis of fair, reasonable and non-discriminatory (FRAND) prices and conditions. Many of the lawsuits are actually about these licensing commitments.

Companies owning SEPs have a range of benefits, such as revenue generating opportunities (every implementer of the standard is by definition infringing and thus a potential licensee), a good bargaining position for cross licenses gaining access to both SEPs and non-SEPs, and more. Also on a higher level, Blind et al. (2011b) found that the ownership of essential patents boosted firms' financial returns, and Aggarwal et al. (2011) provide empirical evidence of the influence on stock market returns. Given the attractiveness of owning such patents, it will come as no surprise that companies that do not have any (or believe they have too few) regularly try to purchase them, often at quite astonishing prices. We will give two examples here. In 2010, a consortium that included Apple, Microsoft and RIM acquired a significant part of the patent portfolio of the former Canadian firm Nortel for US\$ 4.5 billion. This portfolio is believed to contain a large number of essential patents for 4G technology, among other standards. In 2011, Google purchased Motorola Mobility for US\$12.5 billion, and many believed this was mainly done to acquire ownership of the company's patent portfolio. These transactions are probably the best illustration of the value that companies attach to essential patents, even though we have to bear in mind that in both examples, the portfolios obviously also included non-essential patents.

But how do companies obtain essential patents in the first place? To answer this question, we need to go back to the standardization process. Most standards are developed in open standard setting organizations, using a set of rules, of which consensus among the participants is an important one. In principle, any interested party can become a participant. In the case of telecommunications or IT technology, it is usually the companies that participate. At Technical Committee (TC) or similar meetings, they discuss technical approaches in order to meet the standards' design requirement and eventually determine – on the basis of consensus – the final version of the standard. The Technical Committee may include technologies patented by the participants, but may also (knowingly or not) incorporate technologies covered by others' patents. For many modern telecommunications or IT standards, it is not unusual that the final standards incorporate many patented technologies, sometimes up to thousands – these are the essential patents. Inclusion of such patented technologies can be a good thing, as these may improve the standards' performance, cost-effectiveness, or environmental friendliness, to name but a few things. In such cases, the cost of essential patents (licensing costs but also the resource-consuming licensing negotiation processes) may be worth the additional value of the standard. However, if such patents are included without contributing substantially to the standards' value, it could be considered suboptimal from the public perspective (yet perhaps optimal from the individual patent owner's perspective).

In recent years, several insiders have raised the issue of such undesirable inclusion of patented technologies. Some insiders have even expressed concerns over this process, whereby parties can propose technologies *“just for getting patented technology into the standard rather than to improve the standard [...] No mechanism exists to determine whether a patent claim brings a standard forward (real innovation) or just tries to get a patent into the standard in order to make money.”*<sup>1</sup> One such strategy was recently

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<sup>1</sup> Presentation by Dirk Weiler (Chairman of the ETSI General Assembly and Chairman of ETSI's IPR Special Committee) titled 'Standards Related Patent Quality: A view from a standardisation organization. Presented at the EC/EPO Workshop on “Tensions between intellectual property rights and standardization: reasons

outlined at a conference by the former director of a large multinational's research lab, who explained how in his firm, new patent applications were prepared on the basis of contributions of other firms.

In this study, we call the phenomenon of strategically filing patents during or just before standardization meetings, 'just-in-time' inventions, which result in 'just-in-time patents'. We highlight the differences in patent filing between those who participated in the standardization meetings, and those who did not. Section 2 starts by discussing previous literature on essential patents and the way they came into existence. In Section 3 we discuss the standardization process and develop hypotheses concerning just-in-time inventions. In Section 4 we introduce our data and present our findings. In Section 5 we close with conclusions and a discussion.

## **2. Existing literature on standard essential patents**

In the past two decades, there has been an increasing interest and amount of literature on standards in patents. In this section, we will review that literature, and identify what we consider as the relevant remaining gaps in that knowledge.

The existing literature is varied in its nature and can, roughly speaking, be divided into the following categories: (1) the existence of standard essential patents, (2) features of standard essential patents, (3) effects of standard essential patents on the standardization process, (4) effect of standard essential patents on the market (including antitrust/competition concerns), and, finally, (5) firm strategic behavior regarding standard essential patents. We will briefly review these bodies of literature.

**The existence of standard essential patents.** Over time, researchers and policy makers became increasingly aware of the phenomenon of patents in standards. While initial insights were on a case by case basis, the first more systematic approaches to understand this phenomenon were performed by Rysman & Simcoe (2008), who also created a public database known as [ssopatents.org](http://ssopatents.org). A few years later, a large-scale empirical fact-finding study commissioned by the European Commission (Blind et al., 2011a) showed that the standards developed by eleven of the largest standard setting organizations incorporated well over 4000 (claimed) essential patent families, yet the distribution is very skewed – both between standards and in ownership. Since not all these standard setting organizations require their members to disclose the identity of every individual essential patent (family) they own, the actual number is probably considerably higher. In 2012, several researchers in this area took the initiative to develop a large, up to date database of standard essential patents, which is in fact also one of the main data sources for this study (Bekkers et al., 2012).

**Features of SEPs.** A second line of research has investigated in what respect standard essential patents are 'different' from regular patents. Rysman and Simcoe (2008) observed that, on average, essential patents have a higher forward citation score than comparable, non-essential patents. This could be interpreted as standard being able to

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and remedies". Brussels, November 22, 2010. Available from [http://ec.europa.eu/enterprise/sectors/ict/files/ict-policies/5\\_weiler\\_en.pdf](http://ec.europa.eu/enterprise/sectors/ict/files/ict-policies/5_weiler_en.pdf).

select and integrate valuable technologies. While these are important findings, we should bear in mind that there are still key issues on cause and effect; for instance, patents may receive additional citations after they are included in a standard. If the standard is successful in the marketplace (or is expected to be so), then companies will direct their R&D efforts towards inventions related to that standard (either as complementary technology, or perhaps essential patents for future generations of that standard); with such directed R&D efforts, the likelihood that essential patents are cited increases. These efforts can result in the problem of endogeneity, and while such problems are difficult to correct, Rysman and Simcoe (2008) try to do so by comparing the received citations before and after the patent was disclosed by its owner as being essential to the standard.

**Effects of SEPs on the standardization process.** In various ways, the existence of essential patents can have an impact on the standardization process as such. Among other things, there is the problem that a single patent can fully block the standardization processes, potentially creating a need to halt work altogether, or withdraw an issued standard (see Farrell et al. 2007). But there are also more indirect effects. Dokko and Rosenkopf (2010), for instance, have shown how companies owning patents have a greater influence on the decisions in standardization processes. The existence of standard essential patents may also have an impact on the lifetime of standards. In a recent paper, Baron et al. (2012) provide evidence that essential patents reduce the likelihood of standard replacement. As such, the authors argue, essential patents may lead to a “lock in” of outdated standards, rather than encourage investment and increase the pace of standardization.

**Effect on the market and antitrust/competition.** Perhaps even more challenging are the effects essential patents have on the market that is served by these standards. In fact, such effects are the main legitimacy of the specific rules many standard setting organizations have adopted for such patents (see Section 3). Among the concerns are patent hold-up, royalty stacking, and ambush/patent blocking (Lemley & Shapiro, 2007). Given such concerns, there is an increasing amount of policy literature on antitrust/competition aspects and other consequences of strategies with SEPs, which is well summarized in a recent special issue of the Antitrust Bulletin (see Besen & Levinson, 2012), the book of the American Bar Association on the Antitrust Aspects of Standards Setting (Kobayashi & Wright, 2010), and the 2011 US Federal Trade Commission report, The Evolving IP Marketplace (FTC, 2011). Others, however, stress that there is no direct evidence for royalty stacking and note that licensing rates are typically high in the industries in question, which is not necessarily a consequence of stacking (e.g. Geradin et al. 2008).

**Firm strategies with regard to SEPs.** The body of literature most closely related to the focus of our paper, and perhaps also the most fascinating part, concerns research on firm strategies for essential patents. Since few now doubt the huge attractiveness of owning such patents, how do companies obtain them? To what degree do they reflect genuine R&D and contribution of knowledge with a high technological merit (a strategy in itself), and to what extent are they the result of their owners’ specific conduct? And what is this conduct exactly? In her study on the standardization of the 3G W-CDMA standard, Leiponen (2008) focuses on the role of private alliances, highlighting industry consortia. By being part of such alliances and consortia, firms increase their chances of

having their own (patented) technical contributions accepted in the standard. Bekkers et al. (2011) studied the determinants of patents being (claimed) essential. They found that patents with a high value ('technical merit') have an increased likelihood of becoming (claimed) essential, but the patent owner being an active participant was a much better determinant. One possible strategy is that firms use continuation patents in order to obtain patents that are essential to technical standards, as argued by Omachi (2004). Along the same line of thought, Berger et al. (2012) find that patent applications that are eventually disclosed as being standard-essential, are amended more often than other, otherwise comparable patents. Arguably, firms amend these patents to add claims to the patents that will eventually be essential to implement the standard.

Taking into account the current literature on patents and standards, we appreciate the wide variety and depth, but also conclude that knowledge on how companies obtain essential patents in the first place, examining in more depth their actual conduct during the standardization process as such, remains scarce. This is the gap in the literature our contribution aims to address.

### **3. Hypotheses on essential patents and the standardization process**

Standardization is a voluntary process, where interested parties come together and aim to reach a consensus on the exact content of a standard. These interested parties may include companies that are prospective implementers of the standard, as well as technology developers, end users, intermediate users (such as network operators in telecommunications), component suppliers (such as manufacturers of chip sets or software), and more. Also public entities like national governments may participate. Obviously, different participants may have different preferences, depending on their own (market) situation, their technological strengths and weaknesses, preferences of their clients, and so on.

Standard setting organizations were established to facilitate the standardization process, but it is important to stress that standards are created by participants, not standard organizations themselves. To secure basic principles such as openness, neutrality, and to ensure their activities are not considered as collusive or anti-competitive by competition or antitrust authorities, standard setting organizations have developed sets of rules, which are usually binding upon their members or participants. Rules about patents that are essential to implement their standards are usually known as the so-called IPR rules or IPR Policy. Usually these include requirements to disclose essential patents (i.e. informing the standard setting organization (SSO) when a party believes it owns such patents) and requests to make a commitment to license such patents at certain conditions (such as F/RAND: Fair, Reasonable and Nondiscriminatory conditions). Nevertheless, there is quite some variance in the exact rules applied by various SSOs. Lemley (2002) was among the first to analyze this institutional variety, whereas Chiao et al. (2007) empirically explored standard-setting organizations' policy choices. A comprehensive and up to date review is provided in a recent report commissioned by the US National Academies of Science (Bekkers & Updegrave, 2012).

As discussed in the introduction, an essential patent is one that covers a technology that is indispensable in order to produce a device that implements the standard; there is

simply no alternative but to use this patented technology. So essentiality depends on the exact scope of the patent (the language in the patent claims) and on the exact content in the standard (the wording of its specifications). So when do patents become essential? Different situations are conceivable. Firstly, the people drafting a standard may include a technology that was already developed and patented long before discussions on the standards began. They might do so because they realize this patented technology is the best way or even perhaps the only way to create a standard with agreed functional specifications. It might increase performance, be cost-effective, save energy consumption, etc. Patented technologies with extraordinary technical merit are likely to be recognized by all participants and do not necessarily require the patent owner to participate in 'pushing' the patent in. Secondly, technical challenges or trade-offs can arise while working on the standard, and participants perform R&D and use their knowledge to address these. Indeed, some may come up with very original and creative solutions, for which they might apply for patents right away. In this case, the patent filing is parallel in time to the standardization effort. Lastly, companies may try to apply for patents and get this technology included in the standard, even if it does not offer great improvements or technical merit to the standard. There are strong incentives to do so, because, as we have seen, owning an essential patent offers great advantages. Whether the patent has great technical merit or not, the advantages are there to enjoy – just the mere fact that the specification of the standard is written in such a way that it overlaps with the language in the patent claim is sufficient. When patents are applied for just before or during standardization meetings, we will refer to them as *just-in-time patents*.

On the basis of the above, we postulate that there is a huge incentive for firms to try and obtain essential patents. Submitting technical proposals for the standard (in 3GPP that can be done electronically in advance of the meeting) and/or participating at meetings can help to accomplish this goal. At the meeting, you can plea to have your technology included, or perhaps bargain with others to obtain votes for inclusion, in return for other favors such as returning votes for other decisions. The submissions and other meeting information, which in 3GPP is instantly made electronically available to non-participating members, also allows companies to consider other parties' ideas, combine or recombine and subsequently file patents on these. We assume standardization meetings play a pivotal role in obtaining essential patents, and that the mechanisms discussed above result in a cyclic relationship between essential patent filings and the occurrence of standardization meetings. More specifically, we formulate the following hypotheses:

*H1: There is an increased intensity in essential patent filing just before and during a standardization meeting.*

While the above hypothesis considers those patents that are eventually disclosed to be essential, it does not yet reveal the likelihood that a given patent will become essential. In line with the arguments above, we would expect that those people who participate in meetings increase this likelihood by pleading and bargaining, while those not attending the meetings are not able to increase this likelihood. Our related hypotheses are thus:

*H2. Patents applied for just before or during a standardization meeting have an increased likelihood to become essential patents*

It was argued above that there might be a difference in technical merit. Patent citations are, arguably, the best indicator of technical merit for a study of this type (we will refer to this measurement later). While earlier studies have already shown that essential patents, on average, receive more citations than non-essential patents that are otherwise comparable, we predict here that there are differences *between* various types of essential patents. More specifically, we expect that essential patents filed just before or during a meeting are of lower merit (i.e. receive fewer citations) than essential patents filed at any other time.

*H3. Standard essential patents applied for just before or during a standardization meeting have a lower technical quality than comparable patents*

Finally, it might be the case that incentives to engage in just-in-time patenting vary as a result of a firm's different positioning. There might be differences as a result of the business model (e.g. upstream vs. downstream in the knowledge market), and with firms that have been part of the 'essential patent game' for many years versus newcomers. While we are interested to learn about such differences, we have no specific a-priori expectations here, so we will not postulate any hypotheses.

For all the above hypotheses, please note that when we refer to essential patents, we mean those patents that are claimed by their owner to be essential, since we have no objective means of testing whether they are actually essential. Also, note that such claims are usually only made after it has become clear what the standard really looks like, which may be long after the actual meeting. So, in this paper, when we talk about 'essential patents', we mean specifically patents eventually disclosed by their owner as being essential to the standard.

#### **4. Data and findings**

To test our hypotheses, we turned to the development of the W-CDMA<sup>2</sup> and LTE standards, the most successful global technologies for respectively 3G and 4G mobile telecommunications. Their standardization efforts took place in an organization called Generation Partnership Project (3GPP), which is a partnership of several regional standard setting bodies, including Europe's ETSI as well as Japan's ARIB and South Korea's TTA. The direct successor of the successful 2G GSM standard, the W-CDMA/LTE standard that we focus on, already has over a billion worldwide users,<sup>3</sup> a number that is expected to grow considerably as more advanced services are adopted in both developed and developing countries around the globe. The development of the standards discussed here was anything but dynamic. While the first version of W-CDMA was released in early 2000, the standard saw numerous improvements in later years. Over time, new specifications were added such as HSPA, to improve data transmission speeds. In fact, over a period of a decade, these data transmission capacities gradually

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<sup>2</sup> In Europe, the W-CDMA standard is also known as UMTS, although technically speaking, the latter has a somewhat wider technical scope. Worldwide, the W-CDMA is also known as 3GPP, after the name of the partnership.

<sup>3</sup> Based on statements from the Global mobile Suppliers Association (GSA) and Informa Media & Telecom.

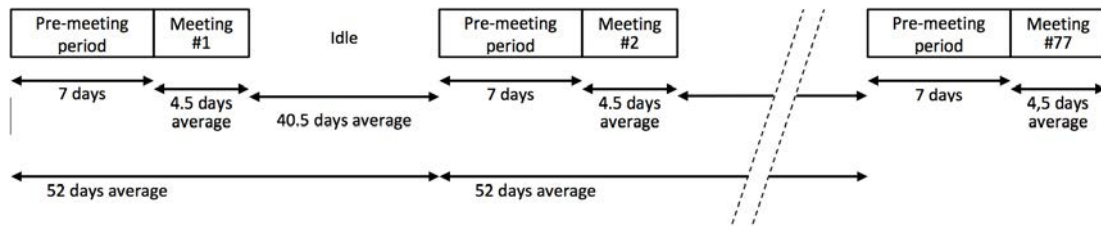


increased to a factor of almost one thousand higher than the original version.<sup>4</sup> In addition, the development of the 4G LTE standard was evolutionary, smoothly integrating in the existing standardization activities.

These constant improvements in W-CDMA and LTE, discussed at numerous meetings over more than 10 years, make this a very attractive case study to test our hypotheses. Also the availability of data on meeting participation and essential patents make this case particularly suitable. Furthermore, the nature and volume of that data (77 meetings at quite regular intervals, 939 individual participants at these meetings, affiliated with 53 different firms, as well as over 14,000 patents in the relevant technology area, of which 988 are claimed essential) are attractive for putting our hypotheses to the test.

We also collected data on all the meetings of the 3GPP RAN1 group. This is the group responsible for the physical layer of the radio interface, thereby defining the most central element of the standard. We collected all the data, starting with this group's first meeting (held January 21-22, 1999) to what is known as the 60th meeting (held February 22-26, 2010). In fact, there were a total of 77 meetings in the considered period (the numbering by 3GPP is not always sequential; there might be a *27bis* meeting, for instance), so the average spacing between the start days was slightly under two months (52 days). For our study, we also examined the period of several days preceding each meeting, called here the 'pre-meeting period'. A schematic of the timing of meetings is presented in Figure 1.

**Figure 1: Schematic presentation of the occurrence of 3GPP RAN1 meetings.**



Data on claimed essential patents was retrieved from the public Open Essential IPR Disclosure Database (OEIDD). This database, first presented at the NBER in early 2012, includes harmonized data of over 40,000 patent disclosures at main standardization bodies (Bekkers et al., 2012). The relevant W-CDMA and LTE entries in this database were matched with PATSTAT, the comprehensive patent database developed by EPO and OECD, providing us detailed metadata on patent families and inventors, among other things. This was complemented with additional data on firms' business models, home region and so on from other sources.

<sup>4</sup> The first version of the 3GPP standard, known as R99, included specifications for data transport up to a transmission speed of 384 kbit/s. Release 11 of this standard, finalized in the third quarter of 2012, includes a data transmission mode known as HSPA+, which provides speeds of up to 337 Mbit/s.

#### 4.1 Testing the first hypothesis: Relationship between patent filing and meeting occurrence

The first hypothesis considers whether there is a cyclic pattern in (preliminary) patent filings, induced by the meeting schedule. Table 1 shows the findings. Here, the first row ('pre-meeting') shows the patenting intensity for all the periods of 7 days that precede the meetings we consider. (Since there are 77 meetings in our analysis, the cumulative length of these periods is exactly 77 weeks.) The second row shows the patenting intensity for all the days on which the actual meetings took place. Since the average meeting length was four and a half days, this adds up to a total of 51 weeks. The third column (Idle) shows the patent intensity for all remaining periods in between the meetings – excluding the period preceding the first meeting and the time following the last meeting we consider.<sup>5</sup>

**Table 1: Claimed essential patents filed before, during or after a meeting**

<i>Period (1)</i>	<i>Cumulative length in weeks (2)</i>	<i>Claimed essential patents with priority date within that period (3)</i>	<i>As (3), by participating firms, inventor(s) present at meeting (4)</i>	<i>As (3), by participating firms' inventor(s) not present at meeting (5)</i>	<i>As (3), by non-participating firms (6)</i>
Pre-meeting	77.0	520 (6.8/week)	326 (4.2/week)	159 (2.1/week)	35 (0.5/week)
During meeting	51.3	204 (4.0/week)	95 (1.9/week)	69 (1.3/week)	40 (0.8/week)
Idle	452.9	1170 (2.6/week)	580 (1.3/week)	395 (0.9/week)	195 (0.4/week)
Total	581.1	1856 (3.2/week)	988 (1.7/week)	608 (1.0/week)	260 (0.5/week)

*Note: In a few cases, meetings were held very close together. As a consequence, a total of 38 claimed essential patents (that is 2.0 percent of all patents) overlapped by being both in a post-meeting and a pre-meeting period. In the calculation of the totals, we have removed the duplicates.*

Now we turn to the findings. As Column (3) in Table 1 shows, the patenting intensity in the 'pre-meeting' periods is much higher than in the idle period between meetings. Also the patenting intensity during the meetings is higher, but this effect is less pronounced. In order to gain a better understanding of why this effect occurs, we further broke these patent filings down into three categories: patents where one of the meeting participants is listed as inventor (Column 4), patents filed by firms that participate in the meetings but where the inventors are not meeting participants ('colleagues back home', Column 5), and patents by firms not participating in the meetings at all. The effect is strongest for participants-inventors. During the pre-meeting period, their patenting intensity is over 3 times higher than in the idle periods. During the actual meeting period, it is 1.5 times higher. For the colleagues back home, both effects are less pronounced but still clearly present. Finally, for companies not participating in the meetings at all, we see another, interesting pattern (Column 6). The pre-meeting period hardly shows any rise in patenting activity at all. However, during the time the meeting takes place (which they are not attending) their patenting activity doubles. Table 2 is based on the same data as the previous table, but groups the filings of all participants together. The results suggest that we can accept both hypotheses: participating firms peak the week before a meeting, while non-participating firms peak during the meeting.

<sup>5</sup> If we include these periods, our data would contain (among other things) some very valuable patents applied for long before the series of meetings, which could substantially bias our measurements.

**Table 2: Claimed essential patents filed before, during or after a meeting (grouped together)**

<i>Period (1)</i>	<i>Claimed essential patents by participating firms with priority date within that period (2)</i>	<i>Claimed essential patents by non-participating firms with priority date within that period (3)</i>
Pre-meeting	487 (6.3/week)	35 (0.5/week)
During meeting	164 (3.2/week)	40 (0.8/week)
Idle	975 (2.2/week)	195 (0.4/week)
Total	1626 (2.8/week)	260 (0.5/week)

Now turning to Hypothesis H1 (“*There is an increased intensity in essential patent filing just before and during a standardization meeting*”), we do indeed observe a sizable phenomenon, and thus accept this proposition. In addition, we observe two different *types* of increased intensity: the meeting participants show a significant peak in filing in the 7 days before a standardization meeting, whereas non-participants show a (smaller but still notable) peak that occurs *during* the standardization meeting.

#### **4.2 Testing the second hypothesis: Does meeting participation increase likelihood of patent inclusion?**

As argued before, standardization meetings offer opportunities to their participants to ‘position their patents in the standards’. That is, by making technical submissions that are covered by their own patents, by proposing their patented technologies at the meeting, and by bargaining with other participants about the content of the standard, they can attempt to have the final standard covering their own patents.

So, how effective are meeting participants in having their patented technology included in the standard? This question is the core of Hypothesis 2. To address this question, we constructed a dataset of *all* US patents and patent applications by inventors who were identified as having participated at one or more of the 3GPP meetings under consideration. We restricted this search to the years 1999 to 2010, the period in which our studied meetings took place. We considered the resulting 14,524 patents as a ‘pool’ of patents that are *potentially* essential to the 3GPP standard. In this respect, this dataset differs from the one we used in the previous section, which included (disclosed) essential patents only. Then, we studied the determinants of whether such a patent is disclosed by its owner to be a standard essential patent, using the earlier mentioned Open Essential IPR Disclosure Database (OEIDD).

Table 3 reports our findings. In these LOGIT regressions, the dependent variables are whether or not a patent has been disclosed as essential. Model 1 tests the two core hypotheses; since a single patent can only be applied for either in the pre-meeting period or during the meeting (and never at *both*), we can enter both variables at once, without being concerned about any effect they might have on each other. For patents applied for just before a standardization meeting, we see a significant and strong positive effect. We also added a number of control variables to test how robust this effect is. Since it might be argued that patents with a higher technical merit or ‘value’ are more likely to be essential, we included in Model 2 the number of received forward citations of the patent in question, excluding self-citations. While this effect in itself is

found to be significant (as expected, in line with the earlier findings of Rysman and Simcoe, 2008), it does not affect our core hypothesis at all – it is really an independent effect. Since companies with a large patent stock may have different strategies than those with a small patent portfolio, we included in Model 3 the total patent stock of the assignee. In Model 4 we did the same for the stock of declared essential patents only. Again here, both effects are significant yet also do not affect our core hypothesis.

**Table 3: Determinants of patent essentiality**

	Model 1	Model 2	Model 3	Model 4
Patent filed during pre-meeting period	0.5301 [7.32]***	0.5236 [7.19]***	0.5236 [7.19]***	0.5388 [7.28]***
Patent filed during meeting period	0.0354 [0.31]	0.0337 [0.29]	0.0333 [0.29]	0.0681 [0.59]
Forward citations (no self-citations)		0.0181 [8.49]***	0.0181 [8.48]***	0.0164 [7.41]***
Patent stock of assignee (Log10)			-0.0081 [-0.12]	0.1864 [2.48]**
Stock of essential patents of assignee				0.0079 [17.39]***
Constant	-2.7672 [-64.06]***	-2.8247 [-63.99]***	-2.7922 [-9.91]***	-4.5271 [-13.94]***
N	14524	14524	14524	14524

\* p<0.1, \*\* p<0.05, \*\*\* p<0.01

However, the above is not true for patents that are filed during a standardization meeting (the second row in Table 3 ). Here we find no significant effect, and this remains the same after adding all the control variables.

Turning now to Hypothesis H2 (*‘Patents applied just before or during a standardization meeting have an increased likelihood to become essential patents’*), we can only partly accept this proposition: patents applied *just before* a standardization meeting indeed have an increased likelihood to become essential patents, and this effect remains remarkably robust after adding several relevant control variables. However, patents applied *during* a standardization meeting do *not* have an increased likelihood of becoming essential patents.

### 4.3 Testing the third hypothesis: Does the technical merit of just-in-time patents differ from other patents?

One important question now would be whether these just-in-time patents are any different from ‘normal’ patents, whose timing is not specifically linked to a standardization meeting. In particular, we are interested in whether they are cited equally often as other claimed essential patents. We used forward citations as a proxy of the technological importance of a patent (Carpenter et al., 1981; Trajtenberg, 1990; Karki, 1997). The interpretation is relatively straightforward: an invention with great technological impact will attract attention to the following inventions. Hence, technologically important patents will have more citations than less important patents. While there have been long discussions on how good citations are as a predictor of the *value* of a patent (see, among others, Gambardella, 2008), we believe they are much

more a direct indicator of technologically important patents, or ‘technical merit’, which is what this paper is studying. To obtain a reliable citation performance measurement, it is important to consider the distribution of incoming citations over time. Rysman and Simcoe (2008) have shown that for claimed essential patents, this citation tail is longer than otherwise identical non-essential patents. Therefore it is important to ensure that the patents we include in this analysis had sufficient time to collect incoming citations. With this in mind, we selected all claimed essential patents or patent applications in our dataset with a priority date of 2005 or earlier (slightly over 1000 patents in our dataset meet that criterion). Using patent citation data compiled in 2012, we see that all these patents had at least 7 years to collect citations. Even the most recent patents in this selection are well into their citation tail, reassuring us that our citation score is robust.<sup>6</sup> Including too recent patents would make the analysis more prone to error and bias. Note that our set of selected patents does not include patents with a priority date older than 1999, the year in which the first of our 77 studied standardization meetings took place. This is important because earlier papers have observed that claimed essential patents preceding the standardization effort often have a much higher citation score, being selected for their technological contribution, even though they are ‘old’ (Bekkers et al., 2011). Excluding this group prevents unwanted bias in this respect. Finally, while the following analysis includes all citations, we also performed the same analysis with self-citations removed. The outcomes are similar. Also when we performed the analysis using earlier cut-off dates, we got similar results, suggesting that the citation score measurement is robust and not impacted by truncation biases.

Within our selection, older patents had more opportunities to collect citations than younger patents. To correct for this, we followed the approach suggested by Jaffe & Trajtenberg (2002). For each priority year in our dataset, we calculated the average citation performance of all non-essential patents in the appropriate technology classes.<sup>7</sup> Any essential patent score can thus be compared to the average citation score in that year. Since all our patents are in a relatively narrow set of technology classes displaying rather similar citation performance, there was no need for a technology class correction. While we took the citation performance of non-essential patents as a base reference point, all our conclusions are based on comparing different types of essential patents, avoiding the earlier mentioned problems of endogeneity.

Figure 2 shows the main results of our analysis. The bars in this graph represent the citation performance of claimed essential patents for the three time periods defined earlier in this paper. Firstly, we observe that all the scores are higher than one. In other words, claimed essential patents have a higher citation performance than non-essential patents. This finding is in line with nearly every other study in this field. We could argue that this higher score may be the result of endogeneity rather than reflect a higher patent value; however, this question is irrelevant for our analysis since our aim is to compare groups of claimed essential patents, not compare claimed essential patents with non-essential patents. Secondly, we observe that claimed essential patents by

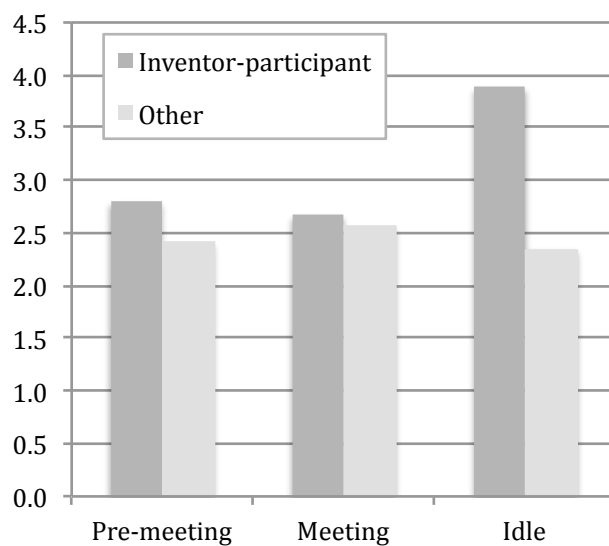
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<sup>6</sup> Rysman and Simcoe (2008) estimate the citation tail on the basis of age since patent *grant*. At an age of 4 years, an average essential patent has already collected 40 percent of all the citations it will receive over its lifetime. If we assume that the priority date of a patent lies 3 years before the grant date, this 40 percent is reached 7 years after the priority date.

<sup>7</sup> In the interest of computation time, we did not take the full population of non-essential patents but a large sample (around 10,000 patents, i.e. 10 times the number of essential patents in the selection).

inventor-participants applied for in the ‘pre-meeting’ period have a much lower citation performance than the (larger) group of patents in the ‘idle’ period. Our observations were similar for the period during the meeting. We expect, however, that the performance score for inventors not participating in the meetings would not be dependent on timing. Indeed, Figure 2 shows this is not the case. Thirdly, we see that the average citation score of inventor-participants is higher than that of other inventors of claimed essential patents. This can perhaps be understood from the disclosure rules in standardization settings. These rules typically state that disclosure is mandatory for known essential patents.<sup>8</sup> In our context, the qualifier ‘known’ is an important one: if the meeting participant is the inventor of a patent, it is apparent that he or she ‘knows’ about the patent. As the patents by inventor-participants had to be disclosed, they arguably had a better dissemination than other patents.

**Figure 2: Citation performance of claimed essential patents for three different periods.**



On the basis of these findings, we can firmly accept Hypothesis H3 (*‘Standard essential patents applied for just before or during a standardization meeting have a lower technical quality than comparable patents’*). Both claimed essential patents applied for by inventor-participants in the week preceding a standardization meeting, as well as patents applied for during the meeting, have a significantly lower citation performance than claimed essential patents by inventor-participants applied for at any other time.

#### **4.4 Explorative analysis: Who employs just-in-time strategies?**

Considering the above, we need to pose the following questions: which organizations engage in just-in-time patenting in standards and do all meeting participants act in the same way, or are there differences between specific types of companies? In this section we address these questions by studying the determinants of just-in-time behavior, adopting a more explorative approach. For the patents and their filing moment, we used

<sup>8</sup> For details on SSO IPR policies, see Bekkers, R., & Updegrove, A. (2012). While 3GPP has no IPR rules, its members need to satisfy the IPR rules of the partnering organization(s) via which they gained access to the 3GPP meetings. Most 3GPP participants are ETSI members and the ETSI policy has a ‘known patents’ clause.

the same data as for hypotheses H1 and H3. Then, we identified the companies owning these patents (or, more precisely, the companies that submitted a disclosure that they believed to own an essential patent), and complemented our data with specific information on those companies. (A full description of the data and variables is included as Annex A.) Firstly, we determined the business model that best characterizes the company (in the context of the industry we were considering). While our original data distinguished nine distinct business models,<sup>9</sup> our analysis here reduces that into these companies that are best characterized by an upstream business model (in the knowledge or product market), and those best characterized by a downstream business model. Secondly, we determined from which world region these companies originate – typically taking the region where the firm’s headquarters are based. Thirdly, we identified what we call ‘incumbent suppliers’. These are the manufacturing companies that championed the preceding technology standard (2G GSM, which was in many ways also the institutional predecessor of 3GPP). This calculation was based on 1998 ETSI voting powers, which reflect the revenues of those companies in the mobile telecommunications market before W-CDMA or LTE equipment came on the market (see Annex A for the calculations). Then we considered companies’ total patent stock (for any technology area) as well as their patent stock relevant to the 3GPP standards we are examining. Finally, we included the intensity of participation in the 3GPP meetings.

Before turning to the results, we must stress that due to the nature of this data, it is inevitable that some of the above variables are related (see Annex B for a correlation matrix). Most upstream companies in our dataset, for instance, originate from the US. Most incumbent suppliers, in contrast, originate from Europe (the ‘GSM champions’). The South Korean companies in our dataset have a much higher than average overall patent stock (most of them are in a large business conglomerate known as Chaebol), whereas Japanese companies on average have a much lower stock of SEPs. In the interpretation of our analysis below, we will pay due respect to these interdependencies. Nevertheless, we feel it is valuable to present this combined analysis, as it provides insight into which type of companies embrace certain patenting strategies.

Our results are presented in Table 4, which shows the determinants of a patent strategy where filings are done in the 7 days preceding a standardization meeting. (We also performed the same analysis for filings done during the meeting, but omitted these from this paper as this strategy was found to be less pertinent in the sections above). In Model 1, we started looking at business models. We found that companies with an upstream business model are less likely to display this type of patent strategy. In Model 2, we considered the home country of these companies. With the baseline value in this model being Europe, we see that American companies are less likely to be involved in such strategies than European companies. The same is true for Japanese, Chinese and Canadian firms. In fact, this behavior is especially found among European and South Korean firms. In Model 3 we entered both business model and home base. Given the fact

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<sup>9</sup> These are: (1) Pure upstream knowledge developer or patent holding company (excl. universities); (2) Universities / public research institutes / states; (3) Component suppliers (incl. semiconductors); (4) Software and software-based services, (5) Equipment suppliers, product vendors, system integrators, (6) Service providers (telecommunications, radio, television, etc.), (7) SSOs, fora and consortia, technology promoters (as patent owners themselves), (8) Individual patent owner, (9) Measurement and instruments, testing system.

mentioned above that upstream business models are especially found in the US, it comes as no surprise that the significance of US home base completely disappears, while the other significant geographical relations remain.

**Table 4: Determinants of filing patents in the 7 days preceding a standardization meeting**

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Upstream business model	-0.2044 [-4.88]***		-0.2119 [-2.81]***		-0.2118 [-2.81]***		-0.3507 [-4.19]***		-0.3361 [-3.99]***
US <sup>(a)</sup>		-0.2795 [-4.91]***	-0.1069 [-1.28]		-0.106 [-1.13]		-0.2808 [-2.51]**		-0.3268 [-2.83]***
KR		-0.083 [-1.32]	-0.0764 [-1.21]		-0.0754 [-0.98]		-0.1603 [-1.50]		-0.2066 [-1.87]*
JP		-0.1751 [-2.66]***	-0.1826 [-2.77]***		-0.1816 [-2.28]**		0.0836 [0.86]		-0.0003 [-0.00]
CN		-0.2925 [-2.09]**	-0.2895 [-2.07]**		-0.2885 [-1.96]**		-0.0733 [-0.47]		-0.0774 [-0.50]
CA		-0.3344 [-3.01]***	-0.3418 [-3.08]***		-0.3416 [-3.07]***		-0.3061 [-2.73]***		-0.2667 [-2.34]**
Incumbent suppliers				0.1408 [2.24]**	0.0019 [0.02]		-0.0325 [-0.37]		-0.093 [-0.98]
Total patent stock (Log10)						0.0116 [0.28]	-0.2351 [-3.73]***		-0.2257 [-3.55]***
3GPP SEP stock (log10)						0.0108 [0.59]	0.1975 [5.11]***		0.1732 [4.20]***
3GPP participation intensity								0.0026 [2.45]**	0.0024 [1.75]*
Constant	-1.1236 [-46.83]***	-1.0191 [-21.82]***	-1.0117 [-21.63]***	-1.2083 [-58.06]***	-1.0127 [-15.66]***	-1.2562 [-7.54]***	-0.2926 [-1.30]	-1.4287 [-14.52]***	-0.4748 [-1.90]*
Observations	14524	14524	14524	14524	14524	14524	14524	14524	14524

(a): For all the geographical dummies, the baseline value is home base in Europe.

In Model 4, we considered the effect of being an incumbent supplier. It is a positive, significant effect: the firms that dominated the GSM market (Nokia, Ericsson, Alcatel, Siemens, and others) show this strategic patenting behavior more than other firms. Arguably, they are vetted in the standardization game. Combining this incumbent supplier variable with earlier data (Model 5), we again see an expected interdependence, as most of these incumbent forms are in fact European.<sup>10</sup>

Looking at patent stock gives interesting results. While these two variables do not seem to do much themselves (Model 6), their significance becomes visible if also controlled for countries (Model 7). Interestingly, companies with a large overall patent portfolio show *less* of this strategic behavior, whereas companies with large portfolios specific for the standards we are studying, show *more* of it. Finally, intensity of participation in 3GPP meetings displays a positive effect on this strategic behavior, which remains stable after adding all other variables.

Summarizing, we found that a strategy of applying for patents in the 7 days preceding a standardization meeting is employed by: 1) vertically integrated firms (hence less by US firms, which are mostly upstream firms), 2) the incumbent champions of the previous technology standard (hence more by European firms, where these champions are found), 3) smaller companies that nevertheless have large SEP portfolios for the standard (i.e. very dedicated companies) and, finally and not surprisingly, 4) companies that are very actively participating in 3GPP meetings.

<sup>10</sup> Note that this effect is somewhat harder to see from the regression results, as Europe is the baseline value for the geographic dummies.



## 5. Conclusions and discussion

The main **findings** of this study can be summarized as follows:

- (1) In the seven days preceding a standardization meeting, we observe a large peak in (preliminary) filing of patents that eventually become essential. This effect can be mainly attributed to filings of which the inventors are also meeting participants. Non-participants show a (smaller) peak, which occurs *during* the standardization meeting.
- (2) Patents applied for in the period seven days *preceding* a standardization meeting have an increased likelihood to become essential patents, an effect that remains remarkably stable after controlling other possible explanations. In contrast, patents applied for *during* a standardization meeting are not more likely to become essential patents.
- (3) Essential patents filed by participants in the period seven days before a standardization meeting have a significantly lower citation score than other essential patents. The same is true for essential patents filed during a standardization meeting.
- (4) The strategy of applying for patents in the seven days preceding a standardization meeting is particularly employed by: 1) vertically integrated firms (hence less by US firms, which are mostly upstream firms), 2) the incumbent champions of the previous technology standard (hence more by European firms, where these champions are found), 3) smaller companies that nevertheless have large SEP portfolios for the standard and, finally 4) companies that are very actively participating in 3GPP meetings.

Our **interpretation of the above findings** is as follows: Just-in-time patenting consists of two different strategies. Firms that send participants to meetings are often engaged in what we call an *anticipatory patent filing strategy*, where they file (preliminary) patent applications just before a standardization meeting is held. After filing for these patents, they submit their ideas as (electronic) contributions and go to the meeting trying to get their contributions included in the standard. Indeed, these attempts do result in a higher likelihood of their patented technology becoming essential. However, patents filed using this strategy receive significantly fewer citations than the average essential patent, which probably reflects their lower technical merit.

Firms that do not send delegates to meetings are often engaged in what we call a *combinatory patent filing strategy*, where companies are able to take notice of the submitted technical proposals and ideas of others - which are published electronically - and then file new (preliminary) patent applications by recombining such ideas. In fact, we have found anecdotal evidence of patent examiners receiving no fewer than four identical preliminary patent filings from different firms on the same day, presumably about a technical idea that was shared in the context of a standardization meeting. Such filing conduct is possible because, for the timeframe we consider, contributions and other information shared in the context of the standardization process were *not*

considered to count as prior art in the patent examination process. However, since companies following this strategy did not attend the meeting, they were not able to bargain their technology for inclusion, and hence this group of patents has no greater likelihood of becoming an essential patent than the ‘average’ patent. Also patents filed using this *combinatory patent filing* strategy receive significantly fewer citations than the average essential patent, again probably reflecting their lower technical merit.

We believe our findings have a number of **implications**. First of all, if you believe that standards should only cover patented technology if that technology actually brings technical merit to the standard, then our observed just-in-time patenting behavior should raise concerns. As explained above, we observe that both types of just-in-time patents have a significantly lower technical merit than other essential patents. The inclusion of such patents may result in a range of effects that are relevant to policy makers, competition authorities, standards implementers and end users alike. It may result in higher prices (when the rents are passed on to end users), higher barriers to entry for implementers that do not own patents themselves, and affect the level of competition in the market. It may increase risks such as non-availability of essential patents. Finally, a wider proliferation of essential patents can also increase the risk of patent hold-up: The situation where once the patent is covered by the standard, and implements are locked in, the patent holder charges a higher licensing fee than it could have bargained before the technology was made part of the standard (e.g. *ex ante*). In such a situation, the patent holder not only charges rent for the technical merit of the patent, it also appropriates itself the (high) switching costs of the implementers. Patent hold-up can overcompensate patentees, raise prices for consumers who lose the benefit of competition among technologies, and deter innovation by manufacturers facing the risk of hold-up (FTC, 2011).

On the basis of these implications, SSOs could be recommended to take a critical look at the patent inclusion process, and reconsider whether just-in-time patenting strategies drive an unnecessary high degree of low merit patents into their standard. Furthermore, we believe the implications are also relevant to patent offices. Recently, the EPO has begun cooperating with standard setting bodies in order to include technical submissions and other information shared in the standardization context as prior art (Willingmyre, 2012). We believe this is a very significant step in preventing some of the negative effects of the phenomenon we observe, and would welcome other patent offices to take similar steps. Finally, given the high societal importance of open standards, we believe these implications are relevant for policy makers and competition/antitrust authorities, for reasons already stated above.

Finally, we would like to point out that our study also has **limitations**. First of all, our observations are based on one standardization effort only, the development of 3GPP’s W-CDMA and LTE standard. Although this is an economically very significant standardization effort, offering good availability of data for our analyses, its findings are not necessarily generalizable to other standard setting efforts. Across SSOs, and across technology areas in a broader sense, there may be differences in SSOs and meeting rules, in culture, and in strategic conduct. While we expect the results for the IEEE wireless LAN standards to be more like those in our study than, say, the results for IETF standards, we have not studied them. Future research could investigate to what degree standardization in other areas and organizations is similar or different. A second

limitation of our study is that our observation of standard essential patents is based on disclosures by the patent owners, and might be prone to both over declaration (companies declaring patents as SEPs while they are not) and under disclosure (companies that fail to declare SEPs). Databases of disclosed patents may also have some other forms of bias, such as those discussed in Bekkers & Updegrave (2012). While we are aware of this limitation, there are no real alternatives for a study like this. The ultimate test of essentiality, known as a 'claim chart' that compares each claim in the patent with the relevant clauses in the standard in question, is a very specialist and expensive exercise, especially if it has to be performed for a large set of patents.

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## Appendix A: Overview of variables for regression in Section 4.4

<b>Business model</b>	Upstream business model	A firm's business model is one of the following: (1) Pure upstream knowledge developer or patent holding company (excl. universities); (2) Universities / public research institutes / states; (3) Component suppliers (incl. semiconductors); (4) Software and software-based services.
<b>Geographical</b>	US	Home base is the United States. <i>Note: for all the geographical dummies, the baseline value is home base in Europe.</i>
	KR	Home base is South Korea
	JP	Home base is Japan
	CN	Home base is China
	CA	Home base is Canada
<b>Incumbent suppliers</b>	Incumbent suppliers	Company is full ETSI 'manufacturer' member and has voting power of 18 or more in ETSI per January 1998 (this is the case for 6 out of the total of 31 ETSI 'manufacturer' member companies; note however that not all companies in our overall data set are or were ETSI members at that time.
<b>Patent stock</b>	Total patent stock (log10)	The log10 of the total number of patent families owned by that firm, as determined by the Thomson Reuters Derwent Innovation Index.
	3GPP SEP stock (log10)	The log10 of the total number of USPTO and EPO patents declared essential to the 3GPP W-CDMA and LTE standards, based on the OEIDD database.
<b>Intensity of participation</b>	3GPP participation intensity	Percentage of the 3GPP meetings actually attended by the firm.

## Appendix B: Overview of correlations between variables in regression of Section 4.4

Upstream business model	1									
US	-0.2894	1								
KR	-0.3037	-0.2226	1							
JP	-0.3444	-0.2027	-0.2378	1						
CN	-0.0982	-0.0678	-0.0796	-0.0725	1					
CA	-0.1542	-0.0907	-0.1065	-0.0969	-0.0324	1				
Incumbent suppliers	-0.2459	0.6148	-0.1727	-0.1573	-0.0526	0.2252	1			
Total patent stock (Log10)	-0.441	-0.2871	0.5365	0.2599	0.089	-0.134	-0.1137	1		
3GPP SEP stock (log10)	0.5341	-0.2779	0.3058	-0.6267	-0.167	-0.1756	-0.1571	0.0451	1	
3GPP participation intensity	0.1641	-0.2093	0.1521	0.0429	-0.2254	-0.3122	0.0244	0.1772	0.4195	1

*Note: Due to the large number of observations (over 14,000), almost all correlations are statistically significant at the 1% level.*