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Mapping the International 5G Standards Landscape and How It Impacts U.S. Strategy and Policy

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Standards-setting bodies for 5G technology appear to be working well, but U.S. policymakers are justifiably wary of China's ambitions to manipulate the system. They should stay on guard and provide financial support for U.S. companies to participate.

KEY TAKEAWAYS

- The United States and U.S.-based companies in the wireless industry have long benefitted from global standards that have come out of fair, industry-led processes rewarding the best technologies.
- In that tradition, 3GPP, the primary force behind the development of 5G specifications, is designed with transparency, consensus, and fairness in mind. Both analysis and anecdote indicate its governance mechanisms are generally working well.
- However, this may not always be the case. China has ramped up its use of unfair standards processes and aims to dominate the industries of the future, in part through its official China Standards 2035 plan.
- To protect the integrity of standards-setting bodies, U.S. policymakers and allies should analyze their governance models, informally observe deliberations, and support good-governance mechanisms.
- The U.S. government should ensure there are no barriers to U.S. firms participating in international standards bodies.
- Congress should change the research and experimentation tax credit to allow companies to include their spending on global standard-setting activities.
- Explicit government coordination or identification of strategic standards priorities risks locking in suboptimal standards, accelerating unfair tactics, and balkanizing standards that are supposed to be global.

ABSTRACT

This paper explores global 5G and wireless innovation leadership in standards-setting organizations, analyzing declared patents, the number of standards submissions, and activity and leadership in international standards-setting bodies, specifically the International Telecommunication Union (ITU) and 3rd Generation Partnership Project (3GPP).

U.S. policymakers appear wary of the potential for unfair strategic gamesmanship in standards-setting organizations by Chinese actors, and with good reason. The United States and U.S.-based technology companies throughout the wireless ecosystem have benefitted from years of global technology standards grounded in fair, industry-led processes rewarding the best technology. Chinese policy aims to dominate the industries of the future, in part through its China Standards 2035 process, but not necessarily through fair processes.[1] Understanding the scope and scale of China's standards-setting activities will help to inform policymakers on when, where, and how to direct resources to ensure effective standards creation and continued U.S. leadership in high-technology innovation.

3GPP, the primary driving force behind the development of 5G specifications, was designed with transparency, consensus, and fairness in mind. Both analysis and anecdote indicate its governance mechanisms are generally working well. Conflict is rare, representation does not appear dramatically skewed, and outcomes mostly appear fair. However, this does not mean this will always be the case, or that other standards-setting bodies, particularly in smaller bodies or those with weaker structures, might not be undermined. Analysis of standards-setting organizations' governance models, informal observation, and support for good governance mechanisms across standards-setting bodies—ideally in partnership with like-minded allies—would all be helpful policy actions. In addition, the federal government should provide financial support for industry technical standards efforts. However, explicit government coordination or identification of strategic standards priorities risks locking in suboptimal standards, accelerating unfair tactics, and balkanizing standards that should be global.

A narrow focus on standards bodies themselves would miss rich opportunities for boosting future U.S. standards leadership. Continued U.S. competitiveness in technological innovation requires a coherent set of policies to support the STEM (science, technology, engineering, and math) talent pool and advanced research and development (R&D). Policymakers should look to support the beginning of the innovation road, versus fixating on the near-end of the journey at standards-setting bodies. Supporting standards-setting activity is important, but in order to maintain true competitiveness, policymakers must help enable the activity that allows firms to lead in fair standards bodies.

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INTRODUCTION

Communications operators, various equipment suppliers, chip-set providers, and even, to some extent, nation states tussle to shape the future of telecommunications technologies and markets. A key site of the evolution of wireless technology is in standards-setting organizations, where stakeholders meet to agree on technical specifications for new communications tools.

In recent years, policymakers have grown increasingly interested in wireless standards bodies, and understandably so. With the increasing digitization of our economy and society, wireless networks provide the connective tissue for a host of emerging technologies. The output of these standards bodies continues to grow ever more central to economic competitiveness and geopolitical concerns. High-functioning standards-setting organizations are critical to successful translation of R&D into a flourishing, innovative, wireless ecosystem.

U.S. policymakers are certainly not alone in their interest in these bodies. China, particularly through its government-backed "national champion" Huawei, has made a concerted effort to increase its presence in wireless standards-setting organizations. Claims of Chinese "domination" in standards-setting activities are expressed with increasing alarm: As Sen. Mark Warner D-VA) put it, the fear is that "China is setting the standards for the future."[2] Some point to the growing number of Chinese nationals and Chinese-company representatives who hold leadership roles, as well as the growing number of technical contributions from Chinese companies. Another alarming accusation is that of coordinated voting by Chinese representatives, whereby a group votes as a block for a Chinese government-preferred outcome (understanding that failure to go along with the government's preference will result in punishment) rather than that with the strongest technological merit.

U.S. leaders, both within government and in the private sector, should monitor international standards bodies and work to ensure processes comport with basic good governance practices.

This paper examines the broader context of the wireless standards-setting process and offers an analysis of current metrics for leadership, contributions, and patents to help evaluate the risk of unfair gamesmanship potentially undermining the standards-setting process. It argues that the evidence demonstrates there is no reason to dramatically alter government policy toward standards-setting organizations. Calls for a stronger government presence at standards organizations or of coordination of standards-setting priorities are unlikely to improve U.S. leadership in wireless innovation. Instead, such efforts risk encouraging further unfair tactics from Chinese participants or a turn away from global standards-setting organizations toward promotion of Chinese-only standards bodies.

This does not mean, however, that standards-setting bodies will continue to function in an equitable manner that promotes innovation. Chinese policy is not aimed at out-innovating others while comporting with an international order grounded in rule of law, international specialization, and comparative advantage. Rather, the Chinese government aims to dominate industries of the future, and appears willing to subvert a variety of rules and norms to do so.

U.S. leaders, both within government and in the private sector, should monitor international standards bodies and work to ensure processes comport with basic good governance practices. The primary wireless standards body—3GPP—is working fairly well, following a consensus-based

approach wherein the best technologies and technical standards are likely to rise to the top. However, that does not guarantee transparency and fairness will continue there or at other bodies with weaker governance mechanisms.

The best time to support U.S. competitiveness in future technological innovation, wireless or otherwise, is long before a technical contribution reaches the global-standards stage. It will begin in the laboratories conducting R&D, where ideas and proposals for standards are born. Noticeable disparities in the rising talent pool for wireless technology, innovation, and policy are a warning sign for the future of U.S. representation at standards-setting bodies. Efforts to remain globally competitive should focus primarily on the front end of innovation—rewarding R&D and domestic commercialization and deployment, and encouraging of the next generation of technical talent.

The United States should support good governance at standards-setting organizations, ideally in partnership with like-minded countries. Leveraging the existing global standards-setting ecosystem, the United States could help to ensure innovation and optimization drives forward the future of the global telecommunications market. But policymakers must focus on a long-term strategy to ensure the telecommunications market remains dynamic and competitive.

WHY STANDARDS MATTER

Standards play a crucial role in the future of telecommunications, ranging from hardware infrastructure to software running on top of components. Importantly, internationally recognized standards allow for interoperability. Instead of closed systems wherein only certain equipment works in the United States, and different equipment is required for other regions such as Europe, or where devices can only interact and communicate with components and software from the same manufacturer, standards help to ensure that a range of devices and equipment can operate in a shared system. Essentially the opposite of global standards are national standards, leading to what some have termed the "Galapagos Island Syndrome," a term explaining how Japan's choice of Japan-only technology standards led to innovations in Japan but ultimately inflicted significant damage to an industry that had once been among Japan's most vibrant.[3]

In contrast, global interoperability allows companies to market their products around the globe, which in turn means larger economies of scale, lower technology development and production costs, reduced pricing for customers, and increased innovation. Without common standards, these positive externalities are reduced, leading to slower innovation and higher prices. The wireless communications industry is somewhat unique in that interoperability is a prerequisite for a successful system—a wide variety of components throughout the network must be able to work together to offer the complete service, especially now with the specialization of different firms.

Previous generations of wireless technology faced concurrent and competing standards. For example, the evolution of 2G and 3G saw a split between the United States and Europe, as CDMA networks (Code-Division Multiple Access, developed by Qualcomm) were deployed in the United States, whereas Europe required the use of GSM networks (Global System for Mobile Communications, developed by Ericsson) to favor its own producers.[4] During this time, China also promoted its own 3G standard, TD-SCDMA (Time Division Synchronous Code Division Multiple Access), further complicating the globalization of the wireless market.[5]

Leaders in 5G innovation (and after that, 6G) will help to determine the future of wireless connectivity, including the Internet of Things and autonomous driving. Telecommunications providers are continuously innovating, enhancing, and upgrading their existing networks to support the next generation of technology. Innovation is coupled with standards setting to help ensure interoperability across the global market.

With globalization and the evolution of 5G, standards converged toward the promotion of primarily one set of standards. While convergence helps to solve the risks associated with a bifurcated telecommunications market, it creates a new set of intersecting concerns, primarily an immediate security risk (if one of the United States' primary geopolitical rivals controls global information equipment) and a longer-term economic security risk (5G as the connective tissue for a range of emerging technologies that will be increasingly central to productivity and economic growth). Standards are a key touchpoint within a much broader geopolitical competition between the United States and China.

This report further outlines the risks associated with China's and Chinese-affiliated members' growing leadership role in standards bodies, which may allow China or Chinese companies to unduly influence the agenda in standards-setting groups.[6]

Even indirect government control of telecommunications companies deployed in foreign markets represents a significant security risk.

The risks associated with unchecked Chinese telecommunications expansion are not new to policy and telecommunications circles. Almost a decade ago, the U.S. House of Representatives Permanent Select Committee on Intelligence released a report that finds that "Huawei's corporate history suggest ties to the [Chinese] military" and claims that "ZTE did not alleviate Committee concerns about the control of Chinese state-owned enterprises in ZTE's business decisions and operations."[7] Even indirect government control of telecommunications companies deployed in foreign markets represents a significant security risk. This risk is further heightened when the government has a host of national security laws that reduce the likelihood that a private company will have the ability to maintain independence from the government.[8]

Ensuring the security and optimization of telecommunications equipment is one of the key roles of standards-setting bodies, and as a result, influence within standards-setting bodies can echo across the wireless landscape. So how is influence determined? Is it by leadership positions? Number of patents or royalties received? Contributions submitted or approved? As this paper explores, most of these metrics represent no clear leader, nor do they properly indicate the level of influence a company (or its associated country) might have in standards-setting activities. While these metrics may represent clues worth further exploration, other indicators should be the first source for determining whether an uneven distribution of power exists in market-driven standards setting. Policymakers and industry must look beyond the standards-setting arena.

HOW STANDARDS ARE CREATED

Standards are set across a range of bodies, ranging from the local level to the international stage. Major international and regional bodies that recommend standards with implications for telecommunications include organizations such as:

International

- International Telecommunication Union (ITU)[9]
- 3rd Generation Partnership Project (3GPP)[10]
- International Standards Organization (ISO)[11]
- International Electrotechnical Commission (IEC)[12]

Regional/National

- European Telecommunications Standards Institute (ETSI)—headquartered in France[13]
- Alliance for Telecommunications Industry Solutions (ATIS)—headquartered in the United States[14]
- China Communications Standards Association (CCSA)—headquartered in China[15]
- American National Standards Institute (ANSI)—headquartered in the United States[16]
- Standardization Administration of China (SAC)—headquartered in China[17]

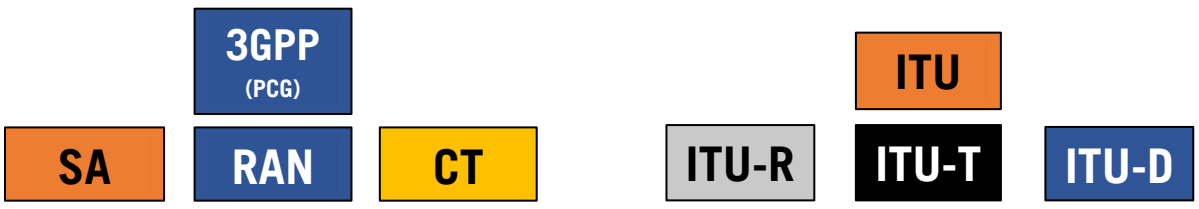
This paper focuses primarily on ITU and 3GPP. It does not explore the standards-setting activity of ISO, IEC, or the standards-setting activity that happens at a national or regional level (e.g., in China, the United States, or within the European Union), all of which impact the broader telecommunications standards-setting debate. However, brief coverage of select regional bodies is offered to provide context.

The relationship between ITU and 3GPP is one of collaboration and support, with 3GPP doing the bulk of the heavy lifting in designing wireless specifications. Both groups share a common membership base and influence each other through a continuous feedback loop. For example, ITU representatives can participate in 3GPP's overarching coordination body.[18]

For the purposes of understanding international leadership in developing wireless innovation, 3GPP is the more-important body to follow. Market participants are far more engaged in developing the technical specifications within 3GPP, whereas ITU work on specifications is generally at a higher level and more abstract. When it comes to 5G, ITU receives and evaluates submissions to conform to its high-level performance expectations for the International Mobile Telecommunications 2020 (IMT-2020) standard—with most stakeholders correctly assuming that ITU acceptance of 3GPP's submission for IMT-2020 was a foregone conclusion.

Within the primary international telecommunications standards-setting organizations (ITU and 3GPP), multiple committees exist to focus on different technical aspects. (See figure 1.[19])

Figure 1: 3GPP and ITU technical committees



3GPP hosts three major technical specifications groups (TSGs): Service and System Aspects (SA), Radio Access Network (RAN), and Core Network and Terminals (CT).[20] Each TSG hosts

several working groups (WG) through which detailed issues are addressed, such as the physical layer of the radio (RAN WG 1) or security (SA WG 3).[21]

ITU is a United Nations (UN) agency that focuses specifically on information and communications technology.[22] ITU's work is divided into three major sectors: Radiocommunication (R), Standardization (T), and Development (D).[23] Both ITU-R and ITU-T contribute to the development of recommendations that impact wireless technology. Within each sector, there are several study groups focusing on specific issues, such as Study Group 17 (SG 17) under ITU-T, which focuses on security.[24]

Representatives (originating from the public and private sectors) from both the United States (labeled in blue) and China (labeled in orange) hold major leadership roles across ITU and 3GPP (see figure 1). While a Chinese national is the secretary general of ITU, a representative from ATIS, which is the North American partner organization affiliated with 3GPP, is the leader of 3GPP's Project Coordination Group (PCG).[25] Separately, individuals who either work for U.S. parent-based companies or are U.S. nationals and individuals who either work for Chinese parent-based companies or are Chinese nationals lead major sub-groups of both ITU and 3GPP.

Contributions are developed and refined in the respective working groups following a consensus-based approach.

Each organization has its own membership, including a mix of public and private sector members. Each organization has its own processes for determining standards and the rules of operation. For example, 3GPP requires members not to miss more than two consecutive meetings to maintain voting status.[26] If a member misses three consecutive meetings, the member will only regain its right to vote during the second meeting the member attends following the initial three-meeting absence period.[27] In 3GPP, individual members retain their voting rights by simply meeting attendance requirements.[28] Contributions are developed and refined in the respective working groups following a consensus-based approach. Few formal technical votes occur.[29]

Individual members must be affiliated with an organizational partner (ETSI, ATIS, CCSA, ARIB, TSDSI, TTA, or TTC) in order to join 3GPP.[30] Each organizational partner is aligned with a region, although its members may have parent organizations aligned with other regions (Huawei, for example, has participated in 3GPP as a member of ETSI and CCSA).[31] Leadership (chair and vice chair positions) is determined through an election process, and there are restrictions in place to avoid any one company or organizational partner from having an outsized influence, unless there are not enough nominations to fill the available roles.[32]

ITU, by comparison, allows a range of entities to participate in the standards and recommendations process, but only permits certain entities to participate in the final approval process (e.g., in ITU-T, only member states and sector members).[33] There are also different tracks for recommendation approval. In ITU-T, there exists the Alternative Approval Process (AAP) and the Traditional Approval Process (TAP), the former of which is faster, more informal, and used more often.[34] Using the AAP track, a recommendation is deemed approved if no additional input is provided from members during the designated comment period.[35] Leadership of study groups is determined by consensus with regional considerations.[36]

Standards organizations exist with the common assumption that industry-led standards will result in a better outcome than will a government-directed process. Nations tap into the competition between telecommunication firms and supply chain members to help determine the "best" standards—the most efficient and effective solution to ensure the deployment and use of 5G and its applications. Standards are agreed upon at the international level as well as at regional and local levels. Unfortunately, there is a concern that China aims to substitute government-selected outcomes, obscured by the decision-making process within standards-setting organizations, for the outcomes that would otherwise occur if members of private industry were able to maintain their independence in standards-setting bodies.[37] The "best" standards may be unable to manifest through a fair process when coordination exists to short-circuit the process.

EVALUATING STANDARDS-RELATED METRICS

Determinations of the scale of one country's or company's role in the standards-evolution process is often based on patents and royalties, leadership roles, and the number of contributions submitted and approved.[38] Some claim these metrics indicate a growing and outsized influence of Chinese actors over the process. Examining 3GPP, these metrics, from a numerical perspective, do not appear to show immediate cause for concern, and should caution policymakers against overreacting.

Patents and Royalties

It is difficult to discern who the leader is in developing 5G specifications from patent data. A simple count of the number of patents is not particularly helpful, as not all patents are of the same importance. Critical patents, referred to as "standards essential" patents (or SEPs), include key components that are necessary to the operation of a standard; however, determinations of how many SEPs a company has depends on the methodology of the analyst.[39] Data from different companies shows a mix of Huawei, Samsung, Qualcomm, Ericsson, and Nokia as the SEP leader.[40] Previous reports from a range of authors offer detailed responses to this "conundrum"—ranging from a disputed definition of what an SEP truly is to different calculation methods when determining the number of SEPs a company has.[41] Chinese firms have an interest in presenting their contributions as influential, but the raw numbers of submitted contributions is a poor proxy for leading research—some patented breakthroughs are far more significant than others.

At least one consistency exists across multiple studies: Chinese companies' 5G patents are primarily "5G-only" and focused on the standalone version of 5G. Other leading patent providers appear more focused on a mix of standalone 5G innovations and patents that build off of existing 4G networks.[42] In fact, according to IPLytics data based on patents declared to ETSI, in 2019, 90 percent of Huawei's patent families and 99 percent of ZTE's patent families were 5G-only.[43] Ericsson, by comparison, has 69 percent of its patent families listed as 5G-only. According to GreyB's data from 2020, Huawei and Ericsson's percentages of 5G-only patent families had decreased, although Huawei still maintained 83 percent of its patent families as 5G-only.[44]

While some studies reflect Huawei dominating the 5G patent market, analysts have pushed back on the authenticity of the number of patents as a marker for success.[45] They claim that Chinese companies are simply submitting as many patents as possible, not for the purposes of actively seeking the approval of all patents, but to increase China's reputation as a leader in 5G in order to garner additional support in standards bodies.[46] Such activity is unlikely to affect the behavior of major telecommunications operators or supply chain providers in standards-setting bodies. But

it could impact the behavior of smaller and newer entrants to the market, assuming such companies lack deep expertise in the committees for which they send representation.

If “patent stuffing" were to increase the likelihood that Chinese companies received external support for their contributions, regardless of quality, it would likely occur at an insignificant scale, as the costs associated with membership in a standards organization are likely to deter most companies from sending uninformed experts to international standards engagements. It would be more likely for a company to support Chinese standards based on the company’s existing market agreements and future agreements (e.g., if Huawei can provide more affordable technology than a non-Chinese competitor can, and the company’s primary concern is cost of technology).

The leader in royalties is similarly opaque, although it is likely Qualcomm. Reporting from 2017 indicates Qualcomm could recover as much as $16.25 per handset, whereas Ericsson could potentially recover $5.00.[47] By comparison, as of 2021, Huawei anticipates charging $2.50 in royalty rates per handset.[48] These rates are only for handsets however, and do not account for other technologies through which companies may secure royalty revenue. With different data points across different years, along with different patent licensing strategies, it becomes difficult to clearly measure royalty rankings.

Patents and royalties offer a strong indication of which firms are leading innovators in wireless technology. Firms investing in long-term research and developing the next-generation breakthroughs in wireless are rightly able to justify higher royalties. But until the data represents more clarity and consistency across a range of reports, it remains an imperfect measurement of influence.

Leadership Roles

International standards bodies offer a range of opportunities for experts from different countries and companies to take a leadership role in the evolution of standards and recommendations. The two major bodies leading the future of wireless standards are ITU and 3GPP, the former of which is an extension of the UN and features a public-private partnership, and the latter of which is driven primarily by the private sector, with regional organizations providing the overall structure for participation.

International Telecommunication Union

ITU has a mix of members and associates who take part in the global telecommunications process. ITU counts over 20,000 professionals as participants, including from the private sector, public sector, and academia.[49] Full access and benefits are afforded to members only, while associates have access to one chosen study group and are able to participate in the process only until the decision-making portion.[50]

Some claim that China is sending a greater number of representatives to international engagements than is the United States.[51] However, the United States claims over 40 percent more ITU sector members and associates than China does (see figure 2).[52] In fact, the United States has the same or more representatives from every category other than academia.[53] However, the overall disparity is reduced when measuring the number of sector members only (see figure 3).[54]

Figure 2: U.S. and Chinese representation in the ITU (including associates)[55]

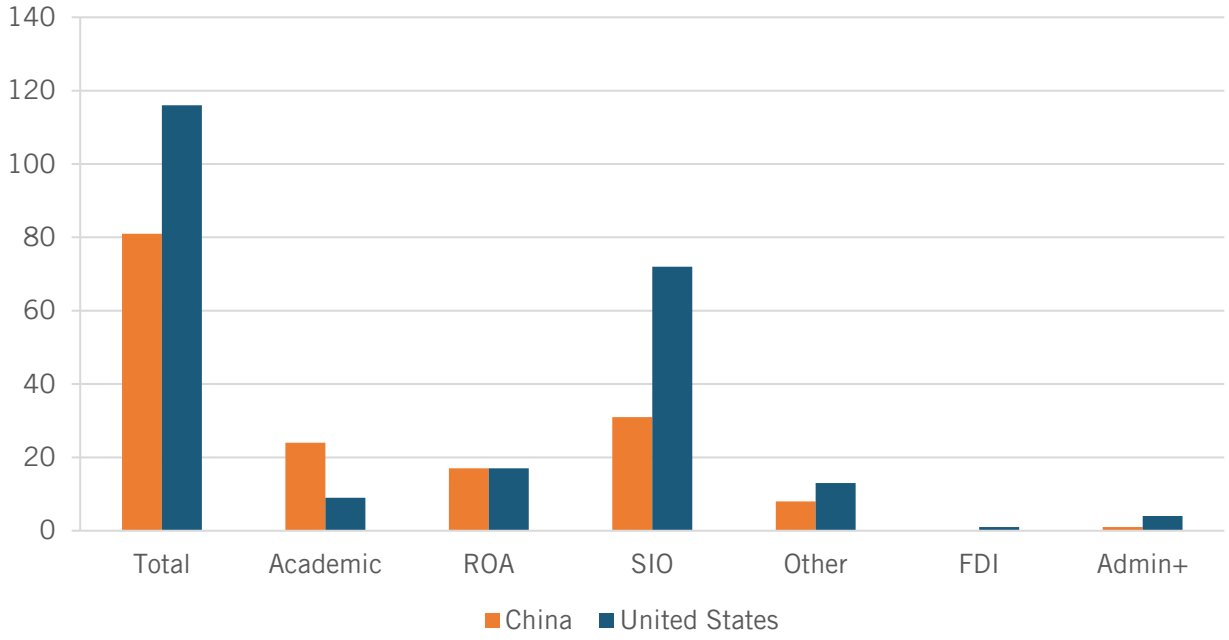
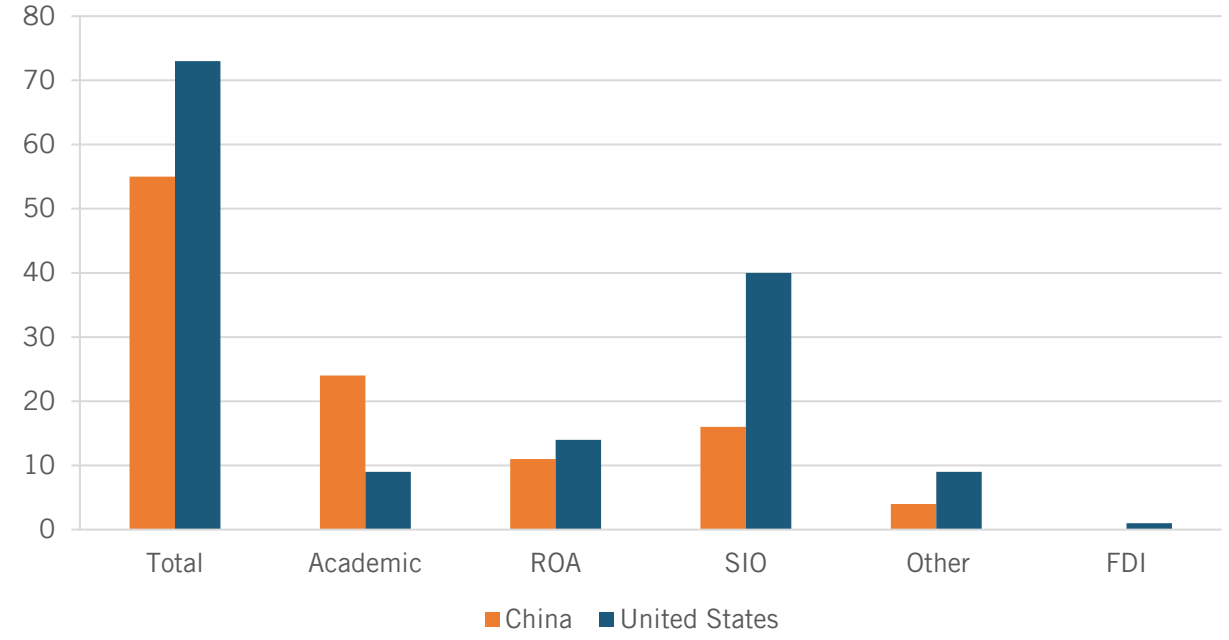


Figure 3: U.S. and Chinese representation in the ITU (members of at least one sector)[56]



When looking at the number of leadership positions across ITU-T (Standardization Sector) study groups, China appears to have a slight advantage (see figure 4). For the purposes of this paper, leadership is measured by the number of study group chair or vice chair positions, along with working-party chair positions. However, because study groups require general agreement to approve recommendations (or at least no stated objection when leveraging the AAP process),

leadership should not be viewed in isolation.[57] Leadership should be considered in conjunction with total study group membership, which includes associates who are unable to formally serve in leadership roles.[58]

Figure 4: U.S. and Chinese associates participating in ITU-T study groups[59]

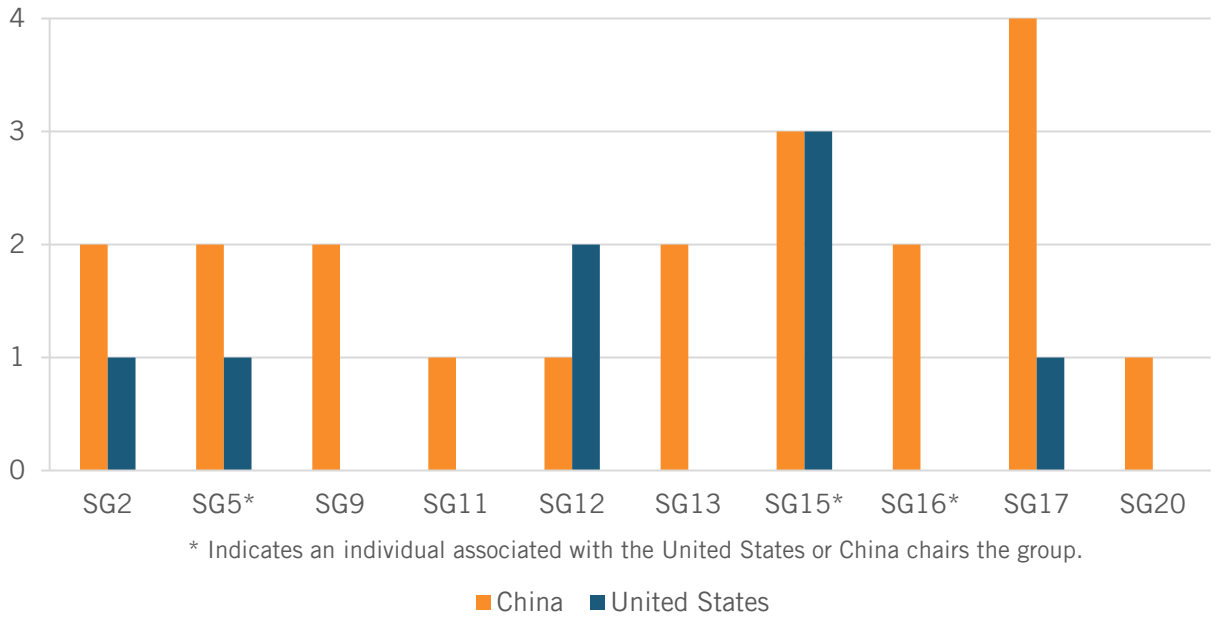


Figure 4 reflects the number of associates specifically participating in each study group, as well as the number of total sector members who would have "membership" in every study group (see figure 5, and refer to figure 6 for the formal name of each study group).[60] Based on the number of associates, there is an even balance between U.S. membership and Chinese membership in the study groups, with the United States and China each serving as the home country for the majority of associates in five respective study groups. In fact, the United States in general has more associates in study groups, along with total sector members. Of note, associates cannot serve as study-group or working-party chairs or study-group vice chairs (although academia members can serve as a working-party chair).[61] After evaluating the number of leadership positions and general membership in each study group, and understanding that standards are agreed upon following general agreement from members, it does not appear that China has a direct and outsized influence within ITU-T.

Figure 5: U.S. and Chinese ITU-T study group associates[62]

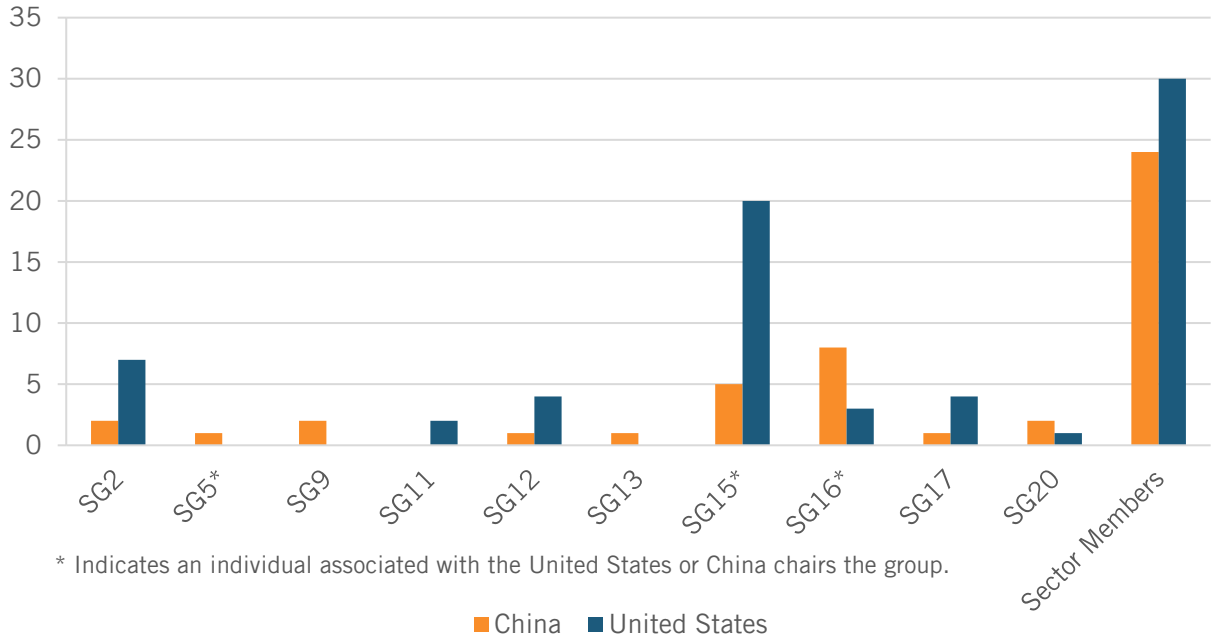


Figure 6: Study groups chaired by U.S. and Chinese representatives or companies (China shown in orange, United States shown in blue)[63]

Study Groups	
2: Operational	13: Future networks (cloud)
5: Environment and circular economy	15: Transport, access, and home
9: Broadband cable and TV	16: Multimedia
11: Protocols and test specifications	17: Security
12: Performance, QS, and QE	20: Internet of Things, smart cities

It is worth noting that IMT-2020, the ITU focus group that helped lay the groundwork for ITU's focus on 5G evolution and directed ITU-T's future 5G activity, was led by a Huawei representative, with an additional vice chair from China Mobile and no representation from a U.S.-based company.[64] However, this group is no longer active (active status was from 2015 to 2016).[65] By comparison, AT&T serves as the chair for ITU-R's Working Party 5D, which leads work on 5G spectrum and has no leadership from Chinese companies.[66]

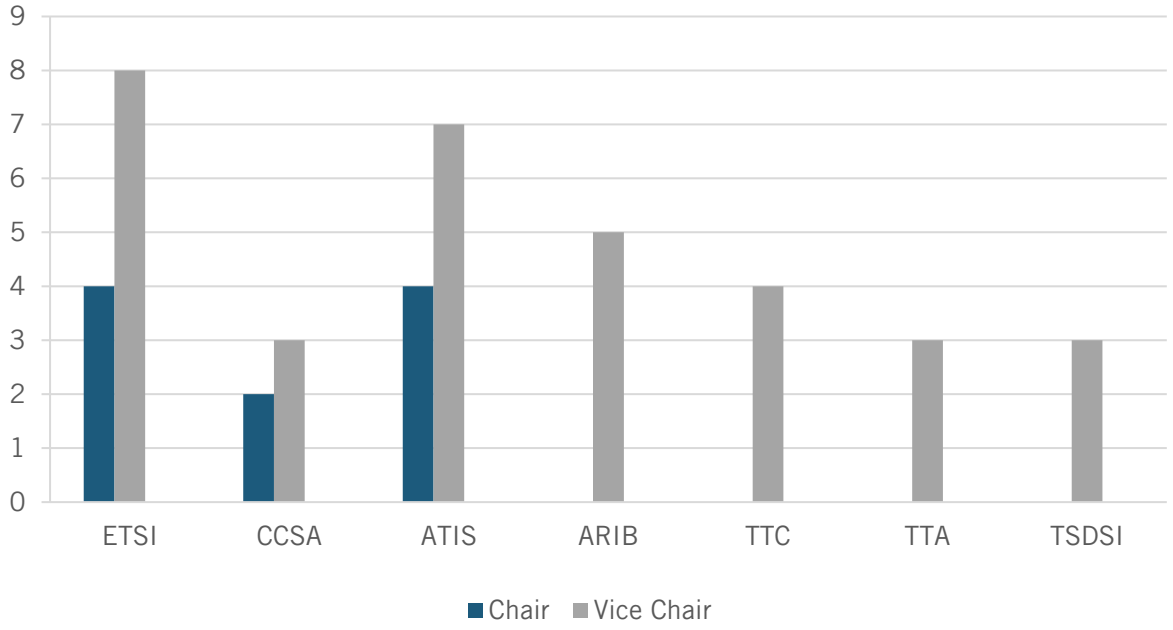
Separately, several key 3GPP standards bodies are not officially part of ITU, namely CCSA. By comparison, ATIS, the North American partner for 3GPP, and ETSI, the European partner for 3GPP, are both regional/international organizations part of ITU.[67] CCSA and several other standards organizations instead have a memorandum of understanding with ITU to govern cooperation.[68]

3rd Generation Partnership Project

3GPP activity is driven by members from a mix of sectors, all of which align with one organizational partner to participate in 3GPP research and decision-making activities.[69] In some cases, subsidiaries may align with different organizational partners than their parent company does. The organizational partners of 3GPP include:[70]

- European Telecommunications Standards Institute (ETSI)
- Alliance for Telecommunications Industry Solutions (ATIS)
- China Communications Standards Association (CCSA)
- Association of Radio Industries and Businesses (ARIB)—headquartered in Japan[71]
- Telecommunication Technology Committee (TTC)—headquartered in Japan[72]
- Telecommunications Technology Association (TTA)—headquartered in South Korea[73]
- Telecommunications Standards Development Society, India (TSDSI)—headquartered in India[74]

Figure 7: Positions held in 3GPP project coordination group leadership since 2011[75]

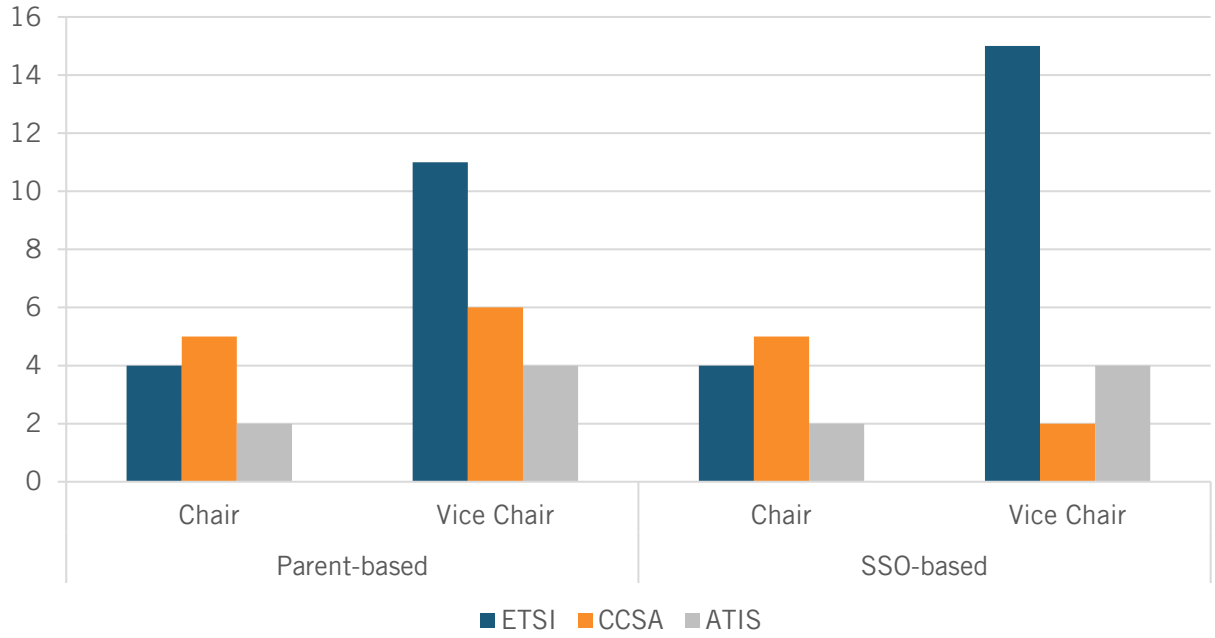


3GPP follows a regional rotation for its PCG, which provides overall management for 3GPP.[76] Since 2011, ETSI has held the largest number of chair and vice chair roles, followed by ATIS (chair and vice chair roles), CCSA (chair roles), and ARIB (vice chair roles) (see figure 7). ETSI, ATIS, and CCSA have each held the chair's role for two terms in the last six years.[77]

The collaborative decision-making process that determines future specifications is driven by work conducted in working groups across 3GPP's three committees. Across working groups, ETSI appears to have a commanding lead in the number of chair and vice chair positions.[78] However, this can be misleading. As noted earlier, company subsidiaries can be registered with different regional standards organizations from their parent company. This can be seen in figure 8, where

two different measurements display the number of chairs and vice chairs per region. If one counts a subsidiary company as part of the parent company's regional standards organization (with the assumption that perhaps that subsidiary is not truly "independent"), then ETSI has fewer vice chairs. This is often the case, as many companies based outside Europe have subsidiaries in Europe (e.g., Apple (UK) and Oppo).[79] However, even if leadership positions are counted based on where the parent company resides (meaning any Chinese-affiliate associated with ETSI or ATIS would count as a leader for China's standards organization), China does not appear to hold an outsized influence, especially if ATIS and ETSI are considered like-minded in their strategic objectives and regional/national values.

Figure 8: Number of leadership positions held in RAN WG3 since 2011[80]



Another metric that can be used for evaluation is the number of leadership positions held within an entire TSG (RAN, SA, or CT), including its working groups. Because there are only one chair and two vice chairs per working group (the TSG itself allows three vice chairs), a natural fluctuation in leadership is observed. (Note: ARIB, TTA, and TTC have held leadership positions within SA working groups not depicted in the figures.)

In figure 9, figure 10, and figure 11, a "+" after the 3GPP organizational partner indicates, for this paper's purpose, leadership roles counted toward the parent company's primary organizational partner (e.g., Apple (UK) would be counted as a leadership role for ATIS instead of ETSI, where it is formally registered, whereas Futurewei would be counted as a leadership role for CCSA instead of ATIS, where it is formally registered). Fluctuations are observed across each organizational partner's affiliated members. Within the last few years, American and Chinese companies observed leadership growth, although both countries saw contraction in their leadership positions in years prior as well. Whereas CCSA+-affiliated members have held 11 chair positions and 26 vice chair positions within SA-affiliated groups since 2011, ATIS+-affiliated members have held 5 chair positions and 50 vice chair positions.[81]

Figure 9: Number of leadership positions held in all service and system aspects groups—ETSI+[82]

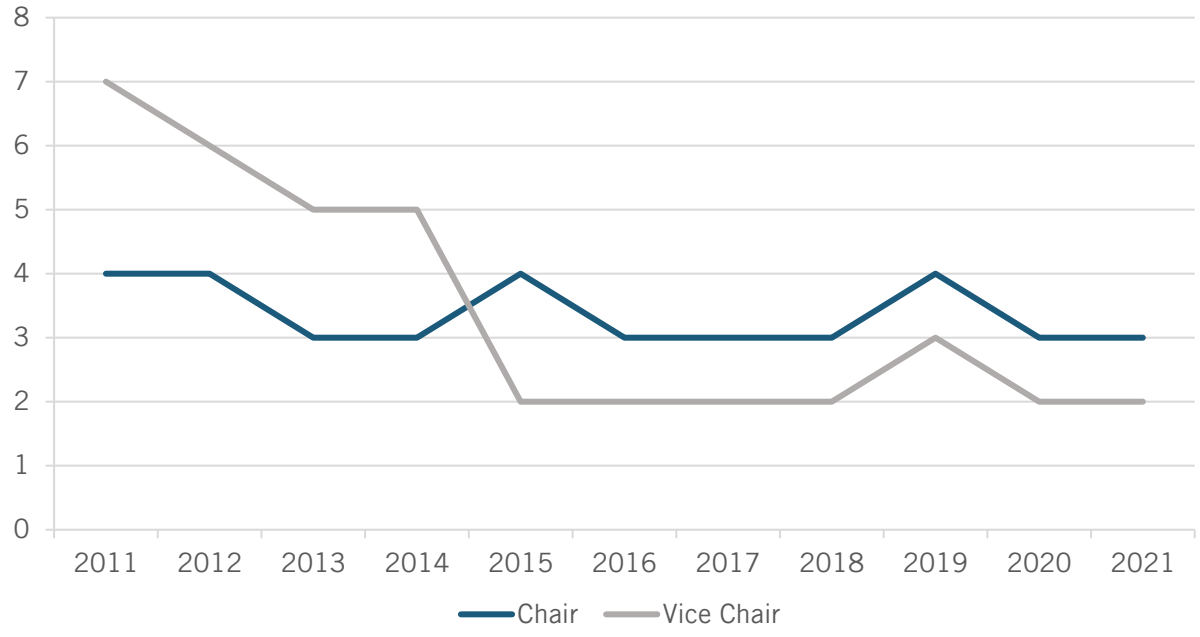


Figure 10: Number of leadership positions held in all service and system aspects groups—ATIS+[83]

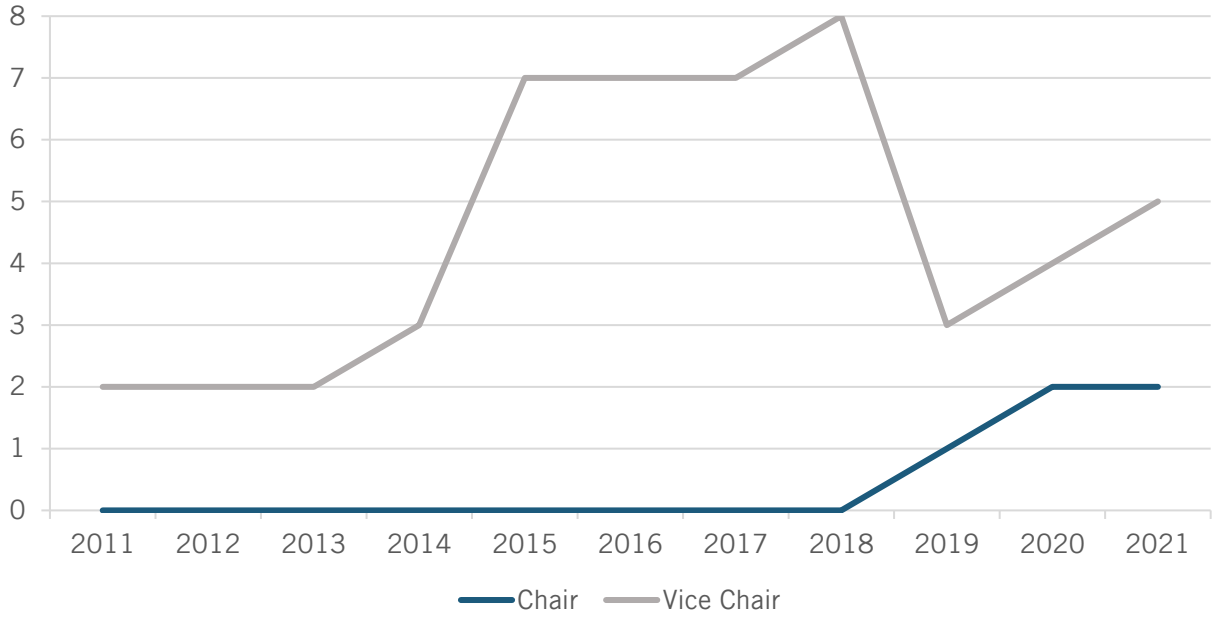
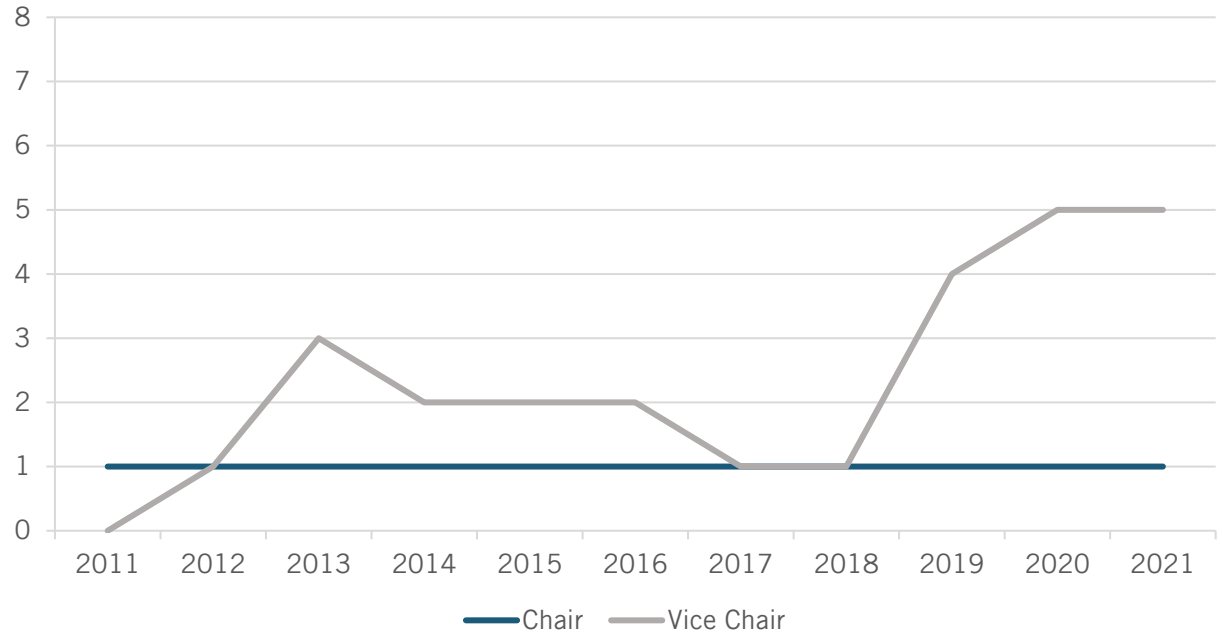


Figure 11: Number of leadership positions held in all service and system aspects groups—CCSA+[84]



It is true that, based on membership numbers, China's standards organization CCSA has more individual members that are part of 3GPP than North America's standards organization ATIS does, by a comparison of 128 to 57.[85] However, as noted earlier, regional standards organizations do not always correspond to a company's country of origin. For example, the United States counts 40 individual members under ETSI, whereas China counts only 10.[86] If companies are counted based on the country of origin of their parent company, the gap between U.S. members and Chinese members is decreased.

Perhaps one may argue that China operates through international allies (e.g., Huawei's enduring presence could be an indicator of telecommunications cooperation). However, among 710 individual members, only 2 are from Africa, 18 are from the Middle East, and 3 are from Russia.[87] The majority of members hail from companies based in North America, Europe (which faces a mix of approvals for Huawei), and Asia (which faces a mix of approvals for Huawei). It does not appear that China currently holds an outsized influence at 3GPP.

Contributions

Measuring the impact of contributions can be difficult. Different measurements result in different numbers, with some counting any edit to a proposed technical standard as a contribution and other measurements focusing on the initiator of the contribution. Once contributions are proposed within a study group (which requires four members to support for introduction), multiple parties work to polish the final standard.[88] Considering the varying impact of any given contribution, this metric is best understood as a rough heuristic of engagement, rather than a sign of leadership. It is also important to consider how often contributions are accepted, whether the group of technical experts agrees the proposed edit or addition to the standard is helpful. A high number of contributions with a relatively low acceptance rate would indicate an engaged participant that may be out of step with the rest of the group for one reason or another.

According to IPLytics data from 2019, Huawei submitted the most contributions to 3GPP for 5G by a considerable margin (19,473), followed by Ericsson (15,072).[89] However, Ericsson's contributions had a higher approval rate (34 percent to Huawei's 30 percent).[90] In fact, two other companies with fewer contributions than Huawei had slightly higher approval rates: Qualcomm (33 percent) and Nokia (33 percent).[91]

Other data indicates Huawei may be playing a larger role in 3GPP contributions. IPLytics data from 2021 reflects Huawei as the leading contributor for *approved* 5G contributions.[92] Huawei is followed by Ericsson, Nokia, Samsung Electronics, and Qualcomm.[93] Of the top-five contributors, only three are in the top five for market share of telecommunications equipment (Huawei, Nokia, and Ericsson).[94] Based on market share, Ericsson and Samsung are contributing above their weight (Nokia's contributions with 14.3 percent approval are comparable to its 15 percent share of the market), whereas Huawei's contribution approval rate is below its market share (22.9 percent approval rate versus its 31 percent market share).[95]

Due to the collaborative nature of contributions, however, measuring influence based on the number of contributions can be misleading. Even so, adjusting these metrics to account for market share indicates Huawei and Chinese companies in general are not necessarily exerting an outsized influence on standards beyond what the market would dictate.

IF THE METRICS DO NOT SHOW A REASON TO PANIC, WHY BE CONCERNED?

Standards-setting organizations are in part a reflection of their corresponding markets and the leaders in innovation. If a particular company has a large share of the market for a specific product (communications operators, various equipment suppliers, etc.), "leadership" in standards-setting bodies would be expected. These companies would have the largest share of funding for R&D, and thus continued innovation, allowing them to be at the forefront of patents and standards.

A myopic focus on standards-setting bodies misses the best opportunity to gain continued U.S. influence over development of wireless standards: Success on the merits of standards-setting leadership reflects years of R&D. The key leaders today have spent the last decade or more innovating. The development of 6G technology that will feed into standards has already started. Ensuring a country's companies or technologies will be competitive when 6G standards are being defined requires looking at the level of research, development, and collaboration that is occurring today. Focusing strictly on standards-setting organizations is like only focusing on the warm-up day of a marathon and completely disregarding the prior months of required training.

A myopic focus on standards-setting bodies misses the best opportunity to gain continued U.S. influence over development of wireless standards: Success on the merits of standards-setting leadership reflects years of R&D.

The long-term contraction of U.S. telecommunications equipment providers is further cause for concern.[96] While the United States still retains some key equipment suppliers, and, notably, Qualcomm is a leading contributor to the standards-setting process, the United States has no competitor with as broad a scope as China's Huawei and instead relies on a patchwork of companies. Such reliance, wherein companies specialize in narrower portions of the overall

telecommunications market, makes preservation of transparency and fairness even more critical in order to protect supply chain security and flexibility.

CHINA'S OTHER OPPORTUNITIES FOR INFLUENCE

Beyond the presented metrics, opportunities remain for China to influence standards setting through direct and indirect means. As in most areas of techno-economic competition, China engages unfairly in standards, a process that outside of China is mostly based on "let the best standard win." The U.S.-China Economic and Security Review Commission's 2020 Annual Report identifies four key concerns for how China may be impacting the standards-setting process: vote coordination, awards for contributions, manipulation of contributions to maximize the number of contributions, and geopolitical influence tapped into to increase the number of members who support Chinese endeavors.[97] This section analyses three: Belt and Road Initiative memorandums of understanding, presence in external organizations, and market share and competitive bidding. This paper does not analyze these risks in great depth, but offers an overview for purposes of informing the larger discussion on standards setting.

Belt and Road Initiative—Memorandums of Understanding

According to expert testimony from the United States-China Economic and Security Review Commission, "The PRC makes diplomatic agreements—such as memorandums of understanding—incorporating PRC technical standards extensively within the BRI realm as a major policy component of its action plans."[98] This goal is stated in China's "Set Sail Action Plan," wherein China indicated its desire to "provide superior products and services to countries or regions of the Belt and Road. Create new platforms for international cooperation."[99] Memorandums of understanding are not inherently concerning, as the massive amount of foreign investment financing for wireless equipment systems provided by the Chinese government often comes with strings attached.[100] However, their influence has the potential to impact the direction of the wireless market if they occur at a large-enough scale. If this influence impacts either a host country's voting record at ISOs or the opinions of a host country's telecommunications-related companies and thus their decisions in industry-led standards bodies, standards-setting organizations' objective to promote optimal standards could be compromised.[101]

This is all part of China's broader international standards efforts. A translation of its most recent five-year standards plan states:

> We will actively promote docking cooperation with the "belt and road" countries in the field of standards, strengthen standardized dialogues among BRICS countries and APEC, deepen standardized cooperation in northeast Asia, Asia-Pacific, Pan-American, Europe, Africa and other regions, promote standard information sharing and services, and develop a mutually beneficial and win-win standardized partnership.[102]

External or Alternative Organizations

Chinese companies are continuing to advance their leadership in the global telecommunications market by participating in other regional bodies, such as the Organization of the Islamic Cooperation's Computer Emergency Response Team (OIC-CERT).[103] OIC-CERT introduced a 5G security group in 2021 that will work together with Huawei in order to ensure the security of the affiliated members.[104] Similarly, Huawei has partnered with the United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Eastern Africa office to enhance digital skills

in the region.[105] Independent of one another, these types of partnerships are not of concern. However, such partnerships and collaboration could have influence in the future of the global market as well as standards-setting bodies, or undermine the advantages of a unified global standard.[106]

Global Market Competition

China's drive to lead the 5G market is incontrovertible. "China treats 5G service expansion as a national strategic priority."[107] Previous reporting indicates a desire for 5G providers to quickly secure 5G subscribers, even when users do not yet have a 5G phone.[108] This is complemented by allegations of unfair bidding that assert Huawei has previously underbid competitors "by 60 percent … offering a price that wouldn't even cover the cost of parts."[109] A report by the U.S. House of Representatives Permanent Select Committee on Intelligence further reveals that "analysts suggest that the Chinese government and military … provide Huawei market-distorting financial support."[110] Activities that give certain telecommunications equipment suppliers an artificial and unfair advantage in the global marketplace, which is not gained through global competition norms nor through advanced innovation and genuinely competitive pricing, leads to market manipulation that could in turn impact general innovation.[111]

NATIONAL STRATEGIES

China is often cited as having a clear strategy of coordination across its private sector representatives. Anecdotal evidence indicates the possibility of vote coordination in standards bodies. In one such example, Lenovo's representative, which had voted for a Qualcomm-led proposal (low-density parity check, or LDPC) in a previous election, switched their vote to a Huawei-led proposal to support the use of polar codes as an alternative to LDPC.[112] In response, Lenovo founder Liu Chuanzhi wrote, "We all agree that Chinese companies should be united and cannot be played off one another by outsiders.'"[113] In other words, he was saying that the interests of China superseded the interests of Lenovo and that he would make decisions based on what the Chinese government wanted.

This type of block voting is of crucial concern. If China is able to coordinate votes to achieve the government's desired outcome, regardless of the best technology, Chinese firms will gain compounding advantages that will likely further consolidate the equipment supply chain. Allied governments should take this concern seriously and monitor for potential abuses and highlight them when they come to light. However, allied governments should not reciprocate the tactic, lest it encourage further retrenchment or balkanization of the standards process. Thankfully, at least in 3GPP, these conflicts appear to be relatively rare—and the polar-coding incident caused a significant amount of reputational harm to Huawei. Instead of sending additional government representatives or detailed coordination of U.S. priorities, policymakers should focus on promoting good governance structures to help ensure a fair process across standards bodies and support pre-standard R&D and innovation broadly so U.S. firms can compete on the merits.

China also promotes participation in international organizations by helping to fund unpaid internships.[114] ITU interns, for example, are obligated to pay for their own housing, health insurance, and travel.[115] Investing early in the advancement of young professionals by eliminating barriers to participation in international organizations enables the growth of China's talent pool, as such costs can easily deter top talent from pursuing or accepting an internship with an international organization, which can have ramifications for their career trajectory.[116]

Supporting young professionals today increases the likelihood that China will have mid- and late-career professionals leading standards-setting organizations in the future. The Chinese government also subsidized companies for engaging in standards processes.[117]

Moreover, one of China's technological innovation plans notes its intent to "[a]ctively participate in the formulation of major international scientific and technological cooperation rules ... proactively set[ting] the global agenda and promot[ing] Chinese influence in international scientific and technological innovation."[118] The role of the central government in ensuring industry alignment on standards is clear.[119] This intent is further complemented by the desire to "[a]ssist Chinese enterprises, alliances, and social organizations in participating in or leading the development of international standards ... and enhanc[ing] the international influence of Chinese standards."[120] And its new standards plan includes proposals to increase subsidies and prizes for standards engagement.[121]

Lenovo founder Liu Chuanzhi wrote, "We all agree that Chinese companies should be united and cannot be played off one another by outsiders."[122]

Public discourse in the United States demonstrates both a growing concern over Chinese influence in standards-setting bodies and a desire for more U.S. government intervention. One such proposed intervention calls for the creation of a government committee to "[a]ct as a liaison between government, academia, and the private sector to coordinate and enhance joint efforts in relation to standards."[123] Moreover, the U.S. Senate recently passed the United States Innovation and Competition Act, which further directs efforts for U.S. investment in international standards bodies, in particular calling for a working group to produce a strategy that articulates how to encourage "promotion of United States leadership at international standards-setting bodies."[124] While these recommendations are different from the level of direction the Chinese government provides, they similarly indicate a general national strategy to enhance U.S. leadership in standards-setting bodies.

POLICY RECOMMENDATIONS FOR THE U.S. GOVERNMENT

There are a number of steps the U.S. government should take to shore up U.S. standards processes in international bodies.

Encourage Good Governance and Fair Participation Across Standards-Setting Organizations

The U.S. government should demonstrate support for participation in standards bodies but should not dictate a specific "U.S. Strategy" for private sector companies to follow. Nor should the U.S. government dictate specific solutions for the private sector. Continued presence in and awareness of such standards-setting organizations can help to facilitate this process. The current Executive Order on Competition demonstrates an enduring commitment to this, encouraging the Federal Communications Commission (FCC) "to consider continuing to attend meetings of voluntary and consensus-based standards development organizations, so as to promote or encourage a fair and representative standards-setting process."[125] Demonstrating a national commitment to fairness and the consensus-based process will help set the tone for future standards setting within the telecommunications ecosystem. A backseat, supportive role is

appropriate to continue to encourage the market-driven process while also elevating the norm of consensus-based decision-making.

Export control restrictions do not apply to U.S. participants interacting with entity-listed Chinese participants in international standards-setting activities. This would only prevent U.S. companies from engaging in standards organizations for fear of legal repercussions.

Remove Barriers to Participation in Standards-Setting Organizations

The U.S. government should offer support for the costs associated with standards setting or allow for tax incentives to encourage participation.[126] Sending representation to each standards-setting engagement can be costly, with yearly estimates around $300,000 per engineer.[127] As noted earlier, should 3GPP technical votes be called, members are only able to vote if they have met the attendance requirements, creating an advantage for those who are able to dedicate company representatives to standards-setting activities and fund their travel expenses. Exposure to the international conversation on standards setting ensures companies are aware of general market innovation, helping to inform the direction of future R&D.

Create Incentives to Participate in Standards-Setting Organizations

As has already been proposed through the U.S. Innovation and Competition Act, the U.S. government should consider providing grants to companies that cannot pay participation fees.[128] In addition, Congress should change the research and experimentation tax credit to allow companies to include their spending on global standards-setting activities when they calculate their total expenditures on research and experimentation.[129] The reason for government support of private sector standards engagement—either through grants or tax incentives—is clear because there are positive externalities to the participation in standards-setting organizations that are not necessarily recouped. Government support can be justified to increase the rate of participation and to counter other government incentives, especially China's.

The federal government should ensure that export control restrictions do not apply to U.S. participants interacting with entity-listed Chinese participants in international standards-setting activities. This would only prevent U.S. companies from engaging in standards organizations for fear of legal repercussions.

In addition, the U.S. government should ensure that it is more active in the regional and international forums in which China is engaged. And it needs to be vocal about supporting the current industry-led, voluntary standards process in such venues.

Encourage the Uptake of U.S. and Like-Minded Countries' Standards and Technologies

The U.S. government should increase financing for telecommunications abroad. For example, the International Development Finance Corporation financed the Global Partnership for Ethiopia, beating out a China-backed bid and demonstrating a positive injection of U.S. funds to create the opportunity for "U.S.-friendly" technologies to flourish.[130] This could be accomplished by building on the Transatlantic Telecommunications Security Act.[131]

Additionally, the U.S. government can encourage the adoption of Open RAN. The executive order on promoting competition demonstrates a commitment to this, encouraging the FCC to provide "support for the continued development and adoption of 5G Open Radio Access Network (O-

RAN) protocols and software."[132] However, Open RAN should not be dictated as a requirement. The U.S. government should encourage the natural evolution of the most competitive products that offer the best solutions for price, security, and innovation.[133]

Invest in the Future

If policymakers desire a strong showing by U.S. firms at standards-setting organizations, it is better to focus on all the difficult work that goes into creating the technology and techniques that go into technical specifications, rather than narrowly focusing on only the end result. The United States should have a comprehensive effort to encourage and reward investment in innovation.

U.S. policymakers can encourage innovation through direct grants for R&D. In fact, "every dollar of federal R&D spurs an additional 30 cents in business R&D."[134] Efforts to directly increase funding and collaboration should focus on aiding high-cost R&D where the delayed cost-recovery process may create a prohibitive barrier that inherently limits the number of companies that can pursue such R&D.[135]

The federal government should also invest more in wireless R&D at universities, federal labs, and industry consortia. For example, the NextG channel model alliance operated by NIST is sponsored by an international research consortium working to advance breakthrough measurement, calibration, and channel-modeling approaches and technologies used for mmWave and submillimeter-wave frequencies. In addition, the Senate U.S. Innovation and Competition Act includes a number of provisions to fund wireless innovation, including funding for the new research directorate applied by the National Science Foundation in the area of advanced communications technology.[136]

The United States must also invest in its future talent pool. This includes supporting the development STEM talent early in students' education in preparation for entrance to STEM fields in college and beyond. Without a replenishing talent pool, where future generations of young professionals seek positions within the telecommunications-related industry or affiliated research or government institutions, the United States will struggle to remain a leader in wireless innovation.

CONCLUSION

Examination of 5G standards contributions, leadership positions, and intellectual property does not indicate reason to panic when it comes to the development of next-generation wireless specifications. Participation by Chinese actors is certainly increasing, but the outcomes of the process generally appear to be fair, with notable exceptions being relatively rare.

The potential for vote coordination undermining fair outcomes is troubling, and policymakers are right to be alarmed. However, reciprocal tactics, such as establishing a committee to coordinate the U.S. approach to standards setting, or dramatically increasing the number of representatives from the U.S. government, will likely backfire. Industry-led standards bodies move quickly, based largely on consensus—and injecting additional geopolitical pressure will likely slow these organizations, encourage further unfair tactics from China, or potentially accelerate balkanization of now-global standards.

Policymakers should analyze governance mechanisms of smaller standards-setting organizations, particularly those that affect key industry verticals, and encourage good processes that see fair outcomes, ideally in partnership with like-minded countries. Policy should also do more to encourage participation in these bodies. But most importantly, U.S. policy should set firms up with the resources to develop the technology that goes into the standards. Broader support for innovation through the academic research process, promoting effective collaboration for pre-standard research, and encouraging and rewarding companies that invest in developing new technology will likely be more effective in promoting standards leadership than focusing narrowly on the very last step of that work.

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About ITIF

The Information Technology and Innovation Foundation (ITIF) is an independent, nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized by its peers in the think tank community as the global center of excellence for science and technology policy, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

For more information, visit itif.org.

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