The geopolitics of digital standards: China's role in standard-setting organisations

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The geopolitics of digital standards: China's role in standard-setting organisations

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Executive summary

Standards for digital technologies are all around us, enabling devices to interact with each other, allowing us to connect to mobile networks, and facilitating the exchange of information. By providing rules or guidelines for the development and functioning of technologies, products, and services, standards foster interoperability and enable safety and quality of service. This report provides an overview of the digital standardisation ecosystem and explores China's role within this ecosystem.

Why standards matter

In addition to their technical functions, standards have economic, social, and (geo)political implications. They support innovation, economic growth, and competitiveness, and facilitate international trade by enabling companies to enter new markets and helping avoid discrepancies between trade partners. In addition, standards can help societies take advantage of the opportunities offered by digital technologies, including when it comes to advancing sustainable development and devising responses to global challenges.

When embedded into technologies put to different uses, standards can provide a broader context for promoting – or abusing – human rights and freedoms. For instance, standards related to internet protocols can pose privacy risks if they do not embed sufficient protections to ensure the confidentiality of communications and the security of data.

Although standards are usually looked at from a technical and economic perspective, they have always had a political dimension, particularly due to their potential to help achieve certain policy objectives, from promoting innovation and protecting consumer rights, to safeguarding critical infrastructures and protecting national security. Given the growing technological competition between nations, standards are gaining more attention in the geopolitical context. If a country's actors can influence standards in strategic industries, that country could obtain a significant advantage on the international stage. This realisation has led to calls for strengthened cooperation between partners on standardisation-related matters, as illustrated by the adoption of a *Framework for G7 Collaboration on Digital Technical Standards* and the establishment of a working group on technology standards in the context of the EU-US Trade and Technology Council (TTC).

A complex and dynamic digital standardisation ecosystem

At the international level, digital standards are developed in a multitude of spaces. Formal standards development organisations (SDOs) – the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), and the International Telecommunication Union (ITU) – are complemented by quasi-formal organisations – such as the Institute of Electrical and Electronics Engineers (IEEE), the 3rd Generation Partnership Project (3GPP), and the Internet Engineering Task Force (IETF) – and a wide range of industry forums and consortia. The large number of organisations, as well as the diversity of membership structures, working methods, and rules and procedures governing the development of standards make the standardisation ecosystem a complex one.

State and non-state actors participate in SDOs driven by technical, economic, and/or (geo)political interests. Many tend to focus their attention on the IEC, ISO, and ITU because standards developed within these organisations are generally understood as being relevant in the context of the *Agreement on Technical Barriers to Trade* adopted at the World Trade Organization (WTO). The agreement calls on countries to base their regulations on international standards as a way to prevent unnecessary barriers to trade.

Beyond its complexity, the standardisation landscape is also highly dynamic, mirroring the interests of key actors and the competition environment in certain industries. While for several decades Western actors (in particular the USA and some European countries) used to take the lead in the development of international standards, the picture started changing in the 1990s and 2000s, as Asian actors (Japan, the Republic of Korea, and China) became increasingly prominent in economic and technological spheres. The growing presence of Asian actors was also coupled with shifts in industry participation, as some of the more traditional actors reduced their involvement in key SDOs, while other, newer actors started playing a more prominent role.

Generally speaking, the SDOs function by well-established rules and are able to adapt to the changing environment in which they operate. But they are also faced with various challenges. For instance, they are called upon to encourage more diversity within their membership and bridge the standardisation gap between developed and developing countries. Other concerns relate to the speed at which standards are developed;

the challenges that may appear if groups of actors – be they entities from the same country, alliances of countries, etc. – attempt to dominate the work; and the tendency of some actors to engage in forum shopping, sometimes leading to the duplication of work across several organisations.

Mindful of such challenges, SDOs are constantly exploring modalities for more efficient and effective processes, while maintaining the quality and integrity of their work. And while questions have emerged on whether new rules are needed to enable SDOs to cope with some of these challenges, it is important to acknowledge that actors always learn to play by the rules in ways that are advantageous to them.

China's approach towards standardisation

Standards play an important role in the context of China's ambitions for economic and technological leadership at the global level. The government sees standards as essential driving innovation, industrial development, and economic growth, as well as in improving the country's competitiveness on international markets.

Overall, China's approach towards standardisation is characterised by several key elements:

- The standardisation strategy is aligned with the broader 'two markets, two resources' approach (i.e. protect the domestic market, while integrating it into the international one), and focuses on two key goals: strengthening the national standardisation system and advancing engagement in international standards development processes.
- Over the past decade, China's standardisation system has undergone a series of changes, and is now described as 'market-driven, government-led'. State entities usually oversee the development of national and sector standards, with most of the work being carried out by the private sector (which is actively encouraged to contribute its expertise to the process). Opportunities were also created for foreign-invested companies to contribute to standardisation processes, although it appears that some barriers continue to exist in this regard.
- China's overall policy framework for standardisation is shaped by the new standardisation law (in effect since 2018), as well as a series of policy priorities set periodically by entities such as the State Council, the Standardization Administration of China (SAC), and the Ministry of Industry and Information Technology (MIIT). Moreover, standardisation objectives are closely connected with industrial and economic policies. For instance, *Made in China 2025 (MiC 2025)* sees standards as important elements in improving the quality of Chinese products (thus increasing their competitiveness on regional and global markets). The *14th Five-Year Plan for National Economic and Social Development* also connects standards with broader technology-related goals. For example, it talks about 'improving' security standards as a way to strengthen network security protection.
- China's strategy of 'opening up' its standardisation system rests on three pillars: (1) active participation in international standardisation processes, (2) strengthened bilateral and multilateral standards cooperation, and (3) harmonisation of Chinese and international standards, through (a) the internationalisation of Chinese standards and technologies and (b) the transposition of international standards at the national level.
- China's growing involvement in SDOs is a result of planned and concentrated efforts, and is driven by one essential goal: The country wants to shift from being a consumer of international standards to becoming a producer and 'exporter' of standards. This goal is also pursued through regional and multilateral initiatives such as the Belt and Road Initiative (BRI) and BRICS (Brazil, the Russian Federation, India, China, and South Africa).

Implications of China's growing involvement in international standardisation

China has emerged as a global economic power, so it is natural that it seeks to have a more prominent voice in international standard-setting. Chinese actors are now much more present in SDOs than they were before 2000; not only in terms of people attending meetings, but also in terms of active contribution, drafting of proposals, and leadership roles within technical groups. This growing involvement comes with both opportunities and challenges.

On the one hand, it is a win for standardisation processes and an indication that China wants to be part of the global system of standards, rather than decouple itself from it. It could also have positive consequences for global interoperability and the safety of products and services, as well as strengthen the acceptance and adoption of international standards at a national level, thus reducing market barriers for foreign companies. The fact that Chinese actors become more familiar with the principles of international standardisation (e.g. transparency, consensus, and relevance) could translate into improvements in the national standardisation system.

On the other hand, the growing involvement of Chinese actors in international standard-setting means more competition, posing a challenge to established standard powers (be they countries or companies). There is also a concern that China is trying to reshape the current international standards environment to one that is more state-driven. This is a legitimate concern, but China may only succeed in advancing such a model if there is not enough opposition from other actors. Some proposals advanced by Chinese actors in SDOs – such as the New IP proposal (intended to design a new protocol system for the internet) and a proposal related to standardising the application of facial recognition in visual surveillance systems – have generated concerns that Chinese actors may try to misuse standardisation as a vehicle to promote technologies that pose challenges to democratic values and human rights.

As these and similar issues continue to fuel discussions, the debate remains open on whether China is or could be dominating SDOs in a way that allows it to dictate how these organisations work or the standards they produce. But it is likely that Chinese actors will continue to strengthen their engagement in international standardisation, in particular when it comes to shaping standards related to advanced and emerging technologies.

Recommendations for maintaining the integrity of the standardisation ecosystem

In the debate on whether SDOs need to change their rules to cope with the challenges of the dynamic standardisation ecosystem and the emergence of new powerful actors, our report argues that a more holistic approach is needed, one focused on maintaining the overall integrity of the ecosystem. The recommendations we outline for governments, participants in international standard-setting, and SDOs themselves cover several key issues, as now summarised.

Governments

- Developing standardisation strategies with priorities and goals for the domestic standards system and the engagement in international processes.
- Encouraging and strengthening the participation of domestic actors (governmental bodies, technical community, private sector, academia, civil society) in SDOs, through funding, awareness-raising, capacity development, and fostering cooperation and coordination, where possible.
- Bridging the gap between the different communities, allowing them to better understand each other's interests and positions on standardisation matters (e.g. technical considerations, economic aspects, human rights perspectives).
- Creating frameworks for cooperation and exchange of information with other countries and their actors within SDOs.

SDOs and participants in SDOs

- Ensuring a holistic approach to the debates and decisions on standard proposals, where technical, economic, human rights, and (geo)political considerations are given appropriate weight.
- Fostering more diversity in standardisation processes and facilitating the participation of actors less represented.
- Ensuring that the rules and procedures governing standardisation work are adhered to.
- Fostering strengthened cooperation within the standardisation ecosystem.
- Enabling clearer communication about standardisation processes and engagement opportunities, as a way to increase transparency and enhance information accessibility.

Introduction

Standards, although invisible, shape the increasingly digital world in which we live, from the protocols that make the internet work to the 3G, 4G, and now 5G standards that enable the functioning of mobile networks and devices. Their main role is to describe how technologies, products, and services are developed and function. As such, they enable interoperability and contribute to ensuring safety and quality of service. But standards are not only about technology; they also have economic, social, and (geo)political implications. We explore these implications in the first section of this report, as we explain why standards matter for the wider society, beyond those who develop them.

Digital standards[1] are set in a multitude of organisations and forums, nationally, regionally, and globally. At the international level, the digital standardisation ecosystem is highly complex, with a large number of organisations and forums with different membership structures, rules, and procedures. This complexity also comes with challenges, both for the organisations themselves and those participating in the work. We unpack some of these challenges in the second section, after we provide an overview of the standardisation landscape. Five organisations are in the focus of this report: the three key formal SDOs[2] – the IEC, ISO, and ITU with its Telecommunication Standardization Sector (ITU-T), as well as 3GPP and the IETF. Other organisations and forums – such as IEEE and the European Telecommunications Standards Institute (ETSI) – are mentioned occasionally.

For historical and economic reasons, the West – notably the USA and some European countries – took the lead in the research and development (R&D) of digital technologies, particularly the internet and its first applications. This resulted in some decades of predominant participation of actors from these countries in SDOs, and their influence over the development of international digital standards. However, the growing relevance of Asian tech actors has brought changes to the international standardisation landscape, first with the participation of Japan and the Republic of Korea, and more recently China.

China became more involved in international standard-setting when it joined the WTO in 2001. Reflecting the country's rapid technological development, Chinese actors have constantly increased their participation in SDOs, in particular the IEC, ISO, and ITU. This did not receive much attention until 2020 when China proposed that ITU take up work on designing a new internet protocol (IP). The now-famous New IP proposal made the headlines and triggered heated debates on China's participation and influence in standard-setting. As China's involvement became 'the elephant in the room' in many subsequent discussions on international standardisation, it has not always been easy to separate hype from reality.

But what drives China's engagement in international standardisation? What does this engagement mean for China, other countries, and the broader standardisation ecosystem? In trying to provide some answers to these and similar questions, we start by looking at the country's national standardisation system and the role that digital standards play in the context of the overall economic and industrial strategies and policies. We then explore China's approach to international engagement and cooperation on standards-related issues, look at the participation of Chinese actors in key SDOs, and discuss opportunities and challenges stemming from this participation. As we attempt to shed more light on the realities of Chinese participation in international standard-setting, we look at a few case studies of such participation.

Our report argues that the digital standardisation ecosystem is both complex and dynamic. It generally functions by well-established rules, although at times some pressure may be exercised over these rules as new dynamics emerge. Maintaining the integrity and health of this ecosystem is essential, but actions in this direction should not come in response to the participation of one actor or another. Instead, they should look at the broader picture and focus on issues such as diversity and due process. We end the report by highlighting a set of recommendations in this regard.

Methodology

This report is the result of research work carried out between June and November 2021. The methodological approach behind it is a combination of desk research and expert interviews. Desk research encompassed primary and secondary sources. Among the former are rules and procedures governing the activity of the

[1] The term *digital standards* refers to standards for digital technologies throughout this report.
[2] Throughout this report, the term *SDOs* refers to international standards development organisations, unless otherwise mentioned.

SDOs the report focuses on, as well as membership information, activity reports, and, in some cases, documents discussed within these organisations (in as much as we were able to access such documents, considering that in many cases access to them is restricted). Primary sources also included relevant policy documents published by China, and relevant statements and declarations issued in the framework of bilateral and multilateral cooperation forums. Secondary sources include mostly academic papers, policy briefs, and opinion pieces published by academic institutions and think tanks.

Most of the statistical data provided in the report is the result of our research; in all instances, we provide information on the sources we used to collect the data.

The second methodological tool was expert interviews. Between July and October 2021, we conducted interviews with 27 policy and technology experts with a wide range of roles and backgrounds: staff and leadership of SDOs, personnel of country missions to the UN in Geneva, staff of international technical and intergovernmental organisations, industry experts, academics, and researchers. Most of the interviewees have participated in international standardisation processes. All interviews were run under the condition of anonymity. Some of the interviewees clarified that they were presenting their own views and not those of their organisations. One limitation has been our inability – despite attempts – to interview Chinese actors who participate in international standard-setting.

What are standards and why do they matter?

From coinage in the Roman Empire and uniform brick sizes in Ancient Egypt (Barrios Villarreal, 2018) to today's IP, standards have been around for centuries. They are commonly accepted benchmarks that provide technical specifications or define processes. They tell us how to do something, and as such foster a coordinated approach. In addition to providing the framework for product development, standards aim to ensure the transparent and safe application of various technologies.

Standards have acquired significant importance in a broad range of areas, such as quality management, aviation, health and food safety, labour conditions, and ethical and environmental areas. So far, ISO alone has published more than 22,000 international standards. Some of the most widely used ones include the ISO management system standards, standards for international security management (ISO/IEC 27001), and occupational health and safety standards (ISO 45000 family) (ISO, no date-a).

Box 1. Definitions of standards

ISO defines a standard as 'a formula that describes the best way of doing something'. Standards are 'the distilled wisdom of people with expertise in their subject matter and who know the needs of the organisations they represent – people such as manufacturers, sellers, buyers, customers, trade associations, users or regulators' (ISO, no date-b).

The European Committee for Standardization (CEN) describes standards as technical documents 'designed to be used as a rule, guideline or definition. It is a consensus-built, repeatable way of doing something' (CEN, no date).

Emphasising the voluntary nature of standards, Šimunić and Pavić (2020) define a standard as a 'voluntary document, aimed at the achievement of the highest possible degree of order in a given context. [...] A standard can give rules, guidelines, or characteristics for activities or on the design, use, or performance of materials, goods, processes, services, systems, or persons.'

Technical and economic implications

The modern, interconnected society we live in would not function without standards. In the mobile phone alone, for instance, there are hundreds of standards. In the past, digital standards mainly related to creating technology and devices. Today, the shift is towards standards for connecting devices (e.g. mobile phones and the internet of things (IoT)) and for connecting people to digital devices and services.

From a technical point of view, standards provide a common language that facilitates interoperability, allowing technologies to interact with each other. They ensure that devices and applications are built using the same rules and communication protocols, and that they can exchange data in compatible formats. The lack of interoperability poses both economic and societal challenges. One example is when users of Mac OS and Windows (operating systems developed by Apple and Microsoft) could not exchange files (Stango, 2004).

In addition to interoperability, ensuring quality of service and quality of experience have also been key goals of standardisation processes. Around the mid-1990s, security became another important concern, and, more recently, issues of trust and values have also come into focus.

Looked at from an economic perspective, standards support innovation and help develop and sustain competitiveness. The value of standards is maximised when they are developed and adopted at the international level (rather than nationally or regionally). International standards facilitate international trade by opening the door for companies to new markets and helping avoid discrepancies between trade partners. This is important not only for big players, but also for smaller economies, which have a strong interest in ensuring that there are well-functioning global standards that allow their companies to export everywhere, under as fair competition terms as possible.

Standards can also contribute to a country's gross domestic product (GDP) and labour productivity. For instance, standardisation is said to save the German economy €17 billion per year, while in France the average gains are estimated at €5 billion per year. In the UK, 28.4% of the annual GDP growth (€9 billion) can be attributed to standards (Wahlster and Winterhalter, 2020).

When combined with intellectual property, there are several additional benefits that standards can bring to companies. Many technologies that are essential parts of a standard are patented (the so-called standard-essential patents – SEPs). SDOs generally require companies that participate in standardisation work to make their SEPs broadly available under fair, reasonable, and non-discriminatory (FRAND) terms. This is meant to ensure that patent owners cannot prevent anyone from using the standard, but they can request royalties from SEPs, so patent users have to pay to implement the standard (Pohlmann and Blind, 2020). Such licensing fees can generate significant revenues for the patent owner. But this mechanism can also create dependencies that companies supplying much of the technology behind a standard could exploit. If a standard is broadly used at the international level, companies whose technologies are not part of the standard would typically need to invest significant resources in adapting their products to maintain market relevance (Voo and Creemers, 2021).

Standards also have the potential to support the development of effective responses to global challenges (e.g. climate change) and the promotion of economic, social, and environmental sustainability (ISO, 2018). Governments and businesses alike are becoming increasingly aware that international standards can help societies take advantage of the opportunities offered by digitalisation, foster the spread of new and advanced technologies sustainably, and contribute to advancing the sustainable development goals (SDGs). As participants in the 2021 International Standards Summit for People, Planet and Prosperity noted, digital technologies that rely on international standards to function safely and efficiently 'can ensure a sustainable, equitable, and prosperous future' (ITU, 2021).

Standards and regulations

Standards are, in general, voluntary. Companies may or may not adhere to standards, depending on their goals and interests, as well as on the content of the standards themselves. But there are also instances when standards are linked to government-led regulations. Standards can serve as a basis for regulation (e.g. in the USA) or can be used as regulatory tools themselves (e.g. in China, where some standards are mandatory). In the EU, standards are sometimes embedded into regulations. Some refer to existing standards to be followed as a way to demonstrate compliance with the regulation, while others mandate European standard-setting bodies to develop certain standards. Oftentimes standards are referred to in regulations as a way to avoid the regulations themselves becoming too detailed or descriptive.

Standards are also useful in ensuring quality for new technologies that are not yet covered by regulations. In addition, they may also help shape the evolution of the market, for instance towards more competition, thus complementing regulations.

Box 2. De facto and de jure standards

De facto standards emerge through market uptake. Without being formally adopted by SDOs, they are accepted and widely used on the market, usually because they are seen as the most efficient and/or reliable in their field, among an array of alternatives (den Uijl, 2015). The QWERTY keyboard and the MP3 audio format are examples of de facto standards. De jure standards are developed and adopted through formal processes, in the framework of SDOs such as IEEE or ISO. Over time, de facto standards can become de jure standards. Two prominent illustrations include HyperText Markup Language (HTML) and Adobe's Portable Document Format (PDF), initially accepted as de facto standards, and later adopted as de jure standards by ISO (Bryer et al., 2011).

Standards competition

It is important to note that the mere adoption of a standard by an SDO does not represent the ultimate outcome. What matters is market uptake, i.e. the extent to which a standard is used across the industry. While some standards become highly successful, others never make it to the market.

In addition, it is not uncommon to have multiple standards covering the same issue. As a saying within the IETF community goes, 'The beauty of standards is that there are multiple to choose from.' Here, too, success is driven by market forces, competition, and consumer choice. Sometimes similar standards function in parallel; other times only one standard wins.

Standards and human rights

Standards used to be seen largely as a technical issue with economic implications. But as digital technologies have become pervasive and embedded into all aspects of society, their relevance for human rights and core values and principles have started to gain increasing attention.

Technology is only neutral until it is used. The same applies to standards. They can either directly impact human rights, or provide a broader context for promoting – or abusing – human rights. For example, standards related to facial recognition technology (FRT) can have implications for privacy, the right to non-discrimination, and other human rights. Standards related to internet protocols can also generate privacy risks, for instance by not embedding sufficient protections to ensure the confidentiality of communications or the security of data (Cooper et al., 2013).

Adding a human rights approach to standards development processes is increasingly seen as essential in ensuring that standards, intentionally or not, do not embed structural risks to human rights. One way to achieve this is to foster convergence between human rights processes and standardisation ones, as recently outlined in a Human Rights Council (HRC) resolution (HRC, 2021).[3] Encouraging and supporting the participation of civil society groups in standardisation work is another way.

Politics of standardisation

Traditionally, developing and applying international standards has largely been about companies competing over influence on the global market. But competitiveness is not the only issue at stake. For state entities and companies involved in standardisation processes, setting standards is – in most cases – a balancing act between various other interests: maintaining the health of the innovation ecosystem, protecting consumer rights and interests, and ensuring safe development of technologies (and related products and services) (Ding, 2020).

There are also other policy objectives that standards can help achieve. They can improve a range of government services, for instance, by enabling uniform electronic medical records or allowing exchange between various government systems while ensuring adequate levels of privacy and security of data. Standards can also help protect national security and safeguard critical infrastructure from malicious cyberattacks, which ultimately is related to protecting national sovereignty (ITU, 2010).

Although standards development processes are usually seen as largely technical, they have always had a political dimension. This is because they involve 'choices and trade-offs which may imply economic or social consequences, or reflect the interests of the stakeholders involved' (Voo and Creemers, 2021). The link between geopolitics and standards is not new either. It was reflected, for example, in the coordination of a European voting bloc at the 1992 World Administrative Radio Conference, to exert influence over the adoption of mobile telecommunication standards (Sung, 1992).

This (geo)political dimension of standards and standardisation processes has become more obvious in recent years, against the backdrop of intensifying technological competition between nations. There is a realisation that, if a country's actors – through participation in standard-setting and international cooperation – can influence standards in strategic industries, that country would likely obtain a significant advantage on the international stage. Beyond the economic and geopolitical considerations, there is also growing attention to the implications that standards could have, directly or indirectly, on core values and human rights.

Standards have started to be mentioned in bilateral and multilateral intergovernmental frameworks, such as the G7, Quad (Australia, India, Japan, and the USA), and the EU-US Trade and Technology Council (TTC) (Table 1). This reflects the growing awareness of the importance of standards and their economic and geopolitical dimensions. And it could result in strengthened cooperation between partners in the long term (e.g. national delegations participating in international SDOs would support each other more). In fact, recent agreements clearly highlight cooperation on standard-related matters as an objective. But challenges may appear also, as the partners would need to understand what standards they are aligned and could work together on, given that sometimes they may have different economic and industrial interests.

[3] Adopted on 13 July 2021, the resolution requests the Office of the High Commissioner to convene consultations on the relationships between human rights and technical standard-setting processes for new and emerging technologies, and to submit a report to the HRC.

Table 1. Recent references to standards in bilateral and multilateral intergovernmental forums.

Forum	Who is involved	Key elements
Quad Leaders' Summit, March 2021	Australia, India, Japan, USA	Quad leaders agreed to establish a Critical and Emerging Technology Working Group to facilitate cooperation on international standards and innovative technologies (Quad, 2021a). The group will facilitate coordination on standards development, including between national standards bodies and working with a broad range of partners (Quad, 2021b).
G7 Digital and Technology Ministers' meeting, April 2021	Canada, France, Germany, Italy, Japan, UK, USA	Ministers highlighted support for 'industry-led, inclusive, multistakeholder approaches for the development of standards', and committed to international collaboration within the G7 and with like-minded partners to ensure that the development of digital standards supports core values. They also expressed 'opposition to any government-imposed approaches that fundamentally seek to reshape the digital technical standards ecosystem'. The *Framework for G7 Collaboration on Digital Technical Standards* adopted at the meeting highlighted several areas of cooperation: • Identifying shared interests in the development of digital standards and promoting inclusive and multistakeholder engagement in standards development processes. • Working with stakeholders to promote more inclusive development and deployment of internet protocols, and to track emerging digital standards that may have a wider societal impact. • Supporting stakeholders and SDOs to strengthen and uphold integrity in the development of standards. • Supporting the participation of civil society and other under-represented actors in standard discussions. • Supporting coordination between SDOs to avoid unnecessary duplication. • Supporting the inclusion, where appropriate, of international principles for digital technologies in standardisation processes (G7, 2021a).
G7 Summit, June 2021	Canada, France, Germany, Italy, Japan, UK, USA	G7 leaders expressed support for industry-led inclusive multistakeholder approaches to standard-setting, in line with core values and principles. They committed to strengthening coordination with regard to engagement with, and appointments to, SDOs, as well as to sharing information and best practices and to supporting multistakeholder participation in standard-setting (G7, 2021b).
EU-US Summit, June 2021	EU, USA	A high-level EU-US TTC was established, one of its goals being to cooperate on compatible and international standards development (in the framework of a dedicated working group to focus on standards related to artificial intelligence (AI), IoT, and other emerging technologies). Also highlighted was an intention to explore the possibility of developing a new research initiative on biotechnology and genomics, with a view to setting common standards (EU-US, 2021a).
EU-US TTC inaugural meeting, September 2021	EU, USA	The creation of a Working Group 1 on technology standards was announced to foster coordination and cooperation in standards for critical and emerging technologies. Both parties highlighted support for the development of standards in line with core values, and expressed an intention to defend their common interests in international standards activities. Sharing information regarding technical proposals and fostering participation in SDOs for civil society, startups, and small and medium-sized enterprises (SMEs) were also emphasised as goals (EU-US, 2021b).
G20 Leaders Summit, October 2021	Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, UK, USA, EU	G20 leaders committed to reinforcing their actions and international cooperation towards digital transformation, including through the use of consensus-based international standards (G20, 2021).

Implications of the growing political attention to standards

The fact that standards have gained increased attention at a political level[4] comes with both positive implications and challenges. If standards and standardisation work are more visible among policymakers, this can lead to having more resources allocated to standardisation processes, and, therefore, more participation. In some SDOs, standardisation can also become more efficient (i.e. a standard is adopted faster) if there is consensus at the political level on the matter at hand.

But if standardisation processes become overly politicised, this could slow them down. It could also mean that discussions and decisions on adopting or not adopting some standards could be influenced more by geopolitical interests and considerations, and less by the technical merits of the proposals. In this context, maintaining the integrity of SDOs is essential. As highlighted by one interviewee, these organisations should not be seen as 'malleable tools whose processes and rules can be bent by any one actor or groups of actors to meet their political interests'.[5] Trying to advance one's policy goals in the context of standardisation work should only be acceptable if this is done openly and transparently, and within the rules of the game. The results of standardisation processes should be based more on the merit of the work itself, and less on political considerations.

There is also a risk that politicisation might attract 'unnecessary attention' for standards development and limit the possible innovation that standards may bring. Political interventions may block innovation if they become too intrusive.

Other challenges come from the fact that political actors do not always have a good understanding of technical issues. Bridging the gap between political actors and the technical community is key. Some SDOs have themselves embarked on a journey to raise more awareness among policymakers on standards. The IETF, for instance, which has traditionally attracted mostly technical communities, has put in place some initiatives inviting policymakers to their meetings and showcasing the connection between technology and policy.

[4] This is particularly the case for those governmental branches (e.g. ministries of foreign affairs) that used to pay little to no attention to standards.
[5] Interview with a standardisation expert, September 2021.

The digital standardisation ecosystem

Where are standards developed?

Modern standardisation is said to have emerged in the mid-nineteenth century as the globalisation trend gained momentum (OECD/ISO, 2016). The growing interdependence and expansion of global trade called for the removal of barriers to the exchange of information, goods, and capital. The first major breakthrough in this regard came in Paris in 1865 at the International Telegraph Conference.

One outcome of the conference was the establishment of the International Telegraph Union – which later evolved into the International Telecommunication Union (ITU) – whose goal was to 'standardise telegraphy equipment, set uniform operating instructions, and lay down common international tariff and accounting rules' (ITU, 2015). ITU was therefore created to address the interoperability of telegraph networks, which was until then challenged by diverse national systems as well as a 'plethora of bilateral and multilateral agreements aimed at setting common international telegraph equipment standards, regulations and agreements on tariffs' (ITU, 2015).

In 1906, the first international organisation dedicated solely to standardisation was created under the name of the International Electrotechnical Commission (IEC). The IEC deals specifically with international standards on electrical and electronic technologies. In 1930, a general international standardisation body – the International Federation of the National Standardizing Associations (ISA) was founded. In 1947, the International Organization for Standardization (ISO) was established as its successor (OECD/ISO, 2016).

Today, the standardisation ecosystem for digital technologies includes a multitude of entities, ranging from formal and quasi-formal SDOs to various industry forums and consortia.

Formal SDOs are generally recognised by national or international authorities. They have well-established rules and procedures for developing and approving standards, most often through consensus-based approaches (ITU, 2014).

At the national level, these organisations usually bring together experts from various stakeholder groups to develop standards. Examples include the British Standards Institution (BSI), the German Institute for Standardisation (DIN), and the French Standardisation Association (AFNOR). Notably different from these is the American National Standards Institute (ANSI), which does not develop standards itself, but oversees their development by accredited standards bodies.

At the EU level, there are three recognised SDOs: the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and ETSI (European Parliament and Council, 2012). Similar regional standards bodies include the Pacific Area Standards Congress (PASC) and the African Organisation for Standardisation (ARSO). At the international level, the IEC, ISO, and ITU are the key SDOs developing standards for digital technologies. Within ITU, the Telecommunication Standardization Sector (ITU-T) focuses on the development of international technical standards for information and communication technologies (ICTs) (known as ITU-T recommendations), although some standardisation work – related to radiocommunication systems – is carried out by the Radiocommunication Sector (ITU-R) as well.[6]

Quasi-formal SDOs are largely similar to formal SDOs in how they are organised and how they work, except that they are not formally recognised by national or supra-national authorities. IEEE, the IETF, and the World Wide Web Consortium (W3C) are typically included in this category (Teubner et al., 2021), as is 3GPP, which develops mobile telecom standards.

Industry forums and consortia are usually formed with a narrow focus. Private sector entities driven by similar interests get together to develop specific standards catering to those interests. Some are even established to develop standards for a single specific technology. Industry consortia are often seen as 'less bureaucratic and more efficient in reacting to market needs' (Pohlmann, 2014). Examples include the Broadband Forum (develops

[6] ITU has three specialised Sectors: ITU-R contributes to the global management of the radio frequency spectrum and satellite orbit resources and develops standards for radiocommunication systems; ITU-T develops standards for information and communication technologies; the Development Sector (ITU-D) focuses on promoting access to telecommunications.

broadband network specifications); the DECT Forum (developed the Digital Enhanced Cordless Telecommunications – DECT standard); the LoRa Alliance (worked on the LoRaWan specification – a low power, wide area networking protocol); the MEF Forum (develops standards for overlay digital services); and the Organization for the Advancement of Structured Information Standards (OASIS).[7]

The large number of organisations and forums involved in the development of standards for digital technologies makes the international standardisation system a complex one. This complexity is also reflected by the diversity of membership structures and working methods of SDOs. For some organisations, their membership is composed of national SDOs (e.g. the IEC and ISO), but they also facilitate the indirect participation of private entities, through the national SDOs. Others have a more diverse membership. One example is ITU. Although it is an intergovernmental organisation at its core, direct participation in standards development work is open to both state and non-state entities. The IETF does not have a formal membership structure, with everyone interested welcome to participate in the work. Each SDO has its procedures and rules governing standard-developing processes; one element they have in common is that they strive to work based on consensus (although voting is sometimes also involved, in particular in the last stages of approving a standard). *See Annex 1 for details on membership structures and standards development processes within six SDOs.*

Box 3. Cooperation between SDOs

Over the years, many of the SDOs that form part of the international standardisation landscape have developed various mechanisms for cooperation.

For instance, the IEC, ISO, and ITU cooperate under the framework of the World Standards Cooperation. The top leadership of the three organisations has regular exchanges to foster cooperation and coordination, while the Standards Programme Coordination Group enables coordination of both existing and new fields of technical activities (e.g. to avoid conflicting requirements or overlaps) (World Standards Cooperation, no date). Liaisons and joint technical groups (focused on co-development of standards) are other cooperation mechanisms. Here, notable examples are the ITU-T–IETF liaisons and the ISO/IEC Joint Technical Committee 1 (JTC1), which focuses on the development of standards for IT.

Another form of cooperation occurs when one major SDO takes up and integrates work developed within another organisation typically focused on a specific issue. One example is the 5G specifications developed at 3GPP, which have been integrated into the 5G radio standard adopted at ITU-R (Recommendation ITU-R M.2150). In another example, digital identification/authentication specifications developed by the FIDO Alliance have been integrated into ITU-T recommendations (FIDO Alliance, 2018). Such cooperation also helps avoid duplication of efforts.

Standards in the WTO framework: The TBT Agreement

Standards play an important role in international trade, probably best illustrated by the fact that they are included in one key World Trade Organization (WTO) agreement – the *Agreement on Technical Barriers to Trade* (TBT Agreement).

With the goal to ensure that **standards do not create unnecessary barriers to trade**, the agreement outlines a series of obligations for member states, as well as a series of principles for the development of standards.

Member states are required to do the following:

- Ensure that technical regulations[8] do not create unnecessary barriers to international trade.
- Use relevant international standards, or relevant parts of them, as a basis for technical regulations, except when such standards would be an ineffective or inappropriate way to fulfil the legitimate objectives pursued.
    - **Technical regulations that are in accordance with relevant international standards are rebuttably presumed not to create an unnecessary barrier to trade.**
- Participate, within the limits of their resources, in the development of international standards by appropriate international standardising bodies.
- Notify other members of proposed technical regulations that are not in accordance with relevant international standards and that may significantly affect trade.

[7] The portal consortiuminfo.org offers a comprehensive overview of the multitude of industry consortia involved in standardisation work.
[8] Technical regulations are defined as documents that lay down product characteristics or their related processes and production methods, including the applicable administrative provisions, with which compliance is mandatory.

The Agreement also contains a *Code of Good Practice for the Preparation, Adoption and Application of Standards*. The Code is open to acceptance by any standards body within the territory of member states, as well as to regional bodies that include participants from WTO members (WTO, 1994). Among other provisions, the Code encourages standards bodies to operate transparently, ensure nondiscrimination towards imported products, and align national standards with international standards whenever possible (DeVaux, 2000).

Box 4. Standards in WTO specific trade concerns

WTO members can raise specific trade concerns (STCs) at the TBT Committee with respect to laws, regulations, or procedures that may affect their trade. Between 1995 and 2020, 274 STCs dealt with inconsistencies with or non-use of international standards. In 2020, for instance, the issue of alignment with international standards came up in relation to cryptography devices and energy performance testing for household appliances (WTO, 2021).

STCs are different from trade disputes, which arise when a member believes another member is violating a WTO agreement. Between 1995 and July 2021, 56 WTO disputes (out of a total of 606) cited the TBT Agreement in their requests for consultations (the first step to initiate a WTO case); only eight have resulted in rulings (WTO, no date-a).

In 2000, to complement the TBT Agreement, the TBT Committee adopted a set of *Principles for the Development of International Standards, Guides and Recommendations*. The document highlights six principles that international standards bodies are invited to follow:

- **Transparency.** All essential information regarding work programmes, proposals for standards, guides and recommendations under consideration and on the final results should be made easily accessible to all interested parties. Procedures should be established so that adequate time and opportunities are provided for written comments.
- **Openness**. Membership should be open on a non-discriminatory basis to relevant bodies. Any interested member should be provided with meaningful opportunities to participate at all stages of standards development.
- **Impartiality and consensus**. Members should have meaningful opportunities to contribute to the elaboration of an international standard so that the standards development process will not give privilege to, or favour the interests of, a particular supplier/s, country/ies, or region/s. Consensus procedures should be established that seek to take into account the views of all parties concerned and to reconcile any conflicting arguments.
- **Effectiveness and relevance.** To prevent unnecessary trade barriers, international standards need to be relevant and to effectively respond to regulatory and market needs, as well as scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions.
- **Coherence**. To avoid the development of conflicting international standards, SDOs are encouraged to avoid duplication of, or overlap with, the work of each other.
- **Development dimension**. Constraints on developing countries to effectively participate in standards development should be taken into consideration in the standards development process. Tangible ways of facilitating developing countries' participation in international standards development should be sought. (WTO, no date-b)

Although it highlights obligations for member states regarding the integration of international standards into regulations, the TBT Agreement does not clarify what is actually meant by international standards. And although it refers to 'international standardising bodies', it only notes that an international body is one 'whose membership is open to the relevant bodies of at least all member states'. This creates challenges for regulators when deciding what international standards to use as a basis for their technical regulations, and which international bodies to take part in. It can also generate regulatory divergence: 'What might be considered an international standardising body or an international standard by a WTO member might not be considered as such by another, creating more barriers to trade' (Barrios Villarreal, 2018).

Despite this lack of clarity, **standards developed by the IEC, ISO, and ITU are generally understood as relevant in the context of the TBT Agreement,** because (a) the three organisations meet the agreement's definition of an international body, and (b) the standards they develop are consistent with the principles for the development of international standards adopted by the TBT Committee.

As these SDOs themselves note, 'policy makers can have confidence when using IEC, ISO or ITU international standards that they are fulfilling their WTO obligations, and not creating unnecessary obstacles to international trade' (IEC/ISO/ITU, no date). This helps explain the interest of multiple actors in participating in these three organisations, since technologies that comply with standards developed there are practically prevented from being barred in international trade.

A dynamic standardisation landscape

State and non-state actors participate in international standard-setting largely driven by economic and political interests. As such, the standardisation landscape – in particular within the IEC, ISO, and ITU – is dynamic, always in flux, mirroring the interests of the key actors and the competition landscape in certain industries.

The broader picture

Let's take ITU-T as an example. In the 1980s, the USA, the UK, and Germany were among the most active contributors. In the 1990s, Japan and the Republic of Korea started becoming more involved. And in the early 2000s, China emerged on the scene and has since gradually increased its participation to the point that today it has the second-largest number of members (after the USA).

The growing involvement of Asian actors – also valid for the IEC and ISO – reflects the region's increasing technological and economic power.

Some Middle East countries have reportedly also started to become more engaged in standardisation work, in particular in areas related to the IoT and smart cities. But some countries have never been very active in SDOs. This is particularly the case for countries in Latin America and Africa to some extent. Although some of them participate in the work, they tend to do so mostly from an observer's perspective, and be standard-takers more than standard-developers.

Box 5. Standardisation gap

Despite the importance of standards from an economic and political point of view, not all states participate equally in their development. This imbalance, in particular between developed and developing countries, is often termed the *standardisation gap*.

Several initiatives have been undertaken to bridge this gap. For instance, ITU has a programme dedicated to 'addressing the disparities in the ability of developing countries [...] to access, implement and influence ITU's international standards' (ITU, no date). At ITU-T, there is also a practice of supporting the creation of regional groups within study groups (SGs), to foster regional diversity in standards development processes (ITU-T, no date-a). ISO has an action plan for 2021–2025 dedicated to 'assisting developing countries in participating more effectively at both the governance and technical levels within the ISO system' (ISO, 2021).

Shifts in industry participation

As new technologies evolve, the interest in creating related standards drives the participation of certain actors in key SDOs. Once these standards are developed, the industry may become less interested in standardisation work. But the cycle continues with new technologies and new players getting involved in standardisation. To illustrate, in the mid-1990s, large companies like Cisco and Nortel and vendors like Microsoft and Sun were very active. In the mid-2000s, mobile companies – such as Ericsson, Nokia, and Motorola – started becoming more involved. Some of these companies are now still active contributors (e.g. Ericsson and Nokia), others less so. And new actors continually find their way into standardisation work. Huawei, for instance, is a relatively new player on the mobile network standardisation scene, compared to Ericsson and Nokia. When it comes to the application layer, companies like Apple, Amazon, Facebook, and Google are also stepping up their participation in certain standardisation areas.

As many of our interviewees noted, a portion of the Western industry that used to be highly involved in some SDOs (in particular ITU-T) has toned down its participation over the past two decades. For instance, telecom operators like BT and AT&T or vendors like Siemens now participate less than in the past. This has happened for several reasons, such as the deregulation and privatisation of the telecom industry, the shifting of focus on new technologies, and the emergence of a plethora of industry consortia working on specific digital

standards.[9] Previously, if industry players wanted a new standard, they would typically try to get it approved at a major SDO. Now, many prefer to turn to industry consortia (or create new ones altogether) focused on specific technologies, where processes are faster, there is no need to 'negotiate' with governments, and the results are more predictable (as these consortia are usually formed by like-minded companies driven by similar interests).

Box 6. Not everyone cares about standards

There is a portion of the tech industry that is not always interested in standardisation. With the uptake of IP-based technologies, it became easier for companies to develop their own solutions at a proprietary level and then put them on the market, without much concern for interoperability (and, therefore, for standards). Many of the mobile phone apps, for instance, are developed following this model. With standards having no place in this model, the result is a lack of interoperability between similar services.

Filling in voids

The fact that the standardisation landscape is in continuous flux means that voids can be created when some actors reduce their involvement. These voids offer an opportunity for other actors to demonstrate strength: 'Voids would always be desirable and pursued. Whoever has the interests, motivation, time, and competency to take up more activities, they are going to do it.'[10]

One concern about such scenarios is that they enable more compact groups to fill in the space left by others, thus leading to less diversity. Less diversity means fewer opportunities for discussions and more chances for proposals aligned with the interests of certain actors to gain traction and go forward.

Challenges that SDOs face

There are ongoing debates on whether and how SDOs should adjust their standards development processes to make them more effective and efficient. But what are the challenges SDOs face that need to be addressed?

Speed of developing standards

There are arguments that the speed at which international standards are developed needs to improve. A typical cycle for a standard to be developed and approved is somewhere between nine months (which rarely happens) and three/four years. The challenge, it is argued, is that the longer it takes to develop a standard, the more chances there are for the standard to be outpaced by technological progress. Speed is one of the reasons why some of the industry prefers to turn to private consortia to develop certain standards.

But the SDOs say that being more agile and more responsive to current realities is a permanent objective for them. They are constantly looking at how to offer more efficient and effective processes, while maintaining the quality and integrity of the work. Achieving this balance is key. Speed cannot come at the expense of the quality of work and the need to achieve consensus in the process.[11]

One thing that could help improve the overall efficiency within SDOs is the behaviour of participants. If standards' proponents were more willing to put their proposals to rest once it becomes obvious that there is little chance of generating consensus, this would save time and allow more attention to be paid to other proposals. Similarly, abandoning work on proposals that generate little interest or have lost relevance because of technological progress[12] could be encouraged more. Instead of spending time on approving something that would likely end up not being used by the industry, that same time could be allocated to more relevant proposals, with overall efficiency gains.[13]

[9] Interviews with SDO participants, July–October 2021.
[10] Interview with an SDO staff member, September 2021.
[11] Interviews with staff members of SDOs, July–October 2021.
[12] Some SDOs have procedures that cover such cases. At 3GPP, for instance, a work item is automatically considered by a technical specification group for stopping if no progress is achieved in a given period of time (usually six months).
[13] Interviews with SDO participants, July–October 2021.

Dominating players

Some SDO participants note that challenges may appear when groups of actors – be they entities from the same country, alliances of countries, etc. – attempt to dominate the work in a way that makes other participants feel like they cannot make their voice heard, or that there is little room to have balanced and open discussions leading to a consensus. While it is natural for some delegations to be larger than others, or for some actors to be more vocal than others, what matters is to maintain the integrity of the standards development processes, and to ensure that participants can interact freely and contribute to the work on an equal basis.[14]

Forum shopping and duplication of work

One of the most frequently mentioned challenges within the standardisation ecosystem is the tendency of some actors to engage in forum shopping. This is not something new. Different actors have always tried to identify the places where their standard proposals stand a better chance of being approved. This becomes more complex when the scenario involves different entities putting forward similar proposals in different SDOs. 'Entities go into one SDO and they start some work there. Then their competitor goes to another SDO and starts doing similar work. Then they both complain that there is duplication of work and they try to block the work of one another. Those who have sufficient resources to be active in different places would sometimes play this game.'[15]

SDOs have tried to develop mechanisms to limit forum shopping tendencies, for instance by strengthening consensus rules within the organisations or fostering more cooperation between them.

What makes forum shopping easier is that there is no such thing as a general agreement on which SDO should deal with which types of standards. There seems to be a form of a tacit understanding between key SDOs that one organisation retains change control for something they originate. If a certain standard is developed within one organisation, any changes to that standard should ideally be discussed with the same organisation. And if another organisation wishes to take up related work (e.g. extend the scope of the standard), it would be expected to liaise with the organisation where the standard was originally developed. So while there is an expectation, for instance, that IP-related issues are dealt with at the IETF, nothing is stopping any one actor from proposing related work somewhere else.

Diversity

When it comes to participation in international standard-setting, diversity is another often-cited challenge. This issue takes multiple forms. On the one hand, it is about the need to attract more participation from developing countries, and to have more stakeholder and gender diversity among participants. For instance, the limited (if at all) participation of civil society stakeholders in standardisation is increasingly being noticed, and some efforts are being made to address this. The European Commission, for example, is offering funds to support the participation of experts representing consumer interests. SMEs also often find it challenging to contribute to standardisation work, given the resources (time, money, expertise) that need to be allocated in this regard.

On the other hand, diversity is sometimes challenged by the complexity of the system. At ITU-T, for instance – where there are 11 SGs, 33 working parties (WPs), and many more areas of work (called 'questions') – even the delegations of developed countries have difficulty following all the work.

Addressing diversity challenges is not only a matter of making standardisation processes more inclusive. It is also a way to limit the likelihood that some actors or groups of actors could advance their proposals faster and with fewer debates. The more actors at the table, the more debates there are.

[14] Interviews with SDO participants, July–October 2021.
[15] Interview with an SDO staff member, August 2021.

Do SDOs need to change their rules?

This question appears more and more often when discussions are held about the challenges encountered within the standardisation ecosystem. Several ideas are brought up for potential new rules that some SDOs could introduce.

One such idea is to introduce a due diligence process to be performed by SDO staff. Standard proposals would be checked against a set of key criteria (e.g. compliance with human rights) and only allowed to go through the standardisation process if they meet these criteria. Other suggestions include the introduction of rules to limit the number of proposals a single actor can put forward within a technical group,[16] or to limit the number of participants that any one actor or national delegation can have at meetings of technical groups. These would be in response to concerns that some actors submit significantly more proposals than others (in some cases of questionable quality), or that sometimes meetings are dominated by certain actors.[17]

Looking at the broader picture, however, it becomes rather clear that, even if the rules are changed, actors would learn to play by those rules in a way that is advantageous to them. As one interviewee pointed out, 'It is a misconceived idea that you have to change the rules to make the system better. No matter what rules you have, actors will always learn how to play within those rules. It is a power game where people come and use the rules to advance their proposals or to try to stop proposals they don't support. The bottom line is "be ready to play the game".'[18]

Other aspects also need to be considered. Introducing new rules would require changes in SDOs' procedures. And this could come with challenges participants may not be ready to address. As one interviewee asked: 'Do we really want to open this up? Once we start discussing new procedures, many more ideas may come up, and we might not like the end results.'[19] Moreover, for any new rules to bring improvements to the standardisation ecosystem, they would have to be introduced across the spectrum of organisations. For instance, if the goal is to ensure that standardisation processes embed certain values and principles, then all SDOs would have to live up to those values. Otherwise, practices like forum shopping and duplication of work would only be exacerbated.

[16] SDOs use different names for the technical groups where standard proposals are developed and discussed. For instance, ITU-T has study groups (SGs) and working parties (WPs). At the IEC and ISO, there are technical committees (TCs), subcommittees (SCs), and working groups (WGs). 3GPP has technical specification groups (TSGs), while the IETF and IEEE have WGs. *See Annex 1 for details.*
[17] Interviews with SDO participants and standardisation experts, July–October 2021.
[18] Interview with an SDO staff member, August 2021.
[19] Interview with a staff member of a technical organisation, July 2021.

China's role in shaping digital standards

Over the past few decades, China has focused on becoming a global technological power, with multiple policies, strategies, and plans having been issued towards this goal. The results are already noticeable, as the country is moving away from being a manufacturing hub to becoming an innovation-driven economy capable of developing and exporting high-end technology.

With this growing technological power also came growing attention to technical standardisation. China sees standards as a key element in driving innovation, industrial development, and economic growth, as well as in facilitating economic and trade exchanges (SAC, 2020b). Standards are also considered essential for improving China's competitiveness on the global market (State Council, 2021), as they contribute to enhancing the quality of Chinese products (State Council, 2015). The government understood that the previous growth model (based on cheap products) is no longer suitable, so a different approach was needed, one focussed on high-end, value-added manufacturing.

China's approach towards standardisation is generally aligned with the country's broader 'go out' strategy dedicated to advancing integration into the international economic system. At the core of this strategy is the 'two markets, two resources' principle, highlighting two connected goals: (1) protection of the domestic market, and (2) integration into the international market (De la Bruyere and Picarsic, 2020).

If standards tended to be used largely as a tool to protect national industries from external competition, the opening-up of the Chinese economy has brought a shift in the country's approach to standardisation. The government is now paying more attention to aligning Chinese and international standards, both by integrating such standards domestically and by increasing the country's involvement in international standard-setting. Standards are also becoming the subject of a growing number of bilateral and multilateral agreements concluded and pursued by the government (Seaman, 2020).

National standardisation system

Given the importance that China attaches to standardisation, standards feature prominently across a wide range of national policies. Not only does the country have dedicated standardisation strategies and plans, but standards also reverberate in industrial, economic, and technological strategies.

China's standardisation system has undergone a series of changes over the past two decades. From a clearly state-driven process (where the government developed standards and the industry had to follow them), standard-setting can now be described as hybrid (Seaman, 2020). While the state maintains overall oversight, the system is not entirely state-controlled, allowing market-driven action (Rühlig, 2020). Companies are encouraged to be key players in standard-setting and contribute their expertise to these processes, within the existing framework. And many do so, trying to make sure that their contributions are aligned both with their interests and with the goals and objectives set by the government.

The Chinese approach to standardisation – with a relatively large number of mandatory standards and the state having an oversight/steering role over the system – is different from EU and US approaches. In the USA, standards have – most of the time – a voluntary nature and are developed by a multitude of private-sector-led bodies. ANSI functions as a private organisation, whose role is limited to coordinating the overall standards system, for instance through accrediting standard-setting bodies. Government agencies are encouraged to participate in standards development processes (ANSI, no date). At the EU level, the development of European standards happens at CEN, CENELEC, and ETSI, in the framework of what could be described as a public-private partnership.[20] While largely voluntary, European standards can also be referenced in regulations (as a preferred way or as a mandatory requirement to comply with specific rules), and there are instances when the European Commission can request standardisation bodies to develop certain standards to support EU legislation and policies (Your Europe, no date).

[20] At ETSI, the industry can participate directly in standardisation work, together with governmental organisations, research entities, and other actors. CEN/CENELEC membership includes national standardisation bodies; the industry and other actors can contribute through the national bodies.

The 2018 standardisation reform

The Chinese standardisation system used to be highly complex, with multiple standards – most of them mandatory – developed at the level of ministries and other bodies under the State Council, research institutes, local authorities, industry groups, and individual companies. The standardisation reform – initiated by the State Council and implemented through a new standardisation law in force since 2018 (National People's Congress, 2017) – has sought to simplify the landscape (Table 2), rethink the role of state entities in standardisation processes, and reduce the number of mandatory standards.

There are now five types of standards, grouped into two broad categories:

- State-led standards (developed under the coordination of state bodies)
  - National standards (mandatory and voluntary[21])
  - Sector standards[22] (largely voluntary; they can become mandatory if approved as such by the State Council)
  - Local standards (voluntary)
- Market-issued standards (developed by the industry)
  - Association standards (voluntary)
  - Enterprise standards (voluntary)

Table 2. China's standardisation system before and after the reform.

	Standardisation system before 2018		Standardisation system from 2018
State-led	MANDATORY	→	MANDATORY
	National standards		National standards
	Sector standards		
	Local standards		
	VOLUNTARY	→	VOLUNTARY
	National standards		National standards
	Sector standards		Sector standards
	Local standards		Local standards
Market-issued	Enterprise standards		Association standards
			Enterprise standards

Based on Seaman (2020)

The standardisation system is coordinated by SAC, which functions within the State Administration for Market Regulation. SAC sets general standardisation policies/strategies, issues national standards, and maintains some level of overall supervision on the development of association standards (which, however, do not need to receive SAC approval).

National standards and sector standards are usually developed within TCs (and related SCs and WGs).[23] These include experts from both the public and the private sectors (e.g. government agencies, research institutes, companies, industry associations, academia), and are usually overseen either directly by SAC or by relevant ministries or other state bodies (there are also cases of TCs overseen by industry bodies). For instance, TC485 on communications falls under the guidance of MIIT, while its secretariat is ensured by the China Communications Standards Association. TC260 on information security is directly subordinated to SAC, but it is chaired by the Cyberspace Administration of China. *See Annex 2 for a detailed overview of the standardisation system (types of standards and how they are developed).*

[21] *Voluntary* standards are also referred to as *recommended*.
[22] Various sources also use the term *industry standards* or *professional standards* to refer to this type of standards.
[23] There are over 1,300 technical committees and subcommittees working on standards. Some of them mirror similar committees within international SDOs such as ISO and IEC. Details can be found at http://std.samr.gov.cn/org/orgTcQuery (available in Chinese only).

Standards are subject to review within five years of adoption. The review processes aim to determine whether standards still meet the needs of economic and social development and technological progress; if this is no longer the case, standards are revised or withdrawn.

The implementation of the new standardisation framework has led to what could be described as a **partial liberalisation of the standards system**. On the one hand, the overall number of mandatory standards has decreased. In September 2019, the National Center of Standards Evaluation (NCSE) reported that many of the sector/industry and local standards that were mandatory before 2018 had been abolished or converted into voluntary standards, and the number of mandatory national standards was also reduced (NCSE, 2019). On the other hand, the role of the private sector has increased. The introduction of association standards has created more space for the industry to develop standards that respond to market needs and support innovation.[24] Also, when national and sector standards are developed within TCs, most of the work is reportedly driven by experts from the private sector, while state institutions maintain the formal, overall leadership.[25]

The government, however, still has a steering role when it comes to the standardisation framework. As one interviewee noted, 'The system cannot be changed directly from a state-driven one to a purely market-driven one; the government is not in the habit of completely giving up control.'[26] For instance, beyond the role of state bodies in the development of national and sector standards, the government can also influence the degree to which some association or enterprise standards are used or not (e.g. it can encourage certain standards over others in the framework of public procurement processes). Moreover, standards can sometimes become part of the regulatory framework after adoption. Even if not originally adopted as mandatory, some standards can be referenced in certain regulations that require compliance.

The **participation of foreign companies** in standardisation processes has also been somewhat simplified, and most of the TCs are open to participation from such companies. A set of guidelines issued by SAC, the National Development and Reform Commission (NDRC), and the Ministry of Commerce (2017) state that foreign-invested enterprises are entitled to the same treatment as domestic ones when it comes to participating in standardisation work. This principle was later codified in the Foreign Investment Law (adopted in 2019, and in force from 2020), which introduced an obligation for the state to guarantee that foreign-funded enterprises could equally participate in standard-setting (the law also clarified that the mandatory national standards apply to foreign-funded companies) (National People's Congress, 2019).

In practice, however, there seem to be certain TCs and related WGs where the participation of foreign companies remains challenging. For instance, members of the US-China Business Council reported that two WGs within TC260 on information security do not allow foreign companies to participate. While there are no formal policies against such participation, their applications to participate 'remain in perpetual limbo' (Kamensky, 2020a). As one interviewee noted, 'Whether and to what extent foreign companies can contribute to standards-setting very much depends on whether China considers that the respective companies can bring something to the table.'[27]

Box 7. Additional insights into China's standardisation system

The report *The Shape of Things to Come: The Race to Control Technical Standardisation*, jointly released by the European Union Chamber of Commerce in China, the Swedish Institute of International Affairs, and the Swedish National China Centre, offers insights into the challenges met by European businesses involved in the elaboration of domestic standards in China. A survey of 93 European businesses from different sectors operating in China was conducted in 2021 and highlights effects of the 2018 reform on the Chinese standardisation system. The results of the survey indicate that there is a predominance of SAC-mandated national standards and sector standards developed under the oversight of relevant national ministries.

The study also lists a number of challenges faced by European and foreign businesses trying to actively participate in the elaboration of standards. Despite the acknowledged greater access to standardisation processes, some actors still report difficulties in obtaining full access, citing the state-centric nature of Chinese standardisation as a major hurdle. However, the extent of the difficulties highlighted in the survey heavily depends on industry sector and company size (Rühlig, 2021).

[24] There is, however, criticism that the large number of both association standards and associations that develop such standards generates confusion, duplications, and sometimes contradictions in standards, and, overall, a fragmented standards environment (Kamensky, 2020a).
[25] Interviews with researchers and standardisation experts, July–October 2021.
[26] Interview with a standardisation expert, October 2021.
[27] Interview with a researcher, August 2021.

Advancing the standardisation reform

Since the entry into force of the new standardisation law in 2018, advancing the standardisation reform has been a key goal highlighted across several policy documents. After reviewing some of the most recent such documents – SAC's standardisation priorities for 2020 and 2021 (SAC, 2020a; 2021a), and the *Outline for National Standardisation Development* issued by the State Council (2021) – we have identified several core elements of this continuous reform process:

- Promoting a **more open national standards** development process, and **optimising the 'market-driven, government-led'** standardisation system. This relates not only to advancing the involvement of Chinese companies in the standardisation work, but also ensuring the participation of foreign-funded enterprises.
- **Continuing to simplify the system of mandatory national standards** (e.g. ensure it is of appropriate size and implement a coordinated approach for the development of such standards).
- Ensuring that national standards are **effectively implemented** (through strengthening the supervision of standards implementation), and i**mproving the evaluation and revision of national standards** (e.g. through the introduction of external expert evaluation mechanisms).
- Improving the system of **sector standards** and **reducing the number** of such standards (e.g. by expanding the coverage of individual standards).
- **Increasing the number of association standards** and encouraging the private sector to develop high-quality, original standards. Facilitating the integration of standards developed by the industry into national and sector standards.
- Encouraging enterprises to develop **higher-quality standards** and continuing to implement the 'forerunner' system (a system designed to identify the best enterprise standards).[28]
- **Preventing** the use of standards for protectionist goals (e.g. in the case of local standards) and trade monopolies.
- Improving the cooperation between different technical standardisation organisations and promoting **cross-industry standardisation**. Better cooperation mechanisms would help address problems related to overlaps and redundancy in standards, and misuse of resources.
- **Strengthening capacities for standards development**, including through establishing new standards laboratories, research institutes, and innovation bases; integrating standardisation into the curricula of higher education institutions; building training programmes for standardisation professionals; and providing incentives for engagement in standardisation work.

Box 8. China Standards 2035

China Standards 2035 has been covered extensively in the Western media; it has been described, for instance, as ' presenting tremendous threats to those competing with Beijing' (De la Bruyere and Picarsic, 2020), or as something that 'could result in a technological cold war' (Gargeyas, 2021).

However, *China Standards 2035* has neither been released as an official document, nor approved or consensually agreed in the State Council. And it is unclear when – or whether at all – this will happen.

China Standards 2035 can best be presented as a research project commissioned by SAC and led by the China Academy of Engineering. The goal was to assess the Chinese standardisation landscape and provide further recommendations for improvement. Work started in January 2018 and a report is said to have been submitted to the State Council in February 2021. Some of the recommendations outlined in this report are said to include:

- The development of a national standardisation strategy that would transform China into a 'standardisation power' by 2035.[29]
- A continuation of the standardisation reform, by moving to a two-layer standardisation system, i.e. instead of the current system with five types of standards, have a simplified system with only national standards and association standards. This could mean that standards developed by the private sector would be given more importance.
- Further engagement of Chinese stakeholders in international standardisation (SESEC, 2021a).

It seems, however, that at least some of these recommendations have been received with reticence by various actors within the standardisation ecosystem. For instance, the move to a two-layer system would create discontent among the standardisation communities involved in the development of standards that would be eliminated (the voluntary national standards, the local standards, etc.) (Rühlig, 2020; SESEC, 2021a). Should authorities decide to go ahead with this plan, it is estimated that it could take up to ten years to implement.

[28] Also called a 'top runner system', this system is seen by some as a way for state authorities to maintain some guiding role over the development of enterprise standards (Rühlig, 2020).

[29] The development of such a strategy was also outlined in SAC's priorities for 2020 and 2021. The strategy was to be based on the *China Standards 2035* study and aligned with the *14th Five-Year Plan for National Economic and Social Development*, and to be elaborated by a drafting group including representatives from regions and industry sectors.

Standardisation priorities for digital technologies

China has made it a clear goal to increase the global competitiveness of its technological sector. This is highlighted in several policies and plans adopted in recent years. Improving the quality of products, advancing research in core technologies, and strengthening innovation capabilities in key areas are among the objectives set within plans such as *MiC 2025* and the *14th Five-Year Plan for National Economic and Social Development*. Standardisation plays an important role within these documents, with standards being seen as key in meeting the demands of market competitiveness and innovation.

Besides being referred to in industry and technology plans and strategies, China's priorities related to setting standards for digital technologies are also highlighted in various standardisation documents, such as the annual standardisation priorities set by SAC and MIIT, and the State Council's *Outline for National Standardisation Development* from 2021. As the following overview shows, the goal is to develop or strengthen standards covering a vast array of technologies, from communication networks and the IoT, to AI, quantum computing, and biotechnology.

Made in China 2025

MiC 2025 is the country's manufacturing strategy. One of the plan's strategic tasks is to transform China's manufacturing sector and increase its competitiveness, so that by 2049 the country becomes 'the leader among the world's manufacturing powers' and has competitive advantages in major manufacturing areas, including advanced technologies.

In addition to advancing intelligent manufacturing, one of the underlying elements of *MiC 2025* is the development of **strategic industries.** Such industries include **integrated circuits, communication equipment (including 5G, quantum computing, and neural networks), industrial software (including industrial IoT), robotics, biotechnology, and new materials**.

The plan sees standards as important elements in improving the quality of products and in 'meeting the demands of markets and innovation'. It highlights objectives to promote **technology standards** and to carry out standardisation activities in the area of **intelligent manufacturing**.

Environmental issues are also covered in the plan, which commits support for enterprises that implement **green standards** and overall green strategies for their production and management processes. The plan also talks about 'making national security equipment adopt advanced civilian standards and promoting the application of military standards in civilian areas' (State Council, 2015).

Box 9. Military-civil fusion

Advancing the integration of military and civilian standards is an objective that appears across several standardisation policies. The standardisation law requires the state to promote standards that encourage military-civil integration, to increase the harmonisation of military and civilian standards, to promote the use of appropriate civilian standards within the national defence and military system, and to convert appropriate military standards into civilian ones. In its 2020 and 2021 priorities, SAC talks about promoting the development of standards with dual-use (military and civilian), and strengthening the cooperation between military and technical standardisation organisations. This approach is in line with China's overall policy on military-civil fusion, meant to foster stronger connections between the civilian economy and the defence industry (Kania and Laskai, 2021).

Interestingly, no mention is made of military-civil fusion in the standardisation plan released by the State Council in October 2021.

SAC and MIIT priorities for 2020 and 2021

In their standardisation priorities for 2020 and 2021, SAC and MIIT have highlighted a wide range of digital technologies to focus on when it comes to standardisation. This reflects the country's overall goal of excelling across the broad spectrum of digital technologies. Focus areas for standardisation include the following:

- **High-end and intelligent manufacturing**, covering areas such as digital twins, industrial robots, and additive manufacturing.
- **IoT** and related areas such as smart cities, smart homes, smart vehicles, and unmanned aerial vehicles.

- **Cybersecurity,** i.e. the security of networks, products, and services; the protection of critical information infrastructures; data security; and protection of personal information.
- **Information infrastructure/networks.** In addition to highlighting plans to strengthen standardisation in areas such as 5G and next-generation mobile networks, high-speed broadband, cloud computing, and next-generation internet, reference is also made to developing standards for IPv6+ (possibly an advanced version of the IP version 6), and 'fostering standardisation in the field of **new information infrastructure**'.[30]
- **Industrial internet.**
- **Digital services**, such as online education, smart tourism, digital health, and e-commerce.
- **Advanced and emerging technologies** in areas such as AI, big data, blockchain, quantum computing, and virtual and augmented reality.
- **New materials, rare earths,** and **advanced semiconductor materials.**
- **Environmental issues,** including standards for new energy generation, energy internet, and energy efficiency (MIIT, 2021a; SAC, 2020a, 2021a).

14th Five-Year Plan for National Economic and Social Development

Unveiled in March 2021, the *14th Five-Year Plan for National Economic and Social Development* has technology at its core. The plan – which includes long-term objectives for the next 15 years – aims to implement a dual circulation strategy that will boost the domestic market without abandoning the export strategy, and make China more technologically self-sufficient (National People's Congress, 2021).

In line with China's ambition for tech supremacy, the plan sets the goal of achieving economic, scientific, and technological strength, allowing the country to become one of the most innovative nations in the world by 2035. The plan lists several 'strategic emerging industries' whose development and growth will be supported, including a **new generation of IT, biotechnology, quantum computing, AI, future networks, genetic technology, and new materials.** Also envisioned is support for R&D of innovative applications of key digital technologies in areas such as **high-end chips and general-purpose processors, AI algorithms, sensors, cloud computing systems, big data, and network security**. The country will also invest more in areas such as mathematics and basic science, which it sees as underpinning current and future technologies.

The plan includes several references to standards. For instance, within the overall goal of creating a good digital ecosystem, **improving (cyber)security standards** is seen as an important element towards strengthening the protection of network security. Strengthening the standards system for **intelligent manufacturing**, developing standards for **new infrastructure**, and establishing a uniform system of standards, certifications, and labels for **green products** (such as energy-saving household appliances) are also highlighted among the objectives.

Outline for National Standardisation Development, 2021

Issued in October 2021 by the State Council, the *Outline for National Standardisation Development* establishes goals and objectives dedicated to 'promoting the development of standardisation' in China. The document reiterates the role of standardisation in improving national competitiveness, and highlights the importance of advancing the 'market-driven, government-led' standardisation system.

When it comes to digital technologies, the outline sets a series of objectives related to researching and developing standards covering a broad range of areas:

- Advanced technologies: AI, quantum information, and biotechnology.
- High-end and intelligent manufacturing.
- IoT and related areas: intelligent/connected vehicles and robots, unmanned vehicles.
- Digital services, such as e-commerce, digital finance, the platform and the sharing economy, digital government services.
- New infrastructure.
- Data security, personal information protection, and cybersecurity.
- New materials.
- New-generation information technology.
- Big data, blockchain.
- New/green energy and green manufacturing.

[30] *New infrastructure* is used as a broad term that encompasses innovation infrastructures (research institutes, innovation-focused industrial parks), information infrastructures (5G, IoT, AI, cloud computing, blockchain, data centres, and internet communication networks), and integrated infrastructures (inter-city high-speed rail and inner-city rail systems, ultra-high voltage power transmission, and charging stations for electric vehicles) (Wong, 2020).

China's engagement in international digital standard-setting

Policy for international engagement and cooperation

China wants to become a technological force, highly competitive on the international market. Self-reliance in science and technology is seen as a strategic priority underpinning national development (as highlighted in the *14th Five Year Plan for National Economic and Social Development*). But this self-reliance does not mean detachment. As Chinese Premier Li Keqiang noted, scientific development requires international cooperation; decoupling in this area as well as in supply chains will do no country any good (*South China Morning Post*, 2021).

Closely aligned with these policy goals is China's strategy to open up its standardisation system. As highlighted in various standardisation policy documents, this strategy rests on three pillars: (1) active participation in international standardisation processes, (2) strengthened bilateral and multilateral standards cooperation, and (3) harmonisation of Chinese and international standards, through (a) the internationalisation of Chinese standards and technologies and (b) the transposition of international standards at the national level. These priorities are spelt out in the standardisation law, which notes that the 'state shall promote participation in international standardisation activities, engagement in international cooperation and exchanges on standardisation, [as well as the] adoption of international standards, and the harmonisation of Chinese and foreign standards' (National People's Congress, 2017).

Participation in international standards development organisations: Dual focus on technology and governance

China is moving from being a taker and adopter of standards and technologies from abroad, to becoming a technology innovator and exporter, and, as such a more active contributor to international standard-setting. In short, it aims to shift from being a consumer of international standards to becoming a producer.

This is reflected in the country's strengthened engagement in international SDOs. After a period of absence from key organisations, China has gradually rejoined the international standardisation scene starting in the late 1970s. For some 20 years, its participation tended to take a 'learner's approach'; this shifted starting in the early 2000s, with a new focus on not only learning, but also contributing to standard-making.[31]

This focus has been made clear in various standardisation strategies, plans, and policies. For instance, SAC made it a priority for 2020 and 2021 to enhance **active participation in international standardisation work and governance,** with a **focus on ISO and the IEC.** Ways to achieve this include proposing more international standards, enhancing the participation of Chinese experts in SDO technical bodies, and assuming more leadership and secretariat roles within such bodies (SAC, 2020a; 2021a). MIIT adds **ITU** and **the World Forum for Harmonization of Vehicle Regulations (WP.29)** to the list of SDOs to strengthen engagement in. And it also sets a more specific goal for 2021: Chinese actors to take the lead in formulating over 100 international standardisation projects (MIIT, 2021a).

Encouraging and supporting the participation of Chinese companies and experts in international SDOs is another goal for the government. The standardisation law requires state institutions to 'encourage enterprises, social organisations, education institutions, research institutes, and other organisations to participate in international standardisation activities' (National People's Congress, 2017). Similar provisions also appear in *MiC 2025*, the *Outline for National Standardisation Development* (2021), and the annual priorities set by SAC and MIIT.

A system of **rewards for engagement in international standardisation** is implemented. Here, too, the standardisation law provides the overall framework, stating that 'organisations and individuals shall be commended and rewarded for their outstanding contributions to standardisation work'. Central and regional governments are said to be providing annual stipends of up to one million yuan (US$155,000) for companies leading standards development within key SDOs (Pop et al., 2021). It is also argued that some of the mechanisms put in place tend to reward quantity over quality, in the sense that companies/individuals are offered incentives simply for proposing standards, without considering the quality of those proposals or whether the proposals are eventually adopted (Voo and Creemers, 2021).

[31] Interview with an SDO staff member, August 2021.

Another practice is to have **TCs/SCs from ISO and the IEC mirrored at a national level.** The mirror committee mechanism – a practice also implemented in other places, such as the USA and European states – allows national stakeholders to come together and, where possible, develop standard proposals for submission at the international level, and coordinate positions on issues discussed within SDOs' TCs/SCs. According to SESEC (no date-b), around 870 ISO/IEC TCs/SCs have mirror committees in China. For instance, TC260 on information security mirrors the ISO/IEC JTC1/SC27 on information security, cybersecurity, and privacy (US-China Business Council, 2020).

Beyond a more active engagement in the development of international standards, China is also interested in **contributing to 'improving' and/or 'reforming' the standardisation environment**. In 2016, in his message to the 39th General Assembly of ISO (held in Beijing), Chinese President Xi Jinping noted China's readiness to 'improve the system of international standards', 'together with all countries in the world' (Gasiorowski-Denis, 2016). Similar references appear in several policy documents. For instance, SAC notes in its 2020 priorities that China is to 'propose Chinese solutions in the governance reform and improvement of governance capabilities of international standardisation organisations' (SAC, 2020a). In 2021, the administration sets more detailed objectives: 'strengthen research into new ISO governance models and major policy rules and procedures', 'fully participate in the reform of the IEC governance system and in formulating new IEC strategic planning', and 'promote a new layout for international standardisation, in which governments indicate the way and enterprises play the leading role in collaboration with universities and research institutes' (SAC, 2021a). This last objective, which seems to indicate a desire for an international standardisation system resembling the Chinese one (e.g. state-led, industry-driven), is also reiterated in the *Outline for National Standardisation Development* released by the State Council in October 2021. To what extent China has put forward concrete proposals for reforming SDOs remains unclear.

When it comes to international engagement related to digital standards, the policy documents we have looked at tend to frame focus areas in broad, encompassing terms, such as *new technologies* and the *digital domain*. There are, however, a few references to specific fields such as intelligent manufacturing, digital currencies, data security, and quantum computing (Table 3). What the government has highlighted is a focus on areas where gaps exist in international standardisation.

Table 3. Digital standards: Objectives and focus areas for China's international engagement as reflected in recent policy documents.

Policy document	Digital standards: Objectives and focus areas for international engagement
SAC: *Main Points of National Standardisation Work in 2020*	Carry out extensive international cooperation in the fields of **new energy, new materials, quantum computing, digital twins, and intelligent manufacturing.**
SAC: *Main Points of National Standardisation Work in 2021*	Focus on areas lacking domestic and international standards. Submit international standardisation proposals in the field of **new technologies.** Encourage more advanced technologies and innovative achievements to be converted into international standards.
National People's Congress: *14th Five-Year Plan for National Economic and Social Development* (issued in 2021)	Actively participate in the formulation of digital technology standards in areas such as **data security and digital currencies.**
State Council: *Outline for National Standardisation Development* (issued in 2021)	Promote the development of international standards in the field of **sustainable cities and communities [...], green finance and the digital domain.**

Harmonisation of Chinese and international standards

China is aware that its economic growth depends not only on national resources, but also on its ability to be a key player in international markets. Standards play an important role in this regard, and the country has been placing an increasing emphasis on achieving some level of harmonisation between domestic and international standards, aware that Chinese technologies would better compete on international markets if they adhered to international standards.

On the one hand, China aims to **enhance the compatibility between domestic and international standards, and to accelerate the adoption of the latter**. The standardisation plan issued by the government in 2021 set

a specific goal of aligning 85% of its domestic standards with international ones (State Council, 2021). One of MIIT's standardisation priorities for 2021 is to increase the conversion rate of international standards in key areas to up to 90% (MIIT, 2021a). Despite these goals, it is reported that only around one-third of the national standards issued by SAC are based fully or partially on international standards (US-China Business Council, 2020).

On the other hand, China works to **advance the internationalisation of domestic standards and technologies**. In SAC's and MIIT's words, respectively, this means 'encouraging more advanced technologies and innovative achievements to be converted into international standards' and 'promoting the internationalisation of Chinese technology, products, and services' (SAC, 2021a; MIIT, 2021a). Promoting the 'mutual recognition of Chinese and foreign standards', as well as the 'coordinated development of domestic and international standardisation' are other goals set by the State Council (2021). The country is also focusing on publishing translations of domestic standards into foreign languages; by the end of 2019, 721 foreign language versions of Chinese standards had been published (SAC, 2020b).

Promoting one's technologies through standards is a goal that many participants in international standardisation share. For China, the government is counting on the fact that Chinese tech companies innovate at a fast pace, and its goal is to have at least some of these innovations reflected in international standards. This could help strengthen the competitiveness of Chinese products and services on global markets.

Bilateral and multilateral standards cooperation

Advancing bilateral and multilateral standards cooperation – with both developed and developing countries – is another important goal for China's overall standardisation policy.

When it comes to standards cooperation with countries like Germany and France, the focus is on specific areas; for instance, smart cities and sustainable urban development with France (Seaman, 2020), and industry 4.0 (i.e. high-tech manufacturing) with Germany (Fuchs and Eaton, 2021). Cooperation with developing countries and emerging economies covers broader areas, is sometimes connected with trade agreements, and is seen as an opportunity for China to internationalise (or export) domestic standards.

By the end of 2019, China had concluded 97 **bilateral and multilateral cooperation agreements** with 54 national and regional standardisation bodies and international organisations. It also participated in the work of regional SDOs such as the Pan American Standards Commission (COPANT), CEN/CENELEC in Europe, PASC in the Pacific area, and ARSO in Africa. The country has also established 12 **regional standardisation research centres** to serve as support for international standardisation cooperation and carry out bilateral and multilateral exchanges and cooperation. Examples include the Central Asia Standardization (Shaanxi) Research Center, the South Asian Standardization (Chengdu) Research Center, the BRICS Standardization (Zhejiang) Research Center, the American Standardization (Shanghai) Research Center, and the Heilongjiang China-Russia Standards Research Center of Province (SAC, 2020b).

In 2020, SAC outlined as objectives the establishment of standardisation cooperation mechanisms among BRICS countries; deepening cooperation mechanisms with the EU, the African Union, the Association of Southeast Asian Nations (ASEAN), Northeast Asia, Central Asia, and South Asia; and strengthening cooperation with Canada, France, Germany, Russia, Saudi Arabia, the UK, and the USA (SAC, 2020a). In 2021, the focus was on intensifying cooperation in Northeast Asia, and with Germany, Russia, and the UK; expanding cooperation with other countries and regions such as Pakistan, Costa Rica, and ARSO; actively participating in PASC standardisation activities, the Asia Pacific Economic Cooperation's (APEC's) Sub-Committee for Standards and Conformance, and COPANT; and broadening cooperation with regional standards organisations in Europe and the Gulf region. A more general goal was to strengthen cooperation with ISO and IEC members in key fields of global technological innovation (SAC, 2021a).

Complementing the annual priorities set by SAC, the State Council highlighted among the objectives of its multi-year *Outline for National Standardisation Development*, the promotion of standardisation cooperation with countries part of the BRI,[32] strengthening standardisation dialogues among BRICS and APEC countries, and deepening standardisation cooperation in North-East Asia, Asia Pacific, Pan-American, European, and African regions.

[32] The *Belt and Road* is an initiative driven by the Chinese government to improve the connectivity and the economic cooperation between Asia, Europe, and Africa. The initiative involves substantive investments in the development of various types of infrastructures (e.g. roads, railways, ports, telecommunication networks) across partner countries.

Promoting the role of standards in international trade and global governance also seems to be a key goal for China (SAC, 2020a). Following up on WTO-related issues, participating in activities related to standardisation issues in the context of free trade zone negotiations, and exploring standardisation coordination and cooperation in the framework of the Regional Comprehensive Economic Partnership (RCEP)[33] are highlighted as priorities for SAC in 2021 (SAC, 2021a).

International standardisation cooperation is seen not only as a matter of state responsibility, but also an area the private sector can contribute to. MIIT, for instance, highlights the importance of encouraging industry associations – along with professional standardisation organisations – to strengthen exchanges and cooperation with international counterparts (MIIT, 2021a).

Box 10. Standards in the framework of the Belt and Road Initiative

Standardisation cooperation and the internationalisation of Chinese standards are also tackled in the framework of the BRI. Within this initiative, the Digital Silk Road is targeted at creating markets for Chinese products (based on domestic standards) and at fostering regional cooperation (Voo and Creemers, 2021).

In 2015 and 2018, action plans were issued to facilitate standards cooperation with BRI partners in areas such as networks and infrastructure, trade (including e-commerce), finance, energy, and the environment (SAC, 2021b). The two Belt and Road Forums held in 2017 and 2019 also covered standard-related issues. At the 2017 forum, China concluded agreements on mutual standards recognition with several countries, including Belarus, Cambodia, Ethiopia, Greece, Kazakhstan, Malaysia, Mongolia, Russia, Serbia, Switzerland, and Turkey (Seaman, 2020). At the second forum in 2019, it was announced that SAC had started developing a standards information platform to enable the exchange of standards information among BRI partner countries (Second Belt and Road Forum for International Cooperation, 2019). The platform is also mentioned in SAC's priorities for 2021 (SAC, 2021a).

References to promoting standardisation cooperation among BRI countries are also made in the *Outline for National Standardisation Development* issued by the State Council in 2021. And one of MIIT's priorities for 2021 was to promote the translation of mandatory national standards and sector standards for use by BRI countries (MIIT, 2021a).

The formal promotion of Chinese standards through cooperation agreements and initiatives, such as the standards information platform, is complemented by a de facto diffusion of standards through the deployment of Chinese technologies via BRI projects. This is part of China's overall strategy of promoting its products and services beyond the country, as a way to gain profit and drive economic growth.* But there are concerns that 'China offers countries subsidies to win the work and then uses its standards to lock in partner nations that would face major costs switching to international standards' (Pop et al., 2021). And even if countries do not formally adopt Chinese standards, relying on Chinese technologies could result in a de facto commitment to such standards (USCC, 2020).

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*According to official data, China's total direct investments in countries involved in the BRI reached US$136 billion between 2013 and 2020. At the same time, the total turnover from projects Chinese companies contracted in the BRI framework reached nearly US$640 billion (SESEC, 2021b).

Participation in the IEC, ISO, and ITU: What do the numbers say?

China started placing more emphasis on its involvement in international standardisation once it joined the WTO in 2001. As noted previously, the TBT Agreement calls on countries to base their regulations on international standards as a way to prevent unnecessary barriers to trade. In practice, this means that countries should not be placing trade barriers against products and technologies that abide by international standards. And although WTO does not specify what is meant by international standards, those developed by the IEC, ISO, and ITU are generally understood as being relevant in the framework of the TBT Agreement. This is one of the reasons behind China's growing involvement in these three SDOs.

In this section, we look at what the numbers say regarding the involvement of Chinese actors in the IEC, ISO, and ITU, focusing on overall participation and the number of leadership and/or secretariat positions within technical groups. We compare these with the participation of actors from other countries, and, where possible, provide historical data to showcase the dynamism of the standardisation landscape.

[33] RCEP is a trade agreement (to enter into force in 2022) among several Asia-Pacific countries: Australia, Brunei, Cambodia, China, Indonesia, Japan, Laos, Malaysia, Myanmar, New Zealand, the Philippines, the Republic of Korea, Singapore, Thailand, and Vietnam.

Participation in ISO

China joined ISO in 1978. Since 2008, the country (through SAC) has been one of the 20 members of ISO's Council, the governing body of the organisation. China is also a member (until 2023) of the Technical Management Board (TMB), together with 14 other countries. The Board ensures the general management of TC structure (including establishment, coordination, and dissolution of ISO's technical bodies), the supervision of their activities, and the development and maintenance of the rules for the work of ISO's TCs. Between 2015 and 2018, Zhang Xiaogang, a Chinese national, served as ISO President.

Participation in technical committees and subcommittees

As of 1 November 2021, China is a participating member of 732 TCs and SCs, and an observing member of 13 additional committees (Figure 1).[34] This places China at the top of the countries with the largest number of TCs and SCs they are fully active in; it is followed by the UK (714), Germany (703), Japan (646), and France (633).[35]

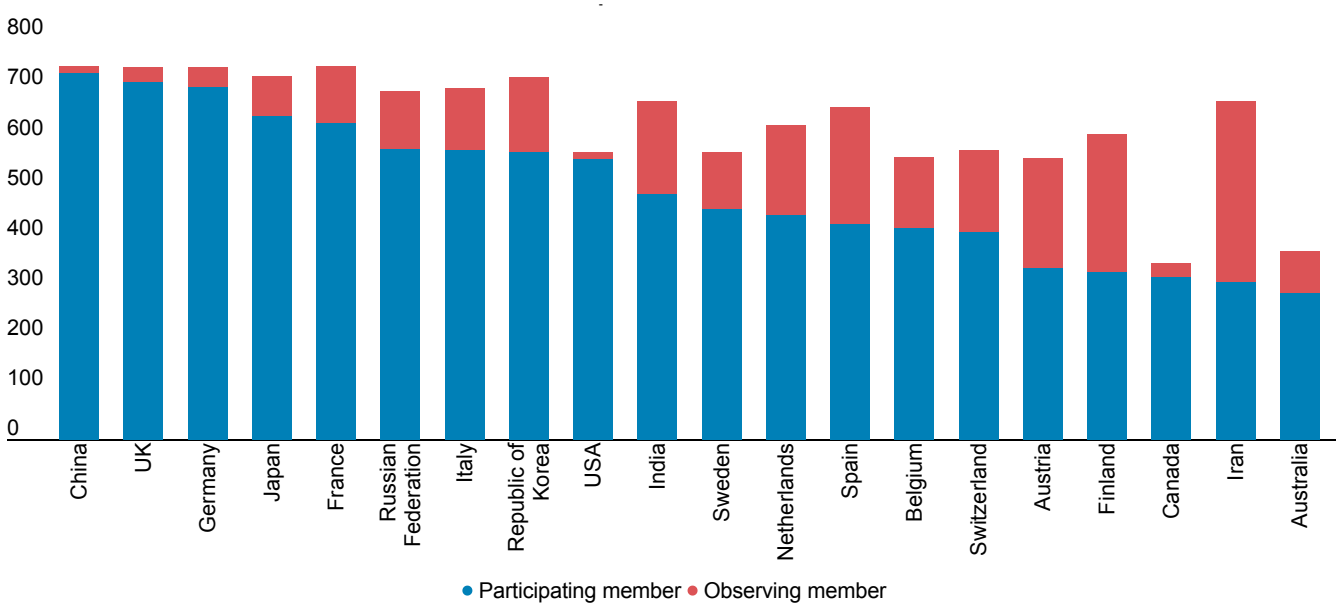

Figure 1. Participation in ISO TCs and SCs: Top 20 most active countries by TCs and SCs they are active in as participating members (November 2021).

Based on ISO membership data

Secretariat positions

Mere participation in committees does not necessarily translate into influence. What countries tend to look at to measure and compare their weight in ISO is the number of secretariat positions held within TCs and SCs.[36] Providing a secretariat position reflects the desire of a member to get more involved and allocate more resources to standardisation work (AFNOR, 2021).[37]

Here China occupies 6th place (with 68 secretariat positions,[38] around 9% of all positions), after Germany (132), the USA (98), Japan (81), France (79), and the UK (77) (Figure 2).

[34] Members decide whether they want to join a committee as a participating member (with an obligation to vote on all issues submitted for voting and to contribute to meetings) or as an observer (with the right to receive documents, submit comments, and attend meetings, but without the ability to vote).
[35] Data for ISO includes 20 out of the 22 ISO/IEC JTC1 subcommittees. The other two subcommittees (SC25 and SC41) are serviced by the IEC, so they are included in IEC statistics.
[36] The study only focuses on secretariat positions, and not on chairperson positions for the following reasons. According to ISO directives, the chairs of the TCs/SCs are nominated by the secretariat of the respective committee and approved by the Technical Management Board. In the majority of cases, the chairs come from the same country as the secretariat. (By comparison, IEC directives encourage secretariats to appoint chairs from a country/national committee other than their own.) Moreover, ISO does not provide information about the national committees that chairs are associated with.
[37] According to ISO rules, secretariats are expected to act in a purely international capacity, and not reflect the views and positions of the SDOs they represent. The same applies to the IEC. *For more details, see Annex 1.*
[38] And an additional three twin secretariats.

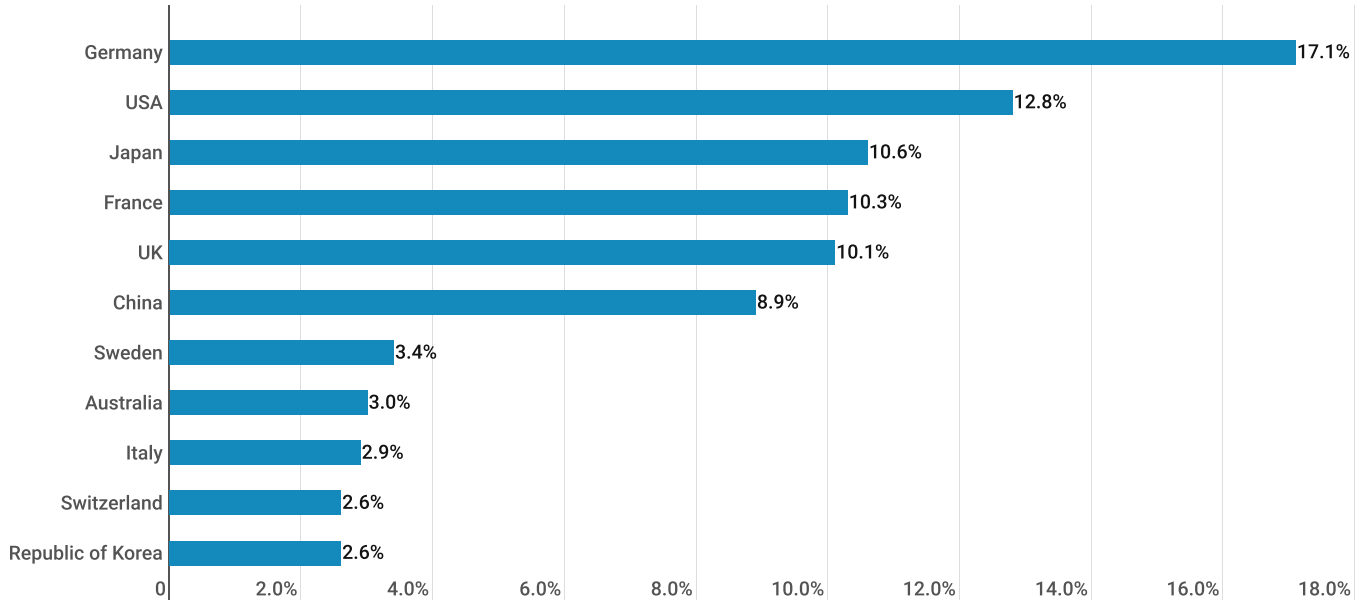

Figure 2. Distribution of ISO TCs and SCs secretariats: Most active countries (November 2021).

Based on ISO membership data

The number of secretariat positions held by China **has risen significantly**, from 6 in 2000 to 79 in 2019; this was followed by a decrease in 2020 (to 66), and then a slight growth in 2021, to 68 (Figure 3). By comparison, the number of secretariat positions held by Japan also grew constantly between 2000 (35) and 2021 (81). The Republic of Korea, too, has seen an overall increase in secretariat positions (from 0 in 2000 to 20 in 2021). France, Germany, and Canada were relatively constant in the number of secretariats held. The UK registered a decrease in secretariat positions up to 2012, followed by an increase up to 2017 and then a relatively constant number. For the USA, the number of secretariats has been oscillating over the years, but with a visible decreasing trend (from 139 in 2020 to 98 in 2021).

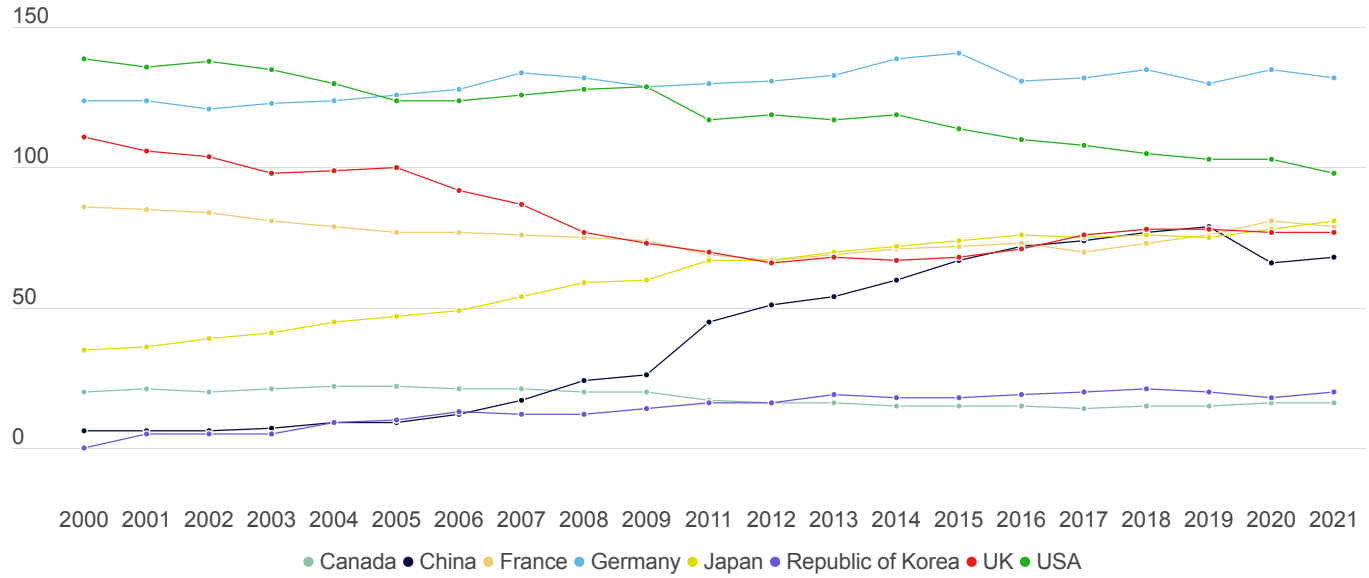

Figure 3. Evolution of ISO TCs and SCs secretariat positions held by selected countries between 2000 and 2021.

Based on ISO annual reports, 'ISO in figures' publications, and ISO membership data

Participation in digital-related committees

Beyond this general overview, we have also looked at China's participation in **TCs and SCs that are focused on, or are related to, digital technologies**. Our analysis has identified 100 such committees, dealing with issues ranging from cloud computing and AI, through intelligent transport systems and health informatics, to nanotechnologies and additive manufacturing. Also included are committees whose main focus is not on digital technologies, but which touch on digital-related issues (e.g. security of financial services, digital photography, medical software).

China is a **participating member in all 100 committees**, but **holds the secretariat for only 7**, representing 7% of all positions (Figure 4). The USA (24%), Germany (16%), and Japan (14%) are in the lead. Worth mentioning is that China holds no secretariat position within the ISO/IEC JTC1 on information technology, although it participates in all 22 SCs.[39]

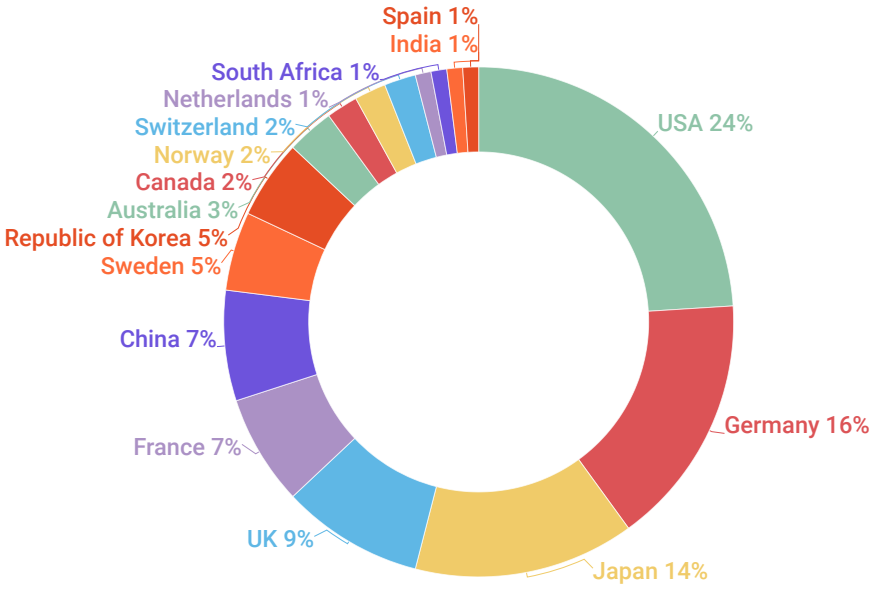

Figure 4. The distribution of secretariat positions within 100 digital-related ISO TCs and SCs (November 2021).

Based on ISO TC/SC information

Participation in the IEC

China joined the IEC in 1957. The country is present in several of the organisation's management bodies. It has one member[40] on the IEC Council Board. Three of the 11 members of the Market Strategy Board represent Chinese companies. In addition, 1 of the 15 members of the Conformity Assessment Board represents China.[41] The same applies to the Standardization Management Board, with 1of the 15 members representing China.[42] Yinbiao Shu currently serves as IEC President (2020–2022), having acted as President-Elect in 2019, and Vice-President between 2013 and 2018.

Participation in technical committees and subcommittees

As of 1 November 2021, China is an active participant in 188 TCs and SCs (94% of all committees) (Figure 5).[43] This is relatively similar to the participation of Germany (189 committees) and Japan (186 committees).

[39] Among the 22 SCs of the ISO/IEC JTC1 on information technology, the USA holds 7 secretariat positions, Japan 5, and the Republic of Korea 3. The rest are distributed between Germany (2), the UK (2), Australia (1), France (1), and India (1). The USA also holds the secretariat position for the overall JTC.
[40] With a term of office ending at the end of 2021.
[41] With a term of office ending at the end of 2021.
[42] With a term of office ending at the end of 2021.
[43] Data for IEC includes 2 of the 22 ISO/IEC JTC 1 subcommittees (SC 25 and SC 41). The other 20 subcommittees are serviced by ISO.

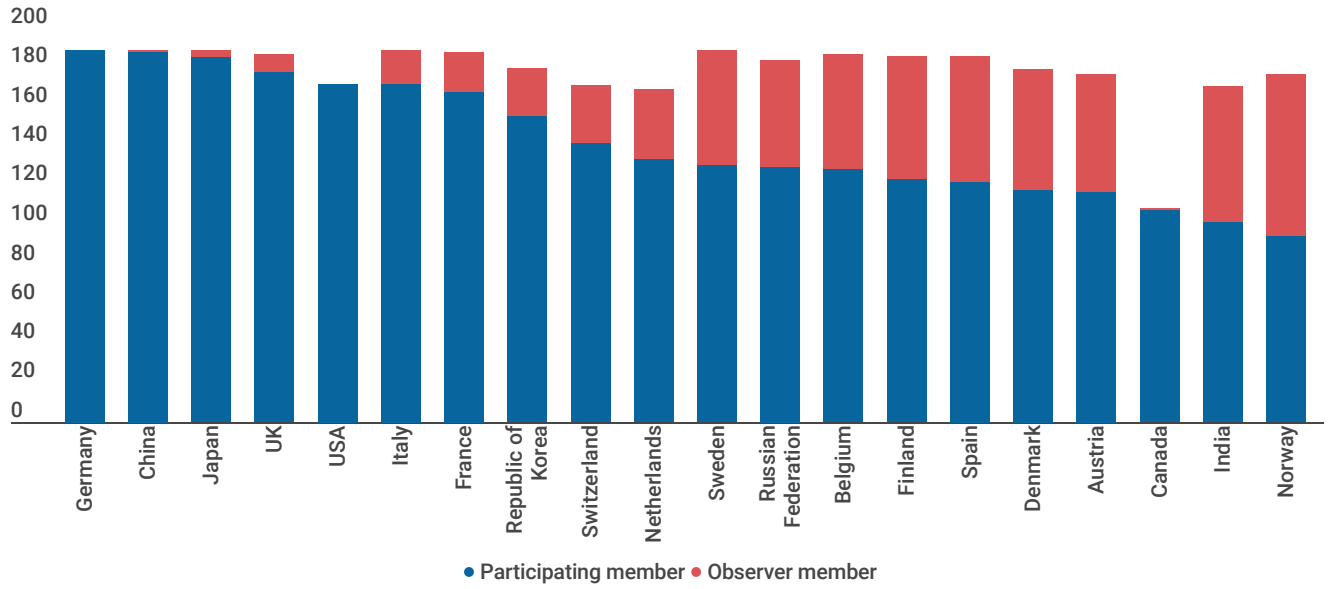

Figure 5. Participation in IEC TCs and SCs: Top 20 most active countries by TCs and SCs they are active in as participating members (November 2021).

Based on IEC membership data

Secretariat and chair positions

China holds the secretariat for 11 IEC TCs and SCs, representing 5.7% of all positions (Figure 6). In this regard, it occupies 7th place, after Germany (36 secretariats), the USA (27), Japan (23), France (22), the UK (19), and Italy (14).

China occupies the same 7th place (5%) when it comes to the number of TCs and SCs it chairs (10 committees), after Germany (57), the USA (28), France (22), Japan (19), Italy (14), and the UK (13).

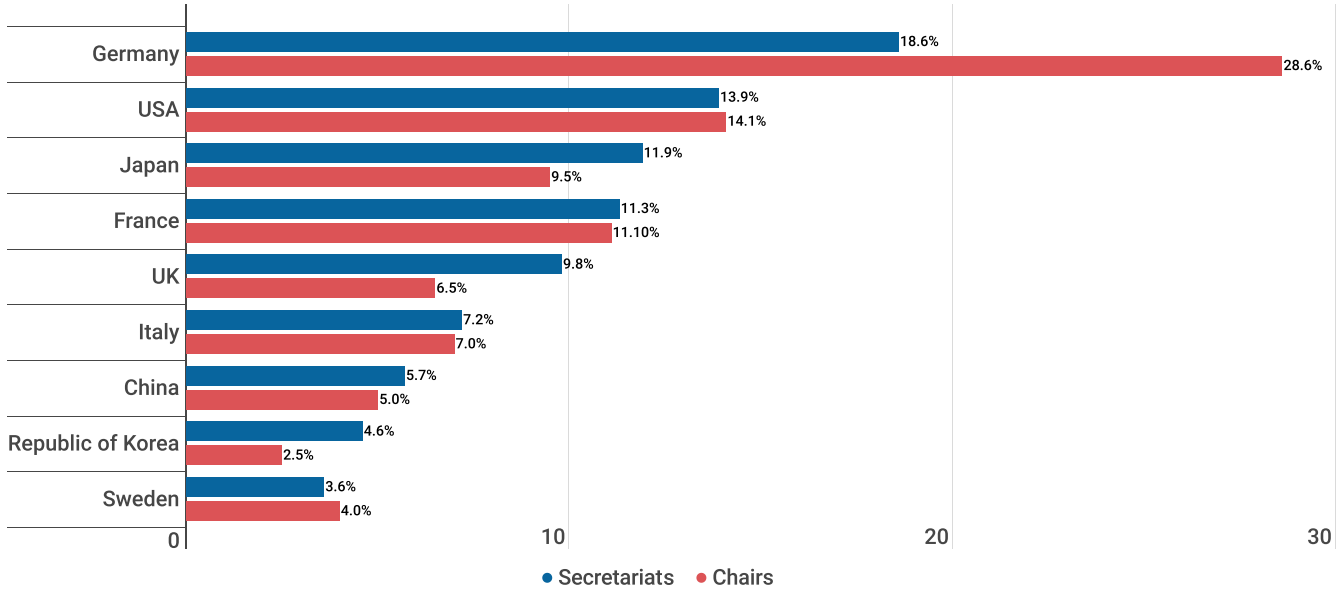

Figure 6. Distribution of IEC TCs and SCs secretariat and chair positions: Most active countries (November 2021).

Based on IEC membership data

Participation in ITU standardisation work

Overall participation

China joined ITU in 1920. Currently, it is the second country by the number of ITU members, after the USA (Figure 7).[44] In terms of high-level leadership positions, Houlin Zhao has been serving as ITU Secretary-General since 2015 (two consecutive mandates: 2015–2018 and 2019–2022). Before that, he served as Deputy Secretary-General for eight years, and as director of the Telecommunication Standardization Bureau (TSB) for the previous eight years.

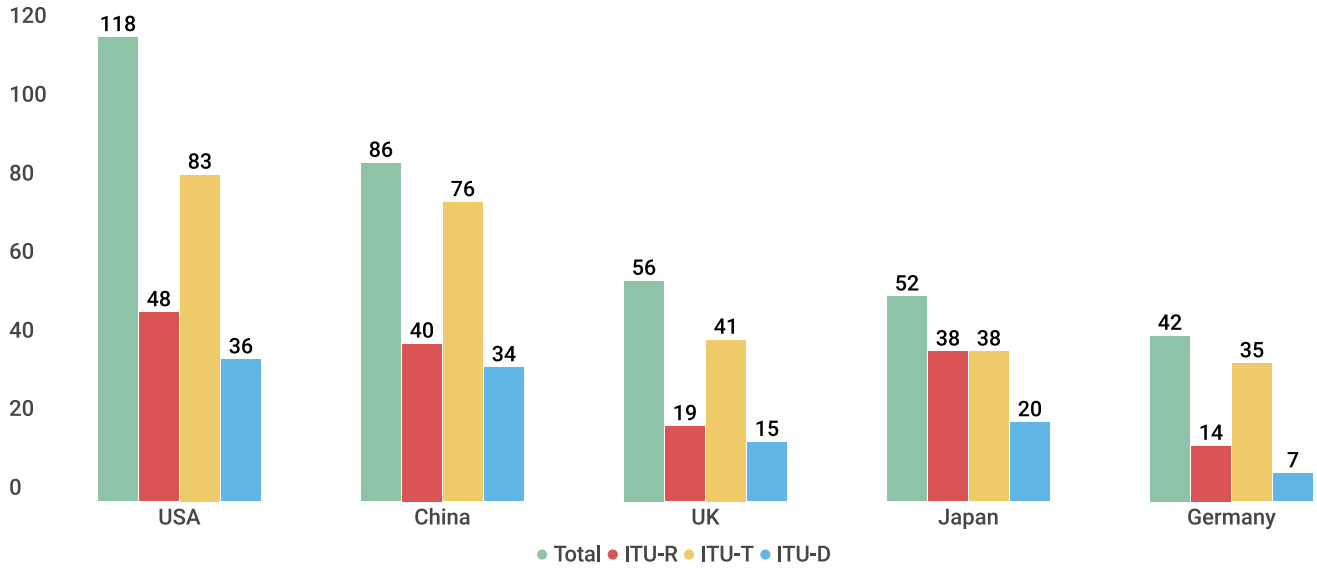

Figure 7. Top 5 countries with the highest number of ITU members (October 2021).

Based on ITU membership information

Box 11. ITU members

The USA has the largest number of entities registered as ITU members (118 entities, representing 10% of all ITU members). It is followed by China (86; 7%), the UK (56; 5%), Japan (52; 4%), and Germany (42; 3%) as the top five countries with the largest number of participants. Other countries with 20 or more entities participating in ITU (not included in the chart) are France (34 entities), Switzerland (21), Canada (20), and the Republic of Korea (20).

Looking at participation by ITU Sector, it can be observed that ITU-T attracts the largest participation. Among the five countries, Japan is the only one with an equal number of participants in ITU-T and ITU-R; for the rest, the largest number of members participate in ITU-T. Members often participate in more than one Sector.[45]

Participation in ITU-T

Study group chair and vice-chair positions

At ITU-T, the current study period (SP) (2017–2020), which should have ended in 2020, continues until spring 2022, due to the postponement of the World Telecommunication Standardization Assembly (WTSA).[46] For this period, there are 11 SGs. Each SG carries its work within WPs, each dealing with a set of questions. Thirty-three WPs are exploring a total of 129 questions.

Among the 11 SGs, **2 are chaired by Chinese entities** (Huawei and the China Academy of Information and Communi-

[44] Compared with ISO and the IEC, where there is only one formal member per country (the national bodies/national committees), ITU has a more complex membership structure, including member states, sector members, associates, and academia. *For more details, see Annex 1.*
[45] The statistics are based on ITU membership information. It is important to note that multinational companies have national branches that participate in ITU in addition to their main offices; these branches appear in ITU membership data as associated with the countries where they are registered. For example, Telefon AB - LM Ericsson is counted as a Swedish entity, while Ericsson Canada is counted as a Canadian entity. Other relevant examples are Huawei/Futurewei, Intel, Nokia, Orange, and Sony.
[46] WTSA-20 was initially scheduled for November 2020. It is now planned to be held in March 2022 in Geneva.

cations Technology (CAICT)), **and 2 by a Japanese company** (KDDI Corporation). The remaining 7 groups have chairs from Ghana, the Republic of Korea, the Russian Federation, Switzerland, United Arab Emirates, the UK, and the USA.

In terms of **SG vice-chairs, the largest number of positions are held by Chinese entities** (10), followed by entities from the Republic of Korea (8), Argentina (7), Tunisia (7), and Japan (6) among the top five (Figure 8).

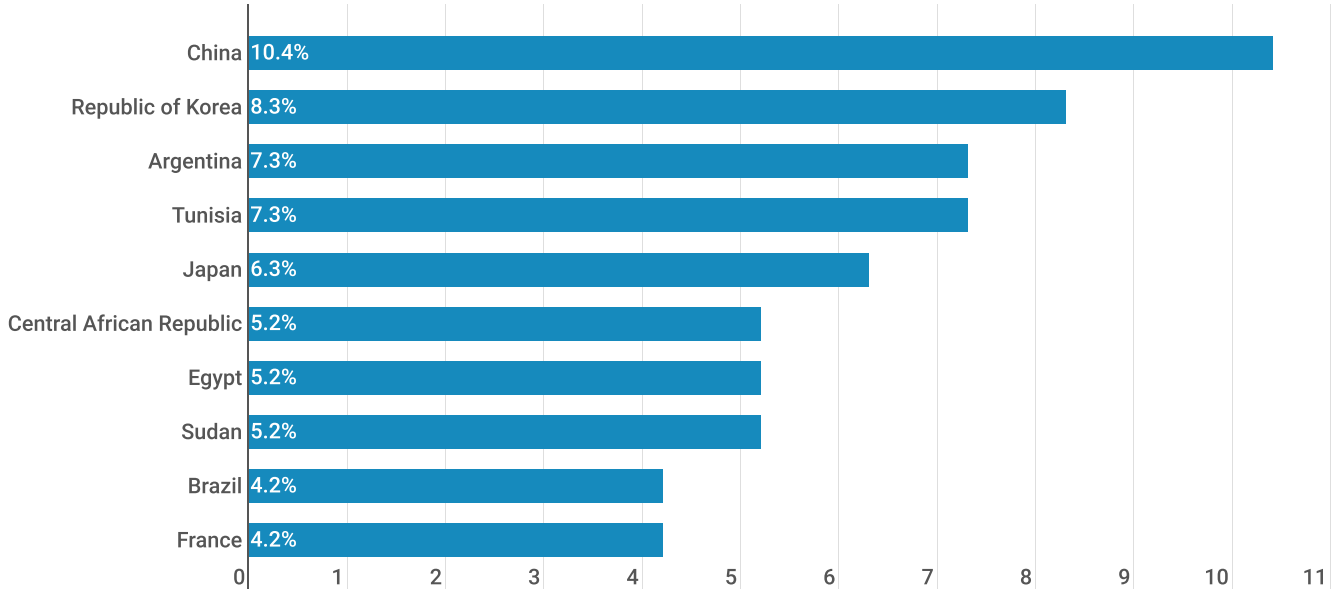

Figure 8. Distribution of ITU-T SG vice-chair positions | Top 10 countries.

Based on ITU-T SG information (SG management roles)

Working party chair, vice-chair, and rapporteur positions

Within the WPs, Chinese entities **hold the most chair positions**, followed by the Republic of Korea and Japan. When it comes to **vice-chair roles**, entities from China, Argentina, and the UK take the lead. The statistics differ slightly by one element: whether the entity in leadership position is associated with the country where it is registered (based on ITU membership information) (Figure 9) or with the country where its headquarters is based (Figure 10).

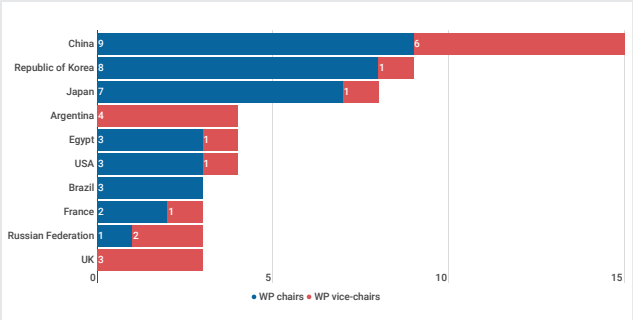

Figure 9. Distribution of ITU-T WP chair and vice-chair positions, by country where the entity is registered | Top 10 by total number positions.

Based on ITU-T information (SG management roles and ITU-T members)

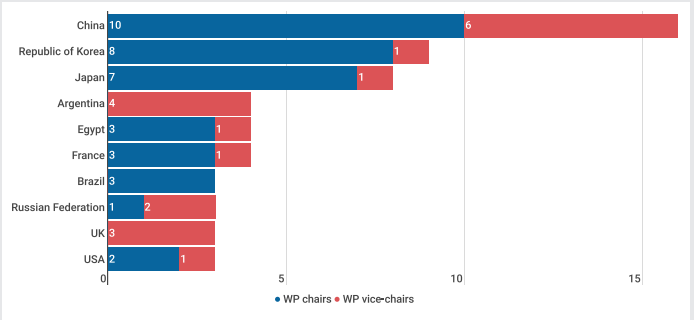

Figure 10. Distribution of ITU-T WP chair and vice-chair positions, by country where the entity's headquarters is based | Top 10 by total number of positions.

Based on ITU-T information (SG management roles)

Rapporteurs are individuals tasked by an SG with the responsibility to lead the work around a specific question or small groups of questions. For each question, there are usually several rapporteurs, co-rapporteurs, and/or associated rapporteurs. From a total of 317 such roles, 29% are held by representatives of Chinese entities, followed by entities from the Republic of Korea (13%), Japan (8%), the USA (5%), and Germany (4%) (Figure 11).[47]

[47] The stats consider the location of the entities as indicated in ITU-T data. For instance, Ericsson Canada is counted as a Canadian entity; Futurewei is counted as a US entity. However, the share of rapporteur positions stays relatively similar if the entities are counted by the countries they originate from (e.g. Ericsson as Sweden and Futurewei as China).

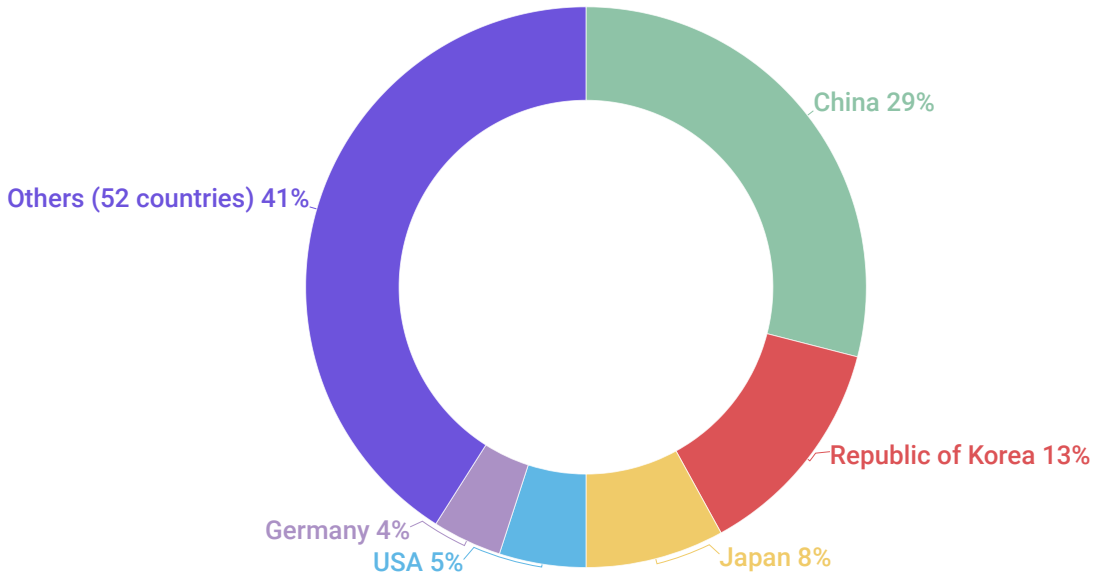

Figure 11. Distribution of ITU-T rapporteur positions, by country where the entity is registered.

Based on ITU-T information (SG rapporteurs)

Table 4. Most active entities within ITU-T, by number of positions held

Most active entities by the number of leadership positions within SGs and WPs	Most active entities by the number of rapporteur positions
Electronics and Telecommunications Research Institute (Republic of Korea) (11)	Huawei (China) (20)
Orange (France) (8)	Electronics and Telecommunications Research Institute (Republic of Korea) (19)
National Telecom Regulatory Authority (Egypt) (7)	China Telecom (China) (16)
Nippon Telegraph and Telephone Corporation NTT (Japan) (7)	China Academy of Information and Communication Technology (China) (13)
Huawei (China) (6)	China Unicom (China) (9)
National Telecommunications Agency (Brazil) (5)	Nippon Telegraph and Telephone Corporation NTT (Japan) (9)
Republic Ministry of Posts and Telecommunications (Central Africa) (5)	China Mobile (China) (8)
China Telecommunications Corporation (China) (5)	Nokia (Finland) (8)
China Academy of Information and Communication Technology (China) (5)	National Institute of Information and Communications Technology (Japan) (6)
	Orange (France) (6)

Based on ITU-T information (SG management roles, rapporteurs)

Study group roles: What changed between 2001 and 2021?

A comparison of the 2001–2004 and 2017–2020 SPs, in terms of distribution of chair, vice-chair, and rapporteur roles within ITU-T SGs and WPs among selected countries shows that the picture has changed substantially over the past 20 years. In the early 2000s, US entities had the largest share of roles: 22 chairs and vice-chairs (across SGs and WPs) and 60 rapporteurs. By comparison, Chinese actors had a very modest presence: 1 vice-chair and 3 rapporteurs. The situation is completely reversed in 2021: the US entities hold 5 chair and vice-chair roles and 16 rapporteurs, while Chinese entities lead, with 25 chairs and vice-chairs, and 89 rapporteurs.

Besides the significant differences between Chinese and US representation in these roles, Figures 12 and 13 show two other notable changes relative to the 2001–2004 SP: (a) the UK has a decreased representation in key roles (from 36 to 11), and (b) the Republic of Korea has a largely increased representation (from 11 to 56).

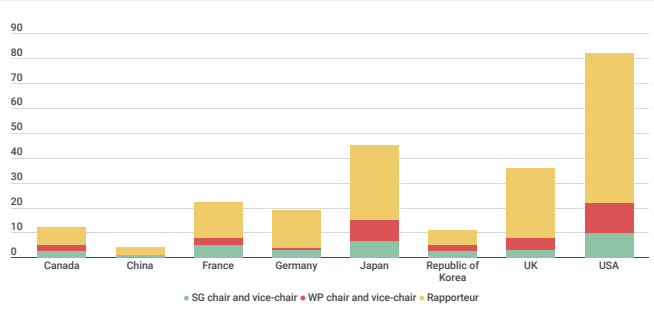

Figure 12. ITU-T SP 2001–2003 | Distribution of SG/WP chair, vice-chair and rapporteur roles between selected countries.
Based on ITU-T information (SG roles, 2001–2004 SP)

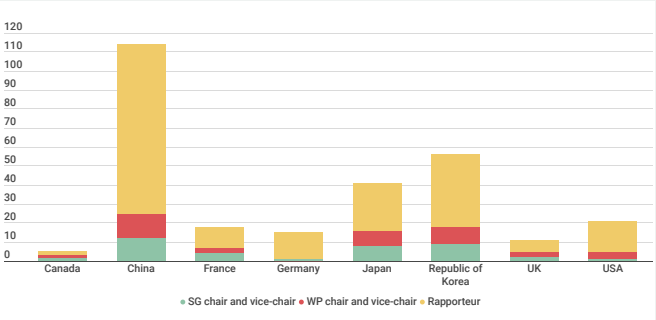

Figure 13. ITU-T SP 2017–2020 | Distribution of SG/WP chair, vice-chair and rapporteur roles between selected countries.
Based on ITU-T information (SG roles, 2017–2020 SP)

Focus group chair and vice-chair positions

Besides the 11 SGs, ITU-T also **hosts 8 focus groups (FGs)** (as of November 2021) dedicated to 'augmenting the Study Group work programme by providing an alternative working environment for the quick development of specifications'. FGs 'address industry needs as they emerge, and when they are not covered within an existing SG' (ITU-T, no date-b). Some of the topics they address include AI and IoT for digital agriculture, autonomous networks, AI for autonomous and assisted driving, and quantum information technology. FGs make their own decisions on working methods, leadership, financing, and types of deliverables. Within the FGs there are usually multiple working groups, topic groups, and ad-hoc groups focusing on specific issues.

When it comes to leadership positions within FGs and their internal structures (e.g. WGs, topic groups), the largest number of **chairs** are held by entities from the USA (15), followed by China (14), Germany (11), Japan (4), and the UK (3). The situation is slightly different for **vice-chair positions**, most of them being held by entities from China (15), followed by Germany (5), India (5), Japan (3), and the Republic of Korea (4) (Figure 14).[48]

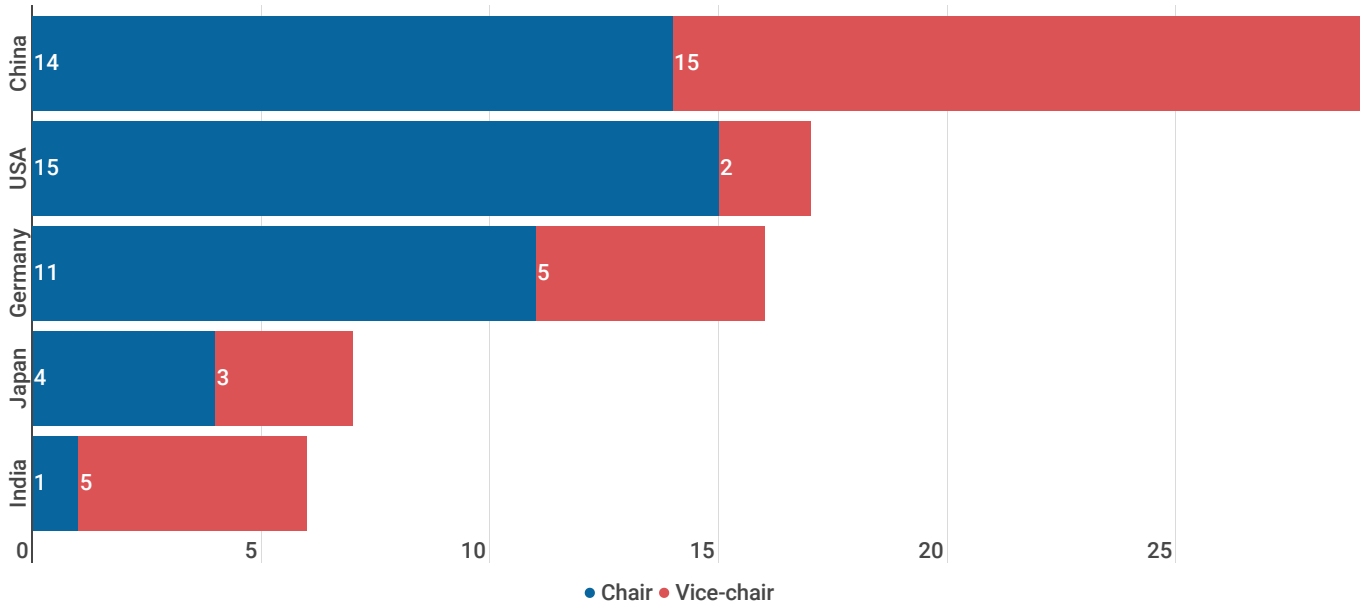

Figure 14. Distribution of ITU-T FG chair and vice-chair positions (including within internal structures) | Top 5 countries.
Based on ITU-T information (FG structure)

[48] The stats consider the entities by the countries they originate in. There are two positions held by Huawei subsidiaries located in Germany and Belgium; these have been counted as Chinese entities.

Participation in ITU-R

Although ITU-T is known as the ITU standardisation arm, technical standards are also developed at ITU-R.

There are six SGs at ITU-R, each with several WPs. The six groups are each **chaired** by an entity from Australia, Egypt, Japan, the Russian Federation, the UK, and the USA. When it comes to **vice-chairs,** Chinese entities have the same share of positions as those from India and Morocco (6 each), followed by France, the Republic of Korea, and the Russian Federation (5 each), while the rest of the 57 vice-chair roles are distributed among entities from 37 countries (Figure 15).

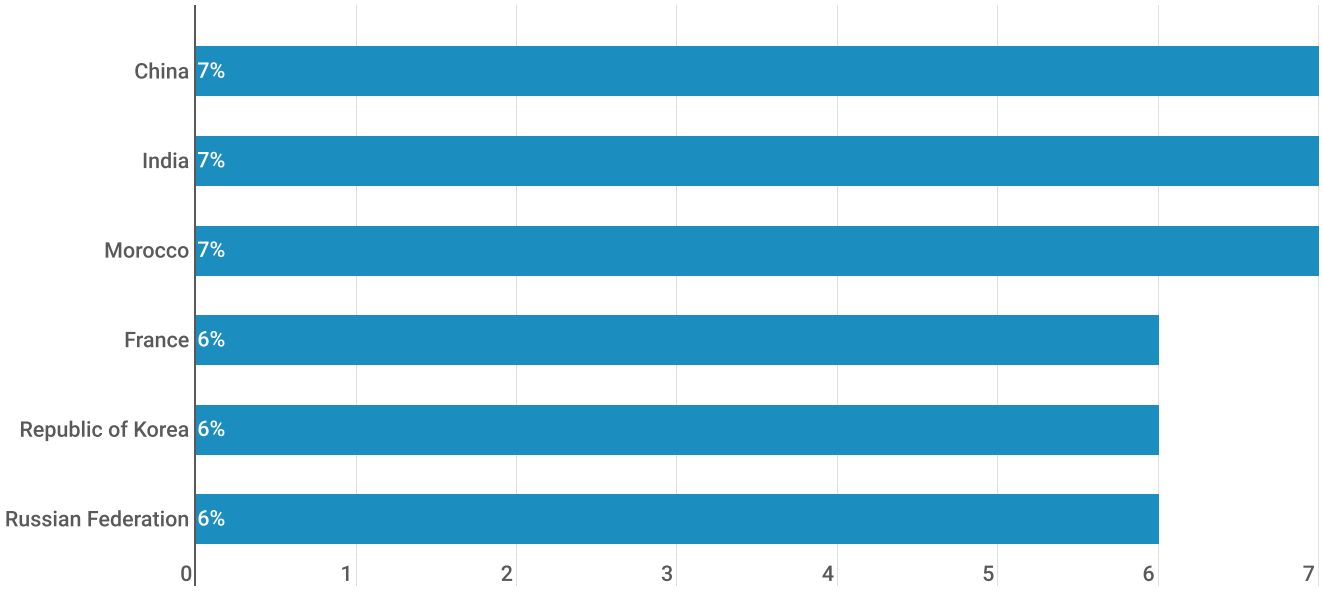

Figure 15. Distribution of ITU-R SG vice-chair roles | Top 6 countries.

Based on ITU-R information (SG leadership)

Within **WPs**, the largest number of **chair positions** are held by entities from the USA. The same goes for **vice-chairs**, where the USA is followed by China. The overall statistics differ slightly depending on one element: whether the entity in the leadership position is associated with the country where it is registered (based on ITU membership information) (Figure 16) or with the country where its headquarters is based (Figure 17).

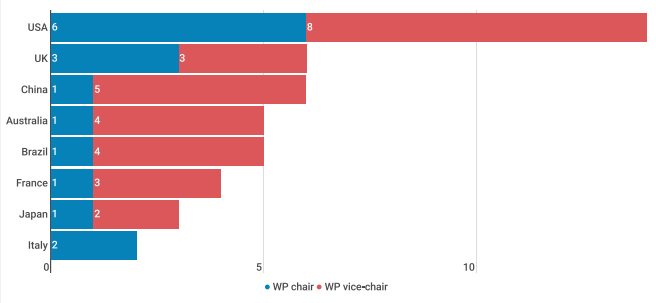

Figure 16. Distribution of ITU-R WP chair and vice-chair positions, by country where the entity is registered | Most active countries.

Based on ITU-R information (SG/WP management roles)

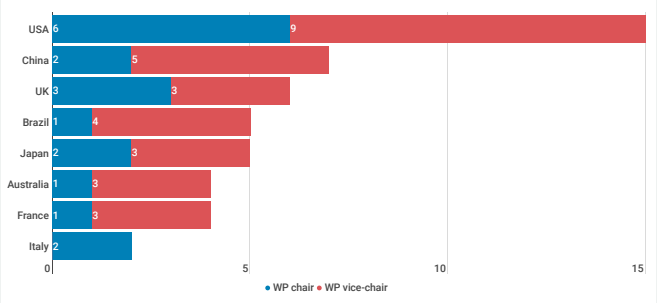

Figure 17. Distribution of ITU-R WP chair and vice-chair positions, by country where the entity's headquarters is based | Most active countries.

Based on ITU-R information (SG/WP management roles)

Reviewing the numbers

Looking at the three organisations – the IEC, ISO, and ITU-T – it is clear that China is among the most active participants, including in terms of leadership positions. There are, however, some differences in how China ranks compared with other countries in the IEC and ISO, on the one hand, and the ITU-T on the other.

At ISO, China is a participating member in the largest number of TCs and SCs (732), followed by the UK (714) and Germany (703). But it only occupies 6th place (9%) when it comes to secretariat positions within TCs/SCs. Germany is leading in secretariat positions (17%), followed by the USA (13%), Japan, France, and the UK (around 10% each). Among the 100 digital-related TCs/SCs analysed, China holds the secretariat for only 7%; the leaders are the USA (24%), Germany (16%), and Japan (14%).

The situation is relatively similar at the **IEC**. China is a participating member in 188 TCs and SCs. By comparison, Germany is a full member in 189 committees, and Japan in 186. China holds the secretariat for only 5.7% of TCs/SCs, and the chair for 5% of the committees, occupying 7th place in both cases. Germany is again the leader in terms of both secretariat (18.6%) and chair (28.6%) positions. The USA, Japan, France, the UK, and Italy are also positioned ahead of China in terms of TC/SC chair and secretariat positions.

The high number of ISO and IEC committees China participates in can be seen as a reflection of the country's interest in contributing to standard-setting processes across a wide range of areas. But this interest does not automatically translate into influence, especially because China holds significantly fewer leadership positions within TCs/SCs compared, for instance, with Germany, the USA, and Japan. This may mean different things. For instance, it may be that China is still going through what some experts call a 'learning and adaptation phase' within these SDOs.

The situation is different at **ITU-T**. The USA leads by the number of ITU (118) and ITU-T (83) members, with China coming in second (86 ITU members and 76 ITU-T members). UK, Japan, and Germany are also among the top five countries by number of ITU and ITU-T members. But China is ranking higher in terms of leadership positions. While at parity with Japan for SG chair roles (2 each), China holds the largest number of SG vice-chair positions (10.4%), followed by the Republic of Korea (8.3%), Argentina (7.3%), Tunisia (7.3%), and Japan (6.3%). Chinese entities also have the largest number of WP chair and vice-chair positions, followed by the Republic of Korea, Argentina, Japan, and Egypt. When it comes to rapporteur roles, Chinese actors lead with 29%. Entities from the Republic of Korea come next with only 13%, followed by Japan (8%), the USA (5%), and Germany (4%).

The fact that Chinese entities hold many chair, vice-chair, and rapporteur roles allows them to 'have a prominent role in framing the parameters for standardisation processes' (Voo and Creemers, 2021). But, when assessing the overall power that such positions offer, consideration should be given to the fact that decisions within the different ITU-T bodies are largely consensus-based. *See Annex 1 for details on the standards approval process*.

Box 12. Multistakeholderism and inclusiveness

Some of the organisations that are part of the international standardisation ecosystem are praised for being 'more multistakeholder' than others. But critics argue that multistakeholderism does not necessarily equate with inclusion (Voo, 2020). Given the way it functions, it better suits developed countries, whose stakeholders can afford to participate in standardisation work (in terms of personnel, financial resources, capacity, etc.). But it comes at the disadvantage of developing countries, whose actors often lack such resources. So the end result is an ecosystem where actors from more developed countries tend to dominate.

What is also important to note is that China's growing involvement in these three SDOs has happened in the context of a shifting standardisation landscape, where some actors are less involved than they used to be, while others become more active. At ISO, for instance, the number of TC/SC secretariat positions held by China has increased considerably between 2000 and 2021, from 6 to 68. But Japan and the Republic of Korea have also seen an overall increase in the number of secretariat positions between 2000 and 2021 (35 to 81 for Japan, and 0 to 20 for the Republic of Korea). And while the number of secretariats has remained relatively constant for France, Germany, and Canada, it has been oscillating for the USA, but with a visible decreasing trend (from 139 in 2000 to 98 in 2021). At the ITU-T, the Western industry has reportedly reduced their participation, creating a void that was easy to fill in by the Chinese industry when they started becoming more active.

Box 13. China in other standard-setting bodies

Beyond the IEC, ISO, and ITU, Chinese actors are also active in other SDOs. As illustrated in the case studies we cover in this report, China has the largest number of individual members within 3GPP, and it also leads in terms of the number of leadership positions within the organisation's technical bodies. At the IETF, Chinese actors have very little representation in WG leadership positions, but they are very active in submitting documents (surpassed only by US actors). Companies such as Alibaba, Baidu, Huawei, Tencent, and ZTE are advanced members of the IEEE Standards Association. Within the IEEE Computer Society, China comes second – after the USA – in terms of chair and vice-chair positions within the society's 14 committees.

Criticism regarding China's tactics in SDOs

In this section we look at several areas of criticism raised by various stakeholders regarding China's participation in international standardisation.

Many proposals, often of low quality

One criticism brought to Chinese stakeholders' participation in SDOs is 'They submit a large number of proposals that are low-quality or irrelevant to market needs in some industries. [...] This takes valuable time and resources away from considering serious proposals' (US-China Business Council, 2020).

Do Chinese actors submit many proposals in SDOs? They seem to do so. According to SAC (2020b), China put forward 238 new standard proposals at ISO and the IEC in 2019. A review of written contributions to three ITU-T SGs between 2009 and 2020 shows that China submitted the largest number of contributions (3021), followed by the Republic of Korea (2164) (Voo, 2020). At the IETF, the number of contributions submitted by Chinese authors has increased continuously since 2000, while the number of contributions from US authors has decreased. In 3GPP, Huawei is credited as being the largest contributor of draft documents.

Irrespective of where one actor comes from, it is true that if it submits a large number of proposals, 'everything becomes a numbers game'.[49] The more proposals there are, the less time and resources are available to tackle them. But the number of proposals should also be seen as a logical reflection of one actor's interest in standardisation work and the resources it dedicates to it. In the case of China, it may be a combination of government encouragement and industry interests (including the incentives offered for contributions to SDOs) that drives the large number of proposals. But it does not automatically mean that there is an overarching strategy to overwhelm technical committees with proposals. Moreover, as an interviewee noted, 'If there were more stakeholders contributing and bringing more proposals, there would be a more virtuous circle of interactions happening.'[50]

When it comes to the quality of Chinese proposals, there are complaints that some of them are neither technical nor do they address a real problem or suggest a real solution. This could be tied to different reasons, such as the fact that some of the actors are still on a learning curve when it comes to engagement in SDOs, and the reward system that seems to encourage quantity over quality. At the same time, it is said that low-quality proposals come from other actors as well. What tends to be different is that these actors find it easier to suppress their proposals if flaws are identified and it becomes clear that they cannot be supported.

There are also observations that the quality of Chinese proposals has increased over the years (as resources have been allocated to training SDO participants), and that it is unfair to qualify the majority of them as trivial.[51]

One other aspect that adds complexity to standards development processes is that sometimes similar proposals are put forward in different SDOs. This would indeed mean taking resources away from other work, considering the need for a coherent standardisation ecosystem, with no duplication. But here, too, forum shopping is not a tactic employed only by Chinese actors. Further research into the extent to which forum shopping is carried out by different actors within different SDOs could provide additional insights into the complexity of the standardisation ecosystem.

Box 14. Searching for expertise

There are anecdotes[52] that Western-based standardisation experts (in particular those with leadership positions within the technical groups of some SDOs) are being head-hunted by Chinese companies and offered consultancies and advisory roles. This could be seen as part of the effort to increase the quality of Chinese contributions. But it is also seen by some as a way to leverage certain proposals, in the idea that if someone with credibility in SDOs endorses those proposals, that would influence other actors to do the same.

[49] Interview with an SDO staff member, September 2021.
[50] Interview with an SDO staff member, August 2021.
[51] Interviews with SDO participants, July–October 2021.
[52] Interviews with SDO participants, July–October 2021.

Abusing leadership positions

One other concern is that Chinese actors may abuse leadership positions within technical groups and 'leverage their authority to promote Chinese-led proposals without consensus or block certain proposals for the purposes of economic advantage or national prestige' (US-China Business Council, 2020).

The extent to which this concern reflects reality seems to be unclear. When it comes to blocking proposals, opposing views argue that Chinese actors rarely block anything; and even if they do, it is within anyone's right to express disagreement. And while there are anecdotes that sometimes chairs/vice-chairs/rapporteurs would use their roles to 'push proposals through', there are also arguments that such behaviour is not new within SDOs, and those manifesting it 'don't break the rules, but rather play with them cleverly'.[53]

In general, consensus rules are seen to be functioning relatively well in preventing any one actor from gaining an advantage because they have large delegations or hold leadership positions. The New IP proposal (covered later in the report) is an illustration of this. The work item was not approved because it did not gain consensus. What could help strengthen this is having more actors coming to the table and contributing to the debates.

What Chinese actors may be better at compared with other actors is forming coalitions and gaining support for their proposals from other players (e.g. they can gain such support easier because they have the resources to participate across a large number of groups). But such practices are part of the game and others play it too. The fact that EU countries often tend to act as a bloc is an example. And it is worth mentioning that concerns about coordinated approaches leading to 'bloc voting' and the capturing of SDO processes also used to be raised (in particular by US actors) with regard to EU participation (Witte, 2003).

Violating the spirit of SDOs

China's active participation in SDOs is sometimes criticised as 'violat[ing] the spirit of these organisations, making them less effective for other members and in some cases deliberately attempting to undermine U.S. technological leadership' (USCC, 2020).

While many of the concerns related to China's growing involvement in standardisation may be legitimate, they do not mean that Chinese actors are not playing by the rules. China wants to be recognised as a centre of technological excellence and its participation in SDOs reflects this goal. If this participation involves large delegations, many proposals, and attempts to form coalitions, it does not mean that rules are being broken. As for 'undermining' others, 'It might be a side-effect, but [it is] probably less of a master plan.'[54]

Moreover, China's participation in SDOs is not necessarily just an extension of the broader China-USA economic and tech competition. It is about companies going to the SDOs to have their technological developments recognised internationally; ultimately, this can generate economic advantages.

In international standardisation, all countries and all companies have interests they all try to defend. If one actor can get its standard proposals approved, it means it plays the game well. And if the standard was approved not necessarily because of its quality, but simply because of games well played, this may backfire if the market decides not to follow the standard. This is a risk that actors are well aware of and not necessarily willing to take.

Generally speaking, SDOs have well-established procedures and practices meant to ensure that everyone participating in international standard-setting abides by the same rules and no one actor can manipulate the system to their advantage. As some actors become more involved, this may indeed put some pressure on the rules, and increase the need for the SDOs themselves and participants to ensure that breaches do not occur.

[53] Interviews with SDO participants, July–October 2021.
[54] Interview with an SDO participant, July 2021.

Case studies in international standard-setting

China's involvement in the development of international digital standards relates to a wide range of technologies. Key areas of interest cover technologies seen as being of strategic importance for the country's economy and national security, and closely aligned with industrial and innovation policies and with national standardisation priorities.

China is pursuing two main goals. The first is to catch up and have a stronger presence in rather mature standardisation processes for technologies that have been around for a while. The second is to play a prominent role in the development of standards for new(er) technologies, where there are either gaps in standardisation or the standardisation processes are being shaped.[55] To illustrate, within the ISO/IEC JTC1, China took the initiative to convene work on smart cities, quantum computing, and brain-machine interfaces.

In this section of the report, we explore five case studies of Chinese involvement in the development of international standards for digital technologies. The first two studies look at specific proposals put forward by Chinese actors at ITU (both of which have attracted significant media attention): a proposal for ITU-T to take up work on designing a new protocol (the New IP proposal) and a proposal for standardising facial recognition systems in visual surveillance. The other three case studies focus on the broader picture of the Chinese contribution to international standards development processes related to 5G, autonomous vehicles, and quantum computing.

New IP: Designing a new internet architecture?

Proposals at ITU-T

In September 2019, a contribution titled *New IP, Shaping Future Network* was put forward at ITU-T's Telecommunication Standardization Advisory Group (TSAG),[56] by Huawei, China Mobile, China Unicom, and MIIT. The contribution suggested that **ITU-T considers 'designing a new information and communications network with [a] new protocol system that satisfies and serves for the future'**. Such work, it was said, was needed because the existing network is facing a number of challenges (e.g. with regard to performance, structure, security), which ITU-T should analyse and then 'provide a development path for the future network for the next decade' (Huawei et al., 2019). This contribution was accompanied by a presentation by Huawei that highlighted possible elements of such a new protocol system, called New IP (Huawei, 2019).

The mere idea that a New IP was promoted by Chinese entities attracted significant attention, making it rather difficult to differentiate hype from reality. But, as the Internet Corporation for Assigned Names and Numbers (ICANN) and others noted, there was no concrete proposal for a new standard, or sufficient public information to provide a clear description of what the New IP is, or a clarification of whether the New IP was meant to be deployed in specific scenarios or completely replace the existing protocol. What various documents (e.g. an overview Huawei (no date) published on its website) described was an architecture that would come with several elements, such as variable-length addresses; an approach enabling data packets to embed contracts to be enforced by intermediary network elements; and the concept of 'Many Nets' where a single network would be replaced with many networks interconnected via gateways (Durand, 2020).

In addition to the proposal put forward at TSAG, Huawei and others also presented contributions at SG11 and SG13 (in the context of preparations for WTSA) proposing new questions for the groups to tackle during the next ITU-T SP. The four proposed questions introduced a new term – Future Vertical Communication Networks (FVCN) – but included elements of the previous New IP, such as deterministic networking and ManyNets. These, again, were not proposals for standards/specifications as such, but requests that FVCN-related issues be discussed by ITU-T SGs in the upcoming SP. The groups were not able to agree on approving the proposed questions or reach a consensus to continue discussions on these matters.

[55] This is a goal shared by other standardisation actors too. For instance, the European Commission's rolling plans for ICT standardisation encourages European actors to engage in the identification of gaps in international standardisation for digital technologies, and to contribute to the development of related standards (European Commission, 2021). Such issues are also expected to be covered in the upcoming standardisation strategy.
[56] TSAG acts as an advisory body to SGs, members, and staff. It reviews strategies and priorities of the ITU-T, its operational and financial plans, and serves as the preparatory group for WTSA. TSAG also reviews progress in the implementation of the ITU-T work programme and provides guidelines for the work of SGs.

Box 15. Elements of the New IP elsewhere and related criticism

ITU-T was not the only place where elements of the New IP architecture were presented. At the IETF, Huawei/Futurewei presented some details at a side meeting organised in the framework of the IETF 106 meeting (November 2019) and at a virtual session at IETF 107 (March 2020) (Hogewoning, 2020). A presentation titled *New IP: A Data Packet Framework to Evolve the Internet* was given at the 2020 IEEE 21st International Conference on High Performance Switching and Routing as an invited paper (Li et al., 2020).

Several interviewees noted that the New IP idea did not gain traction at the IETF for two main reasons. First, because the IETF does not see the internet as an overall architecture: 'If you come with a mind set that you want an all encompassing architecture top-down, then the IETF model won't work. The IETF likes to take elements of a proposal and progress on those.' Apparently, there were elements of the proposal that the IETF might have considered to take on, but the proponents only wanted to discuss the entire architecture. And, second, because there was little clarity on the problem that the New IP was aiming to solve and how this would have been done.[57]

What was also criticised was the perceived forum shopping approach. There were complaints that a lot of time was spent in many places discussing a proposal that was not clear or detailed enough. And there was also speculation about a potential 'strategy' behind this approach. Maybe the intention – some said – was not to have New IP accepted for discussion at the IETF.[58]

Concerns and criticism

From statements arguing that the New IP leads to 'more centralised, top-down control of the internet' (Gross and Murgia, 2020) to worries about content monitoring, the New IP[59] idea raised several concerns.

Compatibility. The technical community pointed out that the envisioned architecture cannot be compatible with the existing IP-based infrastructure. As such, it would either replace this infrastructure or run parallel with it. If it is done in parallel, it would require gateways to interconnect with the current network, generating complexity and significant costs for network operators.

Insufficient evidence that the described challenges of the current system cannot be addressed in the current framework, or that the proposed architecture would address them effectively. For instance, it is argued that there is no need for a new architecture to enable interconnection between heterogeneous access networks, because the internet itself was designed, and is able, to interconnect different network types, and it has managed to adapt over time to the emergence of new network technologies. Many of the problems associated with interconnecting networks are not technical, and a new architecture would not solve them (Sharp and Kolkman, 2020). Overall, it was argued that the challenge described could be addressed by 'continuing to evolve the existing IP protocol suite' (IETF, 2020).

Reiterating proposals from the past. It was argued that the New IP came with technical proposals that were made in the past. Although they may work from a technical point of view, they were not deployed for various business reasons. It was not clear why approaches that failed to get deployed in the past would be deployed now.

Overlaps with ongoing work. It was pointed out that some of the elements that the new architecture would address are already being studied (and standards are being developed) by bodies such as the IETF, IEEE, 3GPP, and even ITU-T SGs themselves. 'Creating overlapping work is duplicative, costly, and in the end does not enhance interoperability; proposals for new protocol systems and architectures should show why existing work is not sufficient' (Sharp and Kolkman, 2020).

Uncertainty and costs. It was argued that, although the details of a New IP were not very clear, discussing a new internet architecture could generate uncertainty across the industry and affect investments in internet capacity and access technologies (Austria et al., 2020a). Moreover, deploying a new architecture would come with significant costs and economic burdens for governments (in particular in developing countries), businesses and consumers (Austria et al., 2020b; 2020c).

Privacy and content monitoring. Elements of the New IP proposal indicate that users' privacy would be affected, and pervasive content monitoring could be made easier. As ICANN explains, 'It would allow any intermediary element (router, switch, etc.) to have full access to exactly which user is doing what. Also, content providers would have access to the identity of every user connecting to them' (Durand, 2020).

[57] Interviews with IETF participants, July–September 2021.
[58] Interviews with SDO participants, July–October 2021.
[59] Although the name *New IP* was later dropped from presentations and proposals related to the new architecture, we will be using it in this section for consistency.

Top-down governance and central shut-down. The September 2019 proposal suggested that ITU-T 'shoulder[s] the responsibility of a top-down design for the future network'. This generated fears that a new governance model for the internet is being envisioned, with top-down control. As one interviewee noted, 'Governance for a technology tends to follow the structure of how the technology is standardised: if the development of the standard is top-down, the governance processes that follow would then tend to be the same.'[60] Huawei rejected such claims, saying the proposal has nothing to do with governance models. It did admit, however, that a 'shut-off protocol' is envisioned, but noted that its goal is to contribute to the prevention of distributed denial of service (DDoS) attacks, by allowing 'the attacked network to signal to the attacker's source network the request for preventing further attack traffic'. Such concepts, Huawei claims, are similar to other proposals put forward by US researchers or discussed at the IETF (Huawei, no date). Whether or not such statements hold water, standard proposals that would embed strict controls would have little (if any) chances to get approved at ITU, where consensus is required (Voo and Creemers, 2021).

Inadequate venue for discussion. On the process itself, there was discontent that ideas for new internet protocols and architectures were being discussed at ITU, as opposed to the IETF. There were concerns that this would be 'an opportunity to steer away from the traditional bottom-up decision-making model' (RIPE NCC, 2020) and that having the IP reinvented at ITU could eventually mean that the management of that protocol would fall under ITU's remit. Critics argued that 'new work at the ITU-T should focus on telecommunications aspects within its expert remit and not a fundamental re-design of the internet's architecture' (Austria et al., 2020b; 2020c).

What was said less (if at all)

Is the New IP the only thing to pay attention to? Proposals for new networks, including non-IP ones, are often put forward in SDOs. One example is the Non-IP Networking (NIN) discussed at ETSI, in the framework of a dedicated Industry Specification Group (ETSI, no date). Like the New IP, NIN claims that TCP/IP is no longer suitable for new types of applications. And, also like the New IP, it would not be compatible with the current IP-based system (Durand, 2021). NIN has not attracted anything close to the attention the New IP has, and this should be of concern. Because, if the goal is to preserve the internet as a global and interoperable network, and to avoid risks that could be posed by new networks, then attention should be paid to all proposals for new architectures, no matter where they are discussed and who puts them forward.

Was internet surveillance the end goal of the proposal? This seems to be more of an assumption than a certainty. As the technical community noted, some of the envisioned elements could indeed make it easier to monitor internet content. And it is also worth mentioning that user identification and central shut-down – two of the concerns raised regarding the New IP – are in fact already possible in the current architecture, through the intermediaries (i.e. internet service providers). The New IP might have led to a simpler, more 'automated' process.

Then what is the real 'game'? The idea that the IP needs to be updated is not new (other examples include the QUIC protocol proposed by Google, and Mozilla's push for DNS over HTTP). One of the novelties in the New IP was that the proposal came from Chinese actors (previously less active in this space), whose ambitions to become trend-setters in research and engineering thus gained more visibility. The real game was most likely the possibility of Huawei shaping the standards development process in a way that would give them a jump-start in the market compared to others.

Are Chinese actors playing according to the rules? In the whole debate on whether anything related to the internet architecture should be discussed at ITU or left only to the IETF, one thing was largely missed: Huawei wanted to discuss the overall proposal with others (for context, see Box 15). The company seemed ready to reach some compromise for pragmatic reasons; it cannot risk losing large markets due to standards incompatibility. Huawei did not break any written rules of the standardisation ecosystem; it invited others to 'an open and free discourse', following 'the established path for developing internet technologies in standard bodies' (Huawei, no date).

Is the New IP dead?

While the original proposals put forward at ITU-T were shelved, elements of the proposed architecture appear to show up in different places from time to time. For example, an internet draft titled *Forwarding Layer Problem Statement* was put forward at the IETF by Futurewei in March 2020; the draft was revised three times, the most recent version dating June 2021 (Bryant et al., 2021). Several side-discussions on Future Internet Protocol Evolution and 6G-and-IP have been happening on the margins of IETF meetings,[61] one of the intentions being to form research groups within the Internet Research Task Force (IRTF) to further explore these issues. At ITU-T, proposals on a

[60] Interview with a staff member of a technical organisation, July 2021.
[61] Such discussions happened, for instance, in the context of IRTF side-meetings co-located with IETF 108 in July 2020 (Perkins, 2020) and IETF 109, in November 2020 (IETF, no date-a).

polymorphic network (described as a new type of network architecture and a potential network model for 6G) were submitted at SG13 in March 2021 (ITU-T, no date-c).

Box 16. Chinese actors at the IETF

The New IP debate has brought up concerns that Chinese actors tend to prefer ITU for standardisation work, bypassing other SDOs where member states do not have a say. While such concerns remain a matter of debate, we wanted to see the extent to which Chinese actors contribute to the IETF's work. This is what we found.

The IETF has seven areas with a total of 124 WGs. Each group typically has two co-chairs (there are also exceptions). China has little representation when it comes to WG chair positions: only 3%. Germany has a similar percentage of representation at this level. The USA leads considerably, with 56% of chairs being associated with US entities (Neaher, 2021).

In terms of participation in IETF work, the organisation offers insightful statistics (IETF, no date-b). One element that is tracked is the **number of document (draft/RFC) authors per country.**[62] Here the USA leads, followed by China, Germany, Japan, and the UK (Figure 18).

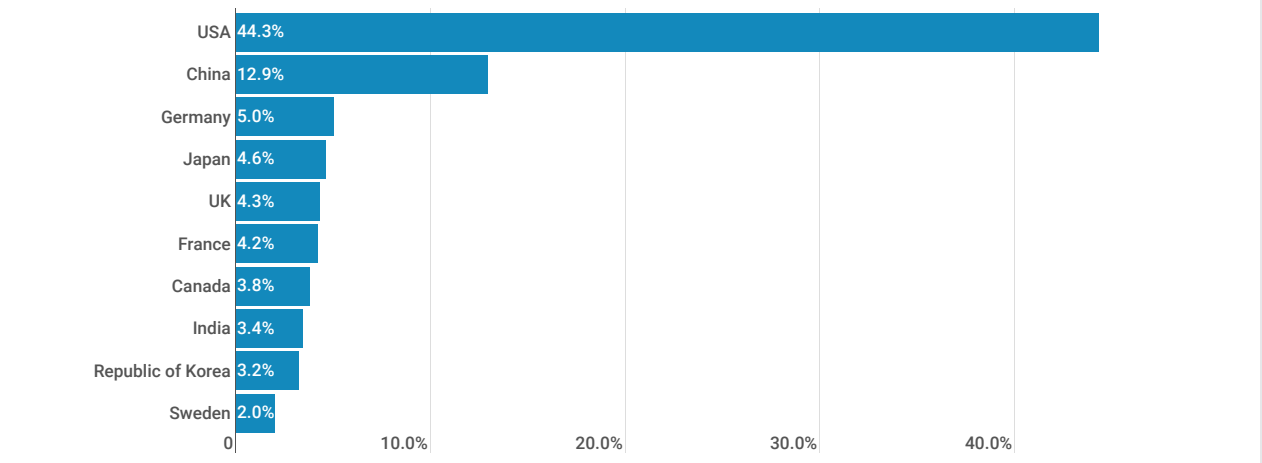

Figure 18. IETF document authors per country | Top 10.

Based on IETF stats

As Figure 19 shows, most IETF document authors are affiliated with Cisco and Huawei.

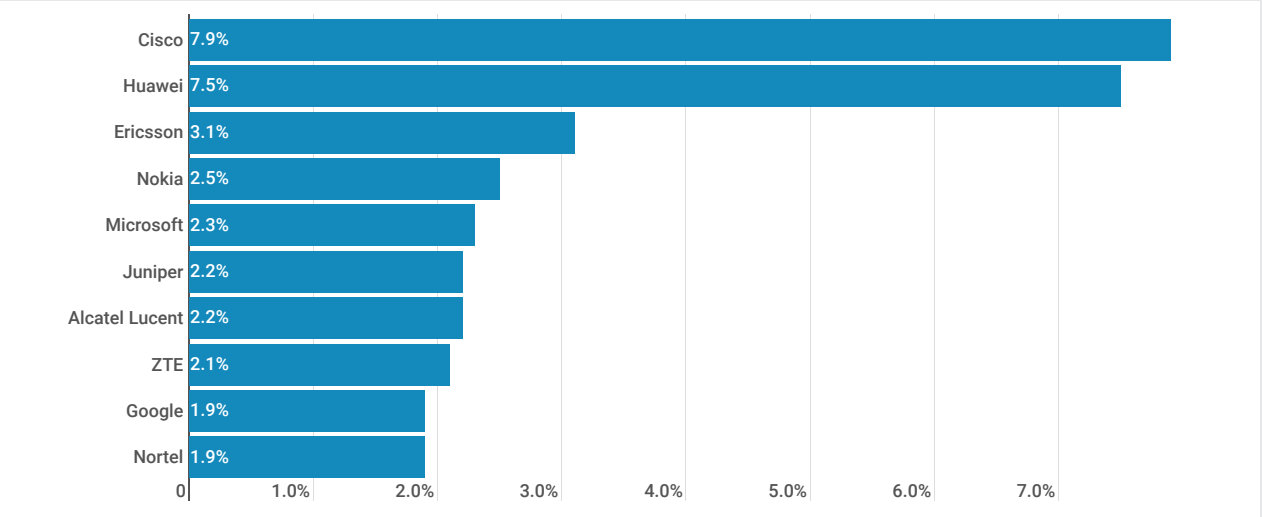

Figure 19. IETF document authors per affiliation | Top 10.

Based on IETF stats

[62] The IETF explains the following: 'The statistics are based entirely on the author addresses provided with each draft. Since this varies across documents, a travelling author may be counted in more than country, making the total sum more than 100%. In case no country information is found for an author in the time period, the author is counted as (unknown)' (IETF, no date-b).

The contribution of Chinese entities in terms of authoring IETF documents has increased constantly over the past 20 years, while the number of authors representing the USA has decreased (Figure 20).

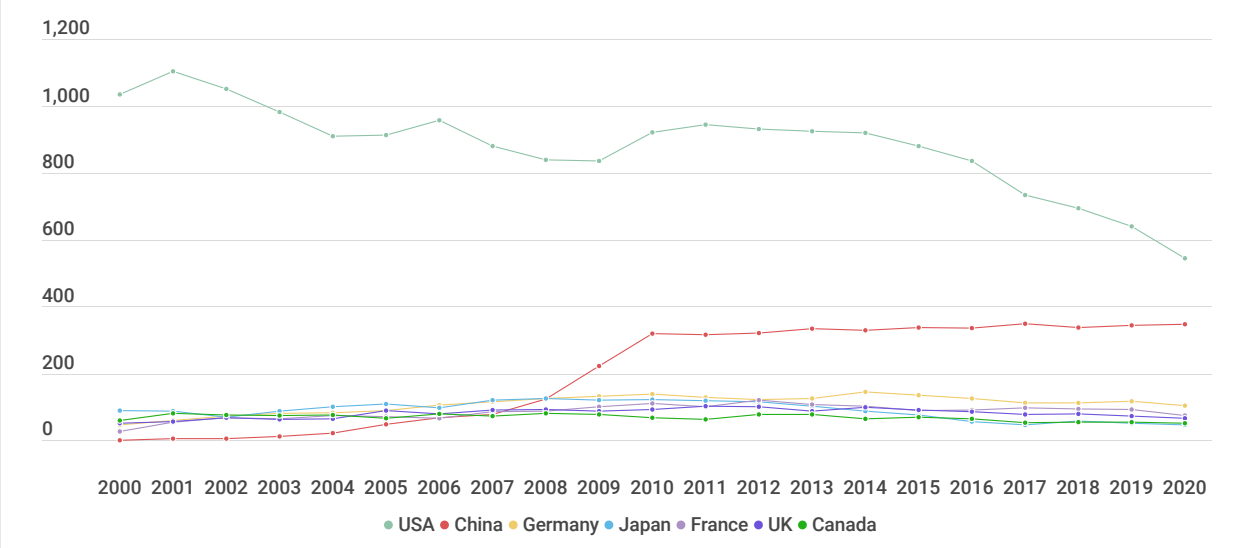

Figure 20. IETF document authors per country | Evolution from 2000 to 2020.

Based on IETF stats

Facial recognition in visual surveillance: A proposal for an ITU-T standard

Proposal at ITU-T SG16

In 2019, China Telecom submitted a proposal for an ITU-T recommendation on *Requirements for Face Recognition Application in Visual Surveillance.*[63] The proposal was put forward in ITU-T SG16 (on multimedia coding, systems and applications), in the context of Question 12 (Q12/16) on intelligent visual systems and services, discussed within WP1 on multimedia content delivery (WP1/16).

The proposal aimed to specify requirements for the application of face recognition in visual surveillance, for use by both the public and private sectors. It outlined use cases and scenarios of face recognition application, as well as requirements of functions, services, performances, and security. In terms of use cases, examples were given of applications used in public security (e.g. searching suspects and confirming their identity), key area management (e.g. in hotel registration, ID checks in airports, railway stations, and construction sites), business and service (e.g. identifying customers), and 'data practical applications' (e.g. being able to track the trajectory of certain individuals if they are found to appear frequently in certain periods of time at certain points within a mall).

The proposed recommendation then outlined several requirements for facial recognition systems, such as:

- Detecting and structuring the features of the human faces from pictures and video, and storing the detected features in a database for retrieval and searching purposes.
- Performing various types of matches: 1:1 (comparing two images), 1:N (comparing one image against N images in a library), and n:N (comparing all n images in a library with all N images in another library to find matches).
- Performing dynamic face recognition.
- Supporting diversification of data sources (e.g. mobile phone images, camera capture, photo scanning).

Following several rounds of controversial discussions within the dedicated working party, the proposal was discontinued in April 2021 (ITU-T, 2021a).

[63] F.FRAVSReqs – Requirements for face recognition application in visual surveillance.

Concerns and criticism

Human rights implications. Critics – in particular from European countries – saw the draft recommendation as being very broad in scope and interfering with fundamental rights and freedoms. For instance, the fact that the face recognition applications presented would be able to detect elements such as gender, age, race, skin colour, and physical features could create the risk of a discriminatory approach based on particular characteristics, as well as of wrongfully exposing and falsely indicting people belonging to certain groups. Another concern was that the proposal does not make it clear that biometric data resulting from facial recognition may not be sold, transferred to third parties or disclosed (unless with the consent of the data subject).

Topic not suitable for technical standardisation. There were arguments that the draft recommendation was 'crossing the line from technical specifications to policy recommendations, including outlining use cases and data requirements' (Gross et al., 2019). It was also said that the proposal has policy and regulatory implications, and is not a purely technical standard nor should it be treated as one. Determining conditions and addressing safeguards for facial recognition to be legally deployed is beyond the scope of technical standardisation; such issues should be tackled within a legislative process. Moreover, because FRT is the subject of heated policy discussions around the world, and regulatory frameworks in this area are only starting to emerge, technical standardisation was considered to be premature.

Inadequate approval process. Initially, the draft recommendation was subject to an alternative approval process (AAP). This approach was seen as not suitable by several member states, who pointed out that the deployment of FRT has policy and regulatory implications, and, as such, a traditional approval process (TAP) needs to be followed. The change from AAP to TAP was confirmed in June 2020 (ITU-T, 2021b). Why does this matter? Because the rules for approving a proposal under TAP are more stringent (Annex 1).

Inappropriate choice of standardisation venue. As was the case with the New IP, there were concerns that ITU-T was not the place to discuss standardisation for FRT, and that such issues would be better off left to other standardisation bodies such as ISO and the IEC. There were also complaints that proposing an FRT recommendation in an SG that focuses on multimedia was misleading, and part of a strategy to attract as little attention as possible to the proposal.

Box 17. Facial recognition at ISO and the IEC

Several standardisation initiatives carried out at ISO and the IEC are of relevance for FRT. Within JTC1, for instance, several biometric-related standards have been developed, in particular in the context of SC27 on IT security techniques and SC37 on biometrics. These standards cover issues such as data formats and data quality, performance testing and reporting, biometric information protection, and use of biometrics in video surveillance systems. One example is the ISO/IEC 30137-1:2019 standard on system design and specifications for the use of biometrics in video surveillance systems (with direct references to facial recognition) (ISO, 2019). Ongoing work looks into topics ranging from requirements and recommendations for face-aware systems (ISO, no date-c) to biometric recognition of subjects in motion in access related systems (ISO, no date-d).

At the IEC, TC79's WG12 focuses on video surveillance systems; one of the group's ongoing projects looks at video surveillance systems for use in security applications, with a focus on performance testing and grading of real-time intelligent video content analysis devices and systems for use of video surveillance applications (IEC, no date-a).

What was said less

Was it a strategy to propose a recommendation on facial recognition in an SG dealing with multimedia? Although there were complaints along these lines (as noted earlier), there were also arguments noting that work on video surveillance systems has been happening in SG16 for many years, and it was natural that, as more techniques – such as AI and recognition of faces and patterns – become available, they would appear in standardisation work.[64]

The FRT proposal was rejected. How big of a win is this? One of the arguments in favour of rejecting the proposal at SG16 was that it was premature to propose standards for facial recognition. Instead, it was said that we have to wait for the technology to become more mature, to be able to fully understand its implications and devise mechanisms to avoid abuses. While this might be true, what was missed was the fact that several recommendations have already been adopted within ITU-T that contain provisions with potential relevance for FRT systems (Box 18).

[64] Interviews with SDO participants, July–September 2021.

The private sector is already developing and deploying specifications for FRT. Rejecting the proposed recommendation does not mean the technology will not continue to be deployed, or that relevant standardisation proposals are not discussed in other contexts. And while this particular proposal has probably received the attention it did because of the geopolitical context, it is important to also look carefully at what other players are proposing and doing in terms of FRT and standardisation. For instance, it is likely that some of the over 100 biometric standards already adopted in JTC1's SC37 are or will be applied in surveillance technologies, posing at least some of the same challenges raised in relation to the Chinese proposal (e.g. in terms of discrimination, privacy) (Voo and Creemers, 2021).

Box 18. Other surveillance-related proposals at ITU-T

The proposal on requirements for face recognition applications in visual surveillance systems has attracted significant attention within and beyond ITU-T. But there have been many other proposals related to surveillance systems/applications, some of them containing elements with potential relevance for FRT.

Our analysis indicates that during the 2017–2020 SP, 33 work items[65] were on the agenda of ITU-T SGs (mostly SG16, but also SG2 and SG5) that covered surveillance-related issues, such as service description and protocols for video surveillance systems, algorithm training application requirements in intelligent video surveillance systems, requirements for big data enhanced visual surveillance services, and architectures for intelligent video surveillance systems.[66] These work items have been led by editors representing Chinese entities (e.g. the Beijing University of Posts and Telecommunications, the Big Data Academy, China Mobile, China Telecom, Dahua Technology, Huawei, ZTE). Almost half of these proposals (15) have been approved; 2 were discontinued (the FRT proposal and one on scenarios and requirements of interworking between video surveillance and telepresence); and the remaining 16 are under study as of November 2021.

Some of the approved and under study proposals include mentions of issues such as face identification, portrait recognition, and human recognition. For instance, a recommendation adopted in 2019 and dealing with big data enhanced visual surveillance systems presents an application scenario in which 'Using the image of the target person as input, users [of the surveillance system] can quickly search for similar objects in massive videos according to the facial, clothing colour distribution or body features of the image.'[67] Another 2019 recommendation notes that a visual surveillance system 'can optionally provide intelligent image identification, including number plate identification, face identification, motion target identification and tracking, etc. Alarm signals can optionally result from intelligent identification. Additionally, more information can optionally be obtained by means of image identification technologies.'[68] A work item under discussion in SG16 dealing with 5G surveillance cameras describes a use case in which 5G ultra-high definition cameras can rely on algorithms to prevent fatigued driving and identify the driver.[69] There are also several proposals under study that describe intelligent systems that identify specific objects (e.g. sites, humans) automatically and output recognition results.

Participation in 5G standardisation: A look at 3GPP

5G, the fifth-generation mobile network, is key in unlocking the potential of advanced technologies such as AI, the IoT, and virtual and augmented realities. Compared to its predecessors (3G and 4G), 5G brings essential improvements in speed, latency, and bandwidth. Other promises are related to larger traffic capacity, ultra-high reliability, and good resilience capability, as well as high emergency efficiency on the network and device side.

5G has an array of policy implications. Many countries are racing to develop and deploy 5G networks because of two assumptions: (a) an early technological lead grants countries a first-mover advantage and (b) dominance in certain technologies grants them an edge in other fields. The security of 5G has also been a key concern. On the one hand, ensuring the security of 5G networks is not only a technical issue, but it also has implications for the national economy and security, given the exponential growth in the number of connected devices. On the other hand, the potential misuse of 5G networks and equipment for surveillance and espionage has been at the centre of heated (geo)political debates (Geneva Internet Platform, no date-a). Chinese companies have been singled out as threats to national security in the USA and in other countries (Lee and Brandao, 2021), although they have disputed the claims (Strumpf, 2021).

The 5G network equipment space is dominated by three main actors: Ericsson, Huawei, and Nokia.

[65] Work item denotes a proposal that was accepted for discussion within SGs or their WPs. Not all proposals put forward by contributors make it to this stage.
[66] The analysis covers work items which include the term *surveillance* in their titles.
[67] Recommendation ITU-T F.743.7: Requirements for big data enhanced visual surveillance services (ITU-T, 2019a).
[68] Recommendation ITU-T F.743: Requirements and service description for video surveillance (ITU-T, 2019b).
[69] F.5GUHDC: Requirements for 5G ultra-high definition surveillance camera (ITU-T, 2021c).

Starting in 2016, 3GPP has carried out significant work on developing 5G standards. The so-called Release 15 – considered to be the first full set of 5G standards – and Release 16 were included in the IMT-2020[70] radio interface specifications adopted by ITU-R in February 2021. There is now work in progress on Release 17, expected to be finalised in 2022, and Release 18, to be finalised in 2024 (3GPP, no date-a).

China, through the China Communications Standards Association (CCSA), is one of the seven organisational partners that form 3GPP. (*See Annex 1 for details on 3GPP's membership structure.*) As of October 2021, 3GPP has 764 individual members from 45 countries and territories. To be an individual member, an organisation has to be a member of one of the seven organisational partners. China leads, with 185 members (associated with either CCSA or ETSI), followed by the USA and Germany (Figure 21).[71]

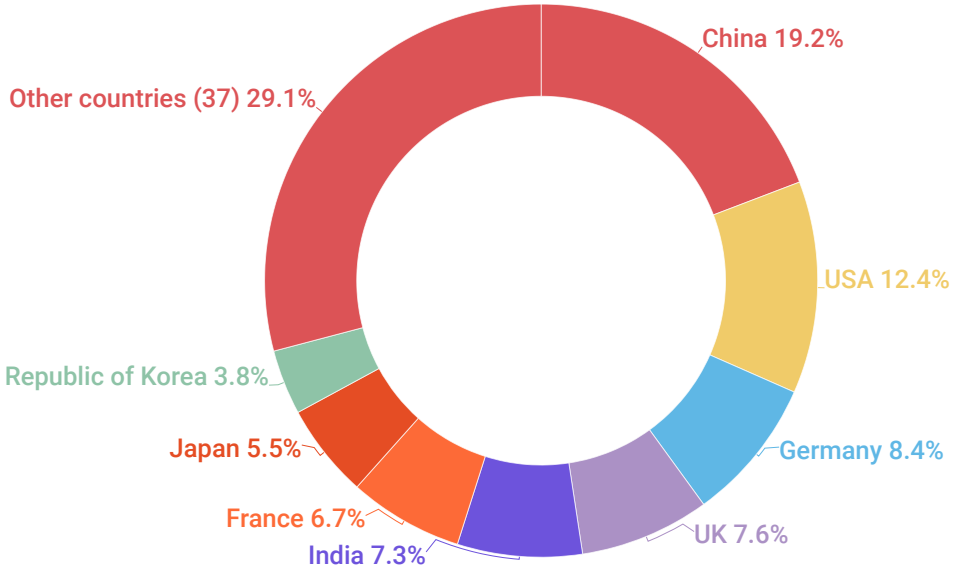

Figure 21. Distribution of 3GPP individual members by country (October 2021).

Based on 3GPP membership information

Chinese entities lead in the overall number of leadership positions (chairs and vice-chairs) within TSGs and WGs (20), followed by entities from the USA (12) and the Republic of Korea (7) (Figure 22). China's share of such positions has increased over the years: 17% in 2012, 19% in 2017 (USCC, 2018), and 36% in 2021. For comparison, the USA's share of leadership positions has fluctuated: 13% in 2012, 25% in 2017, and 21% in 2021.

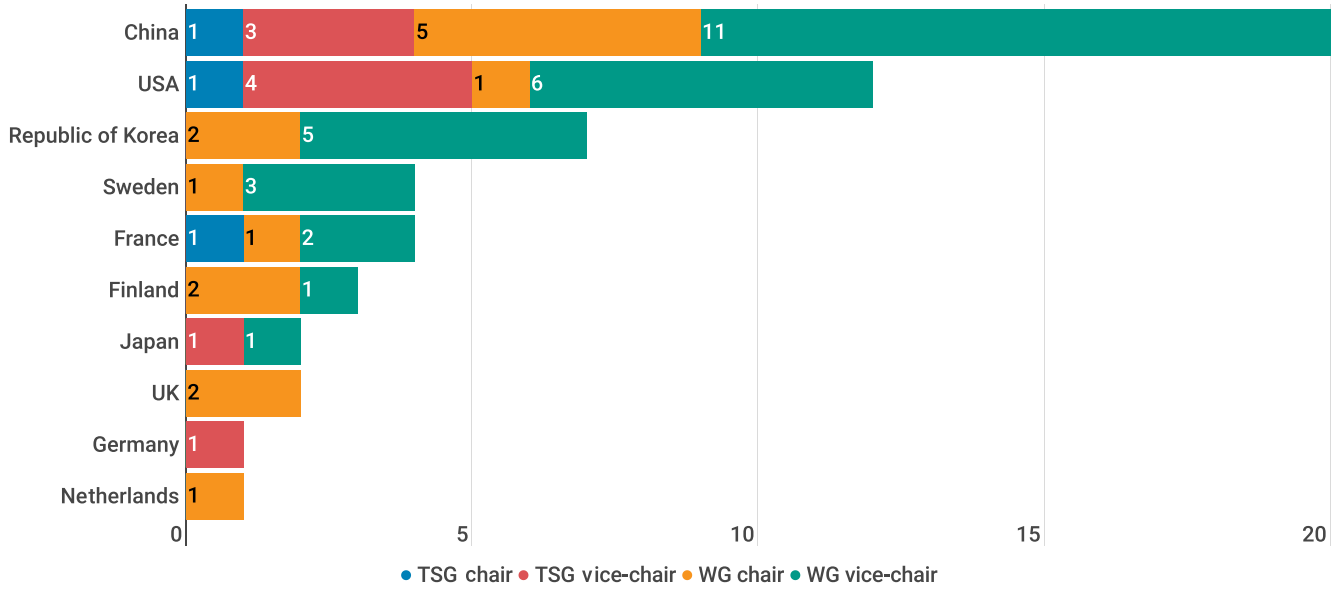

Figure 22. Distribution of 3GPP TSG/WP chair and vice-chair positions (October 2021).

Based on 3GPP information (TSG/WP elected officials)

[70] IMT-2020 (International Mobile Telecommunications-2020) is a term developed by ITU-R for standards/specifications related to 5G networks (ITU-R, no date). The radio interface specifications are part of Recommendation ITU-R M.2150 (ITU-R, 2021).
[71] The stats are based on 3GPP data, which associates entities with the countries they are registered in. Multinational companies participate through different national branches; Ericsson, for instance, has 11 participants as individual members, while Huawei has 12.

The **most active companies in terms of leadership positions** within TSGs and WGs are Samsung (7), Huawei (6), China Mobile (4), Ericsson (4), and Qualcomm (4).

Statistics show that Huawei is **the most active 3GPP member in terms of overall 5G standard contributions submitted and approved** (Figure 23). It is followed by Ericsson, Nokia, and Qualcomm, each with over 10,000 submitted contributors and over 2,000 contributions approved. ZTE is also included in the top of most active companies by the two indicators.

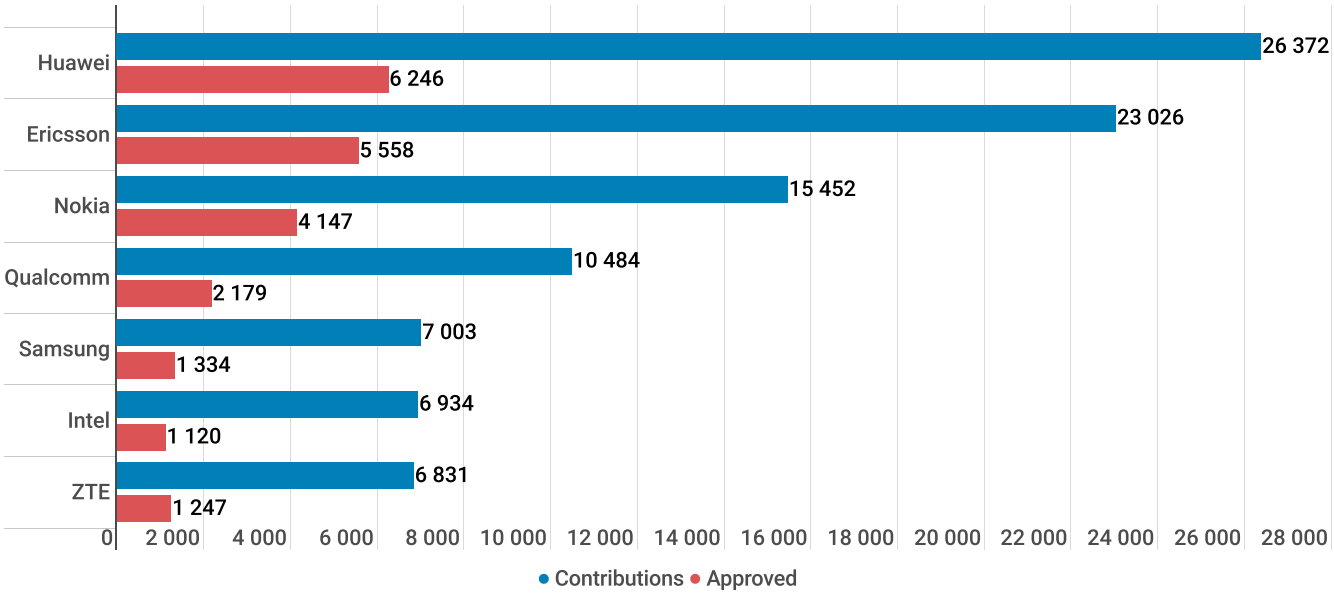

Figure 23. 5G standard contributions at 3GPP | Key contributors.

Source: Pohlmann and Blind, 2020 (data relevant for January 2020)

According to company data, Huawei has also submitted the largest number of standard contributions on 5G security at 3GPP: 385 in 2019 (Huawei, 2020) and 253 in 2020 (Huawei, 2021).

Beyond standardisation, Huawei is also said to lead in terms of 5G SEPs. According to some statistics, Huawei has the most declared 5G SEPs, and is followed by Samsung, ZTE, LG, Nokia, Ericsson, and Qualcomm (Pohlmann and Blind, 2020).

The fact that Huawei is often indicated as leading when it comes to 5G patents and contributions to 5G standardisation work at 3GPP, coupled with security and geopolitical considerations, has generated concerns over the company's role (and China's role, more broadly) in shaping the evolution of the 5G ecosystem and in potentially dominating this space. 5G is indeed considered a strategic industry by the Chinese government (according to *MiC 2025*, for instance). But some researchers argue that China's impact should not be overestimated (Creemers and Voo, 2021). Huawei's contribution to standard-setting should be seen more as part of the company's business strategy to expand the market share for its technology, and less as part of a broader political plan for dominance. Moreover, the mere number of declared SEPs is not necessarily an effective way of measuring the value of the patents and the technology behind them. Statistics that have taken into account essentiality weighting indicate that Ericsson is in the lead when it comes to 5G patent declarations with essentiality weighting, followed by Samsung, Qualcomm, and Nokia; these stats place Huawei only in 5th place (Noble et al., 2019).

Box 19. Other 5G-related standardisation work

Besides the extensive work done at 3GPP and the IMT-2020 relevant activities carried out at ITU-R, standardisation work relevant for 5G is also happening in several other spaces. For instance, at ITU-T, SG13 on future networks has a focus on IMT-2020, as well as cloud computing and trusted network infrastructures. And there are several other SGs that cover non-radio 5G aspects, including SG2 on network management, SG11 on protocols and interoperability, SG12 on quality of service, SG15 on transport, and SG17 on security. Outside of ITU and 3GPP, 5G-relevant standards development processes are also happening within standardisation bodies and industry consortia such as ETSI, IEEE, and the Broadband Forum. Chinese actors are actively contributing to these spaces.

For instance, China holds several leadership positions within ITU-T's SG13 on future networks**:** an SG vice-chair role (Institute of Technology and Standards Research at CAICT), a vice-chair role (China Mobile) for WP1 on IMT-2020 and beyond: networks and systems, and a co-chair role (Institute of Technology and Standards Research at CAICT) for WP3 on network evolution, trust and quantum-enhanced networking. Among the 25 rapporteurs, co-rapporteurs, and associate rapporteurs, China holds 11 positions (more than any other country). Chinese actors are also submitting a significant number of contributions to the SG's meetings. For instance, at the March 2021 meeting, out of 142 contributions, Chinese entities submitted 56%, followed by Korean entities (35%).

Our analysis of 156 5G-related work items[72] on the agenda of ITU-T SGs during the 2017–2020 SP indicate that Chinese entities (e.g. the Beijing University of Post and Telecommunication, CAICT, China Mobile, China Unicom, Huawei, Tencent, ZTE) have been involved in leading the work on most of these items: 42% of all items were/are led by editors representing Chinese entities; 31% had Chinese entities among the co-editors. At a significant distance were work items led by editors from the Republic of Korea (8%) and Japan (5%), with the remaining 14% including editors from various other countries such as Finland, Sweden, and the USA.

Open RAN: An alternative to major players?

Against the backdrop of geopolitical tensions and the tech competition between both countries and technology companies, the concept of Open RAN has been gaining increasing attention. Open RAN refers to an architecture for open radio access network (RAN) and its goal is to open the protocols and interfaces between the various elements of RAN (radio, hardware, and software).

In 2018, five companies (AT&T, China Mobile, Deutsche Telekom, NTT Docomo, and Orange) formed the Open RAN Alliance (O-RAN Alliance) with the goal to 'Re-shape the radio access network (RAN) industry towards more intelligent, open, virtualised and fully interoperable mobile networks.' One of the alliance's goals is to develop open RAN specifications/standards that will 'enable a more competitive and vibrant RAN supplier ecosystem' (O-RAN Alliance, no date). Since its creation, the O-RAN Alliance has expanded its membership, which now includes 30 operator members and over 250 contributors. Other groups advocating for and/or working on Open RAN standards include the Telecom Infra Project, the Open RAN Policy Coalition, and the Small Cell Forum.

Open RAN standards are seen as an opportunity to weaken the market power of major 5G equipment providers and prevent them from dominating the global telecom infrastructure (Bown, 2021). And while avoiding dependencies on Huawei in particular might have been among the implicit goals, the extent to which this could be achieved remains debatable. With Open RAN being built on existing standards (e.g. 3GPP ones[73]), it still embeds technologies and patents to which Huawei has a significant contribution.[74] Some commentators also argue that it is not necessarily realistic to expect telecom operators to rely on Open RAN solutions 'that lack proven deployments at scale, established systems integrators, or performing metrics' for large 5G deployments (Lee, 2020).

Other key controversies around Open RAN relate to (a) security and (b) potential policy/regulatory interventions. Because it introduces new open interfaces and functions that are not part of the 3GPP core standard, Open RAN requires additional security measures. It is also said that the architecture comes with security risks related to a chain of trust for software and hardware (Summer, 2020). Others, however, argue that Open RAN is not less secure than traditional RAN and it can bring security advantages (Open RAN Policy Coalition, 2021). The other controversy stems from attempts by some Open RAN supporters to lobby governments for preferential treatment for the architecture, including through adopting it as a national standard (Makiyama and Forsthuber, 2020). Such actions have generated strong reactions from some market players. Ericsson, for instance, has called on policymakers not to pick winners, but to ensure open markets for competition, technology-neutral regulation, and technology-neutral infrastructure roll-out subsidies (Summer, 2020).

[72] The analysis covers work items which include the terms *IMT-2020* and/or *5G* in their title.
[73] Ericsson notes, for example, that Open RAN is an extension of the 3GPP standard, both in terms of network functions aspects, as well as network implementation aspects (Summer, 2020). Nokia describes the Open RAN specification as being complementary to 3GPP, ONAP (Open Network Automation Platform), and ETSI specifications (Nokia, no date).
[74] While Huawei is indeed the major absence from the O-RAN Alliance, there are other Chinese companies that contribute to the work (e.g. China Mobile, China Telecom and China Unicom as operator members, and ZTE as contributors).

Contributions to standards and technical regulations for self-driving vehicles

China's contribution to the development of international standards for self-driving/autonomous vehicles (AVs) is aligned with the country's goal to be actively involved in standards development processes for new technologies, and is part of a broader 'go global' strategy for automobile standards. Coordinated by a dedicated working group established in March 2020 within the China Automotive Technology and Research Center (CATARC), the strategy is aimed at promoting the internationalisation of Chinese automobile standards and products (SESEC, 2021c). (At a national level, CATARC holds the secretariat for the National Technical Committee on Auto Standardisation – TC114, with a subcommittee dedicated to intelligent vehicles.)

The internationalisation goal is also reflected in the fact that, in June 2021, China opened the China Automobile Standards Internationalization Centre in Geneva, with the goal to facilitate and promote more in-depth participation in and coordination with the international standardisation activities of Geneva-based SDOs.

The international organisations China is seeking to actively contribute to when it comes to the development of standards and technical regulations for AVs are highlighted in the *Key Points of Automotive Standardisation* issued by MIIT in April 2021, and include the World Forum for Harmonization of Vehicle Regulations – WP.29, ISO, and the IEC (MIIT, 2021b).

Participation in ISO

Within ISO, China is leading a dedicated working group for AV safety standards – TC22/SC33/WG9 on test scenarios for automated driving systems (TC22 deals with road vehicles, while its SC33 focuses on vehicle dynamics and chassis components). The WG9 convenor (until the end of 2024) is a representative of CATARC.

It is reported that, within its TC114, CATARC has convened a multistakeholder expert group (including, among others, Chinese researchers and representatives of companies such as Huawei and SAIC Motor) to support China's contributions to WG9, including through the development of draft standard proposals for submission within the WG. This support is said to have been essential in the development of the first WG9 standard proposal – *ISO/DIS34501 | Terms and definitions of test scenarios for automated driving systems*. In parallel with the work carried within WG9, CATARC's expert group was used as a space to draft and review proposals, discuss comments from the WG, and resolve outstanding issues. This work was described as 'a prime example of [national expert support in] providing mature proposals for Chinese representatives to submit' in SDOs (Sheehan, 2021). As of October 2021, ISO/DIS34501 has the status of draft international standard and is in the enquiry stage; this means it has already been approved by the parent TC22 and the next step is to have it presented to all ISO members for a vote.[75]

Has China used its convenor role within WG9 to unduly advance its standard proposal? It does not seem so. Besides the work on ISO/DIS34501 – led by CATARC (with a CATARC employee appointed as project lead) – the WG is also considering other standard proposals. Examples include *34502 | Scenario-based safety evaluation framework for automated driving systems* (in an enquiry phase in October 2021) and *34503 | Taxonomy for operational design domain for automated driving systems*, reportedly led by experts from Japan and the UK. Moreover, it seems that another proposal put forward by China did not find support within the group and, as such, did not advance (Sheehan, 2021).

China's participation in ISO TC22 on road vehicles goes beyond SC33 and its WG9. Chinese experts also participate in the work of the committee's Strategic Advisory Group and the Automated Driving Coordination Group, as well as in the development of standards within SC31 on data communication projects and SC32 on vehicle electrical, electronic components and general systems (Wang, 2020).

Another ISO TC whose work is relevant for autonomous driving and where China is an active participant is TC 204 on intelligent transport systems. The TC developed what some described as the first international safety standard for fully automated driving systems (Butcher, 2021): the I*SO 22737:2021 Standard – Intelligent transport systems – Low-speed automated driving (LSAD) systems for predefined routes – Performance requirements, system requirements and performance test procedures*.

[75] The proposal was registered as a draft international standard on 4 October 2021 (ISO, no date-e). It is not clear whether the ballot has been initiated.

Participation in the World Forum for Harmonization of Vehicle Regulations

Functioning within the UN Economic Commission for Europe (UNECE), the World Forum for Harmonization of Vehicle Regulations (also known as WP.29) is a multilateral body that develops two types of technical UN regulations related to vehicles:[76] (a) UN regulations, which outline provisions related to safety and environmental aspects; and (b) UN global technical regulations, which contain globally harmonised performance-related requirements and test procedures (UNECE, no date-a). Although they are not equivalent to the standards developed by SDOs like ISO and the IEC, these regulations have an important role in defining key technical characteristics for vehicles.

Full participation in the forum is open to any UN member state and regional organisation set up by UN member states; non-governmental entities may participate in a consultative capacity.

Three UN vehicle regulations relevant for AVs were adopted by WP.29 in June 2020, entered into force in January 2021, and became applicable in 54 countries[77]: *UN Regulation No. 155 on Uniform Provisions Concerning the Approval of Vehicles with regards to Cyber Security and Cyber Security Management System*; *UN Regulation No. 156 on Uniform Provisions Concerning the Approval of Vehicles with regards to Software Updates and Software Updates Management System*; and *UN Regulation No. 157 on Uniform Provisions Concerning the Approval of Vehicles with regards to Automated Lane Keeping Systems* (the first international regulation governing the introduction of level 3 autonomous driving[78]) (UNECE, 2021).

In 2018, a dedicated **Working Party on Automated/Autonomous and Connected Vehicles (GRVA)** was established to focus on issues such as functional requirements, cybersecurity, and data storage systems for AVs. GRVA is chaired by Germany, with China and Japan holding vice-chair positions. China is an active participant in GRVA's work, where it contributes mostly through experts from MIIT and CATARC. A WG within China's TC114 is specifically dedicated to mirroring WP.29; the secretariat of this group is held by CATARC (Fraunhofer Institute for Secure Information Technology, 2020).

Box 20. Framework document on automated/autonomous vehicles

China was one of the four contributors (together with the EU, Japan, and the USA) to the *Framework Document on Automated/Autonomous Vehicles*. Adopted by WP.29 at its 178th session in June 2019 and subsequently revised, the framework outlines key principles for the safety and security of AVs of levels 3 and higher. It also defines AV-related work priorities for WP.29 (UNECE, no date-b).

China, through a MIIT representative, holds one of the three co-chair positions for GRVA's *Informal Working Group on Functional Requirements for Automated and Autonomous Vehicles (FRAV)*. The other two co-chairs represent Germany's Federal Ministry of Transport and Digital Infrastructure and the US Department of Transportation. Within the group, China's CATARC was assigned responsibility for coordinating the Other Road User (ORU) workstream (dedicated to defining ORU categories).

Meeting documents for GRVA informal working groups show that China has been an active contributor to the work. Submissions from Chinese participants have covered issues such as performance requirements and user interaction in the AV context, test methods for automated driving, and data necessary for data storage systems for automated driving.

To illustrate, our analysis of contributions submitted to the 20 sessions held by FRAV between October 2019 and October 2021 indicates that Chinese participants have submitted some 11% of all contributions, similarly with contributions from Germany and the USA. Japan leads, with 22% of the contributions. Other significant contributors are the European Commission (with its Joint Research Centre) and the European Association of Automotive Suppliers.

[76] There are two agreements that govern the adoption of technical UN regulations for vehicles. The *1958 Agreement Concerning the Adoption of Harmonised Technical UN Regulations for Vehicles* establishes that UN regulations enter into force for contracting parties to the agreement that do not indicate their disagreement or their intention not to apply them within a certain time. It is up to the countries to decide if they transpose the regulations into national legislation (or whether they apply directly) (UNECE, 2017). The *1998 Agreement on UN Global Technical Regulations for Vehicles* requires contracting parties that vote in favour of a certain technical regulation to transpose it into national legislation (UNECE, 1998).

[77] Mostly European countries, but also non-European countries such as Australia, Japan, the Republic of Korea, and South Africa. Notable absences are China and the USA, although they both contribute to WP.29 work.

[78] For WP.29 activities, there are five levels of automated driving. Level 3 occurs when 'the system is able to cope with all dynamic driving tasks [...] or will otherwise transition to the drive offering sufficient lead time' (UNECE, 2018).

Participation in ITU-T work

At ITU-T, standardisation proposals related to AVs are put forward mostly within SG20 on IoT and smart cities and communities and SG 16 on multimedia. For the 2017–2020 SP, we identified six proposals dealing directly with AVs that were accepted as work items within these groups.[79] Chinese actors are contributing to three of these items.

- The only item approved as of October 2021 deals with the functional architecture of network-based driving assistance for AVs.[80] Five Chinese editors led this work item.
- A proposal on the functional architecture of roadside multi-sensor data fusion systems for AVs led by two Chinese editors from China Mobile and CAICT.[81]
- China Unicom is one of the two editors of a proposal on a taxonomy for ICT-enabled motor vehicles automated driving systems.[82]

Box 21. China's presence in SG20

China has a very strong presence in this SG focused on IoT and smart cities and communities:

- One SG vice-chair role (among the 13 such roles).
- One WP co-chair role (the SG only has 2 WPs).
- For the 7 questions the group addresses, there are 31 rapporteurs, co-rapporteurs, and associate rapporteurs. Among these, 10 are Chinese. China has at least 1 rapporteur/co-rapporteur/associate rapporteur for each of the 7 questions.
- The SG has 96 work items under study, with a total of 313 editors. Among these editors, 195 are Chinese, 38 from the Republic of Korea, and 16 from Russia. The rest are divided among 17 countries. Out of the 96 work items, 43 are led by Chinese editors only.

In October 2019, a **Focus Group on AI for Automated and Assisted Driving (FG-AI4AD)** was formed (within SG16), to support standardisation activities for services and applications enabled by AI systems in autonomous and assisted driving. One of the group's planned deliverables is a specification on automated driving safety protocol. China Telecom held the vice-chair position until October 2021,[83] while the chair role is assumed by a representative of the ADA Innovation Lab in the UK.

Between January 2020 and October 2021, the FG held seven meetings. Our review of the contributions made to these meetings by FG participants[84] shows that most documents were submitted by UK participants (31%), followed by the USA (16%) and Germany (9%). Chinese contributions accounted for only 4% of the total. Looking at the overall number of participants across all meetings, the UK (24%) is again in the lead, followed by the USA (15%); participation from China and Germany was relatively similar (7%) (Figure 24). Among the Chinese participants were representatives of Bytom, CATARC, CAICT, China Telecom, China Unicom, Huawei, and ZTE

[79] The analysis covers work items which include the terms *autonomous vehicles* and/or *automated driving* in their titles.
[80] Recommendation ITU-T Y.4471: Functional architecture of network-based driving assistance for autonomous vehicles (ITU-T, 2021d).
[81] Y.RMDFS-arch: Functional architecture of roadside multi-sensor data fusion systems for autonomous vehicles (ITU-T, 2021e).
[82] F.AUTO-TAX: Taxonomy for ICT-enabled motor vehicle automated driving systems (ITU-T, 2021f)
[83] The report of the October 2021 meeting notes that the vice-chair has resigned.
[84] Submissions by FG leadership and editors, as well as submissions from other ITU-T groups, were not considered in the analysis.

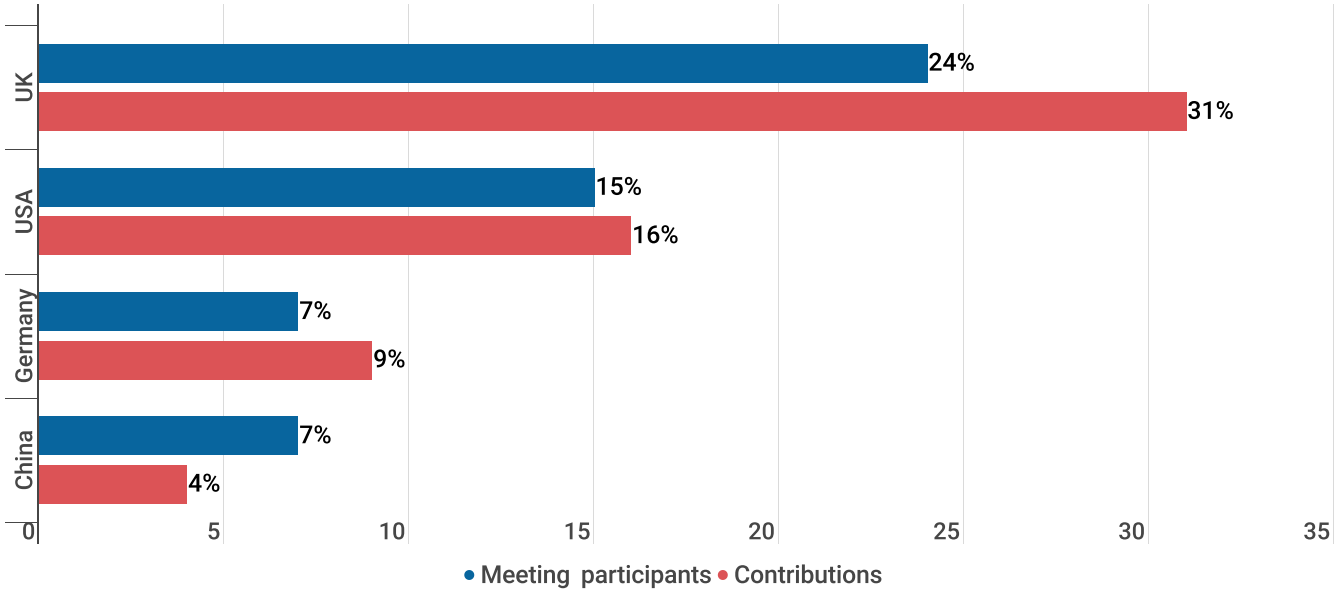

Figure 24. Distribution of ITU-T FGAI4AD meeting participants and contributions among selected countries.

Based on FG meeting documents

Participation in the IEC and IEEE

At the IEC, China is the convener of SEG11 on future sustainable transportation, whose goal is to 'collect best practices and use cases of public, shared transportation for developed and developing economies' and to 'engage with TC/SCs including ISO and other market stakeholders on status and use of existing standards and on the need for new standards related to future sustainable transportation' (IEC, no date-b). Germany acts as a co-convenor. SEG11 functions within the Standardization Management Board.

At IEEE, Baidu, Huawei, and Horizon Robotics are the three Chinese companies that contribute to the IEEEP2846 on assumptions for models in safety-related automated vehicle behaviour. Most group members (17 of 31) come from the USA.

Box 22. Chinese-German cooperation on AV standards

Besides its participation in international standardisation, China is also advancing bilateral cooperation on AV-related standards. The Chinese-German cooperation is one illustration. In 2018, the two governments signed a declaration of intent on cooperation in the area of automated and connected driving. Cooperation in international standardisation was one of the goals highlighted in this declaration (BMVI, 2018).

Also in 2018, CATARC and the German Association of the Automotive Industry concluded a memorandum of understanding to cooperate on the standardisation and regulation of intelligent connected vehicles. Cooperation on standards for automated vehicles also happens within the German-Chinese Standardisation Cooperation Commission. This commission was formed in 2011 and meets annually to foster bilateral dialogue and cooperation on standardisation matters (DIN, no date).

Setting standards for quantum technologies

Quantum technologies and the promises they hold – especially when it comes to quantum computing and their potential to enable unparalleled innovation in areas such as medicine and the discovery of new materials – place them among the technologies that are the subject of an ongoing race for supremacy among nations. In this competition, China and the USA seem to be at the forefront, with the EU, Japan, and others increasingly stepping up their efforts.

Box 23. Applications of quantum technology

Classic computers rely on individual bits to store and process information as binary 0 and 1 states. **Quantum computers** rely on quantum bits – qubits – to process information. In doing so, they use two key quantum mechanical properties: superposition and entanglement. While qubits still use the binary 0 and 1 system, the superposition property allows them to represent a 0, a 1, or both at the same time. This reduces the time needed to process a data set. Entanglement, on the other hand, allows quantum particles to be inextricably linked in perfect unison, even if separated by great distances. In essence, superposition allows quantum computers to solve some problems exponentially faster than classical computers, while entanglement makes quantum computers significantly more powerful.

Quantum cryptography is a method used for the secured, encrypted transfer of information. Unlike other forms of cryptography, it ensures security by the laws of physics; it is not dependent on mathematical algorithms and unsecure exchanges of keys. **Quantum communication** based on quantum cryptography currently qualifies as highly secure, making undetected interception/eavesdropping impossible. Here, the best-known application is **quantum key distribution (QKD)**, which relies on the use of quantum mechanical effects to perform cryptographic tasks (Geneva Internet Platform, no date-b).

As the development of standards for quantum technologies is in an early stage, the international standardisation landscape in this field is still being shaped, and there are opportunities for some actors to take the lead in this process. China has understood this context well and made it a goal to be an important shaper of quantum-related standards.

At the national level, China set up a multistakeholder technical committee on quantum computing (TC578) in January 2019. The committee is under SAC leadership and its secretariat is held by the Jinan Institute of Quantum Technology. Among its members are multiple universities and research centres, as well as companies such as Huawei, Tencent, Alibaba, and CAS Quantum Network. Besides TC578, quantum-related standardisation work is also happening within a Special Task Group ST7 on quantum communication and information technologies (established by CCSA); the China Cryptography Standardisation TC (which works, for instance, on QKD standards); and an Advanced Computing Research Group within TC28 on information technology, led by the China Electronics Standardization Institute (CESI) (SESEC, 2020).

When it comes to international engagement, China is contributing to relevant standardisation work within several organisations, including ITU-T, ISO/IEC, and ETSI. Chinese actors were behind several proposals for the establishment of new groups focused on quantum research and standardisation, as outlined in the following sections.

Participation in ISO/IEC work

Within the framework of the ISO/IEC JTC1, a working group was established in 2020 to focus on quantum computing standardisation – WG14. The group's convenor is a representative of CESI (until the end of 2023). At the national level, CESI created a mirroring committee for WG14 to enable the development of proposals for submission at the WG (SESEC, 2020). As a result, a Chinese proposal was put forward for a project on quantum computing terminology and vocabulary; this was registered in JTC1's work programme in June 2020 as *ISO/IEC AWI 4879 | Information technology – Quantum computing – Terminology and vocabulary* (ISO, no date-f).

It appears that Chinese actors were also behind a standardisation proposal for QKD security requirements (SESEC, 2020). Approved as a work item in 2019 within JTC1's SC27 on information security, the ISO/IEC 23837 has two components: one on requirements for QKD (of the three leads for this item, two represent Chinese entities), and one on evaluation and test methods (with one Chinese representative among the three item leads) (Shi, 2019). In October 2021, both components were in the stage of committee drafts (ISO, no date-g; ISO, no date-h).

Participation in ITU-T

At ITU-T, standard proposals related to quantum technologies are usually submitted at SG13 on future networks (e.g. in relation to QKD networks) and SG17 on security (quantum security).

SG13 has a question (Q16/13) dedicated to future networks – trustworthy and quantum-enhanced networking and services (within its WP3). China – through a representative of CAS Quantum Network Co. – holds an associate rapporteur position. For the 2017–2020 SP, we identified 17 proposals related to quantum technologies (all dealing with QKD networks) that were accepted as work items within the SG.[85] Chinese actors (in particular CAS Quantum Network, Rayton Networks, the Beijing University of Posts and Telecommunications, and CAICT) were involved in 13 of them,[86] as follows:

Quantum-related work items accepted within SG13: 17

Approved as of November 2021: Seven in total, six with Chinese participation

- *One led by Chinese editors only (on applications of machine learning in QKD networks)[87]*
- *Five with editors from China, Japan, and the Republic of Korea (on various issues related to QKD networks, such as functional requirements, quality of service, etc.)[88]*

Under study as of November 2021: Ten in total, seven with Chinese participation

- *One led by Chinese editors only*
- *Six with the involvement of Chinese editors, together with editors from Japan, the Republic of Korea, and the UK*

Within **SG17**, one question (Q15/17) covers security for/by emerging technologies including quantum-based security. China Mobile holds an associate rapporteur position for this question. During the 2017–2020 SP, we identified 11 proposals related to security in the context of quantum technologies that were accepted as work items within the group.[89] Chinese actors were involved in three of them, as follows:

Quantum security related work items accepted within SG17: *11*

Approved as of November 2021: Four in total, two with Chinese participation

- *One led by editors from China, Japan, the Republic of Korea, and Switzerland (on security framework for QKD network)[90]*
- *One led by editors from China, Japan, and the Republic of Korea (on security requirements for QKD networks)[91]*

Under study as of November 2021: Seven in total, one with Chinese participation

- *One led by Chinese editors only (on security requirements and designs for QKD networks)*

In 2019, a **Focus Group on Quantum Information Technology for Networks (FG-QIT4N)** was established – at the proposal of Chinese actors (TC578, 2019) – to provide a collaborative platform for pre-standardisation aspects of quantum information technology (QIT) for networks. A representative of China's University of Science and Technology holds one of the FG's three co-chair positions, while representatives of CAICT and QuantumCTek Co. hold two of the eight vice-chair roles. The WG on network aspects of QIT (one of the FG's two WGs) is led by China-based QAS Quantum Network.

The FG is working on ten deliverables/technical reports on issues such as QKD terminology and use cases, and QKD network protocols and transport technologies. Among these, four are led by Chinese editors (including chief editors and co-editors), three by US editors (with co-editors from China), and one by Japan (with co-editors from China, the Russian Federation and Singapore). The remaining two are co-led by China and the USA; and China, the Republic of Korea, and the USA, respectively.

Between December 2019 and August 2021, the FG held nine meetings. Our review of meeting documents shows that Chinese participants were by far the most active, both in terms of contributions submitted and the number of participants attending the meetings. Among all contributions made by FG participants,[92] 73% were submitted by Chinese entities (e.g. Beijing University of Posts and Telecommunications, CAS Quantum Network Co., CAICT, Huawei, ZTE, China Unicom, Jinan Institute of Quantum Technology). Among participants in all nine meetings, 43%

[85] The analysis covers work items which include the terms *quantum* and/or *QKDN* in their titles. Corrigendums were not included in the analysis.
[86] Among the remaining four work items, three were led by Korean editors only, and one by Japanese editors.
[87] Recommendation ITU-T Y.Supplement70 to ITU-T Y.3800-series - Quantum key distribution networks - Applications of machine learning (ITU-T, 2021(g)).
[88] Y.3801: Functional requirements for quantum key distribution networks; Y.3802: Quantum key distribution networks - Functional architecture; Y.3803: Quantum key distribution networks - Key management; Y.3804: Quantum key distribution networks - Control and management; Y.3806: Quantum key distribution networks - Requirements for quality of service assurance.
[89] The analysis covers work items which include the terms *quantum* and/or *QKDN* in their titles. Corrigendums were not included in the analysis.
[90] Recommendation ITU-T X.1710: Security framework for quantum key distribution networks (ITU-T, 2020).
[91] Recommendation ITU-T X.1712: Security requirements and measures for QKD networks - key management (ITU-T, 2021-h).
[92] Submissions by FG leadership and editors, as well as submissions from other ITU-T groups, were not considered in the analysis.

of them represented Chinese entities (Figure 25). An interesting observation here is that the number of participants from the USA has started to increase with the 7th group meeting.

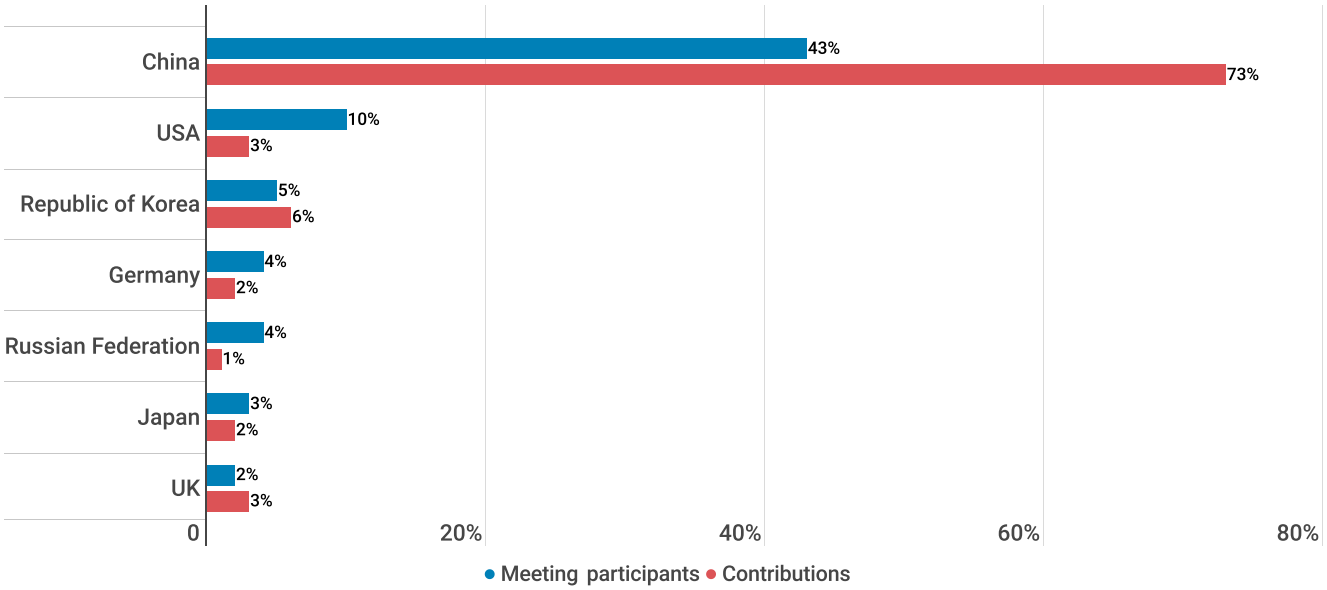

Figure 25. Distribution of FG-QIT4N meeting participants and contributions among selected countries.

Based on FG-QIT4N meeting documents

Participation in ETSI

At ESTI, Chinese actors contribute to the **Industry Specification Group on Quantum Key Distribution (ISG QD)**. As of November 2021, the group has published 11 deliverables on issues such as application interfaces for QKD, components and internal interfaces, and security specifications.

Huawei holds one of the group's four vice-chair positions. Among the group's 41 members, 4 are Chinese: Huawei (the German and UK branches), CAICT, and QIAC – China Information Association Quantum Information Branch. CAS Quantum Network is a participant.

In November 2021, the group had ten items on its work programme. For six of them, Huawei is listed among the supporting organisations. However, none of the work items has a Chinese editor.

Implications of China's growing involvement in international standardisation

What drives engagement in international standard-setting?

China has been rather transparent with regard to the goals it wants to achieve when it comes to standardisation and its engagement in international standard-setting. The country has understood early on the role that standards can play in supporting the implementation of its national economic and industrial policies and in achieving its ambitions of attaining global technological leadership.

The country's growing involvement in international standardisation can be seen first and foremost as an economic matter. On the one hand, it reflects the status quo. China has emerged as a global economic power, so, naturally, it seeks to have a more prominent voice in international standard-setting. On the other hand, it is also a strategic issue. By contributing to the definition of international standards, Chinese actors are trying to ensure that the technologies they develop are in line with – and even reflected in – such standards, allowing them to compete on the international market (sometimes with a competitive advantage, if the standards reflect their technologies). The focus on advanced and emerging technologies – where standards are still in an early stage of development – is a clear illustration of this.

Regardless of how other actors see these goals, they remain legitimate. And they are pursued in a relatively open and transparent manner, through contributions to international processes, together with other actors.

China also argues, rightfully, that the international standardisation ecosystem has largely been shaped by Western actors, and the country is now trying to find its way and its place within this ecosystem (Pop et al., 2021). Moreover, as some interviewees noted, a more active involvement in international standard-setting is also a matter of national prestige. China tends to believe that the attention and respect it is given at the international level does not match its status as a world power. So it tries to change this by being more visible in international settings, including through aiming for leadership positions within SDOs.[93]

Western actors in particular raised concerns that China is trying to use standardisation as a way to export its political ideology and governance approaches. Some of these concerns relate to how some standard proposals from Chinese actors may negatively impact human rights (as was the case with the FRT proposal at ITU-T). Others relate to how some proposals may result in governments having more control over the internet and its evolution (as illustrated in the debates around the New IP). These are legitimate concerns; and it is important that they are addressed holistically – together with technical considerations – within the relevant SDOs.

Participation in SDOs: What makes it different?

There are a few elements that tend to make the participation of Chinese actors in SDOs different from others. One of them is the fact that China affords the luxury of having large delegations (including a strong industry), and, thus, the resources to engage more than others, and the ability to stay on top of things. If we take ITU-T as an example, having large delegations means being able to follow and engage in the work of the multiple WPs. This would play to the favour of any one country in a similar position. Also, the fact that Chinese actors are constantly encouraged (and sometimes incentivised, as it is said) to participate in international standard-setting determines them to be more proactive, to seek more leadership opportunities, and to put forward more proposals.

Some argue that this approach changes the dynamics of international standard-setting, making it more difficult for other actors to compete (especially if they cannot afford to allocate the same resources). While this may be true, no rules are being broken, and it is within any one country's right to follow a similar approach.

Another element is the relationship between Chinese industry and the government, and the blurred lines that exist. Several actors suggest that Chinese stakeholders have a strong, coordinated approach within SDOs, somewhat imposed by the government. Some argue that the state can leverage the 'control' it has over companies to ensure that there is a coordinated, state-driven position within SDOs (Rühlig, 2020). How such lveraging works is, however, unclear.[94] Others observe that, in general, Chinese industry and the government work closely together (which often means that they are better prepared for discussions), compared with the

[93] Interviews with SDO participants and standardisation experts, July–October 2021.
[94] Clarifications on these and similar issues were difficult to obtain, in the context of unsuccessful interview requests.

stakeholders of other countries. But this reflects the goal to have a stronger presence in SDOs and an ability to drive the adoption of international, consensus-driven standards that would facilitate the penetration of markets by Chinese companies.[95]

Moreover, several interviewees also made references to instances when Chinese companies are simply pursuing their own interests. Some gave Huawei's involvement in the IETF and 3GPP as an example, noting that this is more of an instance of a tech company trying to pursue its economic interests through standardisation, rather than the influence of the Chinese government. Another example was of companies like Alibaba and Didi,[96] which have also been under increased governmental scrutiny lately. As the government is increasing its regulatory grip over the tech sector, it remains to be seen whether this will also reflect in how the state interacts with companies involved in international standard-setting.

The plus side of a growing involvement in international standardisation

More inclusive standardisation processes

China's increasing participation in international standardisation is a win for these processes. It means they include global players, who see them as valuable. It is also an indication that Chinese actors prefer to engage in organisations that underpin international order rather than trying to subvert it. And that China, overall, wishes to be part of the global system of standards (and, implicitly, trade), rather than decouple itself from it.

Increased participation in standardisation, in general, has positive implications. It allows a greater diversity of thought and perspective, it creates more opportunities to strengthen and improve standard proposals, and it means that the adopted standards are based on broader international consensus, potentially increasing the odds of them being deployed on the market at a greater scale. 'Overall, it would be worse if Chinese participation would not be there. If we want an interconnected world, we need to have the big players engaged. For instance, if we want to keep the internet as a global network, we cannot do so without participation from a large part of the world.'[97]

Strengthened technical interoperability and standards compatibility

China's involvement could have positive consequences for global interoperability and the safety of products and services. It could also strengthen the acceptance and adoption of international standards at a national level, thus reducing market barriers for foreign companies. These aspects are particularly important given that China is a large exporter of goods, as well as a large market for imported goods. As the US-China Business Council (2020) notes, 'Greater alignment between international and Chinese standards can greatly reduce engineering costs and the time needed for a foreign company to bring a product to the Chinese market, reduce market access barriers, and also allow Chinese companies greater ease in exporting around the world and investing abroad.'

Replicating international principles at a national level

The fact that Chinese actors become more exposed to and familiar with how international standardisation works and the principles and procedures that are followed there (e.g. transparency, consensus, relevance) could translate into improvements in the national standardisation system.

[95] Interviews with SDO participants, July–October 2021.
[96] Interviews with SDO participants, July–October 2021.
[97] Interview with an SDO staff member, August 2021.

Concerns raised regarding a growing involvement in international standardisation

Reshaping the international standardisation system

Challenging the established order. The growing involvement of Chinese actors in international standard-setting inevitably means more competition. It therefore poses a challenge to established standard powers (be they countries or companies), who are concerned that competition with powerful new players could lead to them losing ground. So they need to adjust their involvement and ramp up their resources.

Would similar concerns be raised if a smaller country ramped up its involvement in international standardisation as China did? As one interviewee noted, 'Most likely not. The size and importance of China change the balance of the ecosystem. But what we should also ask ourselves is whether the ecosystem was balanced to start with.'[98]

Challenging the established model. As noted in the section on Chinese policy for international engagement and cooperation, some standardisation policies issued by the government refer to a goal of promoting 'a new layout for international standardisation, in which governments indicate the way and enterprises play the leading role in collaboration with universities and research institutes' (SAC, 2021a). There is a concern that China is trying to export its state-driven digital policy model and reshape the current international environment 'from one largely driven by private self-regulation to a more sovereign-sensitive one that is shaped by nation states' (Rühlig, 2020). This is indeed a legitimate concern, but it must also be acknowledged that China may only succeed in advancing such a model if there is not enough opposition from other actors, which should serve as an argument and a call for all players to ensure that the standardisation ecosystem is diverse and maintains its integrity. This requires fostering more inclusivity and enabling more actors, especially those less present in the standardisation space, to get involved in the processes.

Others, however, note that, beyond stated goals, China's interests in international standardisation are less about exporting a political ideology, and more about advancing economic objectives.[99] And this is something that all participants in SDOs have in common. They advocate for standards that can open markets for technologies, patents, royalties, etc. Generally speaking, standard-setting is a competitive sector. As long as everyone plays by the same rules, it is a fair game where everyone tries to defend their profits.

Challenging Western values and principles

Digital technologies – from the internet to AI – have a much stronger impact on society than previous technologies. The way in which standards for such technologies are shaped can therefore lead to more than just economic implications; they also raise issues of human rights, ethics, and security. Given China's track record when it comes to protecting human rights, as well as claims that Chinese technologies deployed in foreign countries pose security risks, there are concerns that standard proposals from Chinese actors might be driven not only by economic interests, but also by goals that conflict with core values and principles usually promoted by the West. For instance, standard proposals such as the New IP and the one related to facial recognition applications in visual surveillance have fuelled concerns that Chinese actors may try to misuse standardisation as a vehicle to promote technologies that pose challenges to democratic values and human rights (e.g. may facilitate surveillance and censorship).

The interplay between human rights, democracy, and technology is likely to feature prominently in the global standardisation debate on AI and other advanced technologies. While technological solutions can have implications for human rights and democracy, the real-life impact of technology is determined by how it is used, and this often goes beyond the mere impact of standards. It is important to ensure that standardisation processes are also mindful of these issues and take into account the broader interaction between standards, technological solutions, and real uses.

[98] Interview with a staff member of an international organisation, August 2021.
[99] Interviews with SDO participants and standardisation experts, July–October 2021.

Gaining market dominance through standards

China's growing involvement in SDOs is the result of planned and concentrated efforts. One of the goals is to promote the integration of standards and technologies developed at the national level into international standards. This could then act as leverage for Chinese companies to gain market dominance at the international level. This is seen as concerning, considering the broader debate on the potential negative implications that Chinese technologies could have for human rights and democratic principles, as well as the geopolitical context of tech competition between nations.

As long as China plays by the rules (i.e. respects the principles of international standardisation), it is difficult to argue against the approach of using standards to gain more market share. What other actors could do is to make sure that (a) they are able to compete with Chinese technologies on the international market, and (b) they are actively engaged in international standardisation work in a way that allows them to anticipate and mitigate the potential impact of proposed standards on human rights. And, finally, if some standards end up being adopted without adequate safeguards, countries should make sure that their regulations are strong enough to prevent products based on such standards from entering their markets (Voo and Creemers, 2021).

In parallel, China is also trying to promote its domestic standards through the direct export of technologies (e.g. via infrastructure and investment projects in the framework of the BRI). This could result in domestic standards becoming de facto international standards. So far the country has not been particularly successful in achieving such a goal. But the situation may change, especially considering that China is increasing its innovation and export capabilities, in particular when it comes to advanced and emerging technologies that lack international standards (Voo and Creemers, 2021). This is why it is important that China is encouraged to continue its engagement in international standardisation. Having standards for newer technologies developed at an international level minimises the risk of Chinese standards becoming de facto international standards through market adoption.

Box 24. The risk of a (more) fragmented standards system

As noted earlier in this report, China is pursuing not only more active participation in SDOs, but also a strengthened bilateral and regional standards cooperation (e.g. through initiatives such as the BRI and the integration of standards in bilateral and multilateral agreements). This dual approach is seen by some as negatively affecting international standardisation: 'Both efforts undermine the efficacy of international standard-setting bodies and erode their normative influence while furthering the adoption of Chinese technology [...] in emerging markets' (USCC, 2020). There is also a concern that if China focuses more on exporting standards through bilateral and regional frameworks – and less on international engagement and the compatibility between domestic and international standards – this could further fragment the international standards system and create distinct spheres of influences (i.e. international standards and Chinese standards) (Kamensky, 2020b).

The likelihood of this scenario becoming reality is very much dependent on how other actors devise their approaches towards China within the international standardisation ecosystem: A containment approach would inevitably push China towards more bilateral and regional frameworks for exporting its technologies and standards (Seaman, 2020).

Serving as an inspiration for like-minded countries

Questions are sometimes raised about the effects that the greater Chinese involvement may have on other emerging tech powers and developing countries, in particular those that have similar (i.e. more centralised) governance models. Could such countries find inspiration in China's strategy and follow a similar approach? This is unlikely. Among the countries that share the more centralised governance model, China can be described as the most advanced – both economically and technologically – and probably also the best organised. If China's strategy in international standardisation is working, it does not mean that it could work for the other countries as well. They most likely do not have the political drive, the long-term strategies and goals, the capacity, and the technological and scientific communities to support this. 'China could be the leader of like-minded countries, but it does not mean that other countries would follow suit.'[100]

[100] Interview with a staff member of an international organisation, August 2021.

Approaches to China's involvement

China has certainly become more important in international standard-setting over the past two decades. As the numbers show, it is now one of the most active actors in ITU, ISO, and the IEC, but also in bodies such as 3GPP and the IETF. The country has significantly more participation in these organisations now than it had before 2000; not only in terms of people attending meetings, but also in terms of active contribution, drafting of proposals, leadership positions, etc. This is a result of the significant efforts and resources allocated to standardisation work starting in the early 2000s.

Despite the focus on cases like the New IP and the facial recognition proposal – and their coverage in the media – the debate remains open on whether China is dominating or could be dominating SDOs in a way that allows it to dictate how these organisations work or the standards they produce. But Chinese actors will likely continue to strengthen their engagement in international standardisation, in particular when it comes to shaping standards related to advanced and emerging technologies.

Although we should not underestimate the contributions of Chinese actors to international standardisation activities – or the goals behind them – we should be cautious not to overestimate their impact either. Nor should we disregard the fact that the approval of a standard in an SDO is not the end of the game; what matters more is the extent to which that standard is used by the industry. 'Even if China would want to rule the global technology world through standards, or was able to impose them through SDOs, the ultimate arbiter of a standard's success remains the marketplace' (Voo and Creemers, 2021). A broader question – worth exploring, but beyond the scope of our study – is how to ensure fair competition between state-led and free-market economies.

Containment vs cooperation

China's increasing involvement in SDOs and the special attention paid to some of its proposals, coupled with the broader geopolitical context and the tech competition between nations, have led to calls and proposals for strengthened cooperation between like-minded countries as a way to counter China. Suggestions were made, for instance, to create technology alliances of democratic countries that are leaders in the field of technology, to 'help democracies regain the initiative in global technology competition' (Cohen et al., 2020) and 'ensure a level playing field where the most innovative and dynamic companies succeed' (Rasser et al., 2020).[101] Such alliances would foster more active and coordinated participation in standard-setting bodies, as well as 'help counter unfair practices' in standardisation (Rasser et al., 2020).

Goals of strengthened cooperation in international standardisation frameworks are also integrated in more recent initiatives such as the Quad Critical and Emerging Technology Working Group, the *Framework for G7 Collaboration on Digital Technical Standards*, and the EU-US TTC.

While such cooperation is welcome, framing it in a way that would lead to containing/decoupling China should be avoided. As noted in this report, such an approach would be counter-productive. Keeping one major player away from the development of de jure international digital standards via SDOs would push it into directing more efforts towards the establishment of de facto digital standards (through bilateral and regional agreements, export of technologies, infrastructure projects in third countries, etc.).

Instead, finding ways to collaborate with all actors, including Chinese ones, would be a more effective strategy for addressing any challenges that may result from their growing involvement in SDOs. This would also contribute to avoiding a further fragmentation of the standards system and to ensuring the interoperability of key technologies at the global level.

Encouraging China – and other countries – to continue efforts towards a greater reflection of international standards into domestic ones is also worth pursuing.

[101] Dubbed as T-10 and T-12, such alliances would include combinations of the following countries: Australia, Canada, Finland, France, Germany, India, Israel, Italy, Japan, the Netherlands, the Republic of Korea, Sweden, the UK, the USA. The EU would also be involved as a larger bloc.

Recommendations for maintaining the integrity of the standardisation ecosystem

Considerable attention has been given recently to the involvement of Chinese actors in international standardisation and the implications of this involvement. Despite concerns and complaints about various aspects of this involvement, many agree that China is not breaking any written rules of the standardisation ecosystem, and that the country is, in many ways, doing what others have been doing in the past.

In this context – and considering that the standardisation environment is dynamic – it may be more effective if discussions focus less on China and possible ways to respond to its involvement, and more on what can be done to **maintain the overall integrity of the standardisation framework**. Attention should be given to ensuring that the international standardisation processes continue to function by well-established rules, that there are relevant oversight and accountability frameworks in place, and that no one actor – whoever they might be – is in a position to manipulate the system.

Fostering broader participation in SDOs would be a good starting point. 'A good standard is the result of a consensus-based process where a broad community contributes to making it a best practice.'[102] If only a few actors are contributing to such a process, there are fewer chances that the standard would be implemented and/or is representative of the current state of art globally.

Allocating more resources to standardisation work is also essential. As one interview recommended, 'As long as other actors abide by the rules, don't complain if they are able to win the game. Instead, put more resources in the process and step up your own game.'[103] And this should apply not only to standardisation work, but more broadly to the technological space, as a way to ensure that this space is and remains competitive.

There are several lessons that other countries may want to learn from China. If China's strategy – supporting the industry, promoting standards-awareness and education, allocating resources, etc. – proves to be successful, maybe imitating it wouldn't be such a bad idea.

We now outline a wider set of recommendations that could contribute to maintaining the health and integrity of the international standardisation ecosystem.

Recommendations for governments

National standardisation strategies

- Consider developing standardisation strategies, to cover priorities and goals concerning (a) the domestic standards system, (b) bilateral and multilateral standards cooperation, and (c) engagement in international standardisation processes. Align these goals and priorities with broader industrial, technological, and economic policies.
- When setting priorities regarding engagement in international standardisation, encourage domestic actors to be mindful of the types of technologies that are traditionally standardised within each SDO.

Participation of domestic actors in SDOs

- Allocate resources (e.g. funds, personnel) to strengthen national participation (e.g. through national SDOs, Geneva missions (where relevant)) in international standard-setting bodies.
- Encourage the private sector and the technical community to get more involved in SDOs (not only through participation in discussions, but also through submission of standard proposals). Allocate resources to support such participation.
- Raise awareness about the importance of international standardisation and global interoperability at the national level. Run capacity development programmes for actors less represented in standardisation work, such as SMEs, civil society, and academic actors.
- Foster a more active engagement of SMEs, civil society, and academic actors in SDOs (e.g. through providing funding).

[102] Interview with an SDO staff member, August 2021.
[103] Interview with an SDO participant, August 2021.

- Create dialogue platforms enabling businesses, the technical community, civil society, academia, and government actors to interact on standardisation-related matters. This would help bridge the gap between the different communities, allowing them to better understand each other's interests and positions.
- Raise awareness among national actors about the need to assess standard proposals including from the perspective of the impacts they may have on human rights.
- Try to coordinate approaches and positions for participation in international standardisation (among domestic actors), when and where possible. At a minimum, foster exchange of information related to international standardisation.
    - For instance, create an alert system through which industry and civil society groups participating in SDOs can alert governments of standard proposals that raise non-technical concerns and could generate a diplomatic spillover.

Cooperation with other participants in SDOs

- Create frameworks for cooperation and exchange of information with other countries and their actors within SDOs. Given the scarce resources that individual countries usually have when it comes to covering international standardisation processes, such cooperation would enable countries that follow different areas to alert one another of developments that are important to follow.
- When and where possible, coordinate approaches in SDOs with other countries and their actors (organise consultations, hold meetings to identify common priorities, etc.).

Recommendations for all participants in SDOs

- Ensure that standard proposals are assessed not only for their technical relevance and soundness, but also from the perspective of the broader societal implications they may have (e.g. considering issues such as consumer protection, human rights, ethics, democratic principles).
- Avoid making decisions about one standard proposal or another simply based on geopolitical considerations.
- Be vigilant not only about contributions coming from one particular actor, but broadly about the implications of all proposed standards.
- Approach standard proposals that might raise human rights concerns or be against certain values not only with the goal to reject them. Instead, try to contribute to the revision of those proposals so that they are in line with the sought-for values and principles. It is important to keep in mind that rejecting one proposal does not mean that the proposal is shelved for good; it can easily reappear, in the same or in other SDOs, in slightly different forms.
- Cooperate with SDOs in ensuring that the rules and procedures governing standardisation work are adhered to. All actors must work towards maintaining the integrity of SDOs.
- Support SDOs efforts to bridge the standardisation gap and bring more countries (and their stakeholders) into these processes. Having more contributors and more perspectives helps avoid any one actor or group of actors dominating the process.
- Support diverse representation in key roles (e.g. chair, vice-chair, rapporteur, convenor) within bodies such as TCs, SGs, and WGs, reflecting the range of different national, regional, and professional interests.

Recommendations for SDOs

- Foster strengthened cooperation among the multitude of SDOs, to avoid duplication of effort and even forum shopping practices.
- Expand practices through which specifications developed in industry consortia are taken over and adopted as international standards in key SDOs at the international and regional level.
- Foster more diversity in terms of participants in standardisation work, across developing countries, stakeholder groups, gender, youth, etc.
    - For instance, actively support the engagement of SMEs, civil society, and academic actors in standardisation processes through measures such as lower entry barriers (e.g. lower accession costs) and more accessible/easier to understand information.
- Ensure that the rules and procedures governing standardisation work (e.g. due processes, checks and balances, consensus-driven work) apply effectively and efficiently.
- Consider mechanisms (where such mechanisms do not exist) to stop standard initiatives that have lost relevance because of technological progress, or initiatives with little chance of generating consensus.
- Engage in more awareness-raising on the non-technical aspects of standardisation work. Foster convergence between standardisation and human rights processes (e.g. through cooperation with intergovernmental organisations that focus on human rights).

- Enable clearer communication about standardisation processes and engagement opportunities as a way to increase transparency and enhance information accessibility.
- Conduct capacity development programmes (e.g. workshops, seminars) on SDO working methods, rules, and procedures for new participants.
- Consider joining efforts with other SDOs in carrying out a mapping exercise that would offer a general overview of the similarities and differences between their focus areas, membership structures, rules and procedures, engagement opportunities, etc.

Annex 1

Overview of selected SDOs: Membership and standards development processes

This annex covers six selected SDOs (ITU-T, ISO, the IEC, 3GPP, the IETF, and IEEE), and provides an overview of membership structures and standards development processes. These processes are simplified to the extent possible; for detailed information, relevant SDO documents should be consulted.

ITU-T	
Focus	Standards for various fields of international telecommunications and ICTs. Areas covered range from smart cities to future networks, and from telecommunications protocols to security.
Membership	In addition to **member states (MSs), ITU-T is also open to participation from industry, academia, and NGOs, as well as regional and international organisations**. These can join ITU-T as **sector members (SMs)** – with the right to participate across all activities of the Sector, **associates** – which can participate in one study group, or **academia**. Participation involves the payment of a fee. Usually, the term *member state* refers to ministries, responsible telecommunication administrations (e.g. national regulatory authorities) and organisations related to them, and permanent missions to the UN.
Technical groups (where standards are developed)	The standardisation work is carried out within **study groups (SGs) and corresponding working parties (WPs)**. The SGs themselves, their composition and areas of work (called *questions*), and their leadership (chairs and vice-chairs) are typically decided at the World Telecommunication Standardisation Assembly (WTSA), for 4-year study periods (SP). **Approving questions** Member states submit proposals for (new or revised) questions as contributions to relevant SGs. The proposals are distributed to all MSs and SMs of the SG concerned. Before being considered for approval, the Telecommunication Standardization Advisory Group (TSAG) is made aware of the proposals, so it can consider possible implications for all ITU-T SGs; TSAG may recommend changes to the questions. Between WTSAs, new or revised questions may be approved by an SG if there is **consensus** at the SG meeting; moreover, **some MSs and SMs (normally at least four) have to commit to supporting the work**. If consensus cannot be achieved, the SG may request approval by consulting all MSs. MSs have two months to indicate whether they approve the proposed questions. A question is approved if a simple majority of all responding MS are in favour and if at least 10 MSs express their views. At WTSA, when questions for the next ITU-T SP are typically approved, the process is as follows: Proposals for questions are submitted within SGs, which review them and decide (by consensus) whether to submit them for approval. TSAG then reviews all proposed questions. Following approval by TSAG, MSs and SMs are informed of the list of proposed questions. At WTSA, the final review and allocation of questions are made. (ITU-T, 2016) **Electing SG leadership** Member states put forward nominations for SG chairs and vice-chairs. The Director of the ITU Telecommunication Standardization Bureau (TSB) then tries to negotiate a set of SG chairs taking into account the candidates' competence and history of participation, as well as the need for overall geographic diversity. Substantive negotiations usually take place, but the goal is to make the final decisions based on consensus among MSs. The same process applies to SG vice-chairs. Generally, there is a goal for each SG to have at least one vice-chair from each region. Decisions on chairs and vice-chairs of working parties, as well as on rapporteurs and editors – individuals responsible for leading the work on specific questions or work items – are taken within the SGs themselves.

Standards development and approval	The standards development process starts with the submission of a contribution within an SG/WP. If a contribution is approved for inclusion in the SG/WP work programme, it becomes a work item, and one or several editors are assigned to it (ITU-T, 2019c). The work items are discussed within the relevant SG/WP, with the participation of MSs, SMs, associates, and academia. **Standards approval** The final decision on a recommendation (the term used in ITU-T for standards and other products) is made via a traditional approval process (TAP) or an alternative approval process (AAP). Typically, recommendations related to numbering, addressing, tariff, charging, and accounting, and which have policy or regulatory implications, follow TAP, while the rest follow AAP. The change from one procedure to another can be decided by the consensus of MSs and SCs present at an SG meeting. When work on a draft recommendation is considered sufficiently mature within an SG, the SG chair asks the TSB Director to announce (to all MSs and SMs) the intention to apply the relevant approval method. **Alternative approval process** Initially, MSs and SMs are asked to comment on the approval of a proposed recommendation. If an MS or SM considers that the proposed recommendation should not be approved, they should submit comments highlighting their reasons and indicating possible changes that would facilitate further consideration or approval. The comments are considered at an SG meeting, where the final decision on the draft recommendation is made. Efforts are made to reach an **unopposed agreement** on the draft recommendation; if this is not possible, **the recommendation is considered approved if no more than one MS (following consultations with its SMs) opposes it** (ITU-T, 2008). **Traditional approval process** Initially, MSs are consulted on whether they assign authority to the SG that the draft recommendation should be considered for approval at the SG meeting. For the draft recommendation to be considered for approval at the SG level, 70% or more of the replies from MSs need to be in favour. When the recommendation is then considered in an SG meeting, it is approved if there is an unopposed agreement of MSs (ITU-T, 2016).
ISO	
Focus	Standards that cover a wide range of industries, including technology, agriculture, healthcare, and environment management, to name but a few.
Membership	ISO membership is open to national standards bodies (designated as such by national governments). There is **only one member per country (called the *national body* (NB))**. However, the organisation involves more than 100,000 experts from industry, government, academic and research bodies, NGOs, etc., which participate through their national body (ISO, no date-i). There are three member categories. Full members participate and vote in ISO technical and policy meetings. Correspondent members attend ISO technical and policy meetings as observers. Subscriber members are regularly updated on ISO's work but do not participate in the standard developing process.

Technical groups (where standards are developed)	Standards are developed within **technical committees (TCs), subcommittees (SCs), and corresponding working groups (WGs)**. Proposals for establishing new TCs can come from multiple sources, including an NB, a TC/SC, the Technical Management Board (TMB), the ISO Chief Executive Officer, etc. The proposal is approved **if a two-thirds majority of the NBs voting are in favour and at least five NBs express their intention to participate actively in the TC work.** Once approval is given by NBs, the TCs are established by the TMB (composed of 15 members). The scope of work of a TC is decided by the committee itself, through **approval by a two-thirds majority of the voting members**. The same threshold is required to establish SCs. Members decide whether they want to join a committee as a participating member (with an obligation to vote on all issues submitted for voting and to contribute to meetings) or as an observer (with the right to receive documents, submit comments, and attend meetings, but without the ability to vote). **Secretariats and chairs** A TC/SC is managed by a secretariat allocated to an NB. TC secretariats are allocated by the TMB, and SC secretariats by the parent TC. **Secretariats are expected to act in a purely international capacity**, divesting themselves from national points of view. **TC chairs** are nominated by the secretariat of the TC and approved by the TMB, for a maximum period of six years (extensions are possible up to nine years). SC chairs are nominated by the secretariat of the SC and approved by the parent TC – through a two-thirds majority vote of the TC members – for a maximum period of six years (extensions are possible up to nine years). **Chairs are required to act in a purely international capacity;** they cannot serve as the delegate of their NB in the respective committee. WG convenors are appointed by the parent TC/SC.

Standards development and approval	ISO members participating in a TC/SC can assign experts to contribute to drafting standards; these experts can come from any stakeholder group. The standard developing process, from the first proposal to final publication, takes between 18 and 36 months. Usually, the process consists of six stages: proposal, preparatory, committee, enquiry, approval and publication. Proposals for standards (called work item proposals) can be submitted within TCs/SCs by an NB, the TC/SC secretariat, another TC/SC, a liaison organisation, the TMB, or the CEO. **For a work item to be approved for discussion, two conditions must be met: (a) approval by a two-thirds majority of the TC/SC voting members, and (b) a commitment to participate actively in the development of the project by at least four or five members** (depending on the number of TC/SC members). Once the work item is approved, a project leader is usually appointed. A working group consisting of experts and the project leader (convenor) is usually set up to prepare a working draft. Successive working drafts may be circulated within the WG until the best technical solution is developed and agreed on within the group. Then, the draft is forwarded to the parent committee to reach a consensus. This committee stage is optional. If the committee uses this stage, successive committee drafts can be circulated until consensus on advancing an enquiry draft is reached. **Consensus does not imply unanimity; it is understood as general agreement, in the absence of sustained opposition.** All efforts should be made to achieve consensus; in case of doubt concerning consensus, approval by a two-thirds majority of the TC/SC voting members may be deemed sufficient for the committee draft to advance as an enquiry draft. At the enquiry stage, the Draft International Standard (DIS) is shared with all NBs to vote and comment on it. The **DIS is approved if a two-thirds majority of the members of the parent TC/SC support the draft, and not more than one-quarter of the total number of votes are negative**. If the DIS is approved, and no technical changes are introduced in the draft, the project goes straight to publication. If changes are needed, the revised draft needs to go through the approval stage. If this stage is used, the Final Draft International Standard (FDIS) is circulated to all NBs for a vote. **The FDIS is approved if a two-thirds majority of the members of the parent TC/SC support the draft, and not more than one-quarter of the total number of votes are negative.** Once the FDIS is approved, only editorial corrections can be made to the final text. It is then published by the ISO Central Secretariat as an International Standard. All International Standards are reviewed every 3-5 years to ensure they are still relevant (ISO/IEC, 2021a).
IEC	
Focus	Standards for all electrical and electronic technologies, such as fibre optics and cables, smart energy, IoT, AI, and many more.
Membership	IEC members are **National Committees** (NCs) and there can be only one NC per country. NCs send experts to represent national needs in the global IEC standardisation efforts. NCs are open to all stakeholder groups to achieve a balanced representation of all private and public electrotechnical interests in their respective countries. Individuals and companies can only participate in the IEC via their NC. There are two membership levels. To become a full member, a country needs to demonstrate that its NC has been constituted in accordance with IEC rules. Full members can send experts to participate in any IEC TC/SC, apply for management positions, and have voting rights in the IEC Council. IEC associate members can access all working documents and send their experts to a limited number of TCs/SCs. Unlike full members, associate members cannot hold management positions or functions in the IEC and do not have voting rights.
Technical groups (where standards are developed)	Standards are developed within **technical committees (TCs), subcommittees (SCs), and corresponding working groups (WGs)**. The establishment of TCs/SCs/WGs, the designation of secretariats, and the approval of chairs and vice-chairs follow the same procedures as in the case of ISO. The one notable addition is that at the IEC, **TC secretariats are 'strongly encouraged' to appoint TC chairs from an NC other than their own**. Chairs from the same NC as the secretariat should only be approved in exceptional cases (ISO/IEC, 2021b).
Standards development and approval	The process for developing and approving standards is the same as in ISO (see above).

3GPP	
Focus	Standards for cellular (mobile) telecommunications technologies, including radio access, core networks, and service capabilities.
Membership	At the core of 3GPP are seven standardisation bodies – known as **organisational partners** – which determine strategies and general policies: Japan's Association of Radio Industries and Businesses (ARIB) and Telecommunication Technology Committee (TTC), the US Alliance for Telecommunications Industry Solutions (ATIS), China Communications Standards Associations (CCSA), the European Telecommunications Standards Institute (ETSI), India's Telecommunications Standards Development Society (TSDS), and the Republic of Korea's Telecommunications Technology Association. To join 3GPP as an **individual member**, an entity has to be a member of one of the seven organisational partners. Participation in some 3GPP work is also open to **market representation partners** (organisations recognised as able to offer market advice and bring a consensus view of market requirements), **observers** (standard bodies which have the qualifications to become future partners), and **guests** (entities which have the qualifications to become future individual members).
Technical groups (where standards are developed)	Standardisation work happens within three **Technical Specification Groups (TSGs)**: Radio access networks; Services & systems aspects; and Core network & terminals. The TSGs may establish working groups (WGs). **TSG chairs and vice-chairs** are elected by the groups themselves, and appointed by the Project Co-ordination Group (PCG) – the highest decision-making body. Elections are generally held every two years. Candidates must be representatives of individual members. Elections are also run for the appointment of WG chairs and vice-chairs. If there is more than one candidate for any role, a secret ballot is used. When, in the first ballot, no candidate has obtained 71% of the votes cast, a second ballot is held. In the second ballot, if there are only two candidates, the candidate obtaining the higher number of votes is elected. In cases where there are more than two candidates, if none of them has obtained 71% of the votes, a third and final ballot is held among the two candidates who have obtained the highest number of votes in the second ballot. The candidate obtaining the higher number of votes in the third ballot is then elected.
Standards development and approval	TSGs define work items at the proposal of individual members. Each proposed new work item **must be supported by at least four individual members**, who are expected to contribute to the work. New work items are subject to approval by the PCG; they are deemed approved unless a substantial objection is received from an individual member or partner. One or more persons are named as rapporteurs for the work item. Before a work item is completed, the TSG may decide that the work is no longer required. Stopping a work item is also automatically considered by a TSG if no progress is achieved in a given period of time (usually six months). The outputs of work items are technical specifications or technical reports. These are approved in TSGs by **consensus**. When consensus cannot be reached, a vote can be taken; in this case, a proposal is deemed to be approved if 71% of the votes cast are in favour. Technical specifications and technical reports are typically submitted to organisation partners and the ITU for integration into their deliverables (3GPP, no date-b).

IETF	
Focus	Technical standards for the internet.
Membership	Unlike most SDOs, the IETF does not have any formal membership. The IETF recognises only individual members, and not organisational, business, or institutional ones. Participation is open to any interested individual.
Technical groups (where standards are developed)	All work within the IETF is carried out within **working groups** (WGs), which are organised by topic into **several areas** (routing, transport, security). The area structure is defined by the Internet Engineering Steering Group (IESG), composed of area directors: the IESG charters and terminates working groups, selects their chairs, and monitors their progress (IETF, 2004). The WGs usually work based on a charter that describes the specific problem to be addressed or product to be delivered (e.g. standards specifications, guidelines). Every working group has one or several **chairs.**
Standards development and approval	WGs evaluate standard proposals made by the community. Specifications that are intended to become internet standards are initially proposed as internet drafts. They are kept in this status for at least two weeks, allowing community review and input. The internet draft is discussed within a WG, which typically amends the document, suggests optimal technical solutions, and makes recommendations on advancing it through a set of maturity levels: proposed standard, draft standard, and standard. The move from one level to another needs to be approved by the IESG, following a 'last call' process through which comments can be accepted from anyone (IETF, 1996). WGs reach decisions through a process called **rough consensus**: 'If the chair of a working group determines that a technical issue brought forward by an objector has been truly considered by the working group, and the working group has made an informed decision that the objection has been answered or is not enough of a technical problem to prevent moving forward, the chair can declare that there is rough consensus to go forward, the objection notwithstanding' (IETF, 2014).
IEEE Standards Association (SA)	
Focus	Standards that cover a wide range of industries such as aerospace electronics, communications, computer technology, consumer electronics, cybersecurity, electromagnetic compatibility, green and clean technology, and wired and wireless communications.
Membership	The IEEE SA standards development process is open to members and non-members. However, IEEE SA membership enables voting rights in the development of standards. IEEE recognises two types of membership: individual membership and corporate membership. **Individual membership** enables individuals to vote on standards and take leadership positions in standards working groups within IEEE SA. Individuals with such membership cannot represent or act on behalf of an entity. **Corporate membership** is recommended for companies in which standards play a pivotal role in research, product development, and marketing. Participation is based on a 'one-company, one vote' framework. Corporate membership is open to corporations, government agencies, academic institutions, and nonprofit and industry associations. There are different corporate membership fees depending on companies' revenue.

Technical groups (where standards are developed)	Work on standardisation is done within the IEEE SA Standards Board and Working Groups (WGs). The IEEE SA Standards Board encourages and coordinates the development and revision of IEEE standards. Once the IEEE SA Standards Board approves a Project Authorisation Request (PAR), a WG that will develop the standard is established. A WG can elect a chairperson who facilitates the group discussions and is the contact person for technical questions. For individual standards projects, IEEE or IEEE SA membership is not required to participate in a WG. However, officers of IEEE standards WGs developing standards under the individual method must be members of the IEEE SA. For corporate standards projects, IEEE SA corporate membership is required to participate in a WG. Officers of IEEE standards WGs developing standards under the entity method must be representatives of advanced entity members of the IEEE SA.
Standards development and approval	The IEEE standards development lifecycle can last a maximum of four years. The process has six stages. The first stage is **initialising the project.** An individual or a group must submit a PAR which details the scope, purpose, and contact points for the proposed standard. Every PAR that is submitted must have a Standards Committee to oversee the project. Standards Committees for IEEE standards area are IEEE Societies and Committees, Standards Coordinating Committees (SCCs), the Corporate Advisory Group, and even the Standards Board. Upon submission, each PAR is placed on an upcoming New Standards Committee (NesCom) agenda, which gives its recommendation for PAR approval to the IEEE SA Standards Board. The IEEE SA Standards Board must give its approval for the standards development process to begin. Once a PAR is approved, a WG that will develop the standard is established. IEEE SA staff liaisons and staff project editors are available to help the WG in all steps of draft development. The standard's writer uploads the standard for ballot. The Standards Committee decides if the draft standard is stable and starts the **balloting process** by forming a balloting group with everyone interested in the standard. IEEE SA membership or payment of a per-ballot fee is required to ballot on standards. IEEE has two types of balloting: by individuals and by entities. In both types of balloting groups, each balloter (individual or entity) has one vote. **A standard will pass if at least 75% of ballots are returned and if 75% of these bear a 'yes' vote**. The standard and supporting material are submitted to the Standards Review Committee, which recommends to the IEEE SA Standards Board whether to give **final approval to a standard**. Finally, the standard is published. Standards are valid for ten years. After this period, they are either revised or withdrawn from active status. The revision process is initiated by a PAR for the revision of the standard. A standard can be revised before the ten years are up. The Standards Committee should initiate a revision of a standard if any of the material in the standard (including all amendments, corrigenda, etc.) becomes obsolete or incorrect, if three or more amendments to a base standard exist three years after its approval, or when new material becomes available and normal evaluation of need and feasibility indicates revision is warranted. Standards that are no longer useful or contain significant obsolete or erroneous information should be recommended for withdrawal from active status by the Standards Committee, supported by a ballot with a 50% return and at least a 75% approval. The decision to transfer a standard to inactive status is made by the IEEE SA Standards Board (IEEE, no date).

Annex 2

China's standards system

Type	Character	Goals (as described in the standardisation law)	Development process and observations
State-led standards			
Mandatory national standards (referred to as GB standards – 'Guóbiāo' – in Chinese terminology)	Mandatory	Address technical requirements for ensuring people's health and the security of their lives and property, safeguarding national and environmental security, and meeting the basic need of economic and social management.	Proposals for mandatory national standards can be put forward by central government departments (e.g. ministries, other state bodies), as well as departments in charge of standardisation within provinces/autonomous regions/ municipalities, social organisations, enterprises, public institutions, and citizens. SAC reviews the proposals and decides whether to approve them as standards development projects. If approved, SAC issues a project plan and assigns the relevant government department in charge of developing the standard (usually ministries and related bodies). The development of a standard usually happens within a technical committee (TC), which includes both public and private entities. The TC drafts the standard, solicits public comments, conducts a technical review, and issues a decision (usually by consensus, but voting can also happen). The standards are finally issued by SAC. Due to their mandatory nature, these standards serve as de facto legally binding regulations. The standardisation law clearly specifies that 'products and services that do not meet mandatory standards shall not be manufactured, sold, imported, or provided'.
Voluntary national standards (referred to as GB/T standards - 'Guóbiāo tuījiàn')	Voluntary	Address technical requirements that are needed to serve basic and generic purposes, support mandatory national standards, or play a leading role in relevant industries.	Developed under the overall supervision of SAC, through TCs. The industry usually treats such standards as quasi-mandatory, knowing that they tend to be preferred by state institutions (e.g. in the context of public procurement processes).
Sector standards	Voluntary	May be developed where, in the absence of voluntary national standards, national unified technical requirements within a sector are needed.	Developed in the framework of relevant administrative departments (e.g. ministries) under the State Council and submitted to SAC for registration. The drafting of standards usually happens within TCs that include both public and private entities. There are over 60 categories of sector standards covering different sectors (e.g. communications, automobile, machineries).

Local standards	Voluntary	May be developed to address local special technical requirements, such as natural conditions and customs.	Developed under the authority of local governments (departments in charge of standardisation) and only applicable within the respective administrative areas. Local standards must be registered with SAC. There is criticism that such standards serve protectioning purposes. Local authorities may refer to local standards in public procurement procedures, knowing that such standards are typically only used by local producers.
Market-issued standards			
Association standards	Voluntary	The state encourages societies, associations, chambers of commerce, federations, industrial technology alliances, and other social organisations to coordinate with relevant market stakeholders in jointly developing association standards that meet market and innovation requirements. These standards are adopted by the associations' members upon agreement.	SAC and relevant ministries regulate, guide, and supervise the development of association standards (but the standards do not need formal approval by SAC). The standards themselves are developed by private associations – basically any entity that has the status of an NGO granted by the Ministry of Civil Affairs. There is a requirement for standard-developing associations to register themselves and the standard they develop on a national standardisation platform. There is criticism that, due to the large number of association standards, many of them are overlapping or contradictory.
Enterprise standards	Voluntary	Enterprises may, where necessary, develop their own enterprise standards or work with other enterprises to develop enterprise standards.	Developed by individual companies or industry associations. Enterprise standards cannot be less strict than any corresponding national or industry standards (but they can be stricter). (The same applies to association standards.) There is a recommendation for enterprises to register their standards with state authorities.

Based on National People's Congress (2017); Kamensky (2020a); Rühlig (2020); SESEC (no date-a).

Annex 3

Abbreviations

3GPP	3rd Generation Partnership Project
AAP	alternative approval process
AFNOR	French Standardisation Association (Association Française de Normalisation)
AI	artificial intelligence
ANSI	American National Standards Institute
APEC	Asia Pacific Economic Cooperation
ARSO	African Organisation for Standardisation
ASEAN	Association of Southeast Asian Nations
AV	autonomous vehicle
BMVI	Federal Ministry of Transport and Digital Infrastructure (Germany)
BRI	Belt and Road Initiative
BRICS	Brazil, the Russian Federation, India, China, and South Africa
BSI	British Standards Institution
CAICT	China Academy of Information and Communications Technology (China)
CATARC	China Automotive Technology and Research Center (China)
CCSA	China Communications Standards Association (China)
CEN	European Committee for Standardization (Commission Européenne de Normalisation)
CENELEC	European Committee for Electrotechnical Standardization (Commission Européenne de Normalisation Électrique)
CESI	China Electronics Standardization Institute
COPANT	Pan American Standards Commission (Comisión Panamericana de Normas Técnicas)
DECT	Digital Enhanced Cordless Telecommunications
DIN	German Institute for Standardisation (Deutsches Institut für Normung)
DIS	Draft International Standard

ETSI	European Telecommunications Standards Institute
FDIS	Final Draft International Standard
FG	focus group
FRAND	fair, reasonable, and non-discriminatory
FRAV	Informal Working Group on functional requirements for automated and autonomous vehicles (within WP.29)
FRT	facial recognition technology
GDP	gross domestic product
GRVA	Working Party on automated/autonomous and connected vehicles (within WP.29)
HTML	HyperText Markup Language
ICANN	Internet Corporation for Assigned Names and Numbers
ICT	information and communication technologies
IEEE	Institute of Electrical and Electronics Engineers
IEEE SA	IEEE Standards Association
IEC	International Electrotechnical Commission
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IoT	internet of things
IMT-2020	International Mobile Telecommunications-2020
IP	internet protocol
IRTF	Internet Research Task Force
ISG	Industry Specification Group
ISO	International Organization for Standardization
IT	information technology
ITU	International Telecommunication Union
ITU-D	ITU Development Sector
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector
JTC1	ISO/IEC Joint Technical Committee 1
MiC 2025	Made in China 2025
MIIT	Ministry of Industry and Information Technology (China)
MS	member state
NB	national body
NC	national committee
NCSE	National Center of Standards Evaluation (China)
NDRC	National Development and Reform Commission (China)
NGO	non-governmental organisation
NIN	Non-IP Networking
OASIS	Organization for the Advancement of Structured Information Standards
ORU	other road user
PAR	project authorisation request
PASC	Pacific Area Standards Congress

PCG	Project Co-ordination Group
PDF	Portable Document Format
QIT	quantum information technology
QKD	quantum key distribution
R&D	research and development
RAN	radio access network
RCEP	Regional Comprehensive Economic Partnership
RFC	request for comments
RIPE NCC	Réseaux IP Européens Network Coordination Centre
SAC	Standardization Administration of China
SC	subcommittee
SDG	sustainable development goal
SDO	standards development organisation
SEP	standard-essential patent
SG	study group
SM	sector member
SME	small and medium-sized enterprise
SP	study period
STC	specific trade concerns
TAP	traditional approval process
TBT	technical barrier to trade
TC	technical committee
TMB	Technical Management Board
TSAG	Telecommunication Standardization Advisory Group
TSB	ITU Telecommunication Standardization Bureau
TSG	Technical Specification Group
TTC	Trade and Technology Council
UNECE	UN Economic Commission for Europe
USCC	U.S.-China Economic and Security Review Commission
W3C	World Wide Web Consortium
WP	working party
WP.29	World Forum for Harmonization of Vehicle Regulations
WTO	World Trade Organization
WTSA	World Telecommunication Standardization Assembly

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