The process and data behind standard setting in wireless communications

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Abstract

Standard setting has gathered great attention in the academic and policy circles recently. At the heart of the focus are concerns around standard setting organizations and standards essential patents. Questions have been raised about whether there are "too many" standards essential patents, on how and when to access the value of these patents, and whether their owners can cause a potential hold-up of downstream manufacturers. Some concerns that the entire standards process may be held hostage by an incumbent minority have also been raised. However, missing from this dialogue has been an institutional understanding of the standard setting process, built with the help of technologists and engineers who actually participate in this process and are intimately familiar with it. Backed on an institutional understanding, empirical analysis based on relevant data-sets also needs to be scaled up. This paper tries to address these issues for widely adopted third and fourth generation (3G and 4G) wireless cellular standards defined by 3GPP. An institutional background and an extensive data collection effort in this paper lead to some initial findings that can be used to address some of the policy discussions under way today.

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1 Introduction

In the recent years, standard setting and the value of standards essential patents (often referred to as SEPs) has been the focus of many public policy and scholarly discussions. Some of the recent smart-phone litigation wars have rekindled an interest in standard setting and SEPs[1].

Several issues have been raised around standard setting, and proposals abound for changes in policies of standard setting organizations (SSOs), valuation techniques applied by the SSOs, courts, regulators, as well as some proposed antitrust measures (Federal Trade Commission (2011), Kuhn et al. (2013)). For example, issues such as there being potentially too many SEPs causing unreasonably high aggregate royalties have led to proposed valuation techniques for SEPs such as numeric proportionality, step-down royalty rate procedures, or ex-ante valuation of SEP related technologies (Lemley and Shapiro (2007), Chappatte (2009), Lemley (2007)). Another big concern has been the potential hold-up caused by SEP owners. Finally, some have suggested the possibility of large firms potentially controlling the standard setting process (Bekkers et al. (2002)). Several of these issues have been related to the wireless communications standards. However, unprecedented growth of the wireless communications industry and standards belies several of these proposed theories, such as hold-up (Sidak (2008), Geradin and Rato (2007), Epstein et al. (2012)). Indeed, several proposals that have been made disclose a glaring gap in the literature regarding an understanding of the institutional reality of the standard setting process, or basic facts displayed by data.

In his Nobel lecture[2], Ronald Coase called upon economists for understanding the institutional structures for firms for building sound economic principles: *"The efficiency of the economic system depends to a very considerable extent on how organizations conduct their affairs, particularly, of course, the modern corporation. Even more surprising, given their interest in the pricing system, is the neglect of the market or*

[1] The recent high profile cases involving standard setting include *Microsoft vs. Motorola Mobility/Google Inc.* and *Apple vs. Samsung*

[2] In *"The Institutional Structure of Production"*, Prize Lecture, Lecture to the memory of Alfred Nobel, December 9, 1991.

more specifically the institutional arrangements which govern the process of exchange. As these institutional arrangements determine to a large extent what is produced, what we have is a very incomplete theory."

Today, this applies well to an incomplete theory on SSOs. The purpose of this paper is to provide an institutional background on the standard setting process for widely adopted and successful third and fourth generation (3G and 4G) wireless cellular standards defined by the third generation partnership project (3GPP), a consortia of six SSOs. This is accompanied with a large data collection effort including all the 3GPP meeting reports, membership, meeting attendance, submission of technical proposals by various organizations for inclusion in the standards and their outcomes, patenting activity of various organizations, etc. The goal is to further the understanding the standard setting process, and share some preliminary insights from the data.

The theoretical literature on standard setting has been prolific, and has led to an eventual smaller stream of some empirical research. For example,Chiao-et-al (2006) have collected comparative data from 60 SSOs for understanding the procedures employed by SSOs. Empirical work on cooperative standardization processes includes studies by Weiss and Sirbu (1990) and Bekkers-et-al (2002). Specific to 3GPP, Rysman and Simcoe (2008) study the citation rates of patents prior to disclosure to the standards to identify that SSOs such as 3GPP perform well in selecting important technologies into the standard. Leiponen (2008) studies the internal operation of 3GPP to ask whether member firms' cooperative activities outside of 3GPP enhance their ability to influence standardization outcomes within 3GPP. Bekkers-et-al (2009) and Bekkers-et-al (2011) examine the patents for 3G cellular technologies defined by 3GPP and discuss the interactions between the strategic patenting motivations and a firm's industry position and participation in standard setting.

The institutional background and the data collected in this paper relates to the issues discussed below in particular: the questions around the value of SEPs, potential hold-up of downstream manufacturers by SEP holders, and whether major participants can control the standard setting process.

The value of SEPs: Some researchers have expressed concern about the sheer number of SEPs and what this means for aggregate royalties. For example, Lemley (2007) suggests the example of 3G telecom in Europe. The SSO put out a call for essential patents, asking which they must license to make the 3G wireless protocol work and the price at which the patent owners would license their rights. 3G telecom received affirmative responses totaling over 6000 "essential" patents and the cumulative royalty rate turned out to be 130%. Of course, this calculation is entirely contrary to the proven success of the 3G standards and compliant products. How can this dichotomy be explained? Are there really "too many" SEPs? How many is too many? This paper puts this question in context of the scale and size of the standard setting process.

In order to address potentially large aggregate royalties and value SEPs, economists often view SEPs as perfectly complimentary economic inputs. Therefore, some have proposed the numeric proportionality rule, which suggests that all patents essential to the standard should be regarded as equally valuable and treated symmetrically, since they all afford the same market power (Chappatte (2009)). This premise leads to proposed royalties calculated to be proportional to the number of essential patents contributed to the standard. For example, a firm owning 100 standards essential patents out of a total of 1000 patents in that standard can claim 10% of the total royalty that the standard can command. This rule has been soundly rejected by SSOs, and indeed patent pools implementing such rules have seen limited and selective participation by weaker patent holders (Layne-Farrar et al. (2011)). How, then, should the valuation of SEPs be viewed? This paper attempts to provides an institutional explanation for why all technologies and patents covering them are not of equal value, and data to corroborate this. Another often cited proposal for limiting large ex post aggregate royalties is to value patents ex ante. Some authors have proposed that SSOs need to set up an internal arbitration or discussion procedure so the group members can figure out the cost of alternative standards while there are still competitive alternatives (Lemley (2007), Federal Trade Commission (2011)). Understanding the process behind standard-setting and scale and size of the standards is imperative to judge the practical reality of such a proposal.

Potential of hold-up: There has been much discussion about the potential threat of hold-up by patent owners, especially in the context of standard setting (Federal Trade Commission (2011), Lemley (2007)). The potential risk of hold up of downstream manufacturers allegedly due to the threat imposed by a patent holder receiving injunctions after heavy investments into the production of an infringing feature have been made Lemley and Shapiro (2007). Some authors have proposed that the problem of hold-up — a problem that the ABA Handbook labels "patent ambush" and that economists call "opportunism" or "hold-up" (Farrell et al. (2007)) — is especially great in the context of standard setting. This is because ex ante before an industry standard is chosen, there are various attractive technologies, but ex post after industry participants choose a standard and take steps to implement it, alternative technologies become less attractive. Thus, a patent covering a standard may confer market power ex post that was much weaker ex ante. However, no evidence has been offered for the theory of hold-up[3]. This paper explains the consensus building in the standard-setting process in detail, as well as the active meeting participation structure within the 3GPP meetings, in order to explore reasons behind the observed lack of hold-up. In order to understanding the incentives to innovate, it is also important to analyze how and by whom the R&D investments are being made.

Control by major SSO participants: Some concern has also been raised about the potential collusion in standards setting, or the major participants ruling and owning the standard setting process to push their proprietary solutions into the standard. This paper looks at the rate of acceptance of technical proposals into the standards from differently situated participants (e.g.: large and small past contributors) to shed light on this hypothesis.

The rest of this paper is organized as follows. Section 2 provides an institutional background of the standard setting process in 3GPP, including an explanation of the organizational structure and the usual process of development of technical specifications. Section 3 explains the process of data collection from the 3GPP standards body in detail, along with the overall summary statistics. Section 4 discusses some prelim-

[3]Economic expert witnesses during the Microsoft vs. Motorola (Seattle, November, 2011) were explicitly asked by Judge Robart for evidence of hold-up, and none was produced or cited.

inary findings from the data. and Section 5 concludes with some remarks on future work.

2 The standard setting process

This section describes the basic organizational structure of 3GPP along with description of the role and importance of various working groups within the organization, that sets the ground-work for understanding how the organization functions, its rules and regulations, and the standard setting process. The process of standard setting is described in detail, and although the focus is on 3GPP, the process if very similar for other SSOs.

2.1 Organization structure

3GPP is a unified collection of six telecommunications SSOs known as organizational partners. These include: Japan's Association of Radio Industries and Businesses (ARIB), North America's Automatic Terminal Information Service (ATIS), China Communications Standards Association (CCSA), European Telecommunications Standards Institute (ETSI), Korea's Telecommunications Technology Association (TTA), and Japan's TTC (Telecommunications Technology Committee). With wide global representation, the goal of 3GPP is to provide its members with a stable environment to produce reports and specifications that define third generation (3G) and fourth generation (4G) wireless cellular technologies.

3GPP was formed in 1998 to develop a common wireless cellular system for Europe, Asia and North America. The initial scope of 3GPP was to develop 3G wireless cellular system specification based on evolved second generation (2G) wireless cellular system called Global System for Mobile Communications (GSM). This scope was later enlarged to include the development and maintenance of the 2G wireless cellular systems as well. After the development of the 3G wireless system known as Universal Mobile Telecommunication System (UMTS), 3GPP started working on global fourth generation (4G) wireless cellular system, known as the Long Term Evolution (LTE).

The overall structure of 3GPP is depicted in Figure 1

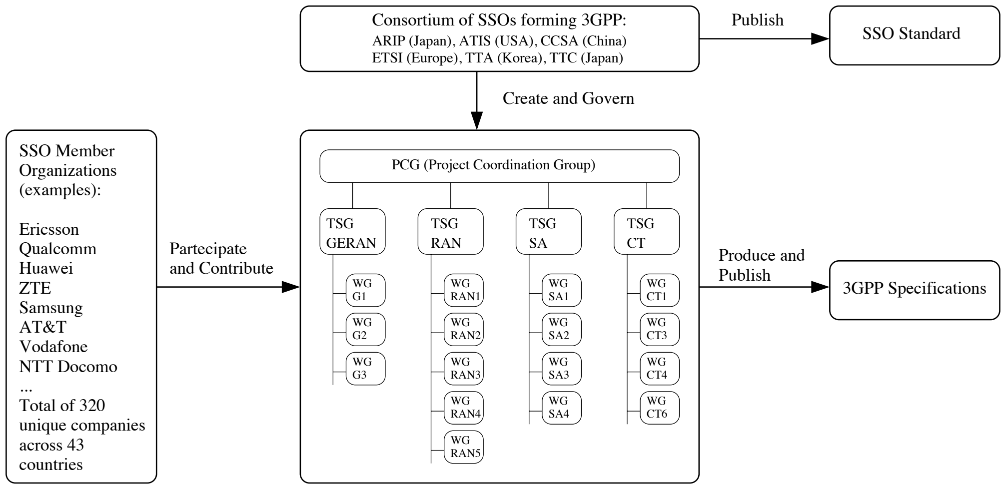

Figure 1: Overall organizational structure of 3GPP.

The organization partner SSOs that first created and now govern 3GPP. The primary governing and logistical support is provided by ETSI, an independent non-profit standardization organization in the telecommunications industry in Europe with worldwide projection. The member organizations (e.g.: firms, research institutes, etc.) directly participate in 3GPP, which is responsible for producing and publishing 3GPP technical specifications. The specifications are developed by delegates from voluntary member organizations. The organizational partner SSOs then take these specifications and publish them as standards. In general, the 3GPP specification number is changed according to the format of the specific SSO nomenclature and the technical specification is converted as-is to the technical standard relating to the SSO. Note that the IPR policies are determined by each of the SSOs independently, and not by 3GPP. Also, member organizations have IPR disclosure obligations to the specific SSOs that they are members of, and not to 3GPP.

As depicted in Figure 1, the organizational structure within 3GPP consists of various layers of hierarchy. Each group and working group is attended by hundreds of delegates, primarily engineers, 2-8 times per year.

- At the top lies the Project Coordination Group (PCG), the highest decision making body responsible for overall management of technical work to ensure that the 3GPP specifications are produced in a timely manner as required by the market place, as well as ratify election results (for the chair position of different groups within 3GPP), and the resources committed to 3GPP. The PCG also handles any appeals from the member organizations on procedural or technical matters. The PCG meets twice per year.

- The Technical Specification Groups (TSGs) report to the PCG, and are responsible for preparing, approving and maintaining technical specifications and reports for specific technology areas. There are four TSGs, each with a specific focus. TSG-GERAN is responsbile for the evolution, future growth and interoperability of the 2G GSM/EDGE Radio Access Network (GERAN). TSG-RAN is responsible for the definition of the functions, requirements, and interfaces of the Radio Access Network (RAN) part of the wireless cellular systems. Quite simply, the fundamental physical wireless air interface that links any two cellular devices is defined here. The radio aspects defined here provide the core wireless functionality on top of which other services and features can be built. The TSG-SA is responsible for the overall architecture, service capabilities and system aspects (TSG-SA) of systems based on 3GPP specifications and, as such, has a responsibility for cross TSG co-ordination. The TSG-CT is responsible for specifying the core network and terminal (CT) interfaces, that relate to the communication between a mobile wireless device (e.g.: a mobile phone) and the infrastructure elements (e.g. servers residing on a service provider's network), and among the infrastructure elements residing in the network. To the extent the CT protocols relate to communication between the mobile wireless device and the infrastructure elements, the wireless physical layer defined by TSG-RAN acts as the transport. Each TSG meets separately 4 times per year. The new versions of 3GPP specifications are released after the TSG meetings, also called plenary meetings.

- The TSGs are responsible for creating working groups (WGs) that focus on specific technical aspects and requirements within their specified technology areas. As shown in Figure-1, there are currently 17 working groups in total. The work product of each working group is a series of technical reports and specifications, that are later approved by the TSG and then the PCG. Each working group meets 6-8 times per year to carry out work on several technical requirements within their respective technology area.

It should be noted that the working groups differ in their technology focus, and the importance of each technology area varies significantly. The working groups under TSG-RAN, for example, are responsible for the underlying radio or physical layer wireless interface and protocols on top of which other services and core network functionalities operate. This is corroborated with the findings from the data discussed in Section 4.1 — majority of the meeting participation time and effort is spent in the RAN working groups. Even within the RAN working groups, RAN-1 and RAN-2 are responsible for the physical channel procedures at the wireless air interface, and the architecture and protocols traversing the wireless air interface, are the most fundamental to overall wireless cellular system.

In addition, standards setting in 3GPP goes through various releases. Each release corresponds to addition of series of major feature additions to the standard. The new releases are backward compatible with the older ones.

2.2 Generating the technical standards

The technical work leading to the technical specifications that become the wireless cellular standards is performed in the various 3GPP working groups. Any new 3GPP project related to a sizeable feature addition to the standard requiring new specifications is initiated in the form of a work item. The work item can be first proposed either at the working group level or the TSG (plenary) level by member organizations, but is always approved by the TSG that the working group falls under. To propose any new work item and corresponding specification development work, at least four supporting companies are required.

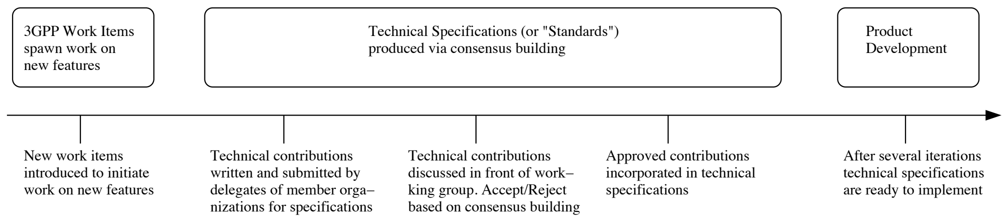

Figure 2: The standard setting process.

Figure 2 shows the process for generating the technical specifications or standards. Each work item is discussed by the members and mapped to one or more technical specifications. Once a work item is approved, work on the technical specifications to define the new feature can begin at the working group levels. For work on any technical specification, member organizations submit technical documents called "contributions", for addressing various technical issues as well as proposing solutions for them. These contributions can be in the form of one of the following types:

- Change requests: A Change request (CR) is a document which specifies in precise detail changes which are proposed to a technical specification. Submitting a CR is the method to propose addition, edits, or modifications to an existing technical specification.
- Discussion papers: A discussion paper is any contribution that discusses technical or non-technical matters within 3GPP work scope. Some discussion papers include proposed technical solutions prior to a formal change request submission.
- Work item descriptions: A work item description is a document that can explain the new work item in detail, the features covered by it, the requirements for the new features etc.
- Other: Other types of contributions include documents such as liaison statements used for communications between different 3GPP groups and between 3GPP and other organizations, draft specifications, reports etc.

The contributions are submitted and made publicly available (on an FTP server) a few days prior to each 3GPP working group meeting. Interested meeting delegates representing the member organizations typically review the contributions prior to the meeting, and come prepared with their comments and feedback. During the working group meeting, the elected chair who runs the meeting announces the agenda and schedules the respective contributions for discussion. The contribution is then presented by the author(s) in front of all the attendees. Critical to the process of discussion, the governing rules of 3GPP make it a consensus building organization. That is, the chair provides equal opportunity to each member organization to object to any contribution. Therefore, in practice, any attendee can raise his/her hand in a meeting objecting to a contribution's potential inclusion in the technical specification(s). If any such objection is made, the author(s) of the contribution has to work with the objector(s), and resubmit a revised contribution. Such a process can take several iterations and revisions. If no consensus can be achieved, the chair must resort to majority voting, i.e., per the governing rules of 3GPP, at least 71% of the member organizations must agree for a contribution to be accepted/approved for inclusion in the technical specification. After a series of such meetings and iterations, a technical specification is formed.

Often, hundreds of technical contributions have been submitted and discussed towards the formation of single technical specification, and the entire process can take several months or years. A technical specification goes through a series of iterations, and is rarely "closed" from any further modifications or edits. Once 60% of the development work on a technical specification is completed, a working group can submit a specification to the TSG that it reports to for "information". The TSG can "approve" a specification and create a version 0.0 when 80% of development work is completed. Hereafter, any technical change must be accomplished with submitting a CR. An approved specification may still undergo significant changes. The TSG can "freeze" specifications for a specific release of the standard when the functionality of that release is stable, and 99% of the development work for a technical specification is deemed to be complete. No new features can be added to frozen specifications, only essential corrections are permitted for the specific release. However, in the next release of the standard, if the technical specification is still relevant, the usual additions or modifications can be proposed through a CR submission[4]. Therefore, technical spec-

[4]Sometimes, the TSG can "close" a technical specification for a particular release of the standard. There-

ifications are live and dynamic documents that can be edited and modified over long periods of time.

When the technical specifications are in a stable format, typically at the point when they are approved by the TSG and have the first version number, product development work can begin. Downstream manufacturers can start implementing the specifications. As a step of formality, the 3GPP technical specifications are also formally approved and published as endorsed standards by the member SSOs[5].

3 Data

In order to understand the dynamics of membership, participation, and the level of effort that go into standard setting of complex cellular technologies, the data was collected on various institutional aspects of 3GPP standard setting. We are interested in 3G and 4G cellular standards efforts, therefore, the data spans starting from 1999 – which corresponds with the completion of the first release (Release-99) of the 3G wireless cellular technology – until end of 2012. The data source for most of the data related to 3GPP is the *www.3gpp.org* FTP server. In addition, we separately collected data for patents that were declared as potentially essential to any of the 3GPP standards to ETSI.

Membership and participation: I first discuss the membership and attendance data. The list of current voluntary member organizations is available online on the 3GPP server at *www.3gpp.org/membership*[6]. Not all member organizations participate or

after, the specification is no longer maintained and no further CRs are considered for that release. A closed specification is still available for product development, and can be edited and modified in the future releases. The TSG can also "withdraw" a specification that has become obsolete.

[5]Details of the when the technical specifications are formally endorsed and approved or published as standards by various SSOs can be found in the ITU documents: "M.1457 : Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)" for 3G specifications and "M.2012 : Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications Advanced (IMT-Advanced)" for 4G specifications.

[6]Total of 395 members. Duplicates. Cleanup by collating the names of affiliates/subsidiaries. Reduced to 320 companies. When a company is listed via multiple locations, geographic distribution indicates the

attend the various 3GPP meetings. Some member organizations do not attend any working group, while others attend one or more working groups. Therefore, the attendance data must be tracked separately. Each 3GPP meeting tracks the attendance – this includes all the organizations that registered for the meeting, as well as a field to track whether the registrants did actually attend the meeting. The data also identifies the individuals from the member organizations who attended the meeting. Therefore, by tracking the attendance data for every 3GPP meeting that has taken place since 1999, we are able to identify the number of meeting attendance records, and therefore the number of man-hours spent in the meetings (assuming 8-hour/day, 1 week long meetings). Some notable issues included normalizing the names of member organizations through the data-set. Apart from fixing the usual spelling error corrections, the some member organizations become members of 3GPP via various subsidiaries (e.g.: the membership record for Vodafone includes Vodafone U.K., Vodafone Germany, etc). The data-set constructed for this paper collapses all the subsidiaries of a single company into one (e.g. Vodafone), and lists the geographic location as the location of the headquarters for the member organization.

Contributions and CRs: Second, I collect data on the contributions that were submitted to the various 3GPP working groups. As discussed in Section 2, there are various types of contributions, such as CRs, discussion papers, work item descriptions, draft specifications, liaisons, notices, agendas etc. I first generate a master list of all types of contributions that are submitted and discussed in meetings. However, most of the contributions do not relate to actual additions or modifications to the technical specifications. Several are entirely non-technical in nature (e.g.: notices, liaisons, agendas etc.). In order to find the best proxy for actual technical proposals made for inclusion in the standards, we also track down the data solely for CRs.

There are a few important issues to note about the data on contributions, which is not maintained explicitly by 3GPP. Whenever a document is submitted to 3GPP, a temporary document number is given to it called a "tdoc". The data on contributions has been reconstructed by merging the list of tdocs that are made available by a

location of the headquarters.

working group following each meeting, typically in a spread-sheet format, which we aggregate across meetings for each working group. Among other things, the data includes the meeting date, type of contribution, the source organization(s), the name of the author(s), and the outcome of the contribution. The data on contributions is not reported consistently prior to 2005 for most of the working groups[7], and therefore, we restrict it to start from January 2005 for all the working groups, until end of 2012. Further, several fields are inconsistent and missing for some document types for SA and CT working groups. Therefore, the contribution data is reported only for all the RAN working groups, for the sake of accuracy.

From the contribution data, we construct the data solely for CRs in order to identify a proxy for the participation in actual technical proposals that were made for inclusion in the standard, based on the type of document field listed in the contribution tdoc lists. In addition, a database of CRs that have been approved for inclusion in the standard, and tied to a specific release and technical specification is officially tracked and maintained by 3GPP. This data is available from 2006-2010[8]. In order to develop in the CR data derived from the contribution data, we use the official approved CR data to check whether the decisions and the source organizations match in both the data-set. The final constructed data-set on CRs includes the meeting date a CR was first submitted and the meeting date of its most recent update, the source organization(s), the name of the author(s), the outcome of the CR, the specification and release number for the approved CRs. Because of this due diligence, the CR data is recorded and complete for all working groups, including those under RAN, SA, and CT.

Outcomes of contributions and CRs: As discussed in Section 2, each contribution or CR is presented and discussed in the respective 3GPP working group meeting with

[7]For some working group meetings, the tdoc listing of the discussed documents is missing, and for others, the source organizations that submitted the contributions are missing. Due to the large number of missing data points, we opted for dropping all the data prior to to January 2005.

[8]3GPP did not officially start tracking down the CR data until beginning of 2006.In addition, the CRs are included in a database once they have been tied to a specification and a release. Thus, and there is a time-lag in updating the database from when the CRs were submitted and discussed in meetings, leading to the information being up-to-date only from 2006-2010.

several potential outcomes. The tdoc list for contributions contains a field explaining the decision made by the working group. Across working groups, this decision field is typically inconsistent in terms of spelling, wording, and amount of detail used. Even within working groups, several outcomes are used that can be clubbed together with others. Therefore, for the sake of consistency and brevity, we found it necessary to categorize these decisions into well-defined buckets (for e.g., we group together the "agreed" and "approved" in a single category called "approved", and the "postponed" and "not treated" in a single category called "not treated".).

Table 1 lists the summary statistics for the data collected on 3GPP standards. A total of 989 meeting attendance records have been parsed across the various working groups. The number of attendance records indicates the total of the number of delegates attending the meetings. Therefore, assuming 5-day/week meetings lasting 8 hours/day (a conservative estimate per several meeting delegates), the number of man-hours spent solely in meetings is calculated. The number of contributions made to all the RAN working groups, and their outcomes are also listed. The data is available for all the working groups individually as well, but not listed here for the sake of brevity. The number of CRs submitted to all working groups and their outcomes is also listed. Finally, the organizations that attended the meetings are identified, as well as the organizations that have made at least one contribution or CR submission to the working groups. The number of contributions and CR submissions are known at the organization level.

Patent data: In addition to the data from 3GPP on membership, meeting attendance, contributions and CRs and their outcomes, we separately collected data on the patents that were disclosed as potentially essential to any of the 3GPP standards to the ETSI SSO. Unfortunately, there is no way to relate these patents directly to the contributions made to the technical specifications without expert engineers and attorneys analyzing the thousands of patents and the hundreds of thousands of contributions, and matching them up. The data on patents is collected from the declaration forms that must be filled out by companies for any declarations, available in the ETSI IPR database located at www.etsi.org. The declaration forms are not filled consistently

	Overall	RAN	SA	CT
No. attendees	473	309	295	170
No. attendance records	79,258	47,009	19,717	12,532
No. meetings	989	475	338	176
No. man hours in meetings	2,972,504	1,746,776	743,672	482,056
No. contributions		183,955		
Contribution outcomes				
Approved		31%		
To be revised		19%		
Not treated		15%		
Noted		26%		
Rejected		9%		
No. CRs	125,712	48,447	35,225	42,040
CR outcomes				
Approved	39%	43%	32%	39%
To Be Revised	35%	31%	39%	37%
Not Treated	10%	7%	12%	13%
Noted	8%	10%	13%	3%
Rejected or Withdrawn	8%	10%	4%	9%
No. attendees with >1 contribution		152		
No. attendees with >1 CRs	146	108	90	75

Table 1: 3GPP Summary statistics – overall.

across various organizations. Most of the fields are optional, and each declaration form can have one or more disclosures for patents that are potentially essential to the standard. Due to several missing fields in the declaration forms, a significant effort has been expended in identifying the correct patent number and the assignee name (of the organization owning the patent). For example, some forms displayed did not display a patent number, but only a patent title. The patent number was retrieved by searching for the title. In addition, some patent data displayed a mismatch in the patent number and title, in this case the the titles were used to identify the correct patent numbers. This exercise significantly expanded the data-set. The assignee names had to be cleaned up and normalized as well. In order to account for any time lag in declarations and the forms being updated by the ETSI database, the data on patents declared as potentially essential to ETSI ranges from 1999-2011.

4 Initial findings

Our preliminary analysis of the 3GPP data proceeds in five parts. First, we identify the current list of member organizations who have chosen to become members of 3GPP, as well as the geographic distribution of these represented organizations. Second, based on the meeting attendance records, we estimate the amount of time spent in the meetings of various working groups as an indicator of the amount of effort expended in standard-setting (solely during meetings), the relative importance of various working groups, and the growing interest in 3GPP standards. In addition, we present the technical specifications per release for understanding the scale of each release. I then turn to what the participation dynamics in the actual working group meetings. I analyze the contribution and CR data to understand how many participants are making active contributions to the standards, and what happens to these contributions. In addition, we look at the data on patents disclosed as potentially essential to these standards, to identify whether the contribution and patenting data are displaying a similar trend. Finally, we turn to analyze whether the approval rates of contributions made to the standards differ across the types of participants (top contributors versus all else).

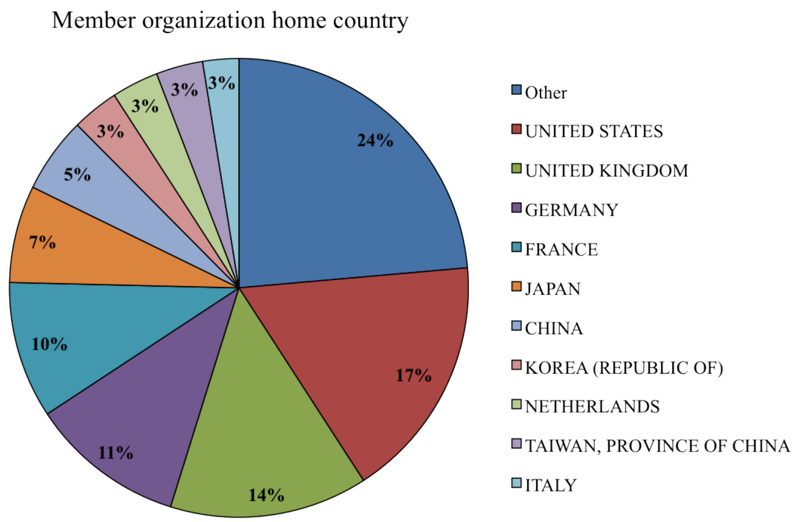

Figure 3: Geographic distribution.

4.1 Membership and attendance

There are currently 320 unique organizations that are listed as voluntary members of 3GPP, representing 43 countries. The largest representation is from companies that are headquartered in one of the various countries in Europe (U.K., Germany, France, Netherlands, and Italy), followed by the United States, Japan, China, and Korea, See Figure 3.

All the member organizations do not typically attend the standards meetings, and some of the attendees are not listed as members. Therefore, the actual attendance is constructed via the meeting attendance records. Over the period of 989 3GPP meetings conducted from 2005-2012, a total of 473 unique organizations attended one or more of these meetings. The geographic distribution of the attendees is similar to that of the actual members. In addition, the data on a per-meeting basis allows us to track the time spent across the various working group meetings. Table 2 lists the breakdown of the total number of participants and meetings in the various working groups, used for calculating the total meeting time spent, shown in Figure 4.

	Overall	RAN	SA	CT
No. of Meetings	989	475	338	176
No. of Attendee Records	79,258	47,009	19,717	12,532

Table 2: Number of meetings and attendee in RAN, SA and CT.

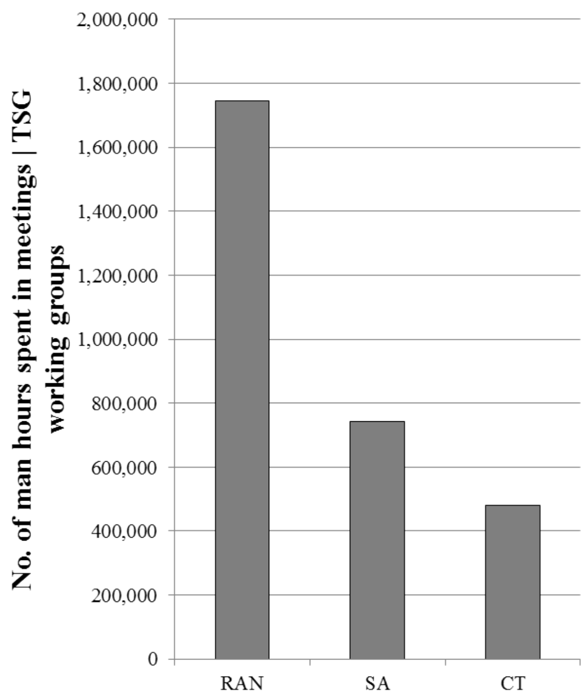

Figure 4: Number of man hour in meetings (total).

Notice that the RAN working groups, in particular RAN-1 and RAN-2, clearly display a much higher number of man-hours spent in meetings. This is consistent with the background explanation of the technology in Section 2, highlighting that all technologies within the standard, and therefore all patents that relate to these technologies, are not of equal value.

4.2 Scale and size of standard setting

Our next set of graphs examines the scale and size of the standard setting effort in 3GPP — in terms of the time spent on standard setting as well as the the number of contributions and specifications.

The time line of the participation in the 3GPP standard setting process in Figure 5 displays an increasing number of man-hours spent in meeting time. Note that the bulk of R&D effort is expended on the technologies discussed and finally adopted in the standards well before and outside of the meetings. Much like academic researchers conducting research culminating in conference and journal publications, the active contributors in the standards bodies typically work on R&D for the associated technologies for months leading up to the meetings. Therefore, the man hours spent in meetings is only a proxy for the amount of R&D activity associated with these standards.

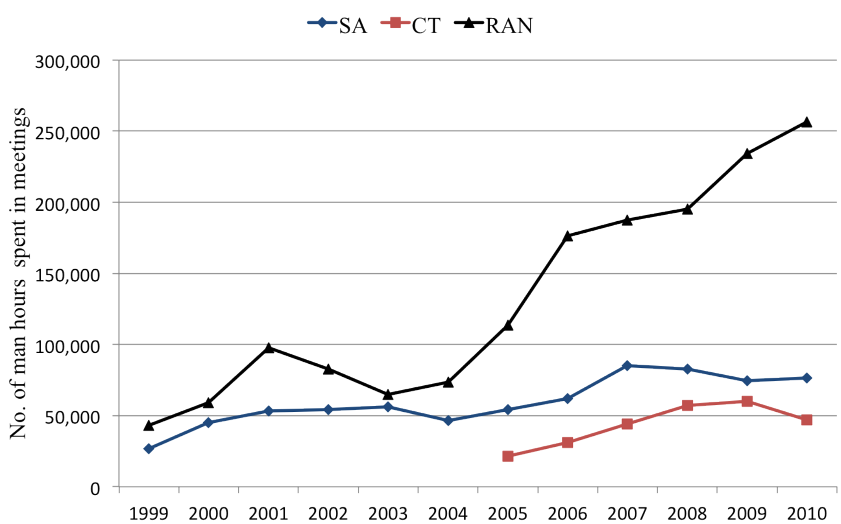

Figure 5: Number of man hour in meetings (timeline).

The number of specifications per release is displayed in Figure 6. Note that each specification has hundreds of technical contributions associated with it. Indeed, the total number of contributions and CRs since 2005, i.e., those related to Release 5 and above, are listed in Table 2.

These charts highlight the scale and size of these wireless cellular standards that

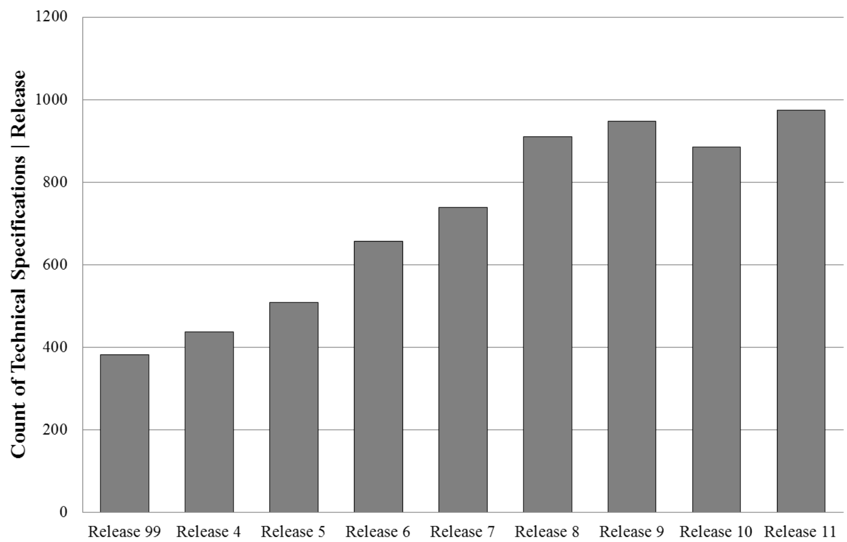

Figure 6: Number of technical specification per release.

have enabled high-speed wireless connectivity and the mobile and smart-phone revolution. Amidst such success, numerous discussions have ensued about the number of patents potentially essential to these standards. It is important to recognize the scale of the standards themselves to put any such discussions in the right context.

4.3 Active participation in standard setting

We now turn to examine the landscape of actual active participation into the standardization process by the 3GPP members and meeting attendees. Not all members or attendees actively contribute to the standard setting process.

Recall from Section 2 that all 3GPP governing rules require all member organizations to have equal voting rights, and require the chair of the meeting to follow a consensus building process. That is, even if an attendee does not approve of a technical proposal under discussion for inclusion in the standard, s/he can raise their hand during the presentation of the proposal and object. Such objection must be on technical grounds with reasons clearly explained by the objector. The next stage typically involves working on a common revised proposal such that the technical objections are addressed, and resubmitting the revised proposal. If the proposal still fails to reach approval or rejection after multiple such iterations, the chair is forced to resort to majority voting. For any proposal to be accepted for inclusion the standard, a majority vote of $> 71\%$ is needed. Therefore, even if attendees do not actively make technical proposals for inclusion in the standards, they have the authority to influence what is and is not included in the standard.

In order to understand the proportion of attendees that are actively contributing to the standard, we look at the contribution and CR data. Since we do not have the data on contributions for SA and CT working groups, we focus only on the RAN working groups for this ration. As the RAN working groups represent the fundamental technologies, and the the largest proportion of man hours are spent in RAN working groups, we believe that this data represents the overall picture of standardization in 3GPP. For the sake of a fair comparison, we count only the contributions and CRs submitted by attendees in the numerator, and only the meeting attendees in the denominator, during the 2005-2012 time period. The data is reported in Table 1 in Section 2.

The data indicates that 49% of attendees ever submitted one or more contributions any one of the RAN working groups, i.e., this includes any document submission such as agenda, liaison, non-technical discussion paper etc.; and 34% of the attendees ever submitted one or more CRs, or actual changes to the technical specifications, to any one of the RAN working groups. Notice that this data includes any attendee organization that may submitted only a single contribution/CR (or just a few contributions/CRs) during the 2005-2012 time period. Therefore, to get a more complete picture of the contribution dynamics, we then set out to examine the distribution of effort made among the active contributors and CR submitters. Even among these active organizations, very few actually make substantial number of contributions. Figure 7 depicts the histogram for the number of organizations by the number of contributions they submitted during the 2005-2012 time period, and Figure 8 depicts the histogram for the number of organizations by the number of CRs they submitted during the 2005-2012 time period.

Therefore, only a minority of attendees actively contribute directly into the standard setting process, and only a small minority heavily contributes to the process. This is

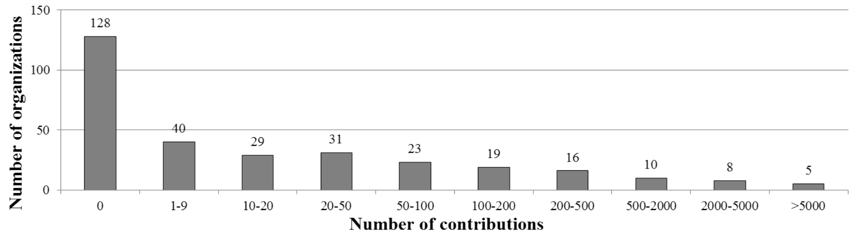

Figure 7: Distribution of contributions in RAN.

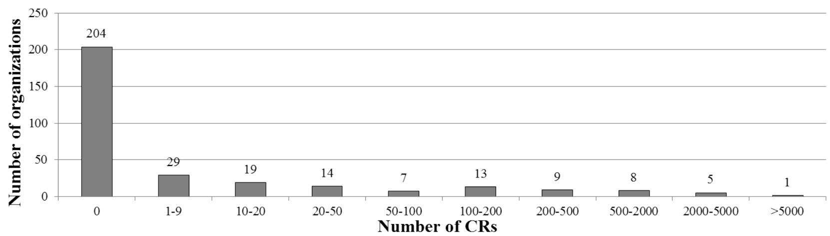

Figure 8: Distribution of CR contributions in RAN.

not surprising, since the investment in R&D that goes into development of technical proposals for the standards is time consuming and costly. However, the rest of the attendees still find value in attending the meetings and being a part of the process. They can utilize these meetings for keeping abreast with the complex intricacies of the technology that they need to implement as downstream manufacturers, as well as have the power to influence the technologies that are adopted into the standard.

This indicates that while a few upstream investors are actively inventing and contributing to the standards, the downstream manufacturers are a large part of the standard setting process as well, with high attendance and equal voting rights. There is little change of ambush or deception with regards to the technology that is entering the standards from any party due to this transparency and equal voting rights. The demarcation between the role of different players is also indicated – the upstream inventors are investing in risky R&D for developing technologies that may or may not enter the standard (and the standard may or may not be successful in the market), while the downstream implementors are leveraging this investment by closely following the standard to comply with it and make compatible products. Thus, cooperative participation from both creates a common surplus.

4.4 Investment in R&D and patenting

In order to better understand the dynamics of the 3GPP participants' R&D investments, we turn to observe the data from patents declarations to ETSI. ETSI's IPR policy requires its members to declare patents essential to the standard, but the SSO does not act as an enforcer or evaluates the declarations reported by the members for essentiality. Therefore, we call the patents found in declaration forms as "disclosed potentially essential to the standard". However, disclosing patents as potentially standards essential also requires the member organization to commit to license the declared patents under ETSI's Fair, Reasonable and Non Discriminatory (FRAND) terms, and under-disclosure may limit the enforceability of the non-disclosed patents a later date. Therefore natural incentives are built in the system for avoiding over- or under- disclosure of potentially essential patents.

Only 22% of all the 3GPP members have even a single patent disclosed as potentially essential to ETSI. This is similar to the percentage of participants making active CR contributions to 3GPP RAN working groups, as discussed in Section 4.3. Among these patent holders, the distribution is similarly skewed as the CR data – Figure 9 displays that only a handful of patent holders have disclosed a large number of patents as potentially essential, while several have disclosed a small number of patents.

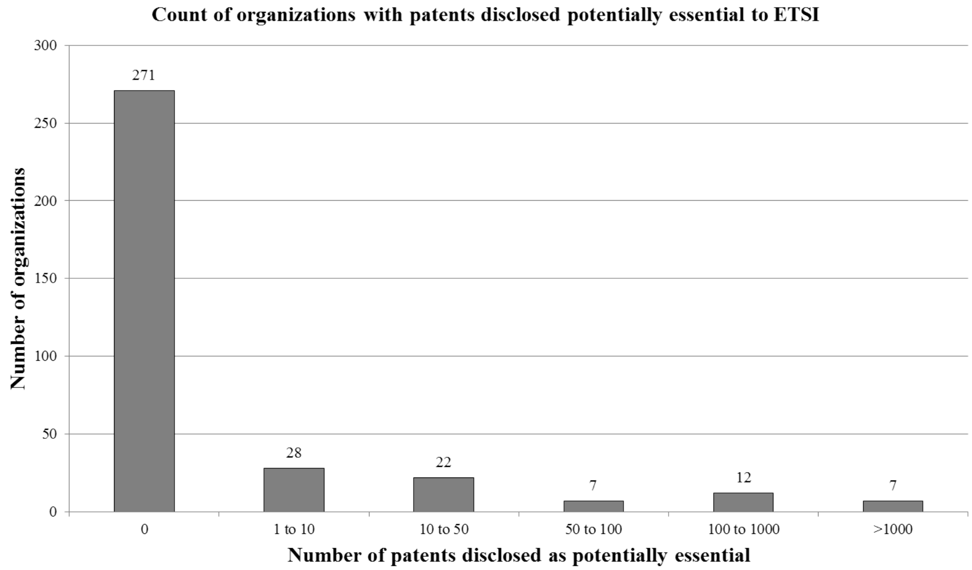

Figure 9: Count of organizations with patents disclosed potentially essential to ETSI.

Therefore, the patent disclosure trend is similar to that of contributions and CRs, indicating a small minority of heavy investors in upstream inventions and R&D.

4.5 Consensus building

Next, we turn to exploring the percentage of proposed contributions are actually approved in the standards. For the RAN working group outcomes listed in Table 1, we find that only 31% of the overall contributions are approved in the standards.

In addition, we try to understand whether there is any difference in the rate of approval for the top contributors versus others – in other words, we try to test the hypothesis whether the top contributors are receiving any favorable treatment. Figure 10 shows that the approval rate for the top 10 contributing organizations is similar to that of all other organizations combined.

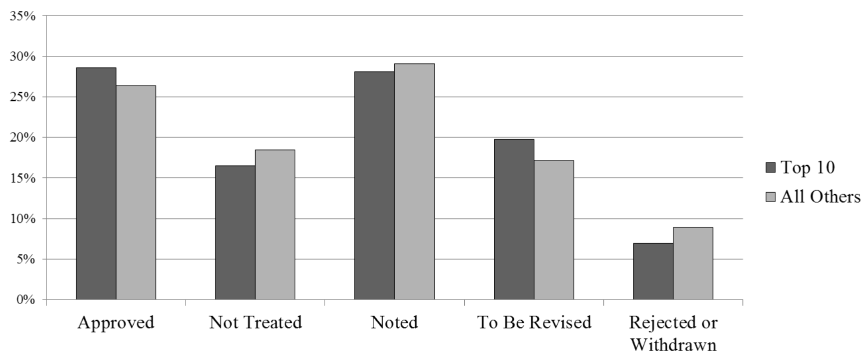

Figure 10: RAN 1 and RAN2: Contribution treatment.

As discussed in Section 2, a contribution may require further revisions and modifications when an objection is raised. This typically requires authors from multiple organizations to work together and resubmit a revised contribution, sometimes requiring several revisions. The data-set is built to track the revision path for all the contributions based on the meeting attendance records, in order to understand the outcomes of the revisions. As contributions are being revised, the number of unique organizations[9] authoring the contributions are increased, as shown in Figure 11. In addition, the likelihood of contributions being approved for inclusion in the standard is higher as the number of unique organization authorship endorsing the contributions is higher.

Together, these data-points indicate towards a positive story about the role of consensus building in the standard setting process. First, no specific advantage seems to be attributable to the nature of the organization proposing a contribution, in terms of the acceptance rates. Second, as contributions are further revised, collaboration among multiple organizations is reflected, improving the rate of acceptance of the proposed contributions. This is in-line with the institutional understand of the standard setting organizations and their rules requiring them to be consensus building organizations with majority voting.

[9]Multiple authors from the same organization may be listed on the contributions. The data is cleaned to count only the number of unique organizations represented in the multiple author-ships.

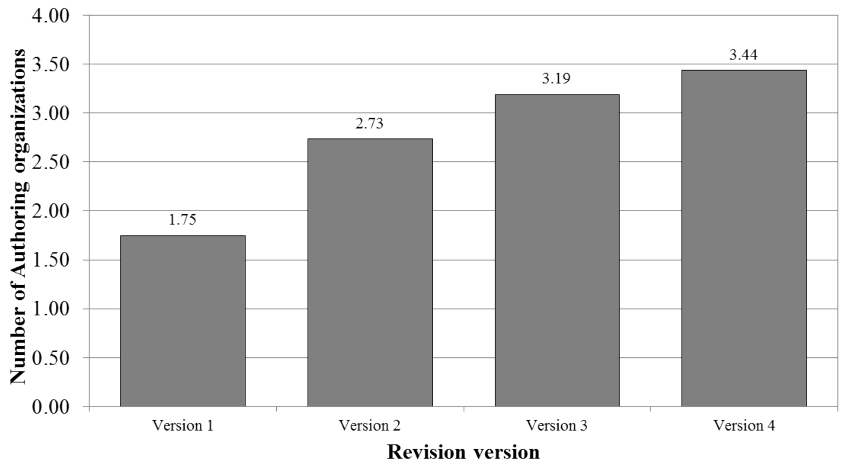

Figure 11: Number of authors vs Revision number.

5 Concluding remarks

This paper demonstrates that understanding the institutional nature of standard setting organizations and studying the data behind them allows for addressing some of the policy concerns under heavy discussion today.

For example, in order to understand the value of SEPs, it is first important to understand the scale and size of the standard setting process for the technologies under study. Behind the claims of a problem of "too many" SEPs for 3G and 4G cellular standards, the understanding of the denominator has been missing. The data demonstrates that there are thousands of large technical specifications forming these standards, each containing hundreds and thousands of complex technical elements. In addition, from the technical focus of the working groups, and the amount of time and effort spent across them, it is clear that all technologies are not equal in their value. Some technologies are core and fundamental to the standard, and the value of a portfolio of patents therefore differs significantly across SEP holders depending on the type of technology focus and the quality of their inventions. Finally, standard-setting is not a one-shot game. Several iterations and revisions are made over the years to technical specifications. Therefore, the standards world is not divided neatly into an ex-ante and ex-post universe. Specifications can be changed and modified over long periods of time, and even made obsolete at times. With several thousands of technical proposals being discussed based on technical merit for consideration of inclusion in the standards, it is also unlikely that discussions regarding the economic value of various alternatives by engineering delegates is either practical or feasible. In order to discuss an economic value, the success of the standards in question should also be known with some certainty, however, intra-standards competition (the approval rate of contributions indicates that not all proposals are accepted) as well as inter-standard competition (various alternative technologies to the standards being defined may exist), render this to be a highly uncertain task.

One of the other major concerns regarding SEPs has been the potential risk of hold-up of downstream manufacturers by upstream patentees. Here, the initial findings from the data are quite telling. Majority of the attendees in the standards meeting seem to be passive participants, with equal right to influence the decision of what is adopted or not in the standards, without making active technical proposals or contributions. This is because active contribution requires upfront investment in risky R&D, which is undertaken by a smaller proportion of the attendees. Since all technical proposals are discussed prior to inclusion on the standard in an open consensus building forum, there is little change of “ambush” or “deception” by inclusion of technologies that are not known in advance to the downstream manufacturers and form the majority of the attendees. The distribution of the patenting behavior reflects the distribution of technical contribution and CR participation — with few active contributors and patentees and a vast majority with a few or no contributions or patents.

The paper then turns to testing whether the major players, or organizations that offer the majority of the contributions and therefore hold the largest number of patents disclosed as potentially essential, are controlling the standard setting process, and potentially “crowding out” newer or younger attendees. The data from the outcomes of CRs and contributions indicates that the success rate (or approval rate) of technical contributions submitted by the top 10 organizations (in terms of the number of contributions submitted over 2005-2012) is the same as that of all other organizations. In addition, the data from tracking the revisions of proposed contributions indicates how consensus building is working: as contributions are revised, the number of organizations signing up as authors of these proposals increase, and with this increase the likelihood of acceptance in the standard increases.

The data collection and analysis of 3GPP contributions, CRs, and their outcomes from the working group meeting reports has been possible due to a deep institutional understanding of the standard setting process. The initial findings only provide some indications into potential workings and dynamics of the various participants in the value chain of standard setting. Several more questions can be asked and several more proposed theories about standard setting can be empirically tested using such data. Researchers working on standard setting and deriving policy implications should carefully consider the institutional background and empirical proof in order to make sound policy recommendations.

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