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Keskusteluaiheita – Discussion papers

No. 997

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CLUBS AND STANDARDS: THE ROLE OF INDUSTRY CONSORTIA IN STANDARDIZATION OF WIRELESS TELECOMMUNICATIONS

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Comments on earlier versions by Talia Bar and Jeff Prince are gratefully acknowledged. This research was financially supported by the joint Wireless Communication Research Program of the Berkeley Roundtable on the International Economy (BRIE) and the Research Institute of the Finnish Economy (ETLA) (www.brie-etla.org). The paper has greatly benefited from discussions with the program participants.

ISSN 0781-6847 08.12.2005

LEIPONEN, Aija, **CLUBS AND STANDARDS: THE ROLE OF INDUSTRY CONSORTIA IN STANDARDIZATION OF WIRELESS TELECOMMUNICATIONS**. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2005, 44 p. (Keskusteluaiheita, Discussion Papers, ISSN, 0781-6847; no. 997).

ABSTRACT: This empirical study explores firms' standard-setting strategies in wireless telecommunications. A quantitative case study of one standards development organization, the Third Generation Partnership Project (3GPP), provides measures for firms' ability to influence technical standardization outcomes. These measures are related to member firms' cooperative activities outside of the 3GPP. A particular focus is on firms' activities in other cooperative technical organizations such as industry associations and fora that aim at developing or promoting specific wireless technologies. Estimation results suggest that firms with dense connections to other 3GPP members outside of the standards development organization through the various cooperative organizations are more influential within the 3GPP. This supports the argument that leading technology firms' standard-setting strategies do not simply involve choosing the one optimal form of cooperation, but setting up a constellation of cooperative arrangements with their peers, to maximize opportunities to influence the industry. However, the majority of member firms in a standards development organization such as 3GPP do not participate in working groups with the goal of influencing standardization outcomes. Instead, these firms are probably trying to learn about new technologies and the potential evolution of markets from the leading companies. It is in their interest to make sure that coordinated outcomes are achieved in the industry. Overall, the results point to the significant role played by private and semi-public cooperative arrangements in determining standardization outcomes. However, these organizations are largely outside of public policy or oversight. In order to enable access to standardization and subsequently network markets for all kinds of firms, standards policy makers might consider supporting consortia activity of small firms and setting some rules about open access.

Key words: Standard setting; wireless telecommunication, cooperative arrangements

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TIIVISTELMÄ: Tässä empiirisessä tutkimuksessa tarkastellaan langattoman viestinnän yritysten standardointistrategioita Third Generation Partnership Project-organisaation (3GPP) puitteissa. 3GPP-aineiston perusteella voidaan arvioida yritysten mahdollisuuksia vaikuttaa langattoman viestinnän teknisten standardien sisältöön. Tekniset standardit ovat tällä toimialalla erityisen tärkeitä ja vaikuttavat yritysten taloudelliseen menestymiseen tulevaisuudessa. 3GPP-järjestön lisäksi monet langattoman viestinnän yritykset toimivat muissa yhteistyöjärjestöissä ja -organisaatioissa, kuten toimialajärjestöissä ja eri teknologioiden markkinointiorganisaatioissa. Tutkimuksessa saatujen tulosten mukaan muissa yhteistyöjärjestöissä toimiminen edistää merkittävästi yritysten mahdollisuuksia vaikuttaa 3GPP-standardeihin. Johtavat teknologiayritykset toimivatkin kymmenissä järjestöissä maksimoidakseen vaikutusvaltaansa. Suurin osa 3GPP:n jäsenyrityksistä ei kuitenkaan pysty vaikuttamaan kovin suuresti standardoinnin lopputulokseen. Nämä yritykset todennäköisesti pyrkivät sen sijaan oppimaan teknologian ja markkinoiden kehityksestä johtavilta yrityksiltä. Teknologiapolitiikan kannalta tulokset osoittavat että johtavien yritysten toiminta eri yhteistyöjärjestöissä vaikuttaa merkittävästi standardoinnin lopputuloksiin, vaikka näihin yhteistyöjärjestöihin ei ole poliittisin toimenpitein juuri puututtu. Mahdollisina politiikan keinoina toimialan avoimuuden lisäämiseksi mainitaan pienten yritysten yhteistyöjärjestöjäsenyyksien tukeminen ja järjestöjen jäsenyys- ja toimintasääntöjen valvominen kilpailupolitiikan yhteydessä.

Asiasanat: Tekninen standardointi, langaton televiestintä, yritysten yhteistyösuhteet

1 Introduction

Technical standard-setting has become an integral part of firms' technology strategy in network industries (see e.g. Cargill 2004). The need for compatibility standards in industries characterized by network technologies is obvious: Without compatibility, exchanging messages or physical objects over the network consisting of devices from different suppliers would be impossible. In addition to physical networks, such as railways and electricity, networked exchange is typical of computer and communications technologies. Here, of course, the good traveling over the network is information. Along with the proliferation of information and communication technologies, the role of compatibility standards in determining the nature and performance of information networks has become central.

Research on standard setting focused for a long time on market-mediated competitive processes (e.g., Katz and Shapiro 1985; Farrell and Saloner 1985 and papers building on these). An exception within this theoretical stream of research is Farrell and Saloner (1988), who modeled the relative merits of market- and committee-based standard-setting processes. However, little theoretical or empirical work built on their work (but see recent papers by Simcoe 2004 and Lerner and Tirole 2004). More recently, an empirically driven literature on standardization processes – few of which are purely market-based – is emerging (Funk and Methe 2001; Weiss and Sirbu 1990; Funk and Methe 2001; Bekkers, Duysters, and Verspagen 2002; Chiao, Lerner, and Tirole 2005). The main insights of this new literature emphasize participating firms' size and intellectual property positions as factors determining standardization outcomes.

This study contributes to the empirical research on committee-based standard-setting by focusing on the role played by firms' connections to each other *outside* of the SDO. These connections can take the shape of private alliances, semi-public consortia, or other public SDOs. While a few earlier studies have alluded to the relationships between informal and formal standardization organizations (e.g., Branscomb and Kahin 1995), it is argued here that the more connected firms are in external cooperative technical organizations, the more likely they are to get into influential positions within the SDO. The empirical context of study is the Third Generation Partnership Project (3GPP), founded in 1998. This SDO coordinates the specification development for one of the competing third generation wireless telecommunication systems, Universal Mobile Telecommunication System (UMTS).

During the 1990s, a striking organizational phenomenon took place simultaneously with the standards specification development within this SDO. Some of the 3GPP members were extremely active in forming and joining dozens of "clubs", or industry fora and associations, in closely related technical fields. By cooperating in these external associations with subgroups of their peers from 3GPP, firms were arguably positioned to more effectively influence the standards development work within 3GPP. They were able to build support for their technical proposals before they even were introduced in 3GPP; they were able to set the clubs' agenda in collaboration with other key players before the rest of the industry was allowed to contribute; and they could negotiate over the key tradeoffs with their association partners to bring forth more polished proposals in 3GPP working groups. All this would increase the speed of decision-making within the 3GPP, thus making the SDO more efficient. However, it is also possible that the less formalized and less democratic negotiation processes in the external industry associations made it more difficult for small firms or competing subgroups to get their voices heard in the standard-setting process, and by the time the specifications were brought to the consideration of 3GPP itself, they were so far along in the development process that it would be difficult for opposing firms to rally support for re-opening the proposals or starting the development from scratch.

Casual observation suggests that Information and Communication Technology (ICT) firms invest substantially in terms of membership fees and human resources in these kinds of industry activities. Simple glance at the association activities of leading ICT companies suggests that participating in dozens if not hundreds of consortia is the rule, not the exception (see e.g. Lemley 2002 on Sun Microsystems' consortia activity and Motorola's activity in section 2 of this paper). While little economic or management research has yet addressed these kinds of collaborative strategies, the antitrust literature and policy makers have started to discuss the implications for competitive outcomes (Gates 1998; Cargill 2001; Anton and Yao 1995). The phenomenon and its analysis thus have both policy and management relevance.

This paper explores firms' cooperative strategies in committee-based technical standard setting and argues that it is not only the technological prowess and market share that matter (Weiss and Sirbu 1990; Bekkers, Duysters, and Verspagen 2002); success in standards negotiations also depends on firms' positions in cooperative (coalition) networks, and one particularly important instance are external industry associations and fora. The novelty of this paper is thus to establish a link between the "club" (consortium) activities of firms and their standard-setting outcomes in more formally operating Standards Development Organizations. While the cross-sectional nature of the analysis prevents drawing conclusions regarding causality, it is shown here that firms whose requests and proposals are successful within an SDO also tend to engage in more consortia than their less successful peers, controlling for firm size, intellectual property positions, industry affiliations, and private alliance activities.

Policy implications suggest that these kinds of consortia may indeed have ramifications for competitive outcomes. Thus, not only the procedures and outcomes of official and formal SDOs need to be scrutinized, it is possible that the smaller and more exclusive fora and associations have a significant impact on standardization and thus subsequent competition in the market. For management practitioners, the results imply that operating in one single standard-setting committee may not be enough; more complex cooperative strategies, including memberships in competing SDOs, industry associations, private alliances, consortia, and fora, appear to be more effective.

The paper next discusses existing empirical literature on standard setting and then introduces the Third Generation Partnership Project in more detail by explaining its mission, organization, and decision-making procedures. Empirical hypotheses about firms' abilities to influence outcomes in such an SDO are developed in section 3. Section 4 presents the dataset and the empirical results. Section 5 concludes and discusses research opportunities for future work.

2 Committee standardization: the case of the Third Generation Partnership Project

2.1 Literature on committee-based standard-setting processes

Two fundamental factors characterize standardization activities in wireless telecommunications. First, standardization is an integral part of innovation activities in technological areas that feature network externalities (cf. Weiss and Sirbu 1990; David and Greenstein 1990). Without interoperability, telecommunication terminals and network infrastructure have no value. Second, Schmidt and Werle (1998) suggest that technical solutions to compatibility problems and the economic implications of technological alternatives are fundamentally uncertain. As a consequence of this substantial technical uncertainty, actors' preferences may remain indeterminate for extended periods of time during standardization processes. Without clearly defined preferences for one solution over another, for many firms in the industry, the "efficiency aspect" of finding (any) solutions to shared problems is more important than the "distributional aspect" related to rents created in the technical system. In other words, standardization games are not entirely non-cooperative. Many aspects of institutionalized standardization may thus be viewed as a coordination game rather than as an attempt to achieve cooperation within a prisoner's dilemma situation.

Participation in standards committees thus represents an opportunity for learning and collective problem-solving rather than only for promoting a specific standard (Schmidt and Werle p. 97). In fact, "few engineers can be expected to grasp all technical issues equally well" (p. 94). Anticipatory standards are thus created under substantial uncertainty and incomplete information, and some individuals and companies are better equipped to contribute to this work than others. Moreover, as David and Greenstein point out (1990), markets do not even exist yet at the time when anticipatory standards are created. Then, the strategic question for firms is how to organize technological co-operation and coordination that is prerequisite for the creation of markets. Indeed, the organizational choice is between standardization committees and R&D alliances or joint ventures, rather than between committees and markets, as has been suggested in the earlier theoretical literature.

In one of the first quantitative empirical studies of standard-setting processes, Weiss and Sirbu (1990) examined the factors that affect technology choices in standardization committees. Their findings suggested that the size of firms in the sponsoring coalition and the firms' technical contributions submitted in the standardization process are particularly significant factors increasing the chances that a sponsored solution is adopted. Additionally, market power of technology buyers (monopsony power) is found to be a significant determinant. In contrast, measures of installed base and technical superiority do not seem to be significant. Hence, this study emphasized the political nature of the standardization process: large firms with market power tend to dominate the process. Additionally, high frequency of contribution in the specification process may be rewarded.

Bekkers, Duysters, and Verspagen (2002) introduce intellectual property rights (IPRs) in their qualitative study of alliance networks related to wireless telecommunications technology in the case of the GSM standard (Global System for Mobile communications). The authors argue that due to its early emphasis on the strategic use of IPRs, Motorola (with the help of its alliance partners Nokia, Ericsson, Alcatel and Siemens) was essentially able to block the entry of Japanese equipment suppliers in the European GSM market in the early 1990s. Until that time, standardization in telecommunications had largely taken place based on “gentlemen’s agreements” to license any essential patents for free or for very low cost. Patenting was not even considered a key strategic activity by European firms, as evidenced by Nokia’s early litigation problems in entering the US markets (e.g. patent infringement cases GTE v. Nokia and Nokia v. Motorola; both of which suits were settled out of court). Globalization of standardization activities in wireless telecommunications has thus drastically changed the nature of the process. As in other high technology fields (Grindley and Teece 1997; Hall and Ziedonis 2001), IPRs have become key assets which firms can use to block harmful suggestions and negotiate licensing and cross-licensing arrangements. In a related study, however, Gandal et al. (2004) examined the timing and Granger causality of IPRs and standardization activities. Their preliminary results suggest a link from SDO activities to patenting, and not the other way around. Anticipatory standardization may thus pre-date innovation itself.

Most recently, Chiao, Lerner and Tirole (2005) have examined the question of “forum shopping” with respect to committee-based standard-setting. They argue that technology suppliers (sponsors) try to maximize their private benefits in choosing to which standard-setting committee they submit their technological solution for certification. The empirical evidence indeed suggests that by operating through more sponsor-friendly venues firms are less likely to be required to make concessions to users of the technology, for example, in terms of royalty-free licensing of intellectual property. Additionally, maturity of the technology is found to be positively associated with sponsor friendliness. The authors suggest that technological maturity proxies for the quality of the standard, and thus, technologies of higher quality are certified through more credible standard-setting organizations. However, the underlying model assumes that firms choose just one organization for their standardization activities. In contrast, empirical observation suggests that firms deploy much more complex strategies. In particular, they tend to simultaneously participate in many different types of standard-setting organizations. In addition to public and open formal SDOs, technology sponsoring firms often join Special Interest Groups, technology fora, and more restricted alliances and joint ventures as well. It is thus not the question of choosing the optimal venue for standard setting but choosing the optimal mix of cooperative arrangements to influence standards development.

In the current study, I focus on one single technological field, which enables controlling for technological variation although it reduces generalizability. I specifically focus on the aforementioned complex inter-organizational strategies. The research question concerns the relationships between the various standard-setting organizations. In particular, I study why firms might participate in multiple industry associations and SDOs within the same technological field. The answer proposed here has to do with the political and social capital acquired through multi-organizational contact with standardization peers.

2.2 Introduction to third generation wireless telecommunications

The notion of third generation wireless telecommunications ("3G") refers to the shift from digital voice communication ("2G") to the era of "mobile internet" or "broadband wireless," in other words, expanding the range of mobile communication services from transmission of voice to various kinds of data, including pictures and eventually multimedia. These new services require substantially higher data transfer capabilities, and the technological bottlenecks lie mostly in the capacity of telephone handsets and the air interface to transfer data—after the signal has reached a base station wirelessly, it continues in the fixed line networks where capacity constraints are easier to solve. The International Telecommunications Union (ITU) defines 3G telecommunication services by the rate of data transfer: 3G implies rates of 144 kbps or higher.[1] Scenarios for the final 3G services mention rates of 2-3 Mbps. Moreover, 3G phones are, according to existing plans, going to be truly global, which means that a cellular phone based on any 3G technology would be usable in any 3G network, anywhere in the world.[2] Roaming is projected to ultimately become international and intercontinental. It remains to be seen, however, if and how filtering technologies between different standards will be developed and implemented.

Already in the era of second generation mobile telecommunications (2G), the toughest battles among equipment manufacturers were fought for control of the air interface standards. The main air interface technologies offered were Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). The former technology was developed and supported by the existing leaders in the industry, including Ericsson, Nokia, and Motorola. TDMA is used in two of the existing 2nd generation standards: GSM (Global System for Mobile communications) that is the dominating system in Europe and has the widest global adoption of all 2G standards, and DAMPS (Digital Advanced Mobile Phone System) that is mainly used in the United States. These standards were cooperatively developed within industry standards organizations in Europe

[1] For comparison, standard telephone modems enable rates of max. 56 kbps; asymmetric digital subscriber lines (ADSL) enable rates varying between 1.5 Mbps to 8 Mbps downstream and 64 Kbps to 640 Kbps upstream.

[2] ITU: “It is the ITU goal that in IMT-2000 all radio access options should work with all network options, e.g., including cdma2000 on GSM MAP and W-CDMA on IS-41.” (Source: www.imt-2000.org)

and in the US. CDMA, or IS-95 as the standard itself is officially called, in contrast, was largely developed and controlled by a single American firm, Qualcomm. Building on a set of pre-existing military technologies, Qualcomm discovered a different way of “slicing” or sharing the limited radio spectrum resource for handling multiple telephone calls simultaneously and was able to show that CDMA is a more “spectrally efficient” technology than TDMA. However, having entered the network market late, the second generation CDMA never caught up with TDMA-based networks in market adoption. Further, being controlled by just one firm that had shown itself to be strategically focused on controlling technological standards in order to generate licensing revenue, other equipment suppliers were reluctant to become dependent on CDMA.

The development of third generation mobile communication systems began in mid-1990s. Air interface questions were again crucial in the beginning. The goal of the Northern European companies Nokia and Ericsson was to develop truly globally adopted standards and prevent the fragmentation of markets that happened with the 2nd generation networks, where markets were divided between DAMPS, GSM, and the CDMA-based IS-95, and additionally, completely different standards were adopted in Japan. In mid-90s, to achieve this goal, Nokia and Ericsson allied with the Japanese firm NTT DoCoMo to promote a wideband version of CDMA (WCDMA). Ericsson had settled earlier patent disputes with Qualcomm and both companies had developed new CDMA-related technologies of their own, to the degree that European companies were confident to start developing and promoting systems based on it. Consequently, after eventful negotiations,[3] the European Telecommunication Standards Institute (ETSI) adopted the UMTS standard based on WCDMA as the selected air interface, but at the

[3] Documented, e.g., in Helsingin Sanomat, Kuukausiliite, June 1999.

same time building on the existing GSM systems for core network solutions. Thus, even though the air interface technology represents a clear break with the past technology used in GSM, other technological solutions in this network system are evolutionary with respect to the earlier GSM systems.[4]

Meanwhile in the United States, 3G standards were also beginning to be battled in late 1990s. Qualcomm and its allies decided to promote an evolution of the 2G standard IS-95, called cdma2000. Thus, despite the initial ideals, the world became fragmented into at least two competing standards camps, with China developing a third, completely different standard. However, both of the two main approaches are incorporated in International Telecommunications Union's (ITU) definition of third generation technologies under the umbrella of IMT-2000, and their supporting organizations, 3GPP (Third Generation Partnership Project for WCDMA/UMTS) and 3GPP2 (Third Generation Partnership Project 2 for cdma2000), collaborate on various aspects such as Internet Protocol implementation. Thus, fragmentation of markets may eventually become less important from the users' point of view if filtering technologies between the two standards indeed get developed and implemented.

Thus far the practical performance differences between UMTS and cdma2000 are not well understood. The CDMA Development Group argues that both IS-95 and cdma2000 systems are designed from the start with packet data services in mind, which is not the case with GSM, and therefore, they are more efficient yet less expensive to deploy. In reality though, as most of the world's telecom operators have GSM- or DAMPS-based 2G networks, the relevant question to them is, is it more economical in terms of costs,

4 Interview with Tommi Kokkola, Nokia Inc.

risks, and market adoption, to build on existing technologies by upgrading, for example, GSM first into a 2.5G system through deployment of GPRS and EDGE, which add packet data capabilities to the previously voice based system, and finally to UMTS, or build a completely new cdma2000 system from scratch. Moreover, as was evident in the performance of 2G systems, more widespread and rapid implementation of GSM networks enabled faster learning to fine tune these complex technological systems, and therefore the *actual* performance differences between IS-95 and GSM were probably more negligible than the differences in spectral efficiency would seem to suggest. Namely, performance of these highly complex telecommunication systems depends on both the inherent efficiency of their technological components as well as on cumulative learning in their implementation. By 2005, however, cdma2000 based networks had gained a lead in early rollout, while UMTS implementation had suffered from technical problems that proved slower than expected to resolve. The early learning advantage thus may this time be accumulated by the cdma2000 sponsors.[5]

2.3 Third Generation Partnership Project

Third Generation Partnership Project (3GPP) evolved from the group SMG (Special Mobile Group) that operated under ETSI and was responsible for the development of GSM standards. 3GPP was created in 1998. It is not a legal entity but a collaborative alliance among standardization organizations from three continents (table 1). Recognition of the need for worldwide standards for the next generation cellular telephone systems implied that standardization activities be organized through a truly global organization.

[5] 131 telecom operators had rolled out cdma2000 networks by the end of 2005, against 81 operators that had launched UMTS networks, according to CDMA Development Group and GSM Association, respectively.

Table 1 3GPP Organizational Partners

Abbreviation	Organization	Region
ARIB	Association for Radio Industries and Businesses	Japan
CWTS	China Wireless Telecommunication Standard	China
ETSI	European Telecommunications Standards Institute	Europe
T1	Standards Committee T1 – Telecommunications	US
TTA	Telecommunications Technology Association	Korea
TTC	Telecommunication Technology Committee	Japan

The purpose of 3GPP is to "prepare, approve and maintain globally applicable Technical Specifications and Technical Reports for a 3rd Generation Mobile System based on the evolved GSM core network, and the Universal Terrestrial Radio Access (UTRA), to be transposed by the Organizational Partners into appropriate deliverables (e.g., standards)".[6] 3GPP is currently the key Standards Development Organization producing standards for 3G networks building on GSM. 3GPP output is submitted to the regional Organizational Partners (see table 2) as well as to the ITU for adoption.

In addition to Organizational Partners, 3GPP has Individual Members and Market Representation Partners. Individual Members mostly consist of firms who must be members in at least one Organizational Partner in order to be allowed to participate in 3GPP working groups. In August 2000, there were 338 Individual Members ranging from telecommunication operators and equipment suppliers to various kinds of technical consultancies and R&D service houses.[7] Individual members can participate in Technical Specification Groups and Working Groups by attending meetings, contributing to specification development, and learning about standardization strategies and new technological solutions.

6 3GPP Working Procedures, retrieved in 2002 from www.3gpp.org.
7 250 individual members remain after removing regional subsidiaries of multinational corporations.

Market Representative Partners are mostly operator-led industry associations engaged in promoting some aspect of wireless communication to the broader public. Their main role is to offer market advice to 3GPP but they do not necessarily develop technical specifications themselves. In 2000 there were five market representative partners: GSM Association, Global mobile Suppliers' Association (GSA), IPv6 Forum, UMTS Forum, and Universal Wireless Communication Consortium (UWCC).

Work in 3GPP is organized through a Project Coordination Group (PCG) and Technical Specification Groups (TSG). Organizational Partners' representatives in the PCG appoint the TSG chairmen, allocate resources to specification groups, modify working procedures as needed, and manage the work progress and time frame. TSGs can form Working Groups (WG) to specific technical areas. For example, in 2000 the GSM EDGE Radio Access Network TSG included such working groups as Radio Aspects, Protocol Aspects, Base Station Testing, and Terminal Testing.

TSG and WG chairmen and vice chairmen are very influential individuals in the standards development organization. According to interviews with standardization practitioners, chairmen are selected based not only on their technical expertise but also their social and communication capabilities in managing meetings and creating an equitable work environment for participating engineers from different companies (see also Dokko and Rosenkopf 2004; Spring et al. 1995). Chairmanships tend to follow technological and market leadership in that representatives from leading equipment suppliers' (Ericsson, Motorola, Nokia, Alcatel, and NTT DoCoMo) and operators (Vodafone, Bell South, T-Mobile, British Telecom) occupy the most chairmanships (table 2).

Table 2 Chairmen and Vice-Chairmen in 3GPP Technical Specification Groups and Working groups

Company	Number of chairmanships
Nokia	8
Motorola	5
Ericsson	4
NTT and NTT DoCoMo	4
Alcatel	3
Vodafone	3
BellSouth	2
British Telecom	2
Lucent Technologies	2
Nortel Networks	2
Omnipoint	2
Siemens	2
T-Mobile	2
Anritsu UK	1
Brand Communications Ltd	1
CSELT	1
Fujitsu	1
Giesecke & Devrient	1
Mannesmann	1
Matsushita Communication	1
NEC	1
Omnipoint	1
QUALCOMM	1
Samsung	1

NB: Information retrieved from www.3gpp.org in August, 2000.

The development of technical specifications in TSGs and WGs proceeds formally through work items. Work items are specific technical features that are suggested by individual members to a working group. Work item proposals need to be supported by at least four members in order to be accepted on the agenda. This alone makes collaboration imperative among participants with interest in specific technical outcomes. Work items can be revised several times by the working group before submission to the respective TSG plenary meeting. After revisions by the TSG, the work item specification is approved and enters “change control”. At this stage and beyond, it is possible to change the specification only if the working group or an individual firm makes a formal change request.

For example, 363 work items were proposed and started in 3GPP TSGs in 2000. Of the over 300 firms that were 3GPP members in 2000, only 58 firms participated in the coalitions that supported work item creation. Moreover, the participations are highly concentrated to a few industry leaders (table 3). These data are aligned with the view presented by Schmidt and Werle that many SDO members participate to learn about upcoming technologies and to align their innovation activities with the industry rather than to actively promote a standardization agenda driven by private benefits from the adoption of their preferred technical solutions. On the other hand, those investing resources in standards development are likely to be interested in certain outcomes that are associated with private benefits (Branscomb and Kahin 1995).

In addition to proposing new work items, change requests provide another mechanism for members to influence the work process of specification development. If, after a work item has been approved by a TSG, an individual member or a working group finds something about the specification objectionable, then a request for change can be submitted. Between 2001 and 2002, most change requests were submitted jointly by working groups, suggesting that a technical error or omission was found and corrected. In addition, 42 firms submitted requests either alone or in cooperation with others. Most prominent participant here was Ericsson, with 364 sole authored change requests, while Nokia (244 solo requests), and Motorola (169 solo requests) were very active too. Additionally, Anite, Vodafone, Setcom, and Siemens each submitted over 100 sole authored change requests.

Table 3 Top 15 firms in 3GPP work item support coalitions sorted by frequency of participation, in 2000

Firm	# participations
Ericsson	39
Motorola	34
Siemens	32
Nokia	30
Lucent Technologies	18
British Telecom (BT)	17
T-Mobile	17
Vodafone	16
Nortel Networks	13
Alcatel	12
NTT, NTT DoCoMo	11
Fujitsu	10
Telia	10
Orange	8
Telenor	8

Individual members of the 3GPP are bound by the Intellectual Property Rights policies of their Organizational Partners. In most cases this implies having to agree to license patents related to essential technologies under "reasonable and nondiscriminatory terms". What this means in practice is not clear, but at least the strategy executed by Motorola earlier in the context of GSM (see Bekkers et al., 2002), whereby the Japanese equipment suppliers were excluded from the cross-licensing arrangements and thus essentially from the European handset markets, should not be possible anymore. However, even if negotiations are open and nondiscriminatory, in reality, firms with the strongest patent portfolios and other technological assets may be calling the shots. If this is true, then the opportunities to influence standards negotiations with companies' competitive advantage in mind may motivate and direct technology development and patenting activities (cf. Hall and Ziedonis 2001 who suggest that bargaining power is a major motivation behind semiconductor firms' growing propensity to patent). This view is supported by the analysis of Gandal et al. (2004) of the relationship between SDO participation and patenting.

By mid-2005, the ETSI IPR database contained 837 declarations of essential IPRs related to the UMTS project, referring to patents registered in the United States. Only 18 firms had declared relevant intellectual property within the UMTS project, and here Motorola, Ericsson, and InterDigital were the dominant companies, each with over 200 declarations of IPR initially registered in the US Patent and Trademark Office. Next well endowed with relevant intellectual assets were Qualcomm, Nokia, and Siemens, each with around 100 essential patents related to the UMTS project. At the end of 2000, in contrast, according to the ETSI database, European firms Nokia, Ericsson, Alcatel and Philips were the leading holders of essential IPRs.

3 Industry associations and the sources of influence in 3GPP

The empirical focus of this study is on the interactions between the political process within standards development organizations (SDOs) and the external relationships among participants. As discussed in the introduction, Rosenkopf and Tushman (1998) have argued that eras of ferment, which relate to preconceptualization stages of standard-setting (Cargill 1995) are associated with the founding of new Cooperative Technical Organizations (CTOs) as well as with a substantial influx of new members to existing CTOs.

Foundings of CTOs may also reflect the need for speedier development of standards than is possible in large and bureaucratic SDOs such as ITU, ETSI, T1, or even 3GPP. As a result, industry leaders may take the initiative—and incur considerable costs—to forge other types of cooperative arrangements in order to promote their technologies.

Cooperative organizations with fewer members and more closely aligned preferences can make decisions much more efficiently than large organizations characterized by highly conflicting interests. Limiting membership in standards consortia might thus accelerate standards development, but this approach may create antitrust liability. Moreover, equipment vendors need to work with network operators in order to make sure that their needs are accounted for and that customer relationships are supported. Operators and smaller technology suppliers have objected to setting up more narrowly focused associations and fora in the standardization area, because these types of firms tend to have more limited expertise and other resources than large equipment vendors to participate in dozens of industry associations.[8]

Thus, equipment industry leaders eventually have to open up the membership in new CTOs, which subsequently slows down standardization progress, but at the same time, enhances customer relationships and recruits new sponsors from among the smaller vendors and suppliers. Moreover, public bodies such as T1, ETSI or 3GPP do not recognize private fora or alliances as organizational partners, which precludes widespread adoption of technical specifications developed in private (closed) cooperative arrangements. Nevertheless, a potential rationale for founding and investing in new alliances and associations that *later* open up for all industry actors may be that founding members are able to define the agenda and maintain some special clauses in the rules and working procedures to secure their own status and private benefits.

[8] Based on interviews with the standardization managers of a small vendor and a small operator, both active members of the 3GPP.

Table 4 Motorola's memberships in wireless telecommunications industry associations in 2002 (possibly incomplete)

Abbreviation	Organization	Founded
ANSI	American National Standards Institute	1918
TIA	Telecommunications Industry Association (US)	1924/1988
CTIA	Cellular Telecommunications & Internet Association	1984
ATIS T1	Alliance for Telecommunications Industry Solutions/Standards Committee T1 Telecommunications (US)	1984
TTC	The Telecommunication Technology Committee (Japan)	1985
TTA	Telecommunications Technology Association (Korea)	1988
W3C	WWW Consortium	1994
ARIB	Association of Radio Industries and Businesses (Japan)	1995
VSIA	Virtual Socket Interface Alliance	1996
UMTS Forum	Universal Mobile Telecommunication System Forum	1996
WAP Forum	Wireless Application Protocol	1997
3GPP	3rd Generation Partnership Project	1998
3GPP2	3G Partnership Project 2	1998
Bluetooth SIG	Special Interest Group for developing Bluetooth-based wireless connectivity between mobile devices	1998
GSA	Global mobile Suppliers' Association	1998
Symbian	Joint venture developing operating systems for wireless devices	1998
HiperLAN2 Global Forum	Forum for developing a Wireless Local Area Network standard	1999
IEEE-ISTO	Industry Standards and Technology Organization	1999
IPv6 forum	Forum for a new Internet Protocol standard developed in IETF (Internet Engineering Task Force)	1999
OSGi	Open Services Gateway initiative	1999
SyncML	Group for developing data synchronization standards	1999
WECA	Wireless Ethernet Compatibility Alliance	1999
Voice XML Forum	Forum for developing a web standard for wireless and landline telephone networks	1999
CWTS	China Wireless Telecommunications Standard group	1999
BWIF	Broadband Wireless Internet Forum	2000
CDG	CDMA Developer Group	1996
LIF	Location Interoperability Forum	2000
MeT	Mobile electronic Transactions initiative	2000
3G.IP	Operator-led 3G network architecture initiative	2000
SA Forum	Service Availability Forum	2001
MGIF	Mobile Games Interoperability Forum	2001
Wireless Village	Group for developing mobile Instant Messaging and Presence Services (IMPS)	2001
WWRF	Wireless World Research Forum	2001
OMA	Open Mobile Alliance	2002
3G Americas	Organization for promoting WCDMA based 3G in North America (following up the work of UWCC, the Universal Wireless Communication Consortium dissolved in 2001)	2002

These data are collected from the organizations' websites in 2002 prior to the consolidation of WAP Forum and a few other organizations into Open Mobile Alliance.

As argued in the introduction, large Information and Communication Technology equipment vendors indeed participate in a multitude of CTOs. Table 4 presents Motorola's memberships in a sample of cooperative organizations within the wireless telecommunications field. During the most active years of standards development in 3GPP, dozens of these external organizations were founded by the (same) key firms participating in 3GPP. Sheer participation costs—membership fees combined with the cost of travel and human resources—can amount to millions of dollars annually per each CTO. Membership in these industry fora is thus associated with substantial investments of people and money.

In the next section, this study empirically examines the hypothesis that firms' connectedness in external cooperative organizations is associated with their capability to influence a standards development organization's formal processes. By being able to set the agenda and procedures in these external CTOs, and later on, eliciting support from operators and fringe players, firms—in most cases large technology vendors—are more likely to propose more well-defined and broadly supported specifications that effectively advance their standardization agenda in a public SDO such as 3GPP.

The above empirical hypothesis is operationalized in the 3GPP context as follows. Data on CTO activity in terms of private alliances and CTO memberships are used to explain, first, 3GPP member firms' ability to reach influential positions within the SDO, such as chairmanships and high centrality in work item support coalitions, and, second, their ability to make successful change requests. According to interviews with standardization practitioners, these empirical measures reflect firms' ability to influence cooperative standardization processes to their advantage.

4 Empirical data and analysis

This section first introduces the cross-sectional dataset of 3GPP member firms' cooperative standardization strategies and control variables and then carries out simple statistical analyses concerning the relationships between participation in external Cooperative Technical Organizations (CTOs) and ability to influence standard-setting activities within 3GPP.

4.1 Data sources, variables, and descriptive statistics

Most of the participation and standard-setting activity data were collected directly from the CTO websites using the Internet Archive. The unit of analysis is individual firms. Main explanatory variables, including information about CTO memberships, intellectual property positions and firm size, date from the year 2000. Dependent variables that proxy for the firms' ability to influence standard setting within the 3GPP concern participation in 3GPP work item support coalitions, 3GPP technical specification group and working group chairmanships, and change requests made by individual firms and approved by the 3GPP. These data date from the period 2001-2002.

Table 5 displays the main dependent and explanatory variables. Dependent variables measure firms' centrality in work item support coalition networks, chairmanships in technical specification groups and working groups, and change requests that firms submitted in order to make changes into existing work items in the specification development process. Work item coalitions are groups of at least four member firms that propose specific features for TSGs or WGs to consider and develop. Any member organization is allowed to make work item proposals, but they need at least three other organizations' support of the proposal. This mandatory cooperation probably weeds out "frivolous" proposals that only benefit one single company or that are not technically reasonable or feasible.[9] Ability to successfully form and participate in work item coalitions is assumed to depend on firms' technical expertise and pre-existing cooperative connections ("social capital") in addition to market power.

The variables used here to describe firms' positions in the work item coalition network are degree centrality and betweenness centrality (see e.g., Wasserman and Faust 1994). If two firms were among the supporting firms of the same work item, they are assumed to have a work item network connection. Degree centrality simply counts the number of these connections for each firm, while betweenness centrality measures how often each firm is on the most direct path between two other firms in the network. This is assumed to reflect firms' ability to control information flows within the network. Degree centrality is a very commonly used indicator from the literature on social network analysis (e.g., Powell, Koput, and Smith-Doerr 1996; Tsai 2000) and it is argued to best reflect an actor's access to information and knowledge. Betweenness centrality, on the other hand, is based on a more strategic view of information networks as it gauges the degree to which an actor can control information flows among other actors (see e.g., Rowley et al. 2005).

Chairmanships in 3GPP's TSGs and WGs are assumed to reflect the agenda-setting power of participating organizations. As discussed earlier, chairmen are elected officials that have a history of constructive participation and contribution in standards cooperation and possess both technical knowledge of the specific field of the group and social

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9 According to Adrian Scrase, the CTO of ETSI, the requirement of four supporters ensures that the work program is not clogged up with proposals that have little chance of progressing (e-mail exchange September 2005).

skills to communicate effectively, manage the meetings, and find consensus solutions within the group (Spring et al. 1995). Even though these informal qualifications rule out any blatant bias towards the individual's company affiliation, chairmen arguably are in a position to subtly lead the specification development process in a direction that is beneficial to their own company (cf. Anton and Yao 1995). While the choice of individual chairmen greatly depends on the individuals' characteristics, the variable used here, the number of chairmanships held by each member organization, is likely to depend on the organization's characteristics such as technical, social, and human resources and market power, similarly to the work item coalition network positions explained above.

Table 5 Variables and descriptive statistics

Variable name	Description	Date	Mean	Std.Dev.	Minimum	Maximum	NumCases
Degree centrality	Degree centrality in 3GPP work item network	2001-2002	67.07	147.89	0	825	122
Betweenness centrality	Betweenness centrality in 3GPP WI network	2001-2002	87.19	280.77	0	2064.34	122
Chairdum	Dummy for chairmanships > 0	2001-2002	0.23	0.42	0	1	122
Chairmen	Number of chairmanships and vice-chairmanships in 3GPP groups; sum of 2001 and 2002	2001-2002	0.95	2.56	0	16	122
CR dummy	Dummy for change requests >0	2001-2002	0.34	0.47	0	1	122
CR success rate	Approved change requests divided by total sole authored change requests	2001-2002	0.21	0.35	0	1	122
IPR ETSI	Declarations of essential IPR in ETSI	1995-2000	1.80	6.75	0	51	122
IPR USPTO	Patents granted in the US Patent and Trademark Office	2000	223.21	500.65	0	2895	122
Employees	Number of employees	2000	64555.70	86245.00	190	430200	94
Alliances	Number of private alliances with other 3GPP members	1995-2000	4.76	10.05	0	57	122
CTO 3GPP	Memberships in CTOs institutionally related to 3GPP (market representation partners)	2000	2.15	1.98	0	8	122
CTO non-3GPP	Memberships in CTOs unrelated to 3GPP	2000	1.86	2.35	0	9	122
Total CTO	Total CTO memberships	2000	5.01	4.08	1	17	122
Japan	Japanese		0.10	0.30	0	1	122
North America	North American		0.32	0.47	0	1	122
Europe	European		0.45	0.50	0	1	122
Asia	Asian		0.17	0.38	0	1	122
Computer	Computer or consumer electronics industry		0.14	0.35	0	1	122
R&D services	R&D service provider, including equipment testing		0.07	0.26	0	1	122
Equipment	Network or terminal equipment (hardware) vendor		0.21	0.41	0	1	122
Component	Component provider for telecom networks or terminals		0.13	0.34	0	1	122
Operator	Telecom operator		0.26	0.44	0	1	122
Software	Software provider		0.17	0.38	0	1	122
Consulting	Technical consulting service provider		0.04	0.20	0	1	122

Finally, success in change requests is a direct measure of the ability of companies to influence the specification development process. Change requests are made only after a first version of a work item has entered change control; according to 3GPP procedures, the work item draft should be at least 80% complete at this point and it is approved by the respective TSG. Change requests mandate that the work item be re-evaluated by the TSG and in that sense requires new work on the part of the TSG participants. Sometimes change requests are submitted when a member notices a simple technical problem with an existing work item; other times change requests may be submitted to more fundamentally redirect the development of a specification. It is argued here that the same independent variables that explain influence in terms of chairmanships and positions in work item coalition networks also explain successful change requests. Here, we first examine the likelihood of firms to make any change requests and then estimate what kinds of firm characteristics facilitate making successful requests. The latter variable is formed as the number of approved change requests divided by all change requests made by a firm.

Variables used to explain firms' ability to influence standard-setting include firm size in terms of employees; intellectual property measured by patents granted in the US Patent and Trademark Office and essential intellectual property declarations made in the European Telecommunications Standards Institute; private alliances with other 3GPP members as indicated by the CATI database; memberships in other standardization-related industry associations and fora; and firms' industry affiliation and country or region of origin.

Firm size is used to proxy firms' market power and general resources. Sales or the number of employees is available for publicly traded firms, but in order to also include small privately-held firms, we define size classes in the way explained in table 6. Small private startup firms, for which these measures are typically lacking or associated with significant measurement error, are included in the first class.

Table 6 Firm size classes

Size class	Number of employees
Size 1	0 – 100
Size 2	101 – 1000
Size 3	1001 – 10000
Size 4	10001 – 50000
Size 5	50001 – 100000
Size 6	100000 –

Firms' intellectual property positions measure their technological capabilities. Two variables approximate different aspects of technological expertise. First, the number of patents granted by the United States Patent and Trademark Office (US PTO) in 2000 measure firms' general technological assets. For some of the firms in the sample, these may be related to technological fields that have little to do with wireless telecommunications. Nevertheless, US patents are argued to proxy for firms' technological potential in the wireless telecommunications area. The second technological capability indicator concerns declarations of essential IPR in the ETSI. 3GPP members are required to declare any intellectual property rights that may be implicated by the standard-setting activities. Firms are also required to sign an agreement to license any such IPR to other companies in reasonable and non-discriminatory terms. ETSI holds a database of such declarations concerning 3GPP specifications[10]. The advantage of this IP measure is that it focuses more closely on IP related to wireless telecommunications technologies.

[10] In an earlier version of this paper, IPR declarations from the US telecommunications institute TIA were also included. These had no explanatory power in the estimations.

Holdings of IP in the US PTO are highly skewed, most firms holding no or very few patents and the technology giants such as Matsushita or IBM obtaining thousands of patents annually. The numbers of essential IP declarations in ETSI are much fewer, averaging less than two declarations, the maximum being 51 declarations by Nokia between 1995 and 2000.[11]

The number of private alliances with other 3GPP firms is included in the empirical analysis to control for other forms of external cooperation among the sampled firms. While the main focus of the study is on the role played by industry associations and fora as cooperative arrangements, we want to ensure that the results are not confounded by firms' connections originating from general strategic alliance activity. These data are obtained from the CATI database.[12]

Firms' industry forum and association activities are measured as the number of memberships in the cooperative technical organizations listed in table 7. These CTOs were selected from the universe of possible organizations (see table 4 for a sample) as these are related to the wireless telecommunication technology field but not necessarily the UMTS standard. CTOs *institutionally related* to 3GPP include organizations that were 3GPP Market Representatives or Organizational Partners.[13] The objectives of these CTOs are thus necessarily closely aligned with those of 3GPP. CTOs *unrelated to* 3GPP include organizations that develop completely different, and possibly competing, wireless communication standards or component technologies, and organizations that pro-

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[11] Most declarations of IPR concerning the UMTS system have been made in the years after 2000.

[12] CATI is a large database of R&D and technology alliances and joint ventures developed by John Hagedoorn at the Maastricht Economic Research Institute on Technology (MERIT) in the Netherlands. Access to the database in this study is provided through cooperation with the Research Institute of the Finnish Economy and granted by Marc Van Ekert and John Hagedoorn.

[13] Of the 3GPP Organizational Partners, only ARIB, T1, TTC, and ETSI are included because the other SDOs did not publish membership information on their websites in 2000.

mote services related to the UMTS standard but not affiliated with 3GPP as market representatives. In order to gauge the impact of firms' different affiliation strategies, we will use three different explanatory variables derived from firms' CTO memberships: total memberships; memberships in CTOs related to 3GPP; and memberships in CTOs unrelated to 3GPP.

Table 7 Cooperative Technical Organizations included in the empirical analysis

Cooperative Technical Organization	3GPP- related	Unrelated to 3GPP	% of total membership that are 3GPP members
Third Generation Partnership Project (3GPP)			100
UMTS Forum	x		47
GSA (Global mobile Suppliers Association)	x		91
GSM Association	x		n.a.
IPv6 Forum general members	x		49
IPv6 Forum founders	x		40
T1 Telecommunications (USA)	x		37
ARIB (Association for Radio Industries and Businesses; Japan)	x		9
ETSI (European Telecommunication Standards Institute)	x		30
TTC (Telecommunication Technology Committee; Japan)	x		28
UWCC (Universal Wireless Communication Consortium)	x		26
3GPP2 (Third Generation Partnership Project 2)		x	59
CDG (CDMA Development Group)		x	44
WECA (Wireless Ethernet Compatibility/Wi-Fi Alliance)		x	52
Hiperlan2 Global Forum		x	56
MWIF (Mobile Wireless Internet Forum)		x	57
Voice XML		x	8
Bluetooth Special Interest Group		x	100
3G.IP		x	100
TIA (Telecommunication Industry Association; USA)		x	9

The total sample size is 122 firms. The total membership of 3GPP excluding corporate subsidiaries and government or non-profit agencies was 247 firms in 2000, and thus the sample contains some 50% of the total population. Firms are included if enough information about them is publicly available through the Internet Archive or company information databases such as Hoovers. Because many of the small and privately held 3GPP members from 2000 have subsequently either merged or been acquired, it is impossible to accurately evaluate the degree to which the sample used here is representative of the 3GPP population. However, as information about publicly held firms is available in the Internet Archive or other databases even after such organizational events, the sample is likely to be biased towards large, successful, and publicly held companies. Inclusion of small or unsuccessful firms would probably increase the accuracy of the results obtained concerning the importance of firm size, technological assets, and connections in terms of private alliances and CTO memberships.

Descriptive statistics in table 5 also provide information about the industry affiliations and geographic origins of firms. The sampled firms were classified in terms of their main markets into telecom operators (26%), telecom equipment vendors (21%), software suppliers (17%), network or terminal component suppliers (13%), R&D service providers (7%) or consulting firms (4%). Additionally, information technology firms such as IBM, HP, Fujitsu, and Toshiba that have their technological roots in the computer or consumer electronics industries were grouped separately. These firms have tremendous capabilities in rather different technological fields, but because of the convergence of telecommunications and computing, they have relatively recently entered the wireless communications standard-setting activities and probably carry out R&D in this area but may not yet have launched products. It turns out that it is important to control for this group of firms separately from other equipment and software providers. As far as geographic distribution of the sampled firms, most firms originate from Europe (45%), followed by North America (32%), and Asia (17%, of which more than half are from Japan). Most of the remaining 6 firms come from Israel.

4.2 Regression analyses

In this section we carry out simple regression analyses to assess the statistical determinants of firms' ability to influence standard setting in the 3GPP standards development organization. In particular, we are interested in the effect of external Cooperative Technical Organizations. Table 8 shows the estimation results for the determinants of work item coalition degree centrality. The estimation method used is Tobit (censored) maximum likelihood, because the distribution of the dependent variable is censored from below at zero.

According to the estimation results, degree centrality in work item coalitions depends positively on the total number of CTO memberships. In particular, memberships in CTOs *unrelated* to 3GPP appear to facilitate operation in work item coalitions. Additionally, essential IPR declarations in the ETSI, alliances with other 3GPP member firms, and industry affiliation to the telecom operator group significantly increase coalition centrality, while industry affiliation to computer/consumer electronics reduces coalition network centrality.

Table 8 Determinants of 3GPP work item coalition degree centrality

	Coeff	Std error	Coeff	Std error
Constant	-41.92**	16.98	-21.17	16.05
Size 3	-49.57*	28.68	-49.71*	28.62
Size 4	-15.61	33.06	-15.34	32.98
Size 5	13.31	36.60	17.17	36.61
Size 6	-13.05	39.37	-7.73	39.51
IPR ETSI	8.08***	1.61	7.80***	1.62
IPR USPTO	-0.018	0.036	-0.029	0.038
Total CTO	17.54***	3.56		
CTO 3GPP-related			9.15	7.98
CTO 3GPP-unrelated			25.76***	7.87
Alliances	4.94***	1.81	5.02***	1.81
Equipment	-2.63	28.57	-4.49	28.62
Operator	66.59**	27.64	74.64***	28.40
Computer	-150.10***	45.66	-137.96***	46.69
Japan	-36.25	45.64	-41.22	45.94
North America	-17.98	20.99	-25.25	21.88
Sigma	89.82***	6.44	89.54***	6.42
Log likelihood	-607.53		-606.84	

Notes: N=122. Tobit Maximum Likelihood estimation. *** implies significance at the 99% level of confidence, ** at the 95% level and * at the 90% level.

Table 9 Determinants of 3GPP work item coalition betweenness centrality

	Coeff	Std error	Coeff	Std error
Constant	-128.38***	40.28	-101.10***	37.71
Size 3	-82.07	69.01	-83.16	68.52
Size 4	-31.85	77.88	-30.13	77.06
Size 5	0.87	88.82	10.21	88.14
Size 6	-86.62	89.60	-72.46	89.09
IPR ETSI	27.88***	3.56	26.81***	3.57
IPR USPTO	-0.081	0.080	-0.12	0.08
Total CTO	17.74**	8.30		
CTO 3GPP-related			-10.75	18.32
CTO 3GPP-unrelated			47.04**	18.80
Alliances	14.42***	4.23	14.75***	4.21
Equipment	-2.65	67.16	-11.26	67.18
Operator	105.73	65.83	135.25**	67.37
Computer	-302.07*	111.19	-264.31**	112.59
Japan	99.05	105.18	83.14	105.70
North America	-53.65	51.93	-80.70	54.55
Sigma	193.34***	16.81	191.35***	16.60
Log likelihood	-488.67		-487.15	

Notes: N=122. Tobit Maximum Likelihood estimation. *** implies significance at the 99% level of confidence, ** at the 95% level and * at the 90% level.

The estimation results for betweenness centrality in table 9 are essentially similar to those for degree centrality. CTO memberships in associations institutionally unrelated to 3GPP provide particularly important connections. Thus, not simply external connections with fellow standard-setting members matter for gaining influential network positions within an SDO, but connections through unrelated, possibly competing standard-setting or technical organizations may provide the necessary political clout. Also, IPR declarations in ETSI remain very important, as do alliance contacts with other 3GPP members. Here, industry affiliation control variables become somewhat less significant determinants of network centrality than in the degree centrality case.

Next we estimate the determinants of chairmanships and vice-chairmanships in 3GPP technical specification groups and working groups. Because the number of chairmen is count data, we provide negative binomial estimates. The problem with the negative binomial method is convergence; therefore the model is slightly more compact and only variables that are statistically significant in the respective Poisson model are retained. The Poisson model is also used for initial values. Results obtained suggest that the ability to set the agenda through group chairmanships significantly depends on CTO memberships, but now connections through organizations institutionally affiliated with 3GPP are more valuable than connections through unrelated CTOs. As before, telecom operators have significantly more chairmanships than firms from other industries, and so do Japanese firms. Computer/consumer electronics firms continue to underperform in obtaining this type of influence asset.

Table 10 Determinants of the number of chairmanships and vice-chairmanships in 3GPP technical specification groups and working groups

	Coeff	Std error	Coeff	Std error
Constant	-3.87***	0.80	-3.69***	0.77
Size 3	0.86	0.91	0.90	0.90
Size 4	0.91	0.95	0.91	0.95
Size 5	1.39	0.99	1.36	0.99
Size 6	1.06	1.00	1.03	0.99
IPR ETSI	0.019	0.020	0.023	0.020
Total CTO	0.22***	0.07		
CTO 3GPP-related			0.35**	0.16
CTO 3GPP-unrelated			0.09	0.15
Alliances	0.04	0.03	0.04	0.03
Operator	1.64***	0.61	1.49**	0.61
Computer	-2.04**	0.81	-2.14***	0.81
Japan	1.99***	0.71	1.98***	0.69
Alpha (dispersion parameter)	0.97*	0.50	0.94*	0.50
Log likelihood	-99.95		-99.54	

Notes: N=122. Negative Binomial Maximum Likelihood estimation. *** implies significance at the 99% level of confidence, ** at the 95% level and * at the 90% level.

The last dependent variable used in these regression analyses is firms' success rate in making change requests (table 11). This variable is left censored and thus the Tobit method is applied. Right censoring is possible in principle but does not show up in the data. Patents granted in the US Patent and Trademark Office were not a significant factor in these models and therefore this variable was dropped. In terms of the estimation results, firm size now comes up as a marginally significant variable. Firms in the fourth size class (10000 – 50000 employees) are more successful than their smaller or larger peers. Larger firm size thus may help but there are limits to that advantage. Again computer/consumer electronics firms perform differently from others, and Japanese firms are more successful than firms from other countries or regions.

Table 11 Determinants of success rates in 3GPP change requests

	Coeff	Std error	Coeff	Std error
Constant	-0.98***	0.26	-0.75***	0.20
Size 2	0.36	0.29		
Size 3	0.10	0.29	-0.06	0.25
Size 4	0.58*	0.31	0.42	0.28
Size 5	-0.02	0.38	-0.18	0.35
Size 6	0.11	0.37	-0.07	0.35
IPR ETSI	0.002	0.012	0.003	0.012
Total CTO	0.10***	0.03		
CTO 3GPP-related			0.14**	0.07
CTO 3GPP-unrelated			0.06	0.06
Alliances	-0.01	0.01	-0.01	0.01
Equipment	0.02	0.24	0.00	0.24
Computer	-0.89**	0.37	-0.93**	0.38
Operator	0.07	0.24	0.01	0.25
Japan	1.16***	0.33	1.19***	0.33
North America	-0.02	0.18	0.04	0.18
Sigma	0.61***	0.08	0.61***	0.08
Log likelihood	-66.83		-67.35	

Notes: N=122. Tobit Maximum Likelihood estimation. *** implies significance at the 99% level of confidence, ** at the 95% level and * at the 90% level.

CTO memberships significantly facilitate influencing standard setting also through the change request process analyzed here. The total number of CTO memberships is significant at the 99% level, and splitting this variable in to CTOs related and unrelated to 3GPP, the former are more relevant. Thus, aligned with the results obtained using working group chairmanships as the dependent variable, making connections outside of the SDO to fellow 3GPP members matters, and moreover, making connections within closely related organizations matters the most. In contrast, connections through private alliances do not appear to facilitate making change requests.

There is a concern about the nonlinearities and measurement error associated with the dependent variable success rate used in these estimations. Namely, for very low numbers of change requests, the success rate can flip very easily from very high to very low, and this may not properly reflect the "true" ability to influence decisions in working groups. Therefore, as a robustness check, the empirical model in table 11 was estimated with the total number of approved change requests as the dependent variable. Regarding the CTO variables and other control variables, the results obtained were qualitatively similar to those reported in table 11. The only difference concerned firm size class variables, which became highly significant in the estimation of total number of approved change requests. This makes sense, because that dependent variable is likely to reflect firm size and resources. Meanwhile, the significance of CTOs related to 3GPP lend support for results in table 11 that they are not driven by these kinds of nonlinearities in the dependent variable.

5 Discussion of results and conclusions

This study has qualitatively described and empirically analyzed the sources of influence in a wireless telecommunication Standards Development Organization. Responding to the call by David and Greenstein (1990) for more detailed institutional analyses of standard-setting processes, and to Farrell and Saloner's theoretical analyses of committee-based standardization, this paper analyses the standard-setting procedures and activities in the Third Generation Partnership Project (3GPP).

3GPP produces technical specifications (i.e., technical standards) for regional standards bodies such as ARIB (Japan), ETSI (Europe) or T1 (USA) to adopt and certify. Its formalized processes of proposing work items, selecting chairmen to sub-committees, and controlling changes to work items in progress have generated a sizable and publicly available paper trail of standard-setting activity. From these documents, information can be gleaned about member companies that are in influential positions with respect to internal coalition networks, chairmanships, or successful change requests within the organization's working groups.

Descriptive analyses of the data support the learning perspective of Schmidt and Werle (1998) in that for most firms, SDOs appear to provide opportunities for learning about new technologies and upcoming standards rather than for strategically influencing the standardization outcome. Namely, only a fraction of 3GPP members participate in work item coalitions or make change requests. Most member firms thus do not attempt to influence the direction of standard setting at all. Furthermore, computer and consumer electronics firms that have entered this technology area relatively recently are significantly less successful in inserting themselves to coalitions, obtaining chairmanships, or making change requests. This suggests that learning about the technology and accumulation of social capital are very important in cooperative standard setting.

The main empirical hypothesis concerns the prolific participation of many 3GPP member firms in external consortia, or Cooperative Technical Organizations, such as industry associations and technical fora. It is argued that through connections to fellow members in these external organizations, firms accumulate "influence capital" by being able to generate support for their technical and other proposals before they come up in 3GPP or develop more refined proposals for discussion in 3GPP working groups. Indeed, the estimation results suggest that it is useful for 3GPP member firms to join external CTOs.

However, it depends on the type of influence activity whether CTOs that are institutionally related or unrelated to 3GPP provide more useful connections. In inserting themselves into coalitions that propose new features to be developed in technical specification groups, firms benefit from connections in unrelated CTOs which may expose them to a different set of knowhow concerning the evolution of technology and markets than other members of working groups. In obtaining working group chairmanships or making successful change requests, in contrast, firms benefit from connections through CTOs that are institutionally related to 3GPP. This may reflect the significance of being in the "inner circle" of the 3GPP world. Although it would require further research to thoroughly understand the reasons behind the different effects of related and unrelated CTOs on firms' ability to influence standard setting in 3GPP, it is speculated here that activities where new technical information is brought to the attention of working groups, namely, coalitions supporting new work items, benefit from more distant connections to unrelated CTOs, while activities where existing features are developed and specified, namely chairmanships and change requests, benefit from being in the inner circle of CTOs related to 3GPP through organizational partners or market representatives.

In obtaining the above results we have controlled for a number of factors identified in previous studies. Perhaps surprisingly, firm size is in most cases not a significant variable here. Firms' intellectual property positions, industry affiliations, private alliance activities, and geographic origins appear to be more relevant factors. Operators—the clients of equipment, component, and software vendors—are frequently in highly influential positions. On the other hand, firms whose main markets are in computer and consumer electronics industries are in most models significantly less influential than other types of firms. This is probably because of these firms' late entry into the wireless telecommunications industry and related cooperative standardization activities. Interestingly, Japanese firms are often in privileged positions to influence the direction of standards development. A possible explanation is the need for European firms to keep them as allies in the competition against mostly North American companies to produce standard that could achieve global dominance. Perhaps, as a result, Japanese companies are allowed to influence the standardization activities more than their size, industry affiliations, or technological capabilities would suggest.

To conclude, this cross-sectional study suggests that firms deploy complex cooperative standardization strategies in trying to promote technical solutions that are most beneficial to them. One of the possible standardization-related activities is participation in technical industry associations and fora, through which firms gain "influence capital" that is associated with their success in formal SDOs. While technological capabilities and market power are important determinants of standardization success, as suggested in earlier research, cooperative activities such as private alliances and CTO participation are also significant determinants of firms' ability to influence standard-setting processes. To our knowledge, this is the first study to explore such complex cooperative standardization strategies in detail.

The policy implications of this study contribute to the emerging antitrust literature on cooperative standard-setting. While it is within the realm of legal studies to determine when CTO-based strategies to influence standard setting are anti-competitive, this study suggests that one dimension of leading firms' cooperative standardization strategies involves setting up CTOs with their like-minded peers. Moreover, activities within these external CTOs appear to be beneficial for getting preferred proposals or changes accepted in the official SDO venue. Interview evidence from smaller players in the SDO studied here, 3GPP, supports this argument: even when membership is open in these technical consortia, it is difficult for players with more limited human and financial resources to simultaneously participate in dozens of CTOs around the world, and this creates an advantage for industry leaders to set the agenda and get a headstart in technical specification development in smaller fora prior to submitting proposals to the official SDO, in this case 3GPP. There are thus public policy opportunities in making sure that the playing field is level, and access to network markets is open, for all kinds of firms, and not only for firms with abundant technological, financial, and human resources.

An empirical caveat of the current study is that the data are cross-sectional. While we can control for simultaneity and reverse causation by utilizing data from or before year 2000 as explanatory variables while the dependent variables date from 2001-2002, there may be firm-level fixed effects, i.e., unobserved heterogeneity, that may bias the results. Such unobservable characteristics might be related to firms' skills, knowledge, or strategies that make them both more likely to engage in CTOs and successful in influencing standard setting. The presence of these unobservables would make the estimation results seem more significant than they truly are. Therefore, the next step in this research program is to set up a panel dataset of firms participating in 3GPP standardization. Meanwhile, the results obtained here should be interpreted as descriptive evidence that firms who are able to influence standard-setting processes tend to deploy complex cooperative strategies involving constellations of private alliances and cooperative technical organizations. In contrast, true causality can be assessed with panel data only in future research.

The research design also reduces the generalizability of the results obtained here. Basically, this is a case study of one standards development organization and one technological field. It would be interesting to examine other organizations to see whether the strategies identified here apply in other environments. Descriptive evidence presented in Kahin and Abbate (1995) lends support that these ideas apply also in the (computer-based) information technology field. Future research could also explore in more detail the role of private alliances and different types of CTOs. Additionally, it would be interesting to understand how standardization networks consisting of alliances, CTO connections and SDO coalitions change over time.

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