Competition for Leadership Positions in Standards Development Organizations

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Abstract

Standards Development Organizations (SDO) make critical decisions shaping the direction of technological innovation. The chairs of SDO working groups, where many of these decisions are reached, play a pivotal role, and their neutrality with respect to the different competing particular interests is critical for SDOs' legitimacy. Nevertheless, these chairs are themselves often affiliated with individual SDO stakeholders - a tension that may result in disputes and distrust towards the SDO and its decisions. We find that individuals are appointed to SDO chair positions primarily because of their individual experience and expertise, suggesting that (despite the evident importance of the strategic motives of participating companies) SDOs act as communities of subject matter experts, in which individuals rise to leadership positions because of their individual achievements. Nevertheless, individuals' affiliation with a leading SDO stakeholder increases their chances of appointment to chair positions. Intriguingly, this affiliation effect is significant at IETF, which is open to any interested individual, but not at 3GPP, where individuals participate as explicit representatives of SDO member companies. This finding suggests that balanced representation of different particular interests may be more conducive to a culture of individual meritocracy in an innovation community than an approach exclusively focusing on opennes to participation by unaffiliated individual experts.

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1 Introduction

Standards Development Organizations (SDO) play a crucial role for technological innovation, in particular in the field of Information and Communication Technologies (ICT). Standardization through SDOs produces numerous benefits, serves as an important driver for innovation and its dissemination (Swann, 2000), and allows companies to profit from the wider diffusion of their technology (Teece, 2018). In particular, SDO standards facilitate interoperability of different devices and components, thus creating large networks of connected (and compatible) devices. Technical standardization decisions in SDOs also shape the direction of technological innovation; as the technical specifications (TS) of SDO standards determine many features and functionalities of complex ICT products, and contribute to the selection of which technical inventions are widely adopted and which are abandoned. Given this role of SDOs as crucial decision-makers in the process of technological innovation, it is unsurprising that there has been increasing attention to SDO governance - i.e. *how* SDOs make decisions - in the academic literature and policy discussions.

Recently, appointments of individuals to SDO leadership positions have moved to the forefront of the policy debate on SDO decision-making. In many SDOs, important SDO leadership positions, such as SDO board members and working group chairs, are held by individuals having dual allegiance. When acting in their SDO role, they are expected to represent the SDO and all its stakeholders; while at the same time, they remain employed and paid by individual stakeholders of these SDOs. This intriguing tension raises significant questions for the legitimacy and trustworthiness of SDO decision-making. Concerns over appointments of individuals affiliated with foreign companies to SDO leadership positions have e.g. been a central issue in recent U.S. policy discussions on the potential national security implications of ICT standardization.[1] These concerns echo allegations or findings of abuses of chair positions by other companies; sometimes leading to significant disputes and antitrust litigation.[2]

In spite of these important policy implications, the growing literature on SDOs and standardization has so far paid scant attention to the role and conduct of SDO leadership. More generally, there is a lack of research explicitly addressing the different incentives and obligations shaping the conduct of individual SDO participants, who - depending on the SDO, the individual's role, and the situation - are subject to potentially contrasting

[1] In a U.S. Senate Hearing, Christopher Krebs, then Director of the Cybersecurity and Infrastructure Security Agency, testified: "Foreign nationals representing foreign companies, including Chinese companies China Mobile Communications Corporation and Huawei, hold key leadership positions on the ITU and 3GPP standards bodies for 5G. These individuals may be able to influence ITU and 3GPP to adopt standards that favor their own companies and put U.S. companies at a competitive disadvantage, potentially affecting their ability to compete in the market for years and increasing the United States' reliance on foreign technology." https://www.judiciary.senate.gov/imo/media/doc/Krebs%20Responses%20to%20QFRs.pdf In a proposed legislative amendment, U.S. Senator Coons stated that "A growth in the representation of Chinese companies and interests in certain standards-setting bodies, including by securing leadership positions in them, could lead to further dominance and lack of balance in standards-setting bodies and increase the risk that block-voting will make it difficult for these bodies to ensure balanced and consensus-based decisions." Section 305 of Senate Bill 687.

[2] see American Society of Mechanical Engineers v. Hydrolevel Corporation, 456 US 556 (1982) and, later, Trueposition, Inc. v. LM Ericsson Tel. Co. (Jan 6, 2012), No. 11-4574, 2012 WL 33075 [2012]

expectations from their employers and from their peers within the SDO. To the best of our knowledge, there has so far been no empirical analysis of the determinants of which individuals get appointed to SDO leadership positions, and what role these individuals' affiliations play for their appointments.

To fill this literature gap, we study the determinants and consequences of individuals' appointments to SDO leadership positions. In particular, we ask one question: are individuals appointed to SDO chair positions because of who they are, or who they work for?

These analyses shed light on fundamental aspects of SDO governance. If individuals are appointed to a chair position primarily because they represent a certain stakeholder, such SDO stakeholders can fill SDO positions at will, and may exert direct control over the conduct of SDO leadership. If, however, individuals are selected because of their individual qualifications, such as SDO experience and technical expertise, influence in the SDO is determined by individually held social and human capital. SDO stakeholders may attempt to acquire this capital, in particular by recruiting SDO leaders and other seasoned SDO participants. Nevertheless, as the value of individuals' social capital depends on their standing in the SDO community (e.g. reputation, individual ties, etc.), they may be less inclined to pursue a company's agenda where it contrasts with the interests of the SDO or its broader stakeholder base.

There is a large number of diverse SDOs, and we expect the relative importance of individual and affiliation characteristics to vary significantly between different organizations. SDOs have different explicit rules and implicit norms governing the conduct of individual SDO chairs and participants. In particular, these rules and norms contribute to determine to what extent individuals are requested and/or allowed to represent particular interests when acting in different roles within the SDO. To account for this significant heterogeneity, we study two different prominent SDOs in the ICT sector, namely the Third Generation Partnership Project (3GPP) and the Internet Engineering Task Force (IETF). Both organizations play a pivotal role in shaping global technological innovation in ICT, and both have working groups where engineers affiliated with a large number of diverse and primarily commercial stakeholders carry out the technical work. In spite of these important similarities, which allow for a general comparisons, the two SDOs are representative of two different institutional models: 3GPP is an *entity-based* SDO, i.e. individuals may only participate as representatives of an SDO member firm; whereas IETF is an *open* consortium, i.e. any interested individual may participate in the technical work, and barriers to participation are low.

To study leadership appointments in these SDOs, we have created a large database with 310,685 individual meeting attendance records and 19,022 observations of working group leadership (individuals holding the chair during a working group meeting). We have collected rich data on the 43,209 individuals in the dataset, including information at the level of the individual (including country of residence, past experience as attendee and chair, track records of technical contributions to SDO activities, and patent inventorship), as well as characteristics of the primary affiliation (including entity type, number of SDO memberships, extent of participation in this SDO, and number of declared standard-essential patents (SEP)). We can thus assess for each SDO which factors matter for appointments to working group chair positions. In particular, we analyze whether affiliations with a *top*

SDO stakeholder increases the likelihood that a given individual is appointed to an SDO leadership position; and whether appointment to an SDO leadership position increases the chances that an individual is recruited by such a company. We use various proxies to identify top SDO stakeholders, including general measures of SDO participation, SEP declarations, and lists of individually identified *Top 5* and *Top 20* affiliations (as measured by the combined attendance records of both SDOs).

Our findings provide new insights into standardization as a process of collaborative innovation driven by a community of subject matter experts, rather than merely by companies' strategic motives. At the same time, they also contribute to the the understanding of SDOs as institutions of private governance. Our analysis demonstrates that regardless SDOs' institutional model (i.e. entity-based or open consortium), individual characteristics (experience and expertise) are the main determinants for appointments to leadership positions. At the same time, they also demonstrate that affiliation still plays a role in leadership selection, reflecting individuals' incentives to pursue the interests of their affiliations. Notably, such affiliation effects in appointments are particularly significant at IETF, even though unlike 3GPP, the governance model of IETF does not require individual participants to represent certain stakeholders. This finding casts doubt on the suggestion that encouraging individuals to represent their personal views may act as an effective check on commercial stakeholders' influence within SDOs.

This result of our study also has broader implications for the legitimacy of decision-making by experts in specialized committees, such as expert gremia of industry or professional associations. Decision-making by communities of subject matter experts plays an important role in a large variety of different areas and industries. The legitimacy of such communities of experts generally rests on an ideal of objectivity. At the same time, individual experts are often employees of stakeholders, or otherwise have vested interests. In this regard, our findings suggest that a culture of individual independance and meritocracy may develop even in an institutional context in which individual experts are explicitly tasked with representing certain commercial stakeholders. At the same time, an institutional setting encouraging individuals to participate on their own behalf may not not necessarily achieve independence of the community from particular interests.

2 Literature Review

Our study is situated at the intersection of different streams of literature on standardization, innovation and social capital, and seeks to advance these literatures by analyzing the interplay between individuals' affiliations and their appointments to SDO leadership positions.

Our study contributes to a large and growing literature on SDO decision-making. Most of the existing literature focuses on the interaction between stakeholders *within* SDOs and SDO committees, thus neglecting the role of the SDO itself and of its agents or representatives. This approach includes models of consensus building (Farrell and Saloner, 1988; Farrell and Simcoe, 2012; Simcoe, 2012), coalition formation (Llanes and Poblete, 2020) or voting (Goerke and Holler, 1995; Lehr, 1996; Bonatti and Rantakari, 2016; Spulber, 2019).

By focusing on SDO leadership, our contribution sheds light on the yet understudied role of SDOs in decision making on standards. While there are abstract models in which SDOs make standardization decisions on technological inputs contributed by participating firms (Lerner and Tirole, 2006; Chiao et al., 2007; Lerner and Tirole, 2015; Boone et al., 2019), there currently is a lack of empirical research on SDO behavior; i.e. the incentives and conduct of individuals representing and/or acting on behalf of SDOs. Our study begins to fill this gap, by studying how individuals' appointments to SDO leadership positions interact with their employment relationships with individual SDO members.

In addition to neglecting the role of SDOs, the existing literature has predominantly focused on the determinants and consequences of *companies'* participation in SDO processes (Axelrod et al., 1995; Riillo, 2013; Blind and Mangelsdorf, 2016; Blind et al., 2020). A large number of studies have studied firm engagement in a variety of SDO-related activities; such as meeting attendance (Fleming and Waguespack, 2009); submission of technical contributions (Fischer and Henkel, 2013), SEP declarations (Bekkers et al., 2011); and SDO or SDO committee memberships (Baron et al., 2019b; Blind and Mangelsdorf, 2016). Research has also studied formation of networks *between* firms (Leiponen, 2008; Aggarwal et al., 2011; Bar and Leiponen, 2014; Delcamp and Leiponen, 2014; Ranganathan and Rosenkopf, 2014); as well as repeat interaction of firms in SDOs (Larouche and Schuett, 2019). While this research acknowledges the social network dimension of standardization, it focuses on the social capital held by firms, and created through inter-firm interactions.

Quantitative empirical research on *individual* participation in SDOs is more limited. Some studies linked composition of SDOs' working groups and the quality of their standards (Simcoe, 2012), and analyzed the role of team composition and individual authors' experience for technical decision-making (Ganglmair et al., 2018). Other empirical studies of individual SDO participants have focused on the role that inventor participation plays for the declaration of patented technologies as standard-essential (Kang and Motohashi, 2015), and observed the incentives of researchers to patent and participate in standards development (Blind et al., 2018). More recently, Baron et al. (2021b) study the role of supportive norms for the appointments of women to IETF leadership positions. The relatively limited focus on individual-level determinants of participation and conduct in SDOs in the empirical literature contrasts with detailed historical accounts of SDOs (Russell, 2014; Yates and Murphy, 2019), which highlight that standards development is traditionally characterized by a set of norms and rules that are widely shared among individual participants.

By focusing on the role of individual SDO participants' affiliations for appointments to SDO leadership positions, we shed light on the interaction of company- and individual-level considerations. Previous research has argued that individuals acquire social capital through their participation in SDOs (Isaak, 2006), and Dokko and Rosenkopf (2010) study companies' acquisition of this social capital through recruitments of individuals with SDO experience. We extend this limited existing literature on the boundary-spanning role of firms' individual employees' participation in SDOs by focusing on the different *roles* that individuals may hold in SDO processes. These different roles are associated with different

foci of commitment to the employer or the SDO and its community.[3] In turn, individuals' standing in an SDO (including their ascension to SDO leadership positions) is determined both by their individual experience and track record, and the relevance and influence of the company (or other stakeholder) that they represent. To the best of our knowledge, the relative weight of these individual- and affiliation-level factors, and their role for SDO governance, has not yet been formally studied.

We can however build on a broader literature on dual allegiances of firms' employees participating in collaborative innovation, and the pressure on these individuals to show loyalty both to their employer as well as to their collaborators in the community (Husted and Michailova, 2010; Husted et al., 2013).[4] For companies, employing individuals with an established position in the relevant community ("men on the inside") is an effective strategy to gain influence over the progress of collaborative innovation (Dahlander and Wallin, 2006; Lee and Herstatt, 2015). Tensions between individuals' dual allegiances may however negatively affect the way they share knowledge with their collaborators (Chan and Husted, 2010; Husted et al., 2013). This tension can also be traced in SDOs where individuals holding leadership positions, usually volunteers, have allegiance both to their affiliations and the SDO and may find themselves in a situation of a conflict of interests. Werhane and Doering (1995) analyze such a conflict of interests by an SDO working group chair at the American Society of Mechanical Engineers (ASME). Some studies suggest that volunteers in standards development committees should be held to high ethical standards and subjected to a stricter control to prevent abuse of SDO processes (Marpet, 1998).

Finally, our study also contributes to the nascent literature on SDO governance. A number of recent books have investigated the history and governance principles of SDOs in the field of ICT (DeNardis, 2014; Harcourt et al., 2020; Russell, 2014; ten Oever et al., 2020; Kanevskaia, 2022), and detailed case studies examined the processes and institutional evolution of single SDOs, such as ISO (Murphy and Yates, 2009; Delimatsis, 2018), IEEE (Zingales and Kanevskaia, 2016), and W3C (Halpin, 2017). Baron et al. (2019a) offered a comparative analysis of governance rules of 17 SDOs, and observed significant heterogeneity in SDOs' governance architecture, including leadership election processes. Nevertheless, our study provides one of the first empirical analyses linking differences in SDO governance mechanisms and norms to empirically observable differences in outcomes.[5]

[3] For a general analysis of multiplicity of foci of commitment in the knowledge economy, see Kinnie and Swart (2012).

[4] Many of the existing studies of dual allegiance in collaborative innovation focus on companies' participation in Open Source Software (OSS) communities (Chan and Husted, 2010; Homscheid and Schaarschmidt, 2016; Schaarschmidt and Stol, 2018)

[5] Chiao et al. (2007) provide an empirical analysis of some SDO governance principles, including the instiutitonal independence of an SDO with respect to its membership, and policies on Intellectual Property Rights (IPR). There is a larger number of studies describing variations in SDOs' IPR policies (Lemley, 2002; Bekkers and Updegrove, 2012), and analyzing the impacts of different rules on firms' participation behavior (Bekkers et al., 2017); but there is less empirical research on the effects of variations in more fundamental aspects of SDO governance.

3 Institutional Background

3.1 Significance of SDO leadership

Stakeholders take part in standardization processes through their employees, which attend the meetings of SDO committees, and propose, deliberate and vote on technical solutions. Individuals may also perform various administrative and management functions, e.g. by serving in the SDOs' boards or by taking up chair positions in technical committees and working groups. By far the most common leadership position that individuals may hold within an SDO is the role of working group chair.[6] Individuals holding a chair position have weighty responsibility, but also considerable power: they coordinate the work of the respective working group, decide on acceptance of technical contributions,[7] and take such pivotal decisions as whether consensus has been achieved or a vote should be conducted. Chairs thus exert a significant influence on the outcome of standardization processes, not least by ensuring their impartiality and balancing the rights and interests of the working group members (Marpet, 1998); at the same time, Chairs' actions and decisions may generate significant delays in the working groups (Harcourt et al., 2020) and lead to antitrust liability of an SDO, bringing about profound consequences for the whole SDO membership.[8]. It is hence not surprising that individuals holding a chair position are subject to certain expectations regarding their integrity and impartiality.

Leadership roles are particularly critical in the highly competitive environment of ICT standardization. Being in charge of chairing working groups meetings, individuals have commitments towards the SDO, their peers, and the profession; however, they still remain employed by SDO stakeholders, and their commitments to their employer may well contradict with their other commitments. Due to the significant power vested with chairs, acquiring leadership positions in SDO working groups is one of the most salient strategies that companies employ to increase their influence on standardization processes. SDOs' impartiality thus depends on the decisions and actions of individuals employed by stakeholders with direct stakes in the outcomes of SDOs' decisions.

Each SDO has its own rules for election or appointment of its leadership that are entrenched in historical traditions and informal practices, and have evolved due to the membership expansion as well as the emerging jurisprudence. The next section examines these rules for two prominent organizations developing leading ICT standards: 3GPP and IETF.

3.2 Chair selection in 3GPP and IETF

3GPP is a global partnership of seven regional SDOs operating in the telecommunications and ICT sectors. Stakeholders participate in 3GPP processes by virtue of their membership in partner-SDOs. 3GPP is rooted in the principle of direct representation of commercial stakeholders: experts serving in 3GPP committees represent the interests of their affiliations.

[6]Although our analysis focuses on the role of the working group chairs, many of the findings may carry over to positions at higher levels of SDO governance.

[7]Trueposition, Inc. v. LM Ericsson Tel. Co. (Jan 6, 2012), No. 11-4574, 2012 WL 33075 [2012]

[8]American Society of Mechanical Engineers v. Hydrolevel Corporation, 456 U.S. 556 [1982] para 43

In turn, IETF is an a-political, loosely organized group of Internet experts with no formal membership requirements. IETF processes are rather informal, with a lot of standards work taking place via exchanges on IETF mailing lists, and are open to all interested parties or individuals (Weiser, 2001). Importantly, IETF is based on individual participation, whereby experts may participate irrespective of which interests or views they wish to represent.

From this perspective, then, 3GPP and IETF approaches to SDO participation are uttermost different: whereas the entity-based approach of 3GPP seeks to reflect consensus of all relevant stakeholders and assure sufficient representation of different types of (commercial) interests, the individual-based approach of IETF seeks to reflect a technical consensus among subject matter experts. Chair appointments in 3GPP and IETF thus present an interesting case study for our analysis, as the two SDOs represent two very different institutional strategies to the shared goal of achieving objectivity in technical decision-making.

3GPP Working Group officials are bi-annually elected by the members of the respective Working Group.[9] If there are multiple candidates nominated for the chair position, the election of Working Groups' officials occurs through secret balloting, with a threshold of 71% of Working Groups' members voting and present; if the processes is unsuccessful, it is followed by a second ballot between the candidates obtaining highest amount of votes.[10] Individuals can be re-elected as Working Group chairs or vice-chairs for the second term, and exceptionally, their tenure in the office can last even longer; however, there are no restrictions for chairs whose tenure is due to expire to volunteer for vice-chair election and vice-versa.[11] Candidates for (vice)-chairmanship should provide a letter of support from the individual Member that they represent at 3GPP, which should also provide assurance of candidate's compliance with antitrust rules if elected for the office.[12]. An incumbent chairman or vice chairman who changes their affiliation is required to present a new letter of support from their new employer. If affiliation is changed due the individual's hire by another company, and not their company's merger or acquisition, the Working Group should also agree by consensus that the individual can remain in their role as a (vice-) chair.[13] Chairs and vice-chairs are also required to maintain impartiality and act in the interests of 3GPP when performing their leadership tasks;[14] Working Group members that question chairs' impartiality may object to chairs' decisions and ultimately voice their objections in the higher hierarchical committee. [15] (Vice-)Chairs can be dismissed through a secret vote of the Working Groups when they fail to effectively perform their duties.[16] To maintain balance in SDO leadership, 3GPP's Working Group's chair and vice-chair, as

[9]3GPP Working Procedures, April 29, 2021, Art.22
[10]3GPP Working Procedures, April 29, 2021, Art. 28
[11]3GPP Working Procedures, April 29, 2021, Art. 22.1.
[12]3GPP Working Procedures, April 29, 2021, Art.22.1, which by analogy apply to working group leadership, Art. 22.2
[13]3GPP Working Procedures, April 29, 2021, Art. 22.1.
[14]3GPP Working Procedures, April 29, 2021, Art.23.
[15]3GPP Working Procedures, April 29, 2021, Art.29.
[16]3GPP Working Procedures, April 29, 2021, Art.24.

well as their successive officials, cannot be from the same region, partner-organization or group of companies, unless no other individual is available to hold the office.[17].

IETF Working Group chairs are assigned by the Area Directors who in turn are selected by the IETF's Nomination Committee (NomCom). NomCom members are randomly drawn from a pool of volunteers and approved by the Internet Architecture Board (IAB).[18] While both technical and communication skills of a chair candidate matter, individuals who have been actively participating in the IETF for a long time are more likely to get appointed as chairs, especially if they gained "favorable prominence" by having previously contributed to the documents or volunteered to review them.[19] IETF chairs have a wide discretion in administering Working Group activities and may also take decisions on its behalf, and are expected to balance "progress and fairness" and ensure that the Working Groups move forward while the process remains fair and open.[20]

At first glance, the procedures for chair appointments in the two SDOs thus demonstrate notable differences. Indeed, affiliation seems to play an important role for chair candidates in 3GPP, which requires companies to take necessary steps to ensure the candidate's appointment, as well as sets limitations to secure commercial and regional balance; while similar requirements are absent in the IETF. Yet, despite these procedural differences, the roles and responsibilities of Working Group chairs in 3GPP and IETF are remarkably similar. Since chairing a working group necessitates specific knowledge of and experience within the particular SDO, as well as specialized technical knowledge on the subject matter, individuals selected or appointed into the roles of the chairs enjoy certain recognition by their peers as authoritative figures in their field of expertise. Next to this professional expertise, neutrality and impartiality are the main requirement for chairs in both 3GPP and IETF. [21] As it can be observed from the recent examples of potential conflicts of interests in SDO leadership, individuals selected or appointed to 3GPP and IETF Working Groups chairs enjoy a great level of trust of their community, and are generally believed to act in the interest of the SDO rather than their employer. [22] At the same time, and due to these high expectations of neutrality, holding a chair position in both 3GPP and IETF is associated with tensions between the individuals' incentives to serve the SDO community, on the one hand, and their incentives to promote the interests of their employer,

[17] 3GPP Working Procedures, April 29, 2021, Art.22.1, which by analogy apply to working group leadership, Art. 22.2

[18] BCP 25, IETF Working Group Guidelines and Procedures, September 1998, https://tools.ietf.org/html/bcp25

[19] RFC 4144, How to Gain Prominence and Influence in Standards Organizations, https://tools.ietf.org/html/rfc4144

[20] The Tao of IETF, November 8, 2018, https://www.ietf.org/about/participate/tao/, Art. 4.1.

[21] While these requirements are explicitly mentioned in the 3GPP Working Procedures, they are applicable in IETF by virtue by the requirement of individual representation.

[22] Impartiality and neutrality of IETF chairs have been challenged on a number of occasions, but neither IESG nir UAB, the IETF's appeal bodies, did not find any evidence of conflict of interests stemming from the chairs' affiliation. See e-mail exchange titled "Continued Buse of Process by IPR-WG Chair", December 26, 2007 https://www6.ietf.org/iesg/appeal/anderson-2007-12-26.txt and Appeal Against the Removal of the Co-chairs of the Geopriv Working Group, April 23, 2007 https://www6.ietf.org/iesg/appeal/gellens-2007-06-22.pdf. See also the TruePosition case, where the decisions of the chair were not considered conflicting with 3GPP/ETSI procedures by these SDOs' governing bodies.

on the other, since each of these commitments provides opportunities for an individual's professional advancement and supports their professional reputation.

While we thus observe very signficant differences in the process of how chairs are appointed at 3GPP and IETF, we thus find that chairs are selected based on similar criteria, and expected to perform similar tasks. Based on this comparison, we argue that empirically observable differences between the determinants of chairs' appointment in 3GPP and IETF may chiefly be attributed to the two SDOs' different institutional model, namely the one based on an explicit representation of commercial stakeholders, and the other on the principle of participation on an individual basis.

3.3 Hypothesis development

3.3.1 Effect of affiliation on appointments to leadership positions

Individuals' appointments to leadership positions are determined in at least three steps: first, individuals need to volunteer for chair positions, and may more or less actively pursue such appointments. Second, individuals' employers have to make their employees available for SDO work, and may more or less actively support their employees' candidacies. Third, chairs are selected among available volunteers by the different groups of selectors (3GPP working group members and IETF area directors).

We seek to assess the relative extent to which an individual's personal characteristics, and the characteristics of the affiliation she represents, impact the likelihood of appointment to SDO leadership positions. In particular, we hypothesize that for a given individual, with her given personal abilities and characteristics, the likelihood of being appointed to SDO leadership positions increases with relevant measures of the individual's affiliation's stakes in the SDO. We hypothesize that affiliation effects are relevant at each of the three layers of determinants of SDO leadership appointments:

- SDO working group chairs have to take time from their regular work, and are compensated by their employers to serve the SDO. The expense of volunteering an individual for SDO work is determined by the workload of the role, and should therefore be similar for all companies, but the return depends on the extent to which a company is able to appropriate the benefits of any influence that the individual may exert within the SDO. We thus expect that companies that are deeply invested in an SDO's activities, and that have significant stakes in the outcome of standardization decisions, are more likely to be willing to incur the expense of "volunteering" their employees' time for SDO leadership work.
- Individuals' motivations to volunteer for SDO leadership positions encompass non-professional reasons, such as intrinsic interest in the work of the SDO, and desire for peer recognition; as well as career considerations, such as ability signaling and networking beyond the boundaries of the firm. These incentives are largely independent of the strategic incentives of individuals' current affiliation. Nevertheless, individuals may also rely on their position within an SDO to further their career with their current employer. Individuals thus have affiliation-specific incentives to invest in the acquisition of human and social capital that is valued by their employer. Leadership position and leadership experience within a relevant SDO are particularly

valued by those companies that are significantly invested in that SDO's activities. We thus expect that individuals affiliated with such companies are particularly motivated to acquire SDO leadership positions.

- Other participants may be more or less likely to choose individuals affiliated with powerful stakeholders to SDO leadership positions.
  - On one hand, individuals affiliated with one of the companies competing for SDO leadership may be less likely to be chosen because of concerns over conflicts of interest, dominance, or potential hidden agendas.
  - On the other hand, these individuals may be more likely to be chosen, because SDOs have incentives to choose representatives of powerful stakeholders. In particular, allowing leading companies to be represented provides incentives for these companies to contribute to standardization and increases the chances of the standards' adoption and success in the market. Also, given that individuals affiliated with such companies are more likely to benefit from the support of their employer for their SDO-related activities, they are less likely to face conflicts of commitment between their work as chair and their regular work duties.

While these mechanisms are different, and they act at different steps of the determination of leadership appointments (individual motivation to volunteer, companies' willingness to make employees available, and selection by SDO), they are all largely driven by the hypothesis that companies with greater stakes in the SDOs's activities are more willing to spend resources on pursuing (or supporting their employees' pursuit of) SDO leadership postions. We do however not hypothesize that companies' efforts in pursuit of SDO leadership positions increase linearly in the extent of companies' stakes in the SDO. Up to a certain level, we expect companies' investments in SDO leadership to be characterized by increasing marginal returns. For one, SDO leadership investments may be characterized by significant indivisibilities - many SDO leadersihp positions may only be filled by volunteering a large portion of the work time of a senior expert. In addition, the ability of a company's individual to pursue the company's goals within the SDO, and the ability of the company to monitor and influence how an individual employee exercices her SDO leadership functions, may plausibly hinge on the influence that a company already exerts over the SDO and its leadership. Collective action problems may further undermine the incentives of companies with intermediate levels of stakes in the SDO to spend significant resources on pursuing SDO leadership positions - given that many companies' vested interests in standards development are correlated, most companies with intermediate levels of stakes have incentives to free-ride on the leadership efforts of larger stakeholders.

For these reasons, we hypothesize that affiliation effects on individuals' likelihood of being appointed to SDO leadership positions are concentrated in a small number of affiliations competing for SDO leadership. While many companies are impacted by standardization decisions, only a small subset of these companies are sufficiently incentivized to invest significant resources in actively contributing to standards development to shape standardization outcomes (Baron and Gupta, 2018). We hypothesize that an even smaller subset of the companies actively participating in SDO activities has sufficient incentives to invest resources in competing for SDO leadership.

Based on these considerations, we can thus formulate our main hypothesis:

Hypothesis 1 (H1) *Affiliation with one of the top SDO stakeholder increases the likelihood of an individual's appointment to SDO leadership positions.*

As pointed out above, finding that affiliation characteristics have a causal effect on individuals' chances of being appointed to SDO leadership positions does not necessarily mean that these individuals are *chosen* by the relevant SDO decision-makers because of their affiliation. The causal effect may also be explained by an impact of affiliation characteristics on individuals' motivations to volunteer for chair positions, or the extent to which individuals' candidacies are approved and supported by their employers. Independently of the mechanism, the aggregate causal effect determines to what extent individuals *owe* their SDO leadership positions to their affiliation; and whether SDO stakeholders may fill SDO leadership positions at will, or must rely on individuals who command significant influence within an SDO community independently of their affiliation.

Next, we will analyze how the effect of affiliation characteristics on appointments to leadership positions is moderated by SDOs' governance rules and informal norms. In particular, we compare the role of affiliation characteristics for appointments to similar roles in two different SDOs, entity-based 3GPP and individual-based IETF. We test two contrasting hypotheses how the different governance traditions of these two SDOs may affect the relationship between individuals' affiliation and their ascension to SDO leadership positions.

Hypothesis 2a (H2a) *Affilation with a powerful SDO stakeholder increases the chances of individuals' appointment to leadership positions at entity-based 3GPP, but not at IETF.*

This hypothesis appears in tune with the premise of IETF's governance model: any individual may participate and be influential, regardless of affiliation. By contrast, individuals may only participate in 3GPP activities as representatives of a 3GPP member; and the governance model of 3GPP vests greater voting power in the hands of the largest stakeholders. Even 3GPP's rules for chair appointments explicitly require the individual's affiliation's approval and support. We may thus expect that individuals' intrinsic motivations and characteristics play a greater role for chair appointments (and individuals' standing in the SDO community more generally) at IETF, whereas individuals' chances of being appointed to 3GPP leadership positions (and acquire significant influence in the 3GPP community more generally) are largely premised on representing a powerful stakeholder.

Nevertheless, we may also formulate an alternative hypothesis:

Hypothesis 2b (H2b) *Affilation with a powerful SDO stakeholder is at least as important at IETF for appointments to leadership positions as it is at 3GPP.*

IETF's *openness* to individually motivated participation does not neutralize the fact that individuals have different incentives and abilities to participate. While any individual may participate in different IETF activities (and many do, in a variety of roles), individuals affiliated with powerful stakeholders may still have superior incentives and greater access to resources (including greater ability to commit their own work time). These effects are also at play in entity-based SDOs such as 3GPP, but these SDOs have explicit mechanisms for balancing the influence of different stakeholders and interest groups. IETF, by contrast, has traditionally shunned the concept of balance (Baron et al., 2021a).

4 Empirical analysis

4.1 Data and methodology

4.1.1 Data on attendees and chairs

We collected meeting attendance and working group chair information from the websites of 3GPP and IETF. After collecting raw names from the SDOs' attendance records, we standardized the individual attendee and chair names, using additional information such as affiliation, contact information, and working group name, for disambiguation. Similarly, we collect affiliation information from the SDO attendance records. In some cases, we use the domain of the e-mail address to identify the affiliation.[23] Individuals may provide different affiliations, such as their employer or a membership organization in which they are member. We attempt to identify the *primary affiliation*, which we consider to be the most likely primary employer of the individual. We thus give priority to company or government authority affiliations over membership organizations. The steps for the standardization of individual and firm names are explained in greater detail in Baron (2020).

In the case of companies, we standardize this affiliation information to the level of the global ultimate owner (GUO).[24] We also use this information to distinguish between "recruitments" and changes of affiliation due to changes in corporate structure.[25]

In the case of 3GPP, we retrieved attendance records of working group meetings. The data includes the meeting reports of the meetings of six 3GPP TSG as well as their 31 working groups. During our observation period (1999 to early 2019), there were a total of 2,720 meetings at these groups. In the case of IETF, we collected attendance records from 75 IETF meetings from 1994 to 2019, inclusive. IETF working groups meet during the general IETF meetings. While in some cases there is attendance data for individual working group meetings, this information is not sufficiently systematically available. Nevertheless, IETF meeting attendance is a condition for working group meeting attendance. IETF attendance data (but not the data on chairs) is thus limited to observations of attendance at the 75 general meetings. In total, we thus collected 310,685 attendance records from

[23] Attendance records of 3GPP list affiliations of attendees. At IETF, information on affiliation varies between meetings; if no affiliation information is provided, we use the domain names of e-mail addresses, or interpolate affiliation (if an individual has attended an earlier and later meeting with the same affiliation information, we assume that this was the affiliation at the meeting for which affiliation information is missing). In total, we observe affiliation for 94,722, or 87.5%, of the IETF attendance observations.)

[24] Standardization of affiliations at the GUO level reflects the standard assumption in economic research that firm conduct is determined at the GUO level.

[25] In the case of mergers and acquisitions, we observe a change of affiliation at the date of the M&A event, regardless of whether the affiliation of the individual in attendance records continues to be the name of the acquired entity or changes to the name of the new parent company. For spinoffs and transfers of companies from one parent to another (e.g. Motorola Mobility acquired by Lenovo from Google), we observe changes of affiliation for those individuals who continuously list the company that was transferred as their affiliation; or if we observe a change in affiliation between the former and the new parent that coincides with the date of the event (e.g. an attendee changing affiliation from Google to Lenovo concurrently with Motorola Mobility's acquisition by Lenovo is identified as having changed affiliation due to a change in corporate structure; whereas a change of affiliation between these two companies in another year would have been classified as recruitment).

2,795 different meetings, with information on 43,209 different individuals and 7,566 different affiliations (at the parent level).

Similarly, we collect data on working group chair names. In the case of 3GPP, meeting reports indicate the role of each individual attendee. In addition to "attendee" or "delegate", possible roles include "chair", "vice-chair", "secretary", and "rapporteur". For the purpose of our analysis, we consider "Chair", "Vice chair", and "Convenor" as chair positions. In the case of IETF, we hand-collected chair and vice-chair observations from the minutes of each working group meeting. Overall, we collected 17,917 chair observations from 9,232 meetings; with 1,286 different individuals serving as chair, and 2,520 different chair positions (i.e. unique combinations of individual chair name and working group name). Of these positions, 1,274 were appointments to chair positions of already existing groups. For most of our analysis, we will focus on these appointments to open positions in existing groups; which allows us to observe past individual participation in the group to build control variables and identify potential candidates for the position.

	3GPP	IETF	Total
Attendance			
Meetings	2,720	75	2,795
Attendance records	202,451	108,234	310,685
Individual attendees	14,441	30,172	43,209
Different affiliations	985	6,609	7,566
Chairs			
Meetings	2,232	7,000	9,232
Chair observations	4,841	13,076	17,917
Chair persons	374	916	1,286
Observation period	1999-2019	1994-2019	1994-2019

Table 1: Descriptive statistics by type of standards organizations

4.1.2 Independent variables

For each of these individuals, we collected information on explanatory variables at the individual and affiliation level. We build several variables from our comprehensive SDO attendance data: **seniority** measures the time elapsed since the first meeting attendance, and **attendance** measures the number of meetings attended (in total, at individual SDOs, and in individual working groups). We don't observe working group attendance in IETF. Nevertheless, we are able to use additional measure of participation in IETF; notably the cumulative number of authorships of *requests for comments*, or RFC (**RFC_author**), and e-mail authorships in IETF mailing lists (Ganglmair et al., 2018).[26] RFCs are the deliverables of IETF, including its standards and non-standard output (Simcoe, 2012). Unlike attendance or RFC authorship data, e-mails can be attributed to individual working groups.[27]

[26]The authors are grateful for permission to Bernhard Ganglmair, Tim Simcoe, and Emanuele Tarantino for permission to use this data.

[27]The matching between IETF mailling lists and working groups results from the author's research for Baron et al. (2021b).

For a general measure of relevant technical expertise, we collect information on patent inventorship in the related technical field. In order to make patent counts comparable accross different World regions, and to account for heterogeneity in patent value, we count *triadic patent families*, or TPF.[28] We count the cumulative number of TPF by inventor over time, by date of first application (**number_patents**). The count is limited to the 20 International Patent Classification (IPC) classes most relevant to the standards of the SDOs in our sample[29] We also count the number of TPF for which at least one member was declared essential to an SDO, by date of first declaration (**number_sep**) (using the SEP declaration data collected by Baron and Pohlmann (2018)). We count both total numbers of SEPs, and SEPs by SDO.

In addition, we produce information on attendees' likely country of residence. Many attendance records include phone, and sometimes fax numbers. We use the country code of the phone numbers to observe country of residence. Second, many IETF meeting attendance records include information on attendees' self-stated country.[30] Third, in the case of patent inventors, the TPF patent database includes information on inventor country of residence. For each individual, we aggregate the different country-of-residence observations, and select the country with the highest number of observations to assign a time-invariant country observation. We aggregate country-of-residence information to six World "regions": Europe, North America, China, Japan, Korea, and the "Rest of the World".

At the affiliation level, we hypothesize that the type of organization, as well as the extent of the organization's involvement in the working group, the SDO, and in ICT standardization in general play an important role in determining the likelihood that their employees are appointed to chair positions. We categorize affiliations by the following types: company, university, public administration (including military, but excluding public research institutes), public research institutes, membership organizations, and other (or unknown). Among companies, we further distinguish between telecommunications network operators and all other companies. We classify the affiliations accounting for the largest number of attendance records by hand. For the remainder, we use detailed regular expression searches; supported by manual classification (see Baron (2020) for details). Using total attendance counts over the entire period, we identify the "Top 5" companies with the largest extent of participation in our four SDOs: Cisco, Ericsson, Huawei, Nokia, and Qualcomm (in alphabetical order). We refer to these companies as the "companies competing for SDO leadership".[31]

[28] These are inventions for which a patent was granted by at least the following three patent offices: the US Patent and Trademark Office (USPTO), the European Patent Office (EPO), and the Japanese Patent Office (JPO). TPF are generally considered to be patents of higher quality and higher value (see Sternitzke (2009) for a discussion). We use the OECD Database of TPF (Dernis and Khan, 2004).

[29] We matched the TPF patent numbers with the Searle Center data on declared SEP (Baron and Pohlmann, 2018), and identify the 20 IPC classes with most patents in TPF declared essential to these SDOs' standards.

[30] We do not know whether attendees receive additional guidance which country to provide, e.g. country of residence as opposed to country of citizenship.

[31] Alternatively, we also use the list of the "Top 20" affiliations, also including Alcatel-Lucent (prior to acquisition by Nokia), AT&T, Blackberry, Deutsche Telekom, Fujitsu, Intel, LG Electronics, Motorola (prior to acquisition of Motorola Mobility by Google), NEC, NTT, Orange, Panasonic, Samsung, Vodafone, and ZTE.

To measure the extent of involvement in the SDO, we count cumulative attendance in the SDO and in the working group at the affiliation level.[32] We count current memberships in standards organizations as a measure of a firm's involvement in ICT standardization in general, using the Searle Center Database (Baron and Spulber, 2018).[33] In addition, we use information on the number of declared SEP collected by Baron and Pohlmann (2018).[34]

4.2 Descriptive statistics

4.2.1 Evolution of attendance and chair patterns over time

Using our comprehensive data on SDO attendees and working group chairs, we can describe the evolution of attendee and chair demographics over time. Figure 1 displays the evolution in the number of SDO meeting attendees at 3GPP and IETF. At both SDOs, attendance has grown over time since the beginning of the observation period (1999 for 3GPP, and 1994 for IETF), even though attendance at IETF briefly peaked around 2000 (during the "dot-com bubble"). There are pronounced differences in the composition of attendee populations in terms of affiliation: 3GPP attendees are almost exclusively affiliated with companies,[35] and attendance is dominated by the "Top 20" affiliations. At IETF, by contrast, there is a significant portion of non-corporate attendance,[36] and the share of Top 20 affiliations in the corporate attendee population is smaller.[37] This reflects the much greater diversity of IETF attendees in terms of affiliations, which is partly a consequence of lower barriers to participation at IETF. In spite of these pronounced differences between SDOs, the composition of the attendee population has remained fairly constant over time at both SDOs.

[32] All cumulative counts at the affiliation level are transferred along with the firm in the case of M&As, i.e. the acquired firm's stock is added to the stock of the acquiring parent company after the date of acquisition.

[33] To account for observation gaps in the membership data, we interpolate the membership information.

[34] In light of the challenges with using patent counts discussed above, we match the information on declared SEP with the OECD TPF database; and only retain information on TPF with at least one member declared to be potentially essential.

[35] The only other affiliation with significant numbers of attendees is "Public Research Institutes", which in this graph is included in "nonprofit".

[36] including academics, nonprofit organizations (e.g. ICANN), and different types of government affiliations, including public administrations, public research institutes, and the military.

[37] There also is a significant portion of attendees for which the entity type of the affiliation is unknown. In part, this is a consequence of the fact that IETF meeting attendance records do not systematically report attendees' affiliation, leading to a larger number of individuals with unknown affiliation; furthermore, given the much larger number of affiliations represented at IETF, there is a larger number of observed affiliations which we could not assign to an entity type.

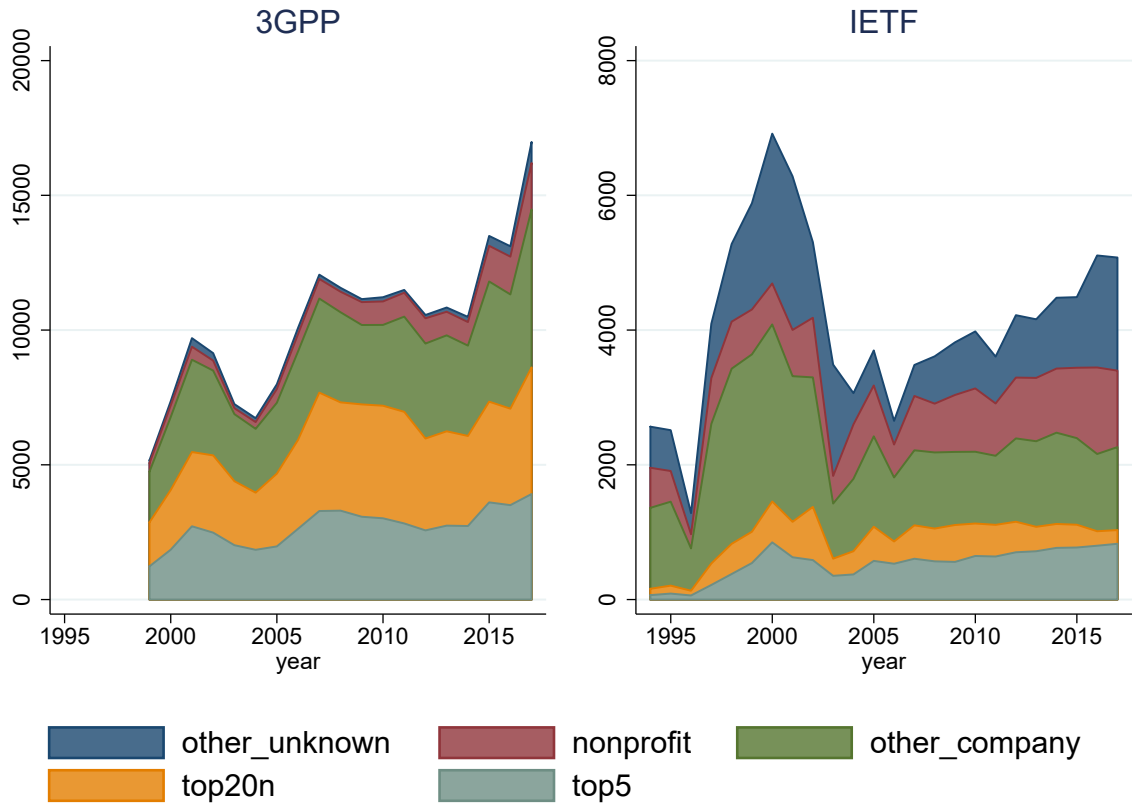

Figure 1: Composition of attendee population over time - by affiliation type and SDO

Similarly, we can plot the evolution of the demographics of the chair population (Figure 2). Top 5 and Top 20 entities are even more dominant among chairs at 3GPP than among attendees, and the share of non-corporate affiliations is smaller among IETF chairs than among attendees. Differences between SDOs are similar to those observed in the attendance data - corporate affiliations, and especially the "Top" affiliations, play a larger role at 3GPP than at IETF; and the composition of the chair population in terms of affiliation entity type has not changed dramatically over time at either SDO.

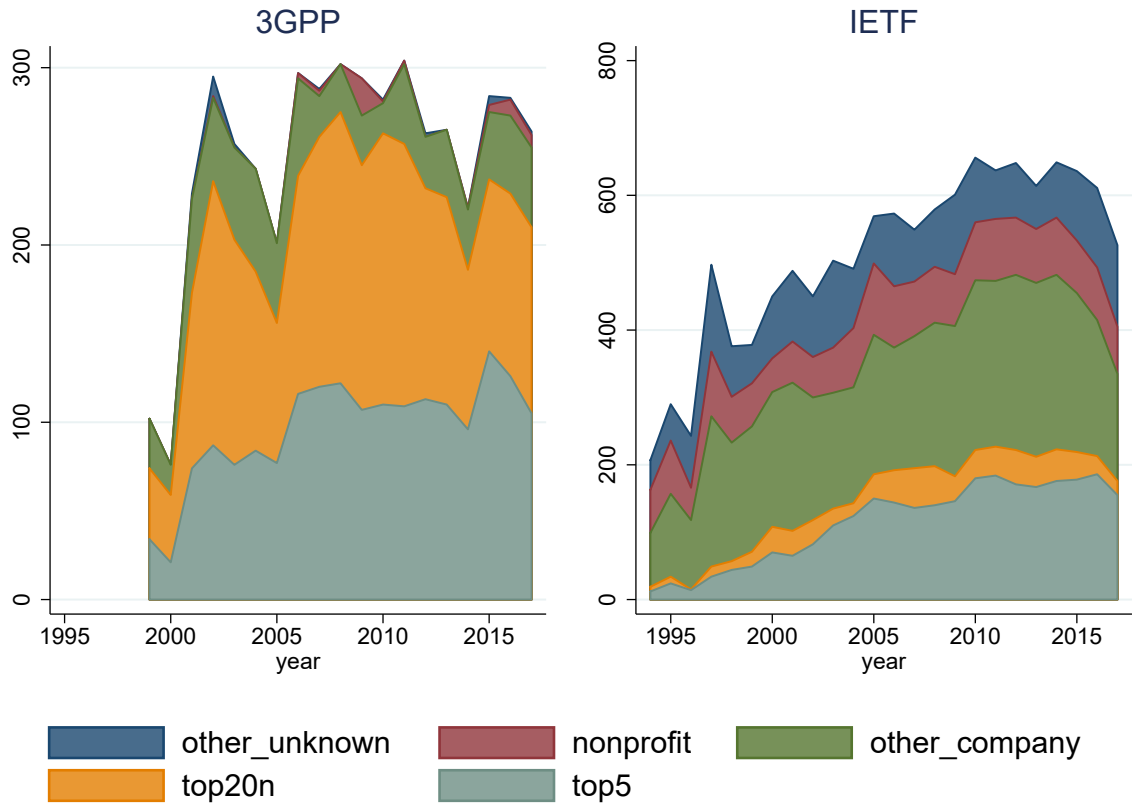

Figure 2: Composition of chair population over time - by affiliation type and SDO

4.2.2 Characteristics of attendees and chairs

Focusing only on the most recent years for which we have untruncated attendance data from both SDOs (2014-2017), we can describe the characteristics of SDO attendees and chairs. Table 2 compares the characteristics of attendees and chairs, confirming that affiliates of Top 5 or Top 20 affiliations are significantly over-represented in chair positions in both SDOs. Affiliations of chairs are thus generally less diverse than affiliations of attendees; at 3GPP, an impressive 82% of the chair positions were held by one of the Top 20 companies. At IETF, 73% of the chairs have corporate affiliations, as compared to only 52% of the attendees.

Chairs at 3GPP also tend to be affiliated with companies (or other organizations) that are generally more involved in standardization. For instance, on average, approx. 100 other individuals affiliated with the chair's affiliation had previously attended a 3GPP meeting (as compared to 66.5 other individuals also affiliated with the affiliation of meeting attendees); and chairs' affiliations were member of an average of 40 standards organizations (as compared to 30 for attendees).[38] The latter difference between chairs and attendees also exists at IETF, but IETF chairs' affiliations are not generally represented by a larger number of individuals within IETF than the affiliations of attendees.

[38]The count refers to standards organizations included in the *Searle Center Database*, see Baron and Spulber (2018).

Working group chairs however differ from attendees not only with respect to the type of affiliation. More significantly, chairs stand out in terms of their individual experience and technical expertise. At both SDOs, chairs have significantly more SDO experience than attendees, both in terms of number of meetings previously attended, and seniority (time elapsed since firts participation in the SDO). At 3GPP, chairs are also significantly more prolific inventors of patents than attendees, including but not limited to declared SEPs. As the signficant difference in seniority suggests that chairs are older on average than attendees, we compare patent inventorship over the last four years preceding each meeting, and find similarly significant differences. This difference is however unique to 3GPP; chairs are generally less prolific inventors of patents than attendees at IETF. Patent inventorship may however not be a relevant measure of technical expertise at IETF, as SEPs play a less prominent role in IETF standards development, and the average number of patent inventorships per attendee or chair is also much lower than at 3GPP. Focusing on IETF-specific measures of individuals' technological track record (RFC authorships and contributions to IETF mailing lists), we see differences between IETF chairs and attendees that are similar to the differences between patent counts of 3GPP chairs and attendees (while 3GPP chairs are listed as inventors of three to four times as many patents than attendees, IETF chairs have authored five to six times as many RFCs and contributions to IETF mailing lists as attendees).

In both cases, not only are the differences between chairs and attendees very large and highly significant, the measures of technical expertise of chairs are also impressive in absolute terms. 3GPP chairs are listed as inventors of more than 15 triadic patent families in the field filed in the last four years alone (indicating a yearly average of almost four inventions of worldwide relevance in the standard-related technology classes per year); and IETF chairs have an average individual track record of 12 RFCs and more than 600 contributions to IETF mailing lists. These numbers underline that working group chairs positions at 3GPP and IETF are reserved for exceptionally qualified individuals, and qualifications for chair positions are largely based on individuals' track record as prolific contributors to technical progress in the relevant fields.

	3GPP			IETF		
	attendees	chairs	t_stat	attendees	chairs	t_stat
meetings_cum_sso	57.03	112.63	-24.7	11.12	32.72	-52.87
meetings_cum_wg	18.46	50.21	-43.62			
seniority	2860.87	4596.61	-24.84	2257.15	5076.62	-38.53
number_patents_4y	4.37	15.35	-17.39	.25	.16	1.83
number_seps_4y	.19	.64	-10.7	0	.01	-2.7
number_mails_cumul				119.68	621.81	-30.22
number_rfc_cumul				2.06	12.07	-45.53
China	.19	.08	8.24	.09	.04	6.08
Europe	.34	.59	-15.39	.25	.3	-3.44
Japan	.08	.1	-2.12	.06	.01	7.88
Korea	.08	.01	7.76	.03	0	6.33
NorthAmerica	.24	.17	4.62	.38	.61	-17.07
RoW	.07	.05	2.28	.19	.04	13.87
attendees_guo_sso	66.52	99.03	-14.18	122.13	80.3	6.61
attendees_guo_wg	11.66	11.04	1.4			
top5	.25	.45	-13.91	.15	.32	-16.01
top20	.52	.82	-17.5	.2	.37	-14.57
sso_count_2014	30.1	39.76	-15.28	25.04	31.31	-8.56
company	.86	.97	-9.22	.52	.73	-14.55
networkprovider	.16	.22	-5.25	.07	.05	1.5
university	0	0	2.09	.14	.08	6.43

Table 2: Descriptive statistics: characteristics of chairs v. attendees

4.2.3 Characteristics of affilates of companies competing for SDO leadership and other attendees

The preceding descriptive analyses have revealed that chairs differ from attendees both in terms of individual and affiliation characteristics. While these comparisons may suggest that both individual- and affiliation-level factors play a role in chair appointments, it is important to also take into consideration the differences between individual characteristics of individuals affiliated with different types of entities. In all SDOs, there are significant differences in the characteristics of individuals affiliated with one of the five top competitors for SDO leadership and other organizations (Table 3). Individual affiliates of these organizations have significantly more SDO experience than other individual attendees, and they are generally much more prolific patent inventors. At IETF, affiliates of top affiliations are also much more prolific authors of RFCs and contributions to IETF mailing lists. These differences surely contribute to explain the outsized representation of these companies in SDO leadership positions. The descriptive statistics alone therefore do not allow disentangling whether top affiliations are over-represented in chair positions, *becuase* their affiliates are more prominent experts and more experienced SDO participants than affiliates of other organizations; or individuals are also (or primarily) appointed because of their affiliation. We will disentangle these effects in the remainder of the analysis, and identify the distinct causal contribution of affiliation characteristics on the likelihood of appointments to SDO leadership positions.

In addition to the direct effect of affiliation on leadership appointments, there may be an indirect effect: affiliation with a certain type of organization may increase individuals' opportunities or incentives to engage in certain activities, such as patenting or attending SDO meetings. Some of the individual characteristics that we observe may thus be induced

by affiliation, rather than due to intrinsic attributes of the individual. Our analysis does not allow us to distinguish between the effects of intrinsic and induced individual characteristics. Nevertheless, we argue that induced individual characteristics nevertheless contribute to the human and social capital individually held by individual SDO participants - even though individuals may *owe* their experience and track record as inventor or contributor in large parts to their past employers, they *own* these human and social capital components, and can take them with them when changing affiliation. Both intrinsic and induced human and social capital may thus contribute to strenghten individuals' position and the role of their membership in a community of individual experts.

	3GPP			IETF		
	all	top5	t_stat	all	top5	t_stat
meetings_cum_sso	57.14	61.28	-5.55	12.27	17.39	-14.82
meetings_cum_wg	16.9	25.68	-36.43	12.27	17.39	-14.82
seniority	2790.84	3210.27	-18.19	2370.44	3263.19	-15
number_patents_4y	3.82	6.9	-14.83	.17	.59	-11.06
number_seps_4y	.18	.26	-5.87	0	.01	-6.12
number_rfc_cumul				2.56	5.15	-14.23
number_mails_cumul				158.12	205.75	-3.56

Table 3: Descriptive statistics: attendee characteristics, affiliates of Top 5 competitors for SDO leadership v. all other attendees

4.3 Regression analysis: who becomes a chair?

As a first step to disentangle the causal effects of individual and affiliation characteristics, we conduct a conditional logit regression analysis of chair *appointments*. The overwhelming majority of new working group chairs are drawn from the working group's past attendees. In our conditional logit analysis, we thus identify for each new appointment the attendees of the working group's meetings of the preceding year, and analyze the factors determining which of these individuals is appointed to fill the chair position.[39]

The results of the conditional logit analyses are presented in Table 4. Not controlling for characteristics of the individual or general characteristics of the affiliation, affiliates of the "Top" companies competing for SDO leadership are signifcantly more likely to be appointed to working group chair positions than attendees with other affiliations (Models 1 and 4). Affiliates of Top 5 companies are significantly more likely to be appointed than affiliates of other Top 20 companies at both 3GPP and IETF; at 3GPP, affiliates of Top 20 companies are furthermore more likely to be appointed than other attendees (at IETF, it is only affiliates of Top 5 companies that are more likely to be appointed than other attendees).

To a large extent, the overrepresentation of affiliates of top affiliations in SDO leadership positions can be attributed to individual characteristics. Controlling for past SDO

[39]For IETF, we include all attendees of the IETF's general meetings of the preceding year - a substantially larger "risk set" including numerous irrelevant observations. By including e-mail contributions to working group-specific mailing lists, we are able to significantly improve the precision of our analysis of new chair appointments.

	(1)	(2)	(3)	(4)	(5)	(6)
		3GPP			IETF	
company	0.938	0.947	1.008	0.577***	0.320**	0.350**
	(1.52)	(1.48)	(1.54)	(5.61)	(3.12)	(2.90)
top5	0.506*	0.327	-0.134	0.852***	0.504**	0.704**
	(2.30)	(1.40)	(-0.41)	(4.82)	(2.83)	(2.78)
top20	0.775**	0.411	0.355	-0.561***	-0.407*	-0.182
	(2.85)	(1.47)	(1.03)	(-3.38)	(-2.44)	(-0.91)
network_op			-0.0847			-0.369
			(-0.27)			(-1.76)
university			-7.793			-0.0828
			(-0.01)			(-0.47)
decl_sep_tpf			0.000593			-0.000142
			(0.92)			(-0.32)
sso_membership_count			-0.00251			0.000206
			(-0.23)			(0.05)
#other_attendees_guo			0.0830*			-0.00656**
			(2.25)			(-2.64)
attendance_wg_lastyear		0.570***	0.574***			
		(9.23)	(9.25)			
attendance_wg_prior		0.0443***	0.0430***			
		(5.87)	(5.69)			
attendance_plen_lastyear		0.555***	0.559***		1.109***	1.112***
		(6.72)	(6.74)		(18.32)	(18.28)
attendance_plen_prior		-0.0299*	-0.0285		0.0237***	0.0237***
		(-2.04)	(-1.93)		(6.11)	(6.05)
#patents_field		0.00488*	0.00461*		-0.0318	-0.0362
		(2.37)	(2.13)		(-1.71)	(-1.87)
sep_inventor		0.0124	-0.0874		0.0686	-0.0465
		(0.05)	(-0.35)		(0.33)	(-0.22)
numbermails_wg_6m					0.00138***	0.00141***
					(7.01)	(7.16)
number_rfcs					0.0130***	0.0132***
					(4.04)	(4.01)
N	37,982	37,982	37,982	1,383,290	1,383,290	1,383,290
Groups	110	110	110	585	585	585

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Conditional logit regression analysis: who is appointed to become working group chair - affiliates of top competitors for SDO leadership, and other attendees

experience and technical expertise in the field (as measured by patent inventorship), the chances of appointment become more similar between affiliates of top affiliations and other attendees, even though the advantage of affiliates of top affiliations does not vanish entirely (Models 2 and 5). At 3GPP, these remaining differences may be fully explained by general characteristics of the affiliation, such as number of affiliates having participated in the SDO, and other measures of the extent of the affiliation's involvement in standardization (Model 3). At IETF, there continues to be a significant residual advantage of affiliates of the top 5 leading affiliations, which is robust to linear controls for standardization involvement (Model 6). This suggests that the likelihood of appointments to leadership positions does not increase linearly in the extent of an organization's involvement in standardization; rather, greater likelihood of ascending to leadership positions is specifically associated wit a very small number of affiliations competing for leadership.

Controlling for a large range of affiliation-level characteristics does not reduce the significance of individual-level characteristics. In particular, experience (both within the working group, and the SDO more generally) is a relevant predictor of appointment to chair positions. Patent inventorship is a significant and relevant predictor of chair appointments at 3GPP, but not at IETF. Chair appointments at IETF are, however, significantly predicted by past contributions to IETF, such as RFC authorship and, most importantly, participation in the working group-specific mailing lists.[40] These individual characteristics thus appear to be primary determinants of individuals' appointments to chair positions, and while the specific types of expertise and experience that matter differ between 3GPP and IETF, the overall role of these individual characteristics is similar at both SDOs.

It is a plausible that the determinants of chair appointments - and the relative weight of individual and affiliation characteristics - differ not only between SDOs, but also between different types of appointments within SDOs. At 3GPP, our data spans appointments to chairs of working groups and TSG plenaries, where TSG plenaries are larger, and have the final say on the adoption of 3GPP TS. We may thus expect TSG plenary chair positions to be more important than working group chair positions. There are also important differences between different TSGs. For instance, the overwhelming majority of SEP declarations at 3GPP are related to only one TSG - RAN. We may thus expect that commercial stakes in 3GPP standards development are particularly pronounced at RAN and its various working groups. Nevertheless, we find no indication that being affiliated with a company or a top SDO stakeholder has a particularly pronounced effect on the likelihood of appointments to plenary or RAN chair positions (Table **??** in the Appendix).

At IETF, different working groups are characterized by different degrees of commercial significance. Simcoe (2012) uses the share of academic (".edu") as compared to commercial (".com") top level domains in working group mailing lists (what he calls the "beard-to-suit ratio") to identify the relative commercial orientation of an IETF working group. We follow this general idea, but use our more comprehensive data on individuals' affiliation to identify the share of individual working group participants (i.e. participants in the

[40] We are concerned about a potential reverse causality for this variable, as individuals who have already learned that they will be the group's next chair may begin sending larger numbers of messages to the group's mailling list (partly adminstrative in nature). To attenuate this concern, we generally exlude e-mails from the six months preceding the meeting at which we observe the new chair from the count.

working group's mailing lists) affiliated with academic or commercial entities, and calculate the suit-beard-ratio as the number of e-mails in a working group's mailing list from an individual with a commercial affiliation divided by the number of e-mails from an individual with academic affiliation. The effect of being affiliated with a company on an individual's likelihood to be appointed to an IETF working group chair position increases in the working group's suit-beard-ratio (significant at 10%), and the baseline effect (i.e. the effect of company affiliation on chair appointments in a working group with a predominantly academic participation) is not signficantly different from zero. This result may indicate that affiliation effects are only relevant at IETF working groups with more pronounced commercial implications. Nevertheless, we do not find that the effect of affiliation with a Top 5 or Top 20 stakeholders on the likelihood of appointments to chair positions significantly depends on the working group's suit-beard-ratio.

4.4 Within-variation in individuals' likelihood of being appointed to SDO leadership positions

4.4.1 Different specifications

The conditional logit analyses described in Section 4.3 can identify the role of different *observable* firm- and individual-level characteristics. They cannot, however, account for unobservable individual characteristics, which may differ between affiliates of different organizations, and correlate with chances of appointment to chair positions. The higher likelihood for individuals affiliated with Top 5 affiliations to be appointed to IETF leadership positions may e.g. reflect affiliation effects (e.g. a greater willingness to make employees available for SDO work) or unobserved individual characteristics (e.g. "ability"). Conversely, individual characteristics (such as SDO experience) may hide affiliation effects, as affiliations more eager to acquire SDO leadership positions are also susceptible of encouraging their employees to attend a larger number of SDO meetings.

To disentangle affiliation- and individual-level *causal* effects, we take advantage of individuals' changes of affiliation. To study affiliation changes of individuals over time, we build a somewhat narrower dataset of individuals with multiple SDO attendance records, and without irresolvable data conflicts (e.g. no affiliation information for any meeting; multiple affiliations for the same meeting or for different meetings on the same day; and back-and-forth changes between different affiliations). While the population of SDO attendees initially necessarily consists in "Novices" (i.e. individuals without prior SDO experience), over time, an increasing share of individuals have had previous SDO experience - either within the same affiliation ("Repeat attendees"), or with a different affiliation ("Hire"); see Figure 4 in Appendix A.2 for a graphic representation. At the time we first observe an individual attending an SDO meeting with a particular affiliation, 16.2% of these individuals have had prior SDO experience with a different affiliation (Table 10 in Appendix A.2). We will particularly focus on cases of changes between two different affiliations, for which we observe the individual in the attendance data over at least two years both before and after the change of affiliation. There are 5,250 such changes of affiliations in our data - this is the source of variation that we exploit for our empirical analysis.

Many unobserved individual-level characteristics are likely to be largely constant over time (such as intrinsic ability), or pre-determined with respect to the period of the individual's participation in SDOs (e.g. education). As we observe individuals' careers accross different affiliations, we can test whether any given individual is more likely to be appointed to a chair position while being affiliated with an organization of certain characteristis (controlling for the general effect of seniority). We thus build a yearly panel dataset, in which we track individuals' current affiliation (at the beginning of the year) and new SDO leadership appointments over time, and we run a fixed-effect OLS regression to analyze the *within variation* in new leadership appointments. In order to focus exclusively on affiliation changes as sole source of variation in affiliation characteristics, we hold each affiliation's characteristics constant at the levels of the beginning of each individual's career.[41]

Specifically, we explain the likelihood of individuals' appointments to leadership positions as a function of the characteristics of their current affiliation, controlling for time-invariant heterogeneity in individual characteristics by including individuum fixed effects. To attenuate reverse causation concerns (as we have shown SDO experience to have an effect on labor market mobility), we generally focus on new appointments as explained variable, as explained by the characteristics of the affiliation held by individuals in the previous semester. The resuts of the fixed effect logit analysis of new chair appointments at 3GPP are presented in Tables 5, and the results of our fixed effect analysis of chair appointments at IETF are presented in Table 6.

[41] e.g. if we observe individual i from 2002 to 2009, with affiliation A from 2002 to 2006 and affiliation B from 2006 to 2009; individual i's affiliation characteristics from 2002 to 2006 are the characteristics of affiliation A in 2002, and individual i's affiliation characteristics from 2006 to 2009 are those of affiliation B in 2002. This way, we ensure that any variation in affiliation characteristics (e.g. increase or decrease in the number of declared SEPs) is exclusively attributable to individual i moving from a smaller to a larger affiliation (or vice versa).

	(1)	(2)	(3)	(4)	(5)	(6)
company	0.000111	-0.000201	-0.000159	-0.000940	-0.000986	-0.00102
	(0.07)	(-0.12)	(-0.09)	(-0.48)	(-0.50)	(-0.52)
top5		0.00140				
		(0.57)				
top20			0.000632	0.00127	0.00168	0.00128
			(0.23)	(0.44)	(0.49)	(0.44)
network_op				0.00630	0.00644	0.00629
				(1.64)	(1.70)	(1.64)
sep_3GPP_guo				-0.00000881	-0.00000515	-0.00000868
				(-1.77)	(-0.59)	(-1.76)
wgchairs_guo_3GPP					-0.000250	
					(-0.35)	
attendance_3GPP						0.000154
						(0.34)
guo_cumul	0.000572	0.000555	0.000583	0.000590	0.000519	0.000576
	(0.31)	(0.30)	(0.31)	(0.32)	(0.28)	(0.31)
_cons	0.00105	0.00122	0.00111	0.00138	0.00158	0.00119
	(0.25)	(0.29)	(0.27)	(0.33)	(0.38)	(0.28)
N	27,882	27,882	27,882	27,882	27,882	27,882

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Year fixed effect included but not reported

Table 5: Individual-level fixed effect regressions: new chair positions, 3GPP

	(1)	(2)	(3)	(4)	(5)	(6)
company	0.00691*	0.00588	0.00496	0.00413	0.00417	0.00348
	(2.33)	(1.91)	(1.58)	(1.30)	(1.30)	(1.11)
top5		0.00583				
		(1.53)				
top20			0.00694	0.00647	0.00680	0.00585
			(1.94)	(1.85)	(1.92)	(1.68)
network_op				0.0127	0.0125	0.0129
				(1.57)	(1.56)	(1.63)
sep_IETF_guo				0.00159*	0.00158*	0.00168*
				(2.04)	(2.04)	(2.15)
wgchairs_IETF_guo					-0.0000937	
					(-0.52)	
attendance_IETF						0.0180***
						(8.84)
guo_cumul	-0.00330	-0.00334	-0.00329	-0.00327	-0.00331	-0.00532**
	(-1.73)	(-1.75)	(-1.72)	(-1.71)	(-1.72)	(-2.72)
_cons	0.0537***	0.0539***	0.0537***	0.0535***	0.0536***	0.0261*
	(5.51)	(5.53)	(5.51)	(5.48)	(5.49)	(2.55)
N	44,665	44,665	44,665	44,665	44,665	44,665

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Year fixed effect included but not reported

Table 6: Individual-level fixed effect regressions: new chair positions, IETF

Models (2) and (3) in both tables reflect the average effects of being affiliated with top 5 and top 20 SDO stakeholder, respectively, as compared to being affiliated with any other company/[42] We may however expect these effects to vary significantly between top stakeholder firms. In order to account for this variation between firms, we estimate 20 alternative specifications of Model 3; in each specification, we split the Top 20 dummy into a dummy for affiliation with one of the Top 20 stakeholders, and another dummy for affilliation with the remaining 19 Top stakeholders. The company-specific dummy in each specification thus represents the effect of affiliation with this specific company, as compared with affiliation with a company that is not one of the 20 top stakeholders. The weighted average of these 20 company-specific coefficients is equivalent to the pooled coefficient for affiliation with any Top 20 company in Model 3. We plot the company-specific coefficients, and their 95% confidence intervals, in Figure 3.

[42]The company dummy captures the effect of being affiliated with a company as opposed to another stakeholder category, such as university; so that the Top 5 and Top 20 dummies only capture the residual effect of affiliation with a top stakeholder company.

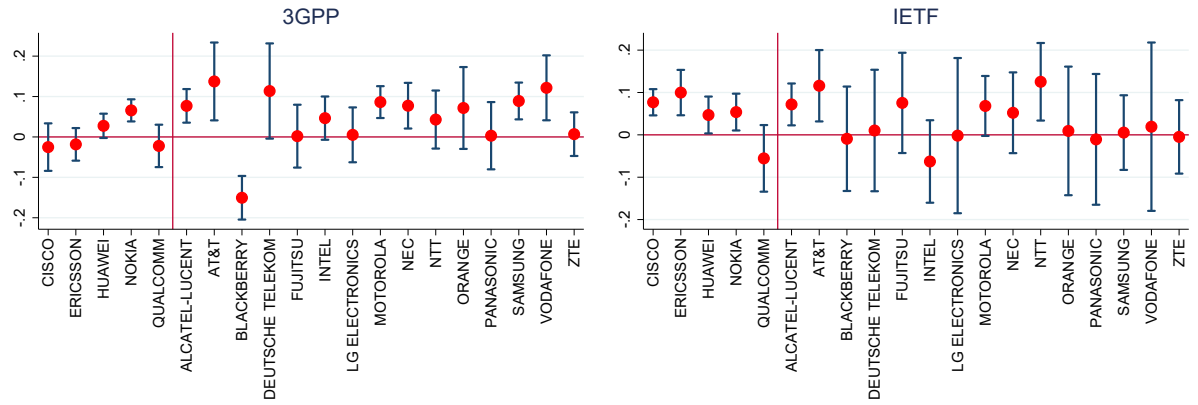

Figure 3: Firm-specific effects on SDO leadership appointments - coefficients and confidence intervals from OLS regression with individuum fixed effects

One potential concern with the fixed-effect approach described above is that several important individual characteristics do change over time in ways that differ from one individual to the other. Especially for individuals observed over long stretches of time, individuum fixed effects may not fully control for unobserved heterogeneity in individual characteristics.

As an alternative approach, we thus focus on individual affiliation changes, and compare the likelihood of chair appointment in the three years before and after the change. Focusing on single changes between two different affiliations, as opposed to tracing entire careers across multiple affiliations, we compare individuals' likelihood of being appointed to chair positions at less distant points in time. These comparisons are less susceptible of being subject to unobserved variable bias, as many of the plausibly relevant and time-variant unobserved individual characteristics (such as other dimensions of experience) are unlikely to change significantly in this short period of time. If we observe significant differences in individuals' likelihood of appointment to chair positions immediately (within three years) before and after they have changed affiliation, we may thus feel more confident that the relationship between affiliation change and likelihood of appointment to SDO leadership positions is causal. The results of the analysis of individual affiliation changeare presented in Tabled 12 and 13 in Appendix A.3.

While the short time window of this analysis may address concerns about unobserved individual characteristics, it does not address (and may arguably even exacerbate) an other concern: reverse causation. Our goal is to use affilation changes to analyze the effect of affiliation on appointments to leadership positions. Nevertheless, it is plausible that appointments to leadership positions (including expected future appointments, which it may be possible for SDO stakeholders to anticipate) cause affiliation changes. In order to corroborate the robustness of our results to concerns about reverse causation, we use affiliation changes resulting from changes in corporate structure (mergers, acquistions, spinoffs, and transfers of firms from one parent to the other). Causation of these changes in corporate structure is established at a significantly higher level of aggregation, ruling out that affiliation changes are immediately caused by an individual's impending appointment to an SDO leadership position.

	(1)	(2)	(3)	(4)	(5) (M&A)	(6) (Spinoffs)
top5	-0.00748					
	(-1.21)					
top20		0.0203				
		(1.06)				
network_op			-0.0144			
			(-0.93)			
#decl_SEP				-0.0000202*		
				(-2.01)		
after	0.0351	0.0330	0.0349	0.0387	0.0422	0.00689
	(1.11)	(1.10)	(1.10)	(1.15)	(0.91)	(0.93)
seniority	-0.0000254	-0.0000248	-0.0000254	-0.0000252	-0.0000281	-0.00000555
	(-1.23)	(-1.23)	(-1.23)	(-1.18)	(-0.94)	(-1.25)
_cons	0.0542	0.0448	0.0543	0.0536	0.0549	0.0176*
	(1.64)	(1.73)	(1.60)	(1.61)	(1.30)	(2.03)
N	2,567	2,567	2,567	2,460	1,711	1,546
Groups	254	254	254	254	173	87

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: New chair appointments, 3 years before and after change of affiliation - mergers, acquistions, and spinoffs - 3GPP

While more robust to time-variant, but slow-moving unobserved individual characteristics and to potential reverse causation, these analyses are susceptible to other concerns, such as measurement error (both the timing of affiliation change and appointment to chair position are inferred from the attendance data, and subject to error), and anticipation (individuals may anticipate a change of affiliation or an appointment to an SDO leadership position, which may affect their labor market mobility or SDO participation decisions). The longer time span of observation in the fixed effect analysis in turn attenuates concerns about measurement error and anticipation. As the different sets of analyses are subject to orthogonal concerns, general consistency between the results of our different analyses would give us some confidence in our preferred (causal) interpretation of observable correlations between affiliation characteristics and appointments to chair positions.

We present the results our preferred specification (changes in the likelihood of chair appointments before and after changes to the corporate structure) in the following Tables 7 and 8.

4.4.2 Findings

The results of our analyses of the effect of affiliation on SDO leadership appointments are largely consistent between the different specifications, but differ between SDOs. Being affiliated with a leading (Top 5) competitor for SDO leadership increases an individual's chances of appointment to a working group chair position at IETF (significant at 10% for both affiliation changes resulting from corporate structure events, and in the fixed effect estimation, highly significant at 1% in the broader analysis of individual affiliation

	(1)	(2)	(3)	(4)	(5) (M&A)	(6) Spinoffs
top5	0.0162					
	(1.95)					
top20		0.00320				
		(0.37)				
network_op			0.00461			
			(0.73)			
#decl_SEP				0.00117		
				(1.60)		
after	-0.0110	-0.00861	-0.00797	-0.00878	-0.00849	-0.0203
	(-1.06)	(-0.81)	(-0.83)	(-0.95)	(-0.85)	(-1.50)
seniority	0.00000290	0.00000320	0.00000325	0.00000320	0.00000601	0.00000878
	(0.39)	(0.43)	(0.43)	(0.39)	(0.79)	(1.16)
_cons	0.0139	0.0130	0.0133	0.00920	0.00732	-0.00256
	(1.02)	(0.94)	(0.98)	(0.57)	(0.56)	(-0.22)
N	2,953	2,953	2,953	2,441	2,763	1,463
Groups	289	289	289	289	270	80

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: New chair appointments, 3 years before and after change of affiliation - mergers, acquistions, and spinoffs - IETF

changes). This is consistent with significant positive effects associated with changes to a company affiliation (e.g. from a university or public administration; significant at 5% in both the fixed effect analysis and the broader analysis of individual affiliation changes, not applicable in the corporate structure changes analysis). Changes to affiliations with larger numbers of declared SEPs[43] are also (albeit less consistently) associated with significant increases in the likelihood of appointments to chair positions (significant at 10 % in the corporate structure event analysis, at 1% and 5% in the fixed effect analysis; not significant in the broader affiliation change analysis). Overall, these results present a fairly consistent picture - affiliation with an entity that has significant stakes in ICT standardization increases the likelihood of appointment to IETF chair positions.

This positive effect has broad support in the group of Top 20 stakeholders. 15 of the 20 companies are associated with an increased likelihood of appointments to chair positions, and for seven of these 20 companies, this increased likelihood is individually significant. Notably, this is true for four of the five Top 5 stakeholders (the exception is Qualcomm - while Qualcomm is overall a Top 5 stakeholder because of its very significant presence in 3GPP, its role in IETF is much more limited). For none of the Top 20 companies, the likelihood of appointments to IETF leadership positions is signficantly *lower* than that of individuals affiliated with a company that is not a Top 20 stakeholder. The signficantly

[43]Counts of declared SEP are measured at the beginning of the individual's SDO career in the fixed effect analysis, and in the year of affiliation change for the broader affiliation change analysis. For the narrower analysis of affiliation changes resulting from corporate structure events; the declared SEPs of the acquired firm are added to the stock of the acquiring parent company.

increased likelihood of appointment to leadership positions can be observed for companies that differ in many important dimensions - companies with individually significant effects are headquartered in the US, Europe, Japan, and China; include telecommunications network operators and equipment manufacturers; SEP net licensors and net licensees. This broad support of the identified positive effect suggests that the increased likelihood of appointment to IETF chair positions is generally associated with being affiliated with a leading SDO stakeholder, rather than a particular company or specific business model.

No such consistent positive effect is observable at 3GPP. Affiliation with one of the Top 5 or Top 20 leading affiliations has no significant effect in any of the specifications. If anything, other measures of an affiliation's stakes in standardization point to a negative effect of being affiliated with a more influential stakeholder. Affiliation changes to or from companies are associated with highly significant negative effects in the broader affiliation change analysis (but not in the fixed effect specification).[44] Being affiliated with a company owning larger numbers of declared SEPs is associated with a negative effect on the likelihood of being appointed to a 3GPP chair position in the corporate structure event analysis and the fixed effect regression, but not in the broader affiliation change analysis.

The evidence thus is broadly consistent with Hypothesis 1: affiliation with a leading competitor for SDO leadership is associated with a higher likelihood of being appointed to chair positions. Nevertheless, we do not find empirical support for our Hypothesis 2a: the effect of affiliation with a leading SDO stakeholder on appointments to SDO leadership positions is not driven by the entity-based 3GPP; rather, we find consistent significantly positive effects of affiliation with a top SDO stakeholder on chair appointments only at IETF (Hypothesis 2b). While we cannot formally compare the magnitude of effects across SDOs, and general heterogeneity in the institutional setting makes it more difficult to pinpoint individual causes for differences in chair appointment patterns in different SDOs, the fact that we consistently identify significant positive top-affiliation effects at IETF but not at 3GPP is remarkable.

5 Discussion

5.1 Main findings

This study contributes to the existing literature with a novel perspective on participation and representation in SDOs as vehicles of collaborative innovation. While most of the previous studies have focused on the interests and strategies of commercial companies participating in standardization processes, our analysis evidences that SDOs also act as communities of individual experts. Within this community, the acquisition of leadership primarily depends on individual characteristics, such as subject matter expertise (as evidenced e.g. by patent inventorship), and individual track records of SDO participation,

[44] Affilation with entities other than companies is rare at 3GPP, however, and mostly concerns Public Research Institutes, many of which in Asia, which are heavily invested in standards-related research. This differs from IETF, where there are many academics whose affiliation is unlikely to have significant stakes in IETF standardization outcomes, and where being affiliated with a company as opposed to a university is a proxy for the presence of commercial interests in standardization (Simcoe, 2012).

e.g., attendance of SDO meetings, seniority, and authorship of technical contributions. Perhaps surprisingly, our findings demonstrate that the role of individual characteristics is prevalent also in an entity-based SDO model, where individuals can only become part of the community by virtue of their affiliation with certain stakeholders,.

Nevertheless, our findings also confirm that affiliations matter for chair appointments. Affiliation with leading SDO stakeholders increases individuals' likelihood of being appointed as chairs; contributing to the over-representation of the employees of a limited number of large companies in SDO leadership positions. Somewhat counter-intuitively, the effect of being affiliated with a major SDO stakeholder on appointments to SDO leadership position is significant at IETF (which is based on individual participation), whereas no consistent significant top-affiliation effects are discernible at 3GPP (which is based on the explicit representation of 3GPP member companies).

5.2 Implications for legitimacy and objectivity of SDO decision-making

Our findings carry important implications for SDOs' independence and legitimacy. Most immediately, we have documented a significant over-representation of the employees of a small number of large companies in SDO leadership positions. This over-representation characterizes both 3GPP and IETF, which are examples of entity-based and individual-based institutional models. These findings suggest that both institutional models fall short of providing an institutional framework for decision-making in which different types of industry participants (let alone non-commercial stakeholders) have equal influence and access to SDO leadership roles. Due to the concentration of leadership position in hands of a limited number of SDO stakeholders, SDO decision-making may become prone to capture by specific commercial interests, thus failing to represent the broader engineering community. SDOs can address these concerns by strengthening their institutional mechanisms to safeguard chairs' independence, such as access to dispute resolution and possibilities to contest chairs' decisions; as well as by encouraging checks and balances in SDOs' decision-making processes (Kanevskaia, 2022).

Nevertheless, and more reassuringly, we also find that SDO working group chairs are largely appointed because of their individually held expertise and experience. To a large extent, employees of leading technology companies are over-represented in SDO leadership positions because they have a significantly stronger technological track record (on average) than individuals affiliated with other types of SDO stakeholders. While employees of certain stakeholders are more likely to hold SDO leadership positions, they do not necessarily owe their standing and influence in the SDO to their affiliation. Working group chairs usually are seasoned members of the SDO's expert community, who presumably enjoy a high degree of professional recognition and can be trusted to pursue the interests of SDOs while acting as chair, rather than focusing on the particular interests of their employers. This important role of individually held social and human capital may at least partly shield the SDO's expert community from undue influence by partial interests, and provide a safeguard for the objectivity of technical decision making in SDOs.

5.3 Relevance of institutional context

Our findings call for a reappraisal of our current understanding of SDOs' institutional models. Intuitively, one may expect that entity-based SDOs are best understood as collaborations between firms (similar to e.g. Research Joint Ventures), whereas individual-based institutional models are primarily communities of individual experts (comparable to e.g. OSS communities). Nevertheless, our findings suggest that institutional SDO models requiring explicit employer representation do not negate the strong effect of individual characteristics: while individuals may only integrate this SDO's community as representatives of an SDO member, their progression within the community (including their ascension to leadership positions) is largely based on their individual track record and expertise. At the same time, institutional models that are based on individual representation do not necessarily result in neutralizing the influence of individuals' employers. Openness to individual participation in the SDO community is thus not necessary for - and perhaps not necessarily conducive to - a culture of individual meritocracy in SDO leadership.

While our data do not elucidate the mechanisms through which individual and affiliation characteristics determine appointments to leadership positions, we can offer some potential explanations for our counterintuitive findings on different institutional models. Economic incentives of companies to control leadership positions in SDOs are clearly present in both individual and entity-based institutional models. Companies may advance their strategic interests in standardization processes by encouraging their affiliates to occupy leadership positions in SDOs, and individuals have incentives to respond to their affiliation's strategic interests to advance their own careers. Hence, even when social capital is owned by individuals and not their affiliations, there is a strong correlation between the interests of the two. However, the extent to which a company is able to advance its interests through working group chairs depends on whether the SDOs' institutional setting enables individuals to exercise their leadership function in a way that advances their employer's interests. We may thus hypothesize that affiliation with a major SDO stakeholder is a less significant determinant of individuals' appointments to leadership positions at 3GPP because of features of the institutional model that mute the effects of individual and affiliation incentives. In particular, specific clauses of 3GPP's policy, as well as the general spirit of the governance model and culture, are intended to preserve a certain commercial balance in the representation of different interests in the SDO, and especially in SDO leadership positions. This contrasts with the policies and governance model of IETF, which has traditionally shunned the concept of balance of interests; and strongly relies on the principles of openness to individual participation to counteract potential dominance of the SDO by individual stakeholders.

5.4 General implications for analyses of collaborative expert communities

Lastly, our analysis also contributes to a broader debate on the legitimacy of decision-making by communities of subject-matter experts; such as expert groups and committees in the context of policy-making, as well as the expert gremia of industry and professional associations. Relying on the consensus decision-making of such expert communities is common in technical or highly specialized policy areas, which require knowledge and skills that are typically possessed by specifically trained individuals (Shapiro, 2004). Despite

their advisory function, these experts have a powerful role in the decision-making of professional institutions, while their objectivity may be tainted by their professional or political ambitions (Leino-Sandberg (2021) on the example of the legal advisors in EU institutions; Böhling (2014) on the example of the EU comitology system; Levidow and Carr (2007); Jones (2004) on the example of agriculture and biotechnology).

Legitimacy of such expertise-based decision-making hinges on the the shared norms and values of expert-communities (Bexell, 2014). Yet, while these experts are expected to perform their tasks objectively, they typically remain affiliated with entities having a stake in the decision-making of these communities. Experts' incentives to serve the interest of their affiliation in order to advance their individual interests, e.g., career progression, may thus hinder their objectivity. As our findings suggest, objectivity in an expert-driven community is not necessarily achieved through an institutional model that is open to the participation of unaffiliated individual experts. At the same time, even communities in which all experts act as representatives of particular interests may see the emergence of an internal meritocracy based on individuals' track record within the community. Technical expert communities may thus acquire a degree of independence from particular interests not because of institutional rules that allow or require individuals to dissociate themselves from their employers' interest (a requirement that is frequently counteracted by the reality of individuals' economic incentives), but because an adequate balance in the representation of different particular interests is conducive to achieving objectivity in the community's decision-making (including its decisions on leadership apointments).[45]

6 Conclusion

This paper contributes with an empirical analysis of determinants for leadership appointments in two important international SDOs in the field of ICT: 3GPP and IETF. These SDOs are individually important in their own right, but they are also representative of two different institutional models, which rely on very different governance principles to achieve objectivity in technical decision-making. While 3GPP aims for adequate representation of the principal stakeholders, IETF is open to individual participation of any subject matter expert, without consideration of the particular interests that individuals may choose to represent.

While we document a significant over-representation of the affiliates of large SDO stakeholders in the leadership positions of both SDOs, this over-representation can largely be explained by these individuals' superior expertise and experience. Indeed, individuals' technological track record appears to be the principal determinant of appointments to SDO leadership positions, regardless of the SDO's instiutional model. This does not mean that an individual's affiliation does not matter - through a variety of converging econometric analyses, we are able to document and corroborate a positive causal effect of affiliation

[45] In other words, while traditional notions of scientific legitimacy emphasize the *disinterestedness* of scientific and technical experts, i.e. their detachment from any particular interests (Merton, 1979), at least in the context of selecting the leadership of SDO working groups, achieving balance in the representation of diverse particular interests (rather than absence of such representation) may more effectively serve the epistemic legitimacy of expert communities.

with a top SDO stakeholder. Intriguingly, this top-affiliation effect is significant at IETF, but not at 3GPP.

Our findings add a new, individual dimension to the existing scholarship on standardization and innovation. By analyzing appointments to SDO leadership positions, we are able to observe an objective marker (and a significant dimension) of individuals' progression and standing within the SDO's expert community. Our findings suggest that in both individual and entity-based institutional models of SDOs, individuals achieve recognition and influence in this community because of their individually held human and social capital and individual qualifications and experience. These findings suggest that the bulk of the empirical literature on SDOs and standards-development, which by and large focuses on interactions between firms, may overlook an important dimension of SDOs' institutional reality.

Our results regarding the relative impact of individual and affiliation characteristics on individuals' progression within the two different SDOs furthermore challenge our intuitive understanding of how these different SDOs operate. Significant affiliation effects are observable at IETF, which considers individuals' contributions regardless of whom they represent, whereas affiliation with powerful SDO stakeholders has no significant positive effect on individuals' appointments to leadership positions at entity-based 3GPP. Future research that continues examining SDOs leadership appointments and linking them with SDOs' institutional tenets and formal and informal governance rules may shed more light onto how different SDOs' mechanisms achieve institutional independence and objectivity in decision-making, while preventing undue commercial influence on the conduct of their leadership. If the differences between entity-based and individual-based institutional models observed in our study can be generalized beyond these two SDOs, they may provide an intriguing new perspective on the epistemic legitimacy of expert communities. Likewise, further research is desirable to analyze leadership appointments in SDOs that are not rooted in the tradition of private, decentralized standardization models (such as inter-govermental ITU), an thus to evaluate the consequences of different patterns and tendencies in leadership appointments for the overall resilience and legitimacy of the current global standardization ecosystem.

In order to derive stronger normative conclusions, however, it is necessary to also analyze how individuals' employment relationship with SDO stakeholders affects their conduct *within* chair positions (as opposed to their likelihood of ascension to chair positions, which is the focus of this paper). Future research may also address how ascension to SDO leadership positions affects individuals' career progression and labor market mobility. While our study provides the first systematic empirical analysis of appointments to SDO leadership positions, the interaction between individuals' standing and participation in the SDO community and their professional career and employment thus continues to present manifold opportunities for further empirical research.

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A Appendices

A.1 Appendix 1: Conditional logit analysis by type of appointment

A.2 Appendix 2: Affiliation mobility and attendee cohorts

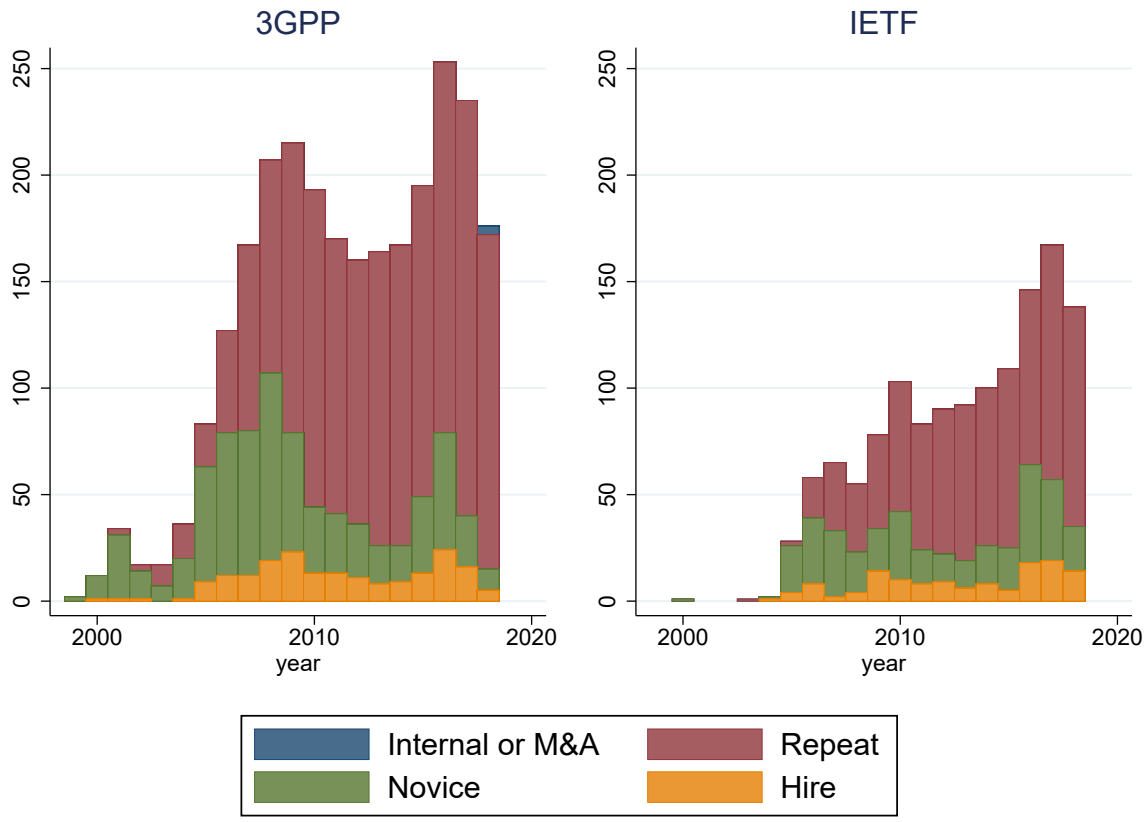

Figure 4: Composition of attendee population cohorts by prior experience and SDO

	3GPP mean/sd/count	IETF mean/sd/count	All SDOs mean/sd/count
Top 5	0.155	0.238	0.194
	0.362	0.426	0.395
	3,099	2,730	5,829
Top 6-20	0.130	0.138	0.133
	0.337	0.345	0.340
	4,054	2,379	6,433
Total	0.141	0.191	0.162
	0.348	0.393	0.369
	7,153	5,109	12,262

Table 10: Percentage of an affiliation's new attendees with previous SDO experience - by affiliation group and SDO

	(1)	(2)	(3)	(4)	(5)	(6)
	3GPP				IETF	
company	1.168	0.798	1.570*	1.303	0.0964	0.127
	(1.88)	(1.22)	(2.09)	(1.68)	(0.73)	(0.90)
company#RAN	11.57	11.76				
	(0.02)	(0.02)				
company#TSG_plen			-0.909	-2.154		
			(-0.71)	(-1.33)		
company#suitbeard					0.0110	0.0110
					(1.87)	(1.81)
top5		0.332		0.151		0.507*
		(1.25)		(0.59)		(2.08)
top5#RAN		-0.00818				
		(-0.02)				
top5#TSG_plen				1.032		
				(1.66)		
top5#suitbeard						0.00339
						(0.48)
top20		0.382		0.337		-0.434
		(1.21)		(1.15)		(-1.90)
top20#RAN		0.140				
		(0.21)				
top20#TSG_plen				0.999		
				(0.88)		
top20#suitbeard						-0.00238
						(-0.35)
attendance_wg_lastyear	0.575***	0.568***	0.579***	0.570***		
	(9.35)	(9.21)	(9.38)	(9.23)		
attendance_wg_prior	0.0459***	0.0441***	0.0459***	0.0452***		
	(6.10)	(5.85)	(6.10)	(5.94)		
attendance_plen_lastyear	0.556***	0.553***	0.560***	0.560***	1.097***	1.095***
	(6.75)	(6.70)	(6.78)	(6.76)	(15.88)	(15.84)
attendance_plen_prior	-0.0316*	-0.0301*	-0.0314*	-0.0311*	0.0225***	0.0221***
	(-2.14)	(-2.05)	(-2.12)	(-2.11)	(5.05)	(4.90)
field_any_top20	0.00527*	0.00478*	0.00535*	0.00465*	-0.0268	-0.0239
	(2.52)	(2.30)	(2.56)	(2.30)	(-1.33)	(-1.20)
sep_inventor	0.166	0.0128	0.168	0.00160	0.142	0.113
	(0.70)	(0.05)	(0.71)	(0.01)	(0.61)	(0.48)
numbermails_wg_6m					0.00142***	0.00140***
					(7.21)	(7.10)
number_rfcs					0.0129***	0.0122**
					(3.40)	(3.12)
N	37,982	37,982	37,982	37,982	1,030,779	1,030,779
Groups	110	110	110	110	436	436

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Conditional logit regression analysis by type of appointment

	3GPP mean/sd/count	IETF mean/sd/count	All SDOs mean/sd/count
Top 5	0.081	0.112	0.099
	0.273	0.316	0.299
	481	649	1,130
Top 6-20	0.166	0.170	0.168
	0.373	0.376	0.374
	529	329	858
Total	0.126	0.132	0.129
	0.332	0.339	0.335
	1,010	978	1,988

Table 11: Individuals with previous SDO experience: share attributed to company M&As - by affiliation group and SDO

A.3 Appendix 4: Effect of affiliation on chair appointments

	(1)	(2)	(3)	(4)	(5)
top5	-0.00191				
	(-0.93)				
top20		0.00496			
		(1.27)			
networkop			0.0106		
			(1.52)		
decl_sep_3GPP				-0.00000660	
				(-1.28)	
company					-0.00832**
					(-2.87)
seniority	-0.00000341	-0.00000342	-0.00000337	-0.00000318	-0.00000350
	(-1.15)	(-1.15)	(-1.13)	(-1.09)	(-1.18)
after	0.00491	0.00493	0.00479	0.00474	0.00477
	(1.11)	(1.12)	(1.09)	(1.09)	(1.09)
_cons	0.0118**	0.00924*	0.0103*	0.0116**	0.0189***
	(2.83)	(2.49)	(2.46)	(2.84)	(3.46)
N	22180	22180	22134	22180	22134

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: New chair appointments, before and after change of affiliation - 6 year window - 3GPP

	(1)	(2)	(3)	(4)	(5)
top5	0.00903**				
	(2.72)				
top20		0.00682*			
		(2.55)			
networkop			0.00616		
			(1.48)		
decl_sep_IETF				0.0000382	
				(0.06)	
company					0.00438*
					(2.01)
seniority	-0.000000154	-7.81e-08	-5.07e-08	-7.49e-08	-9.52e-09
	(-0.07)	(-0.04)	(-0.02)	(-0.03)	(-0.00)
after	-0.000680	-0.000593	-0.000317	-0.000317	-0.000422
	(-0.26)	(-0.23)	(-0.12)	(-0.12)	(-0.16)
_cons	0.0159***	0.0153***	0.0164***	0.0168***	0.0133**
	(4.21)	(4.02)	(4.40)	(4.51)	(3.28)
N	35062	35062	35053	35062	35053

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13: New chair appointments, before and after change of affiliation - 6 year window - IETF