GSMA

Towards better mobile quality of service in Asia Pacific

Assessing the role of regulation

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GSMA

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Executive summary

Ensuring that consumers enjoy a good quality of network service is a priority for both telecoms operators and policymakers. For operators, quality of service (QoS) is a key differentiator in competitive markets. Regulations around QoS have been evolving for the last decade, with notable developments in some countries in the Asia Pacific region in recent years.

To examine how QoS regulations have evolved in Asia Pacific, the GSMA undertook a study employing quantitative and qualitative methods. The objective was to take a closer look at how we understand QoS, the factors that influence it (including success drivers) and the impact of regulations on consumer welfare and industry sustainability.

The findings of the study help bring to light some significant challenges and issues for consideration for regulators, and can help inform policy-making on QoS.

The past decade: strong market-driven growth

Mobile connectivity across Asia Pacific has undergone remarkable transformation over the past 10 years. Consumer demand for advanced digital services has spurred market-driven growth in QoS. Mobile operators have responded with significant investments in new network generations, resulting in dramatic improvements.

Notable trends include:

- average download speeds increased from 3 Mbps in 2014 to 26 Mbps in 2023 (an eight-fold increase)
- upload speeds increased rapidly (also an eight-fold increase)
- latency (response time) fell from 200 ms to less than 50 ms
- dropped voice calls halved.

Regulation extends beyond direct QoS obligations

While some countries in the region (e.g. India) have implemented direct QoS obligations, others have not (e.g. Japan, New Zealand). However, effective government involvement extends beyond these regulations. For example, key policy areas that stand to impact QoS include the following:

- **Spectrum management:** Efficient spectrum allocation reduces deployment costs, enhancing network availability and quality. This allows operators to use frequencies more effectively, leading to wider coverage and increased capacity for data transmission.
- **Taxation and infrastructure:** Excessive mobile device taxes and barriers to infrastructure deployment can hinder QoS advancements. High taxes discourage consumers from upgrading to newer devices that often support faster connection speeds. Similarly, infrastructure hurdles delay network expansion and limit access to high-quality services in underserved areas.

External factors have a significant impact on mobile QoS

GSMA Intelligence conducted a study to explore how QoS regulations are evolving in Asia Pacific, using both qualitative and quantitative methods. The survey results and analysis demonstrate that external factors significantly impact mobile operator performance:

- **Spectrum management**: Spectrum availability plays a critical role. Limited spectrum restricts operators' ability to offer high-speed services and cater to growing demand for data.
- **Power access:** Reliable power supply is essential for uninterrupted network operation. Insufficient or unstable power can lead to network outages and service disruptions.
- **Infrastructure conditions:** The quality and density of existing infrastructure (towers, fibre-optic cables) directly affect network performance. Poorly maintained or inadequate infrastructure can act as a bottleneck on data transmission and limit service quality.
- **Municipal regulations:** Complex or restrictive permit processes for installing network infrastructure can hinder network expansion and delay service availability in certain areas.
- **Weather conditions:** Extreme weather events such as floods or typhoons can damage network infrastructure and disrupt services.

One-size-fits-all approaches to QoS regulations neglect these external factors and market dynamics, potentially penalising operators for issues beyond their control. Such regulations can focus solely on metrics such as download or upload speeds, and fail to consider the broader context influencing these metrics.

Several factors are driving a diverse mobile QoS landscape

There are several causes of the diverse QoS landscape in Asia Pacific:

- **Network generation:** Moving from 15% to 100% 4G adoption can increase download speeds by 2.5×. Newer network generations offer higher bandwidth and better data transmission capabilities.
- **Spectrum availability:** Increased spectrum allocation boosts download speeds. For example, those countries that made the most spectrum available to mobile operators between 2014 and 2023 almost doubled download speeds as a result. Spectrum availability is crucial to enabling faster connections and data transfer.
- **Fibre infrastructure:** Using high-capacity fibre links for mobile backhaul improves QoS. A 10% increase in fibre coverage correlates to a 5% speed improvement. Fibre-optic cables offer significantly higher data transmission capacity than traditional copper cables, resulting in faster and more reliable connections for mobile users.

QoS regulations have negative, unintended consequences

The study's evidence suggests that imposing direct QoS regulations has minimal or no impact on actual service quality. In fact, the regulations can have the following effects:

- **Increasing costs:** Compliance burdens mobile operators, requiring them to invest resources in monitoring and reporting metrics. These resources could be better directed to network expansion and infrastructure improvements.
- **Hindering progress:** Resources could be spent meeting regulations instead of expanding coverage or upgrading infrastructure. Operators could prioritise meeting pre-defined QoS targets over investing in innovative solutions that can ultimately benefit service quality.

Key considerations for regulators

- Regulators should consider frameworks that include all players in the ecosystem responsible for delivering voice, data and video to consumers.
- Monitoring and reporting of QoS should leverage where possible existing QoS information, such as that already available to operators or available from crowdsourced data.
- Regulators must work closely with operators and relevant stakeholders when developing parameters and benchmarks. They should also consider several factors outside the control of operators and establish whether it is feasible to set specific targets that are largely dependent on factors outside of operators' control.
- Conducting a regulatory impact assessment before enforcing or introducing regulations can be a good way to weigh up any benefits from the introduction of the obligations against their costs.
- Any sanctions need to be proportionate and used as a last resort. The number of countries where severe QoS sanctions are applied is significant, including monetary penalties as well as licence suspensions or criminal prosecutions. However, the empirical analysis indicates that more financially stringent sanctions are not found to be more effective. If anything, they can have negative consequences elsewhere in the form of reduced investments in expanding coverage.

1.
Understanding mobile QoS in Asia Pacific

1.1 The importance of QoS in the digital era

Quality of service (QoS) is increasingly important in mobile communications, with digital services for consumers now fundamental to many aspects of life, and access to the latest digital solutions a driver of competitiveness for businesses. Adoption of mobile technologies has significantly increased over the last decade, with 70% of the global population now using mobile and 57% using mobile internet. Demand has also grown for better connectivity that can support an evolving range of digital services and applications.

Over the last five years, data traffic per mobile connection per month has increased around fourfold, from 3 GB in 2018 to 13 GB in 2023. This strong growth is forecast to continue, reaching 48 GB by 2030. While part of this evolution reflects higher usage time, most of it is explained by digital services that involve greater data traffic – for example, faster speeds to deliver higher-resolution video streaming, or lower latencies for effective video calling. Bandwidth requirements and overall network quality are therefore crucial, making QoS key in this digital era.

This is also the case in Asia Pacific – a region that accounted for 38% of 4G connections globally (and 19% of 5G connections) at the end of 2023.[1] It is a diverse region, encompassing digital pioneers (such as South Korea, Japan and Singapore), fast-growing emerging markets (such as India, Indonesia and Thailand) and late adopters (such as Nepal, Cambodia and Papua New Guinea).

Figure 1

Average mobile data traffic per connection

GB per month

Region	2023	2030	Increase
Japan and South Korea	18	76	4.2×
ASEAN (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam)	12	44	3.6×
India	18	71	3.9×
Rest of South Asia (Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka)	6	17	2.8×
Oceania (Australia, Pacific Islands and New Zealand)	14	56	4.0×
Global	13	48	3.7×

Source: GSMA Intelligence

1 The Asia Pacific region for this study does not include Greater China (China, Hong Kong, Macao and Taiwan).

Market dynamics generate strong drivers for QoS to increase significantly over time. The fast-changing nature of mobile markets means new mobile generations have historically been introduced relatively quickly, as shown in Table 1. Such transitions improve the quality of existing services (speeds increase and latencies fall in each cycle) and allow the development of new applications.

Table 1

Characteristics of mobile technology cycles

	1G	2G	3G	4G	5G
Launch year	1980	1990	2001	2009	2018
Applications	Voice calls	Voice calls, SMS, MMS, browsing (limited)	High-speed browsing, applications	Video streaming, mobile TV	Virtual reality, IoT, cloud computing and AI
Speed	2.4–14.4 kbps	56–115 kbps	5.8–14.4 Mbps	100–300 Mbps	100–5000 Mbps

Source: GSMA Intelligence

While the main role of 2G was to facilitate voice calls, 3G provided always-on connectivity to the internet, shifting the focus to non-voice services. 4G is mainly for data transmission and allowed the wide adoption and development of new applications such as navigation, e-commerce, social media and intelligent transport systems. 5G delivers a step-change in the speed and responsiveness of mobile networks, supporting services such as IoT, AI, big data and cloud-based services.

As users' needs have evolved over time, so has the concept of QoS and its role in delivering broader economic growth. The impacts of mobile technology on the economy are well established, with studies showing that a 10% increase in mobile broadband penetration can increase GDP by 1.0–2.5%.[2]

While much of the focus of public policy remains on reducing the usage gap, the realisation of these benefits also depends on the quality of the service received by users – both consumers and businesses. Mobile users in countries with a lower QoS can be limited in their ability to benefit from mobile services. As a consequence, differences in QoS contribute significantly to digital inequality among countries.[3]

2 See Economic Impact of Broadband, Digitization and ICT Regulation, ITU and Mobile Technology and Economic Growth, GSMA, 2020

3 Ludering, J. (2014). The measurement of internet availability and quality in the context of the discussion on digital divide.

1.2 Measuring mobile QoS

According to the ITU, QoS is defined as the "totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service". Quality of experience (QoE) is defined as "the degree of delight or annoyance of the user of an application or service". The ITU-T Rec.G.1000 defines seven criteria that should be measured for QoS:

- speed – download, upload, latency
- accuracy – speech quality, call success ratio, bill correctness, etc.
- availability – coverage, service availability
- reliability – dropped call ratio, number of billing complaints, etc.
- security – fraud prevention
- simplicity – ease of software updates, ease of contract termination, etc.
- flexibility – ease of change in contract, availability of different billing methods such as online billing, etc.

QoS is defined through a given set of parameters that are measurable, including network performance and non-network performance characteristics.[4] Figure 2 presents a non-comprehensive list of the most common network quality indicators and their importance to consumers.

Figure 2

Network quality indicators

Metric	Importance to consumers
Download speed	Higher download speeds allow consumers to download content more quickly and use data-intensive applications and content, such as video. For example, online video streaming in HD quality requires download speeds of 5–10 Mbps.
Upload speed	Higher upload speeds allow consumers to share more content and enable better performance for services such as online gaming. Upload speeds will become increasingly important for generative AI-based applications that require data transferred from the user to a server where a large language model (LLM) sits.
Latency	Lower latencies substantially improve quality of service that requires short delays such as online gaming, video calls and VoIP. For example, VoIP usually requires latencies of less than 400 milliseconds (ms) if a user requires quality equivalent to traditional fixed line services.
Signal strength	Poor (or no) signal strength means consumers' access to mobile services (voice, SMS and data) is slowed or restricted.
Call reliability	If consumers suffer from dropped or unsuccessful calls, they are unable to use voice services as they need.

Source: GSMA Intelligence

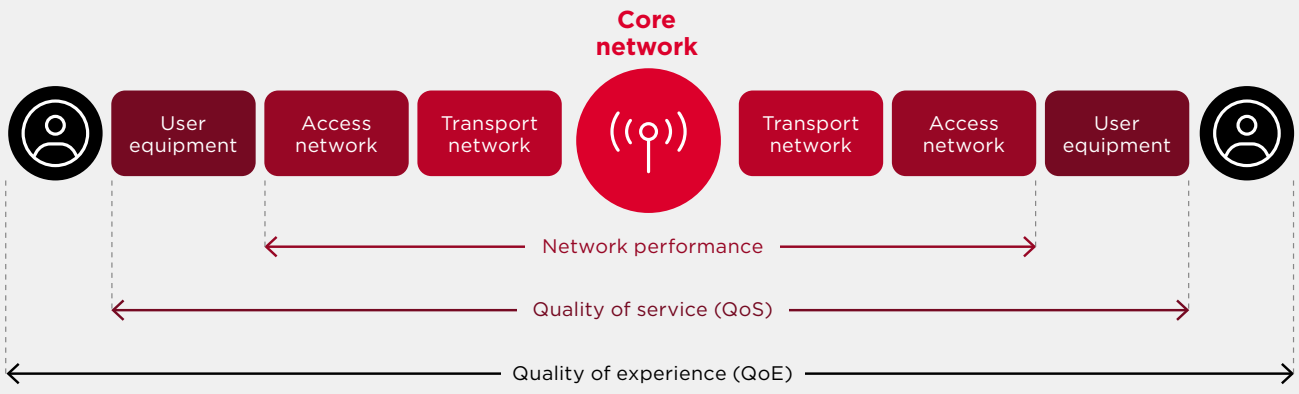
4 Network performance elements include download speed, upload speed, latency, packet loss rate, delay, jitter and bandwidth. Non-network performance elements include user equipment, access network, IP transport, core network ant the rest of the path end to end.

Defining and measuring QoS is complex because it includes all the aspects of a service provided from end to end, encompassing the core, backhaul and access networks, as well as network and end-user equipment. In contrast, QoE is a more recent area of focus for the industry and relates to a consumer's individual perception of an application or service. It therefore involves a subjective determination of end-to-end quality.

The main methods to measure mobile broadband performance have evolved over time and continue to change according to technology development and user demand. Each methodology offers different benefits and drawbacks, so having more than one approach enables a more comprehensive assessment of quality of service. Table 2 presents a description of each method, highlighting its main strengths and weaknesses.

Figure 3

Beyond network performance: QoS and QoE



Source: GSMA Intelligence

Table 2:

Common methods to measure mobile broadband performance

Drive tests and walk tests	Crowdsourced measurement	Network monitoring
Description		
Uses measurement equipment mounted in cars to systematically collect measurements (drive tests), or employs network testers who walk along typical pedestrian paths (walk tests). Measurements taken by technicians in a controlled environment.	This can be based on background QoS monitoring or consumer-initiated tests. The former involves app-based panels that monitor QoS in the background of apps installed on regular users' devices, automatically conducting repeated network performance tests. Consumer-initiated tests involve the collection of measurements wherever consumers are connecting to networks – on streets, inside vehicles, at home, at work and other locations – with high location accuracy.	Operators monitor the performance of the network. The data collected directly from operators can include call failure rates, usage statistics and signal strength.
Advantages		
Consistent collection of measurements (e.g. consistent speed, time of day, application use, or device configuration).	Broad sample of data that better reflects the actual user experience when compared to drive/walk tests. Scalable measurement collection with high resolution in both space and time.	The data is reliable and can be taken across different points of the network.
Disadvantages		
Limited set of observations (few locations and isolated in time). Very resource and labour-intensive. Not possible to pool or aggregate over time, as the tests are taken at different locations. Does not reflect actual device characteristics or user behaviour.	Relies on user participation, which can lead to uneven representation of user demographics, geographic areas, or device types (smartphones are required), potentially skewing the results and limiting the applicability of findings to the general population. The network conditions of the measurements cannot always be precisely identified.	Measurements may not correspond to users' experience of the service, as this depends on other factors such as the device. Aggregated metrics may not reflect differences in QoS (for example, by location, whether indoor or outdoor).
Examples		
RootMetrics CalSPEED RantCell	Speedtest by Ookla[5] FCC's Speed Test app Opensignal 5GMARK Tutela	Operators often provide network quality metrics directly to the regulator.

Source: GSMA Intelligence

5 Ookla, through the service Speedtest, measures network performance indicators going back to 2006. The service is based on consumer-initiated tests, and measures the factors that most impact connection experiences including bandwidth, latency, coverage and video metrics. These crowdsourced measurements are collected wherever consumers are connecting to networks – on streets, inside vehicles, at home, at work and other locations – with high location accuracy.

1.3 Key QoS trends in Asia Pacific

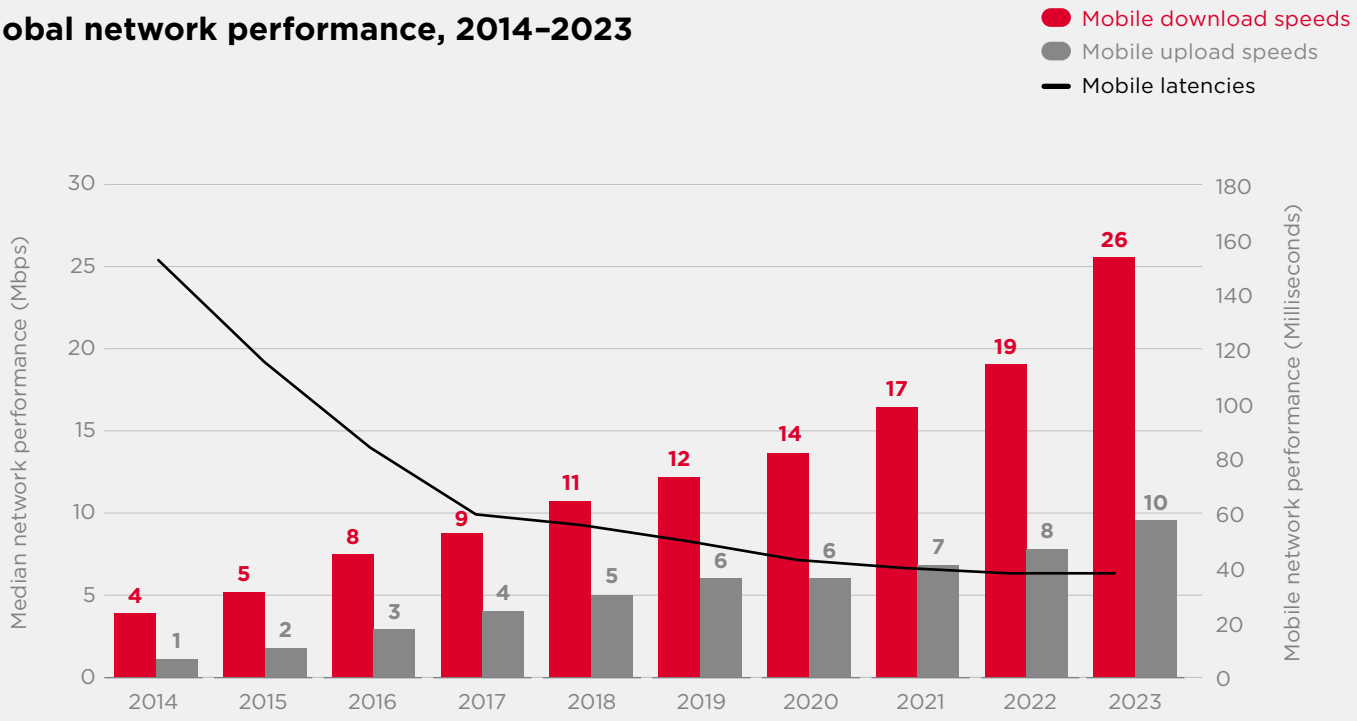
QoS in mobile connectivity has significantly improved over the last decade – in Asia Pacific and globally. This rapid evolution is by and large a reflection of the strong market drivers in place for QoS to increase in most markets. While growing demand among consumers for advanced digital services implies the need for greater QoS, mobile operators' large investments in new generations of networks bring greater network performance capabilities.

As a result, global mobile download speeds increased from 4 Mbps in 2014 to 26 Mbps in 2023 (see Figure 4), while mobile upload speeds increased eight-fold over the same period, reaching 10 Mbps in 2023. Moreover, mobile latencies also declined sharply over the same period, from 155 ms in 2014 to 39 ms in 2023.

A similarly positive evolution was observed in Asia Pacific over the same period. In 2023, mobile download speeds reached a median of 26 Mbps, with upload speeds at 11 Mbps and median mobile latencies at 36 ms.

Figure 4

Global network performance, 2014–2023



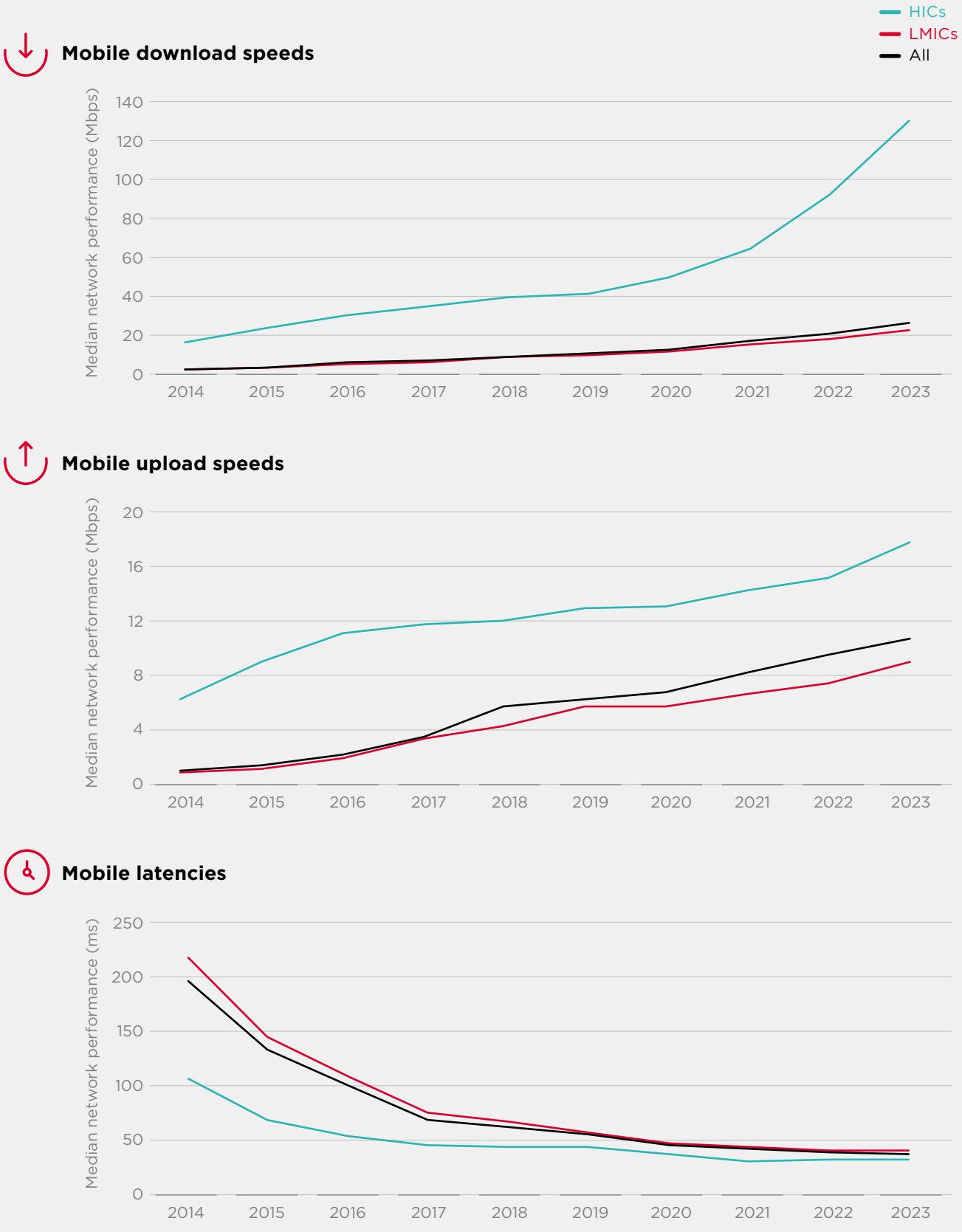
Source: GSMA Intelligence analysis, based on Speedtest Intelligence® data provided by Ookla®

However, there are important differences in mobile QoS across countries in Asia Pacific (see Figure 5). In high-income countries (HICs), the median mobile download speed in 2023 was 129 Mbps, six times faster than in low-and-middle income countries (LMICs) in Asia Pacific and five times faster than the global average.[6] Upload speeds were also twice as high and mobile latencies 20% lower for HICs in Asia Pacific than LMICs in the region. We explore in detail the drivers of these differences between countries in Chapter 3.

6 The countries classified as HICs according to the World Bank income classification 2022 are: Australia, Brunei Darussalam, Japan, New Zealand, South Korea and Singapore. The countries classified as LMICs are: Bangladesh, Bhutan, Cambodia, Fiji, India, Indonesia, Kiribati, Laos, Malaysia, Maldives, Micronesia, Mongolia, Myanmar, Nepal, North Korea, Pakistan, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu and Vietnam.

Figure 5

Network performance: Asia Pacific, 2014–2023



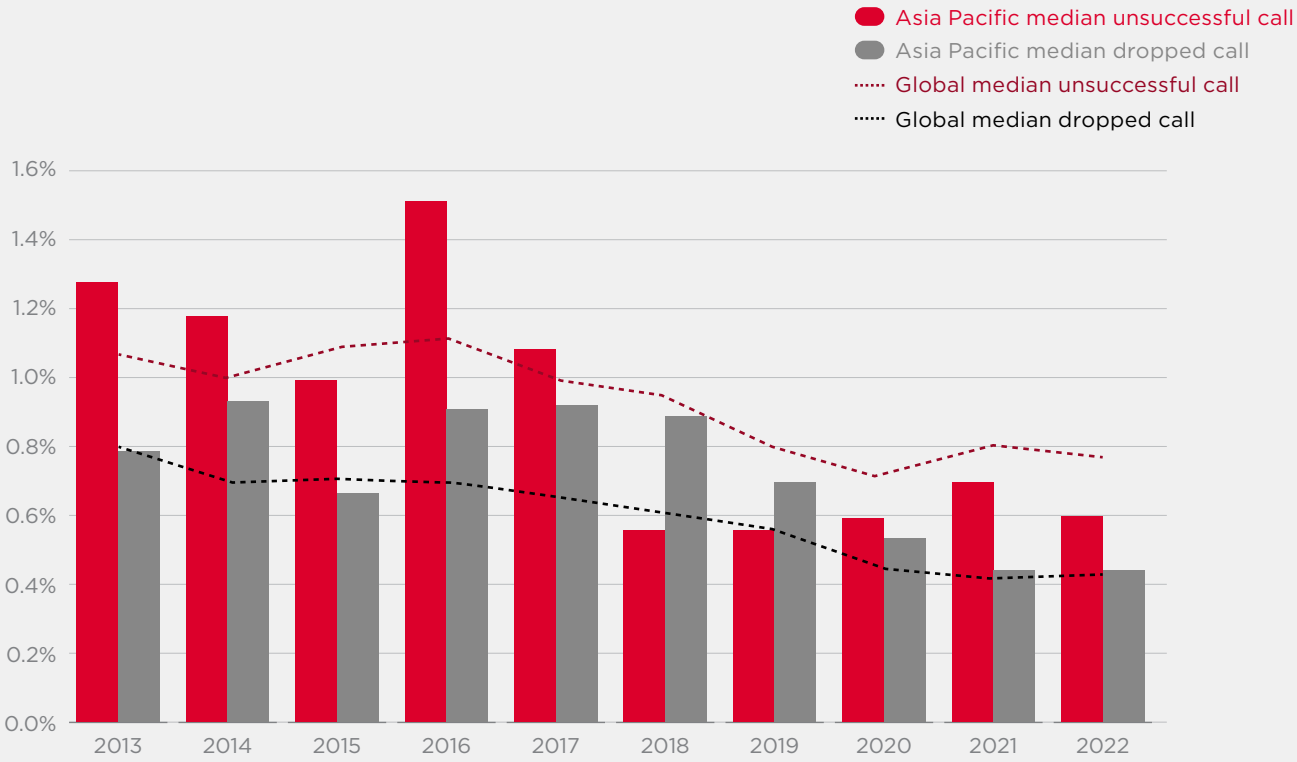
Source: GSMA Intelligence analysis, based on Speedtest Intelligence® data provided by Ookla®

Beyond mobile data QoS, the QoS of mobile voice services remained important for most of the period in Asia Pacific, though alternative app-based voice services (e.g. Teams, Whatsapp) became increasingly popular among consumers during the period. According to the 2023 GSMA consumer survey, 86% of mobile internet users made or received calls on a mobile phone using an online provider at least once in the last three months, with 45% of consumers doing so at least once per day.

Furthermore, traditional mobile voice QoS can be measured by metrics such as ratios on unsuccessful and dropped calls. Both metrics have improved significantly over the last 10 years, highlighting another positive trend in QoS in recent years. In Asia Pacific, the number of unsuccessful calls more than halved from 1.3% of all calls in 2013 to 0.6% in 2022. The dropped call ratio in Asia Pacific also halved, from 0.8% to 0.4% over the 2013–2022 period.[7] Globally, the trend was similar – though with a less marked reduction than in Asia Pacific (see Figure 6). Less information is available for QoS from app-based services.[8]

Figure 6

Unsuccessful call and dropped call ratio for mobile, 2013–2022



Source: GSMA Intelligence analysis, based on ITU DataHub

7 The sample sizes for Asia Pacific countries in 2013 and 2022 were 9 and 16, respectively.
8 In some countries, regulators are considering voice calls over platforms such as Whatsapp to measure QoS.

2.
The role of policymakers in mobile QoS in Asia Pacific

2.1 Government's significant role in driving quality

Infrastructure-based competition in mobile communication markets has a strong track record in delivering significant QoS improvements. For instance, consumers willing to pay more for better quality will often switch to mobile operators with enhanced QoS or coverage. Operators will also have incentives to launch new generations of mobile technologies to attract new customers, which in turn will improve QoS.

However, some governments could decide to intervene in the market if they identify specific market failures that constrain QoS, or to achieve equity objectives and guarantee a minimum level of quality, ensuring no consumer groups are left behind – especially the more vulnerable populations. A potential asymmetry of information between operators and potential customers can on other occasions be a justification for government intervention to protect the interests of consumers.

Mobile communications is clearly a heavily regulated sector, and the role of policymakers in driving QoS can be significant, well beyond the existence and nature of specific QoS obligations. Regulations affecting the broader supply and demand conditions can have significant effects on mobile QoS. For example, spectrum management policies that provide sufficient spectrum to the market under conditions that generate incentives to invest can reduce deployment costs and help expand mobile coverage, boosting network availability and QoS. Sector-specific taxes and import duties on mobile devices can discourage adoption of better performing smartphones, depressing QoS. Likewise, barriers to infrastructure deployment, or obstacles to the deployment or adoption of new mobile network technologies, can all result in lower QoS in the market.

As Chapter 4 shows, these are all fundamental drivers of QoS in mobile. They are therefore a first port of call for reform for regulators looking to improve QoS for consumers.

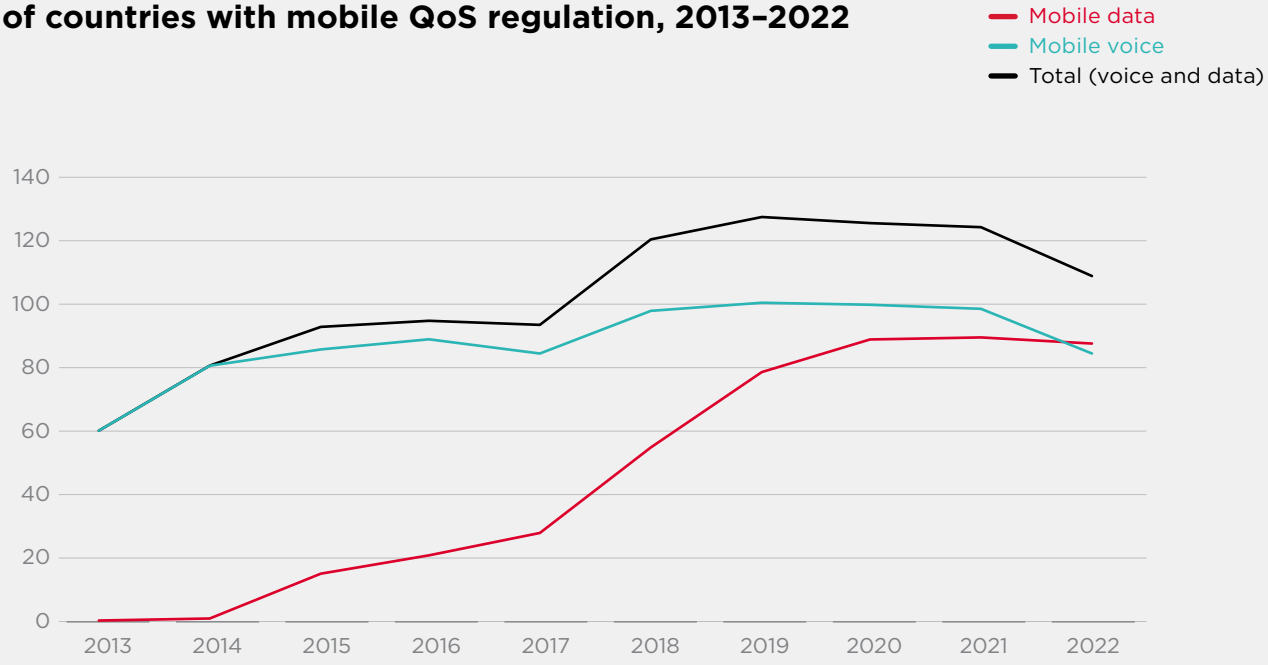
Beyond these, telecoms regulators often implement direct forms of regulation for QoS – for example, by setting minimum QoS standards and monitoring obligations regarding QoS. This can also include defining measurement methods and setting detailed reporting obligations and procedures.

2.2 Direct obligations on mobile QoS in Asia Pacific

Globally, the number of countries with some form of direct QoS regulation for mobile in place (including both voice and data) increased from 60 in 2013 to 108 in 2022 (see Figure 7).[9] At the beginning of the last decade, the focus was on mobile voice, with some form of direct QoS obligation existing in 60 countries. Direct forms of mobile broadband QoS regulation started to appear later, around 2014. These have steadily increased since then, reaching similar levels to direct voice QoS regulations today. The number of countries with obligations on mobile voice QoS has reduced in the last few years, as focus has shifted to mobile data.

Figure 7

Number of countries with mobile QoS regulation, 2013–2022



Source: GSMA Intelligence analysis, based on ITU DataHub

Approximately half of the countries in Asia Pacific have some form of direct QoS obligation for mobile broadband (e.g. Bangladesh, India, Singapore), while the others do not (e.g. Brunei Darussalam, Japan, New Zealand).

There are also significant differences in implementation across countries that have introduced direct QoS obligations. Some countries around the world, such as the UK, France, South Korea and Germany, implement a light-touch regulatory approach that looks to balance protection of consumer interests with ensuring proportionate obligations for all players in the ecosystem. The latter is a key consideration. Platforms that provide voice services over the internet are often not subject to any QoS obligations, as neither are digital platforms subject to mobile data QoS regulations, even though they play a fundamental role in determining the quality of video streamed over their platforms. Strategies that platform players can adopt to improve the quality of video streaming across the network include the use of more efficient codecs, expanding content delivery network (CDN) infrastructure, using adaptive bit-rate streaming, optimising device compatibility, collaborating with ISPs, and employing AI for real-time optimisation.[10]

9 Direct QoS obligations relate to countries with a specific legislative framework.

10 A codec (compressor-decompressor) is a technology used to compress video files so they can be transmitted more efficiently over the internet, reducing the amount of data (bandwidth) required while preserving video quality.

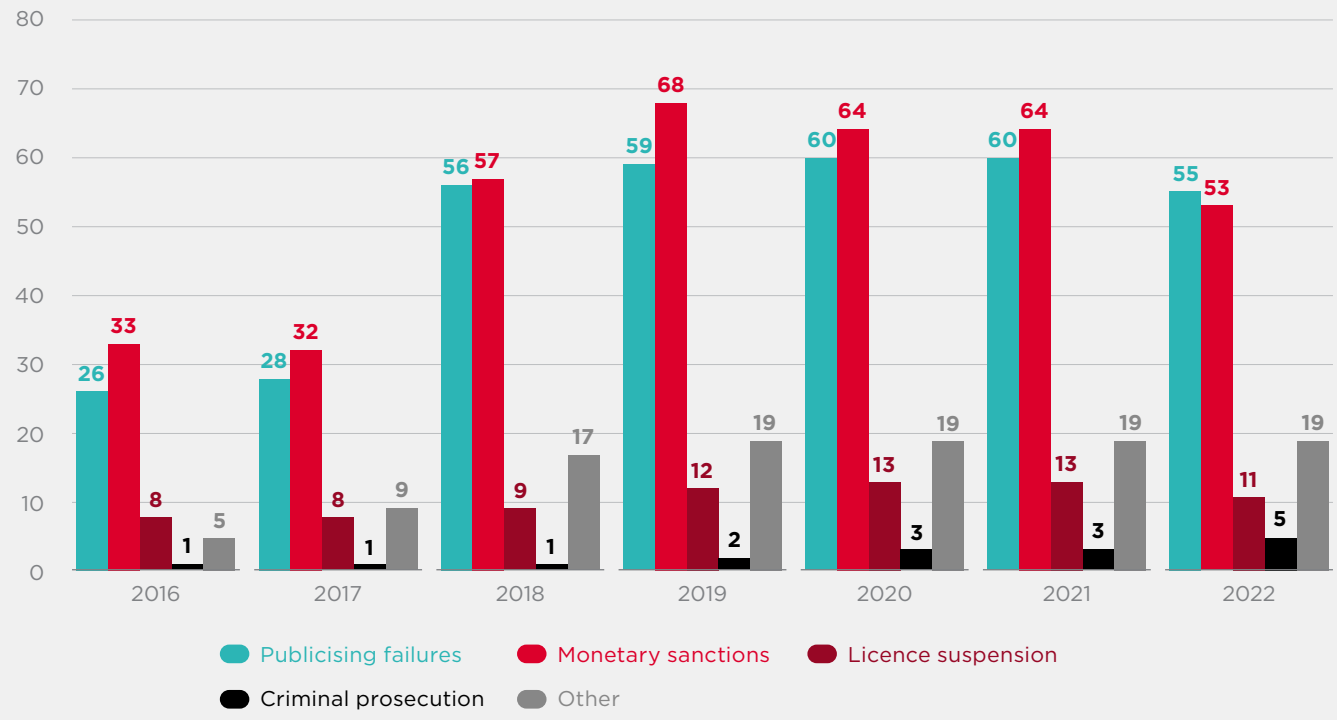
Some QoS obligations involve the regulator setting a range of QoS parameters, targets and measurement criteria, as well as sanctions to enforce compliance. However, this approach can often be ineffective and have unintended consequences. For example, the regulator usually does not have all the necessary information available and could set inappropriate or unrealistic targets that create high compliance costs with unintended potential consequences, such as drawing resources away from actual network investments that would improve QoS.

Alternative approaches such as consumer-focused regulations and co-regulations can often offer a better balance by delivering on policy objectives but minimising compliance costs. Consumer-focused regulations provide consumers with tools to compare offers and services from service providers (speed testing tools, coverage maps) as well as channels to provide feedback and complaints about poor service. Meanwhile, with co-regulation, the regulator works together with service providers to set minimum QoS performance targets, based on analysis of the factors impacting QoS. Any shortcomings identified in the market are tackled through agreed actions by all players – both private and public.

Finally, some regulators impose sanctions for not conforming with QoS obligations.[11] Sanctions can include naming and shaming strategies, or more drastic legal enforcements. The ITU identifies sanctions that range from fines and monetary sanctions, to publicising failures, and in a limited number of cases licence suspension and even criminal prosecution. Globally, the number of countries where at least one type of QoS sanction was applied almost doubled from 26% in 2016 to 46% in 2022 (see Figure 8). Publicising failures were the most common form of sanction in 2022, representing 38% of total sanctions, followed by monetary sanctions at 37%. For example, in 2022, Singapore publicised failures as the mode of sanction, Bangladesh applied monetary sanctions, Pakistan applied licence suspensions, while Mongolia initiated criminal prosecutions.

Figure 8

Number of countries with sanctions applied for non-conformance with QoS, 2016–2022



Source: GSMA Intelligence analysis, based on ITU DataHub

11 The sanctions analysis presented in this section covers QoS regulations in the telecoms industry, including mobile and fixed services. In Chapter 4, the empirical analysis on the effects of sanctions intensity covers only mobile broadband.

3.
The state of QoS in Asia Pacific

While many QoS regulations have been in place since the late 2000s and vary in terms of approach, recent years have seen the implementation of various amendments in some countries to reflect changing usage patterns and advances in mobile networks. The advent of 5G, for example, is set to become a key driver for change in QoS regulations in the coming years.

To evaluate the various approaches and evolution of QoS and QoE regulations in Asia Pacific, GSMA Intelligence conducted a survey of regulators and mobile operators to understand their perspectives and the implications of new and existing QoS regulations in their respective markets. A common theme from the survey was that the definitions for QoS and QoE adopted by most countries in the region largely mirror those used by international organisations, such as the ITU. However, the findings of the survey reveal areas of concern, with significant implications for stakeholders.

3.1 External factors

The survey results show differing views between regulators and mobile operators on the main reasons for QoS failures in markets across the region. While some regulators claim that a lack of network upgrades in line with increasing adoption and usage is the main reason for QoS failures, mobile operators generally highlighted factors outside their control as the main inhibiting factors to adequate QoS performance. Figure 9 outlines some of these external factors.

Figure 9

External factors affecting QoS performance in Asia Pacific

Spectrum
Lack of access to adequate spectrum (quantity and frequency band) can adversely affect network performance and QoS over a mobile network, especially for data services.

Right of way (RoW)
Strict, bureaucratic procedures in processing approvals for RoW can hinder mobile network development. Where approvals are not available and sites are not being built, QoS problems are guaranteed.

Weather
Networks can experience intermittent interference due to adverse weather. For example, a microwave link connecting radio equipment can experience fading due to heavy rain or fog.

Vandalism
This can take various forms, including theft of essential network equipment, particularly remote radio units (RRUs) and baseband units (BBUs), sabotage and other malicious activities.

Signal interference
Interference can be due to indiscriminate use of jammers and illegal signal repeaters and boosters.

Staff safety concerns
Mobility restrictions on telecoms operations in certain areas and at night could be in place due to local security and staff safety concerns.

Infrastructure damage
Road and utility works can result in fibre cuts and other forms of damage to network equipment.

Access to power
Power sources in off-grid locations can be expensive and unreliable. In some instances, the continuous operation of diesel generators is prohibited to prevent noise pollution.

Network safety red tape
Strict EMF policy has the potential to shrink the coverage area. Similarly, there may be restrictions to 5G deployment near airports due to radio altimeter issues.

Municipality-level disruptions
Abrupt site sealing by municipal authorities and resident welfare associations can take place for various reasons, including unfounded concerns and rumours over EMF issues.

Difficult terrain conditions
Signal strength is affected by physical barriers such as mountains. This can lead to poor coverage in the surrounding areas. Rough terrain can also cause interference and reduce data speed.

Source: GSMA Intelligence

In addition to the factors shown in Figure 9, network quality can be affected by consumption patterns, network load, user devices (especially counterfeit handsets) and obstacles between terminals and antennas, whether fixed (e.g buildings and trees) or moving (vehicles). In most cases, existing QoS regulations do not take these extraneous factors into account, meaning mobile operators risk sanctions for QoS failures caused by factors beyond their control. Where the data is consistently available over time and across a significant number of countries, Chapter 4 considers their impacts quantitatively.

The consumer view of QoE/QoS in India

As part of this study, in September 2024, focus group discussions were held with mobile users in India to understand their experience of QoS. This included interviews with a diverse group of men and women from metro and non-metro cities, across different age groups.[12]

The findings reveal that consumers face difficulties in network performance when there are poor weather conditions and where there is a lower level of network connectivity in overcrowded spaces and in basements/underground metro areas. They expect these challenges to be overcome with more 5G coverage.

The findings also show that mobile users use WhatsApp for a majority of calls and that WhatsApp downtime at times is a challenge. Sufficient data allowances on data plans – so users can seamlessly stream content – are another key factor in QoS.

3.2 Stakeholder consultations

Regulators and mobile operators have a mutual interest in the provision of high-quality mobile services. As such, continuous improvement in the quality of mobile services requires collaboration between these and other stakeholder groups.

Insights from the GSMA Intelligence survey show that the majority of regulators consult with mobile operators to varying degrees in setting KPIs and targets. However, this exercise could be viewed as superficial where the concerns and contributions of mobile operators – though backed by clear evidence – are not always taken into account in the final regulations. This may explain the contrasting views between both parties on QoS failures, as highlighted above.

Regulators often cite consumer interests as the primary rationale for their decisions. However, there is a risk that QoS regulations that overlook the genuine concerns of mobile operators could become counterproductive, especially where they are not supported by sufficient assessment of their impact on mobile service provision. In Bangladesh, for example, our survey highlighted the potential for unintended consequences from the imposition of QoS obligations through ad-hoc directives beyond existing QoS regulations.

12 The focus group discussion used a qualitative methodology to address the research objectives. The objective of the discussion – in which participants were asked questions about their daily mobile usage habits and experience – was to understand consumer behaviour in terms of perceptions and quality of experience of mobile network services across telecoms providers and handsets. It included a range in terms of age (18–44 years old), gender and socioeconomic background.

3.3 Compliance costs

If the objective of QoS regulations is to improve the quality of service provided by mobile operators, the financial implications of complying with those regulations must be weighed against customer needs. Respondents to the GSMA Intelligence survey highlighted concerns over the compliance costs of QoS regulations in some countries. For example, the requirement to measure an unreasonably large number of parameters, which may seem reassuring, can represent a significant cost – both from a financial perspective (testing tools) and a staffing one (conducting tests, analysing results and publishing reports).

Besides the proliferation of parameters, the requirement to comply with obligations that have little or no direct impact on QoS improvement is another notable compliance cost driver. For example, new regulations in Malaysia (with effect from 1 April 2024) mandate operators to keep busy-hour Physical Resource Block (PRB) utilisation for all LTE radios below 80%, despite operators demonstrating that PRB utilisation is more of an indicator for upgrades than a sole arbiter for network quality. As a result, the industry will be required to incur considerable rectification costs if this regulation is strictly enforced.

Compliance costs can be particularly challenging for mobile operators when they do not contribute to achieving the key objective of protecting consumer interests. An example is cost incurred from the requirement for more frequent reporting, which channels resources from potential investments to improve actual network quality to more administrative functions around testing and reporting. In India, for example, the regulator has implemented new QoS regulations from October 2024 that require monthly, rather than quarterly, reporting.

3.4 Homogeneous regulations

In some instances, mobile operators face QoS regulations that follow a one-size-fits-all principle for locations that are considerably different in nature. This underestimates the importance of market conditions and external factors in delivering high-quality data services. An example is QoS standards for deep rural areas being set at the same level as those for very densely populated capital cities. Stringent, uniform obligations that do not consider the actual situation on the ground can be a strong deterrent for operators looking to invest in the most remote parts of the country. More importantly, they do not necessarily address the needs of the populations living in those areas.

In Malaysia, for example, new QoS regulations (effective from 1 April 2024) mandate a minimum LTE download speed of 7.7 Mbps at any location on the network. This requirement will rise to 10 Mbps from 1 January 2025. The challenge here could be the over-dimensioning of network resources to meet this requirement in certain areas where the applications used by consumers require much less throughput, resulting in wasteful and inefficient use of limited resources.

3.5 Technical standardisation

The lack of a defined, standardised and objective QoS measurement methodology can produce different interpretations of performance indicators, leading to discrepancies in results claimed by regulators and those reported by mobile operators. There can be ambiguity as to what KPIs should be measured, how they should be measured and what targets should be set for KPIs. Sometimes there is also duplicity; the same thing is measured in several different ways.

Insights from the GSMA Intelligence survey highlight certain areas of concern for mobile operators. For example, regulators and operators typically have different views on how QoS drive tests should be conducted, with areas that require alignment including the thresholds for stationary and mobile tests, the location where the drive tests should be conducted (near the cell towers or at the edge of the coverage area), and how the data should be analysed to produce information about the network (using a generic formula or one provided by the operator/ equipment vendor).

Learnings from other regions – France

France takes a light-touch approach to QoS regulations. The main objectives are to empower consumers to make the right choices based on their usage needs, and to stimulate investments by mobile operators to improve network performance in specific areas. To achieve this, regulator Arcep conducts an annual audit evaluating the quality of services provided by mobile operators. It publishes the report in the third quarter of each year.

The audit, funded by the operators, is carried out outdoor, indoor and in-car at approximately 1.5 million measurement points across the whole French territory (mainland and overseas). The measurements are nuanced, differentiating performance in populated areas and transport paths (e.g motorways and railway lines). The tests are based on simplified parameters for calls, SMS and data services:

Calls/SMS

- Success rate for receiving an SMS in less than 10 seconds.
- Success rate for maintaining a two-minute phone call with perfect quality.

Data

- Web – success rate for loading a web page in less than 10 seconds.
- Throughput – success rate for receiving a 10 MB file and sending a 2 MB file in less than 60 seconds.
- Speed – measurements of downlink and uplink speeds.
- Streaming – success rate for watching a two-minute, HD video in perfect quality.

Arcep ranks operators according to their performance on the different measures, including high-density urban areas, low-density rural areas and transport routes. These rankings have been used by operators in their marketing campaigns and act as a motivation for improving quality. As a result, Arcep attributes a steady improvement in network quality and performance over time to the annual QoS audit. The regulator reported an improvement in mobile QoS in 2023, compared to the previous year.[13]

Arcep has implemented a process that allows third parties into its QoS portal, including local collectives, companies and public services agencies. The regulator has also provided two tools to enable this process: the regulator's toolkit (a guide to Arcep's measurement protocols) and a code of conduct for crowdsourcing, stipulating standards for transparency and quality. Arcep has begun publishing the results of the measurements conducted by the third parties. This is expected to provide end users and public authorities with a more detailed picture of mobile connectivity in the country.

Key lessons

- Conducting the QoS audit on an annual basis reduces the compliance costs associated with reporting for all parties, particularly the operators, who fund the exercise.
- Performing the test in different locations provides a holistic but nuanced picture of network performance.
- Using a simplified set of parameters eases the complexity of measurement for operators and interpretation for users.
- The operators are fully engaged in the process considering their contribution to both the design and execution of the measurements.
- The annual publication of the results on accessible platforms improves transparency and encourages users to engage with the process and utilise the output for decision-making.
- The integration of crowdsourced performance results provides an opportunity to gain real-time data in a cost-effective manner that does not add extra cost or an administration burden on operators.

13 https://en.arcep.fr/news/press-releases/view/n/mobile-quality-of-service-in-metropolitan-france-261023.html

4.
Drivers of mobile QoS in Asia Pacific – empirical results

GSMA Intelligence empirically analysed the main drivers of QoS improvements in mobile communications for the period 2011–2023. This included a quantitative assessment of the role of market conditions, public policies and the introduction of direct QoS obligations. Impacts on QoS were measured according to some of the most common QoS metrics for mobile broadband (such as download/upload speed and latency).

To understand the main factors that drive QoS, GSMA Intelligence carried out original econometric analysis based on panel data models that can isolate (in quantitative terms) the effects of different drivers of QoS. The analysis was conducted on a global sample of 187 countries and a sample specifically for Asia Pacific, which includes 35 countries. Methodology and data sources are discussed in Appendix 1. A more detailed explanation of the methodology is provided in a separate technical paper. The list of countries included in the study is presented in Appendix 2.

4.1 Mobile QoS is driven by market and regulatory factors

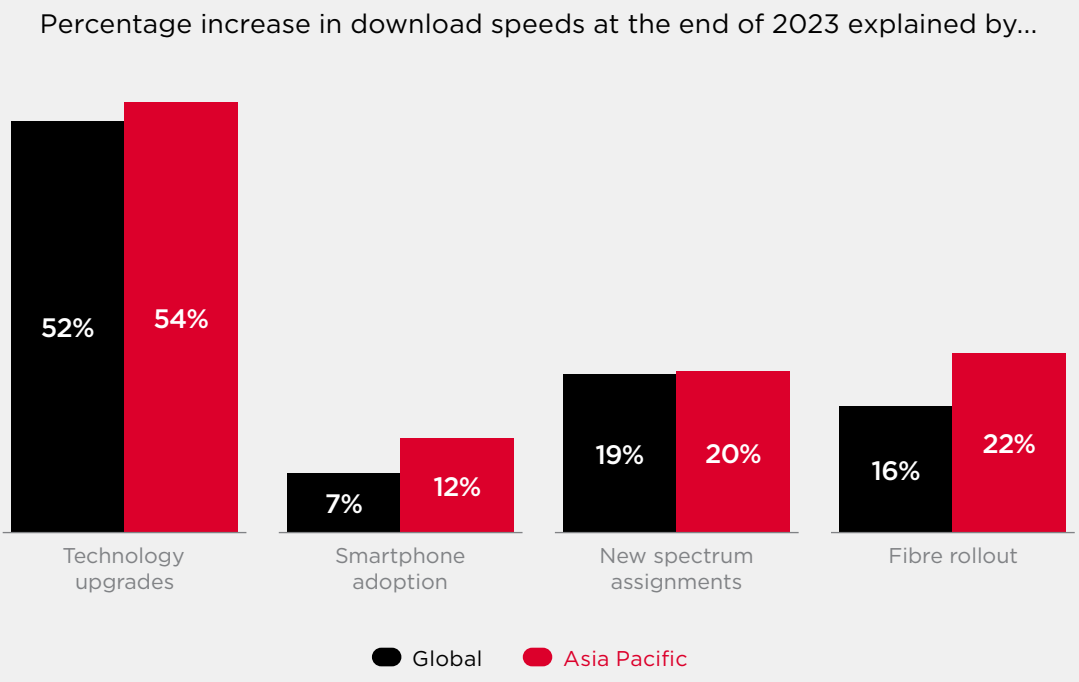
The evidence shows, both globally and for Asia Pacific, that mobile QoS improvements over the period were largely explained by the following:

- the adoption of new mobile technology generations (4G and 5G, in particular)
- the adoption of better devices and smartphones
- an increase in the amount of spectrum available to roll out each technology
- the footprint of fibre networks in the country
- broader factors that impact investment conditions, such as the resilience of the electricity grid and the quality of regulations more generally in the country.[14]

Figure 10 summarises the magnitude of these effects by presenting the changes in mobile download speeds over the last decade that can be attributed to the increase of each metric over the same period.

Figure 10

How improvements in the main QoS drivers impacted download speeds in Asia Pacific, 2011–2023



Note: Impacts are modelled based on simulations using the results of the econometric analysis. Each variable is modelled separately, so aggregation is not recommended as there may be some overlap (for example, new spectrum assignments enable technology upgrades). In the case of fibre rollout, the final year of analysis is 2021 instead of 2023.

Source: GSMA Intelligence

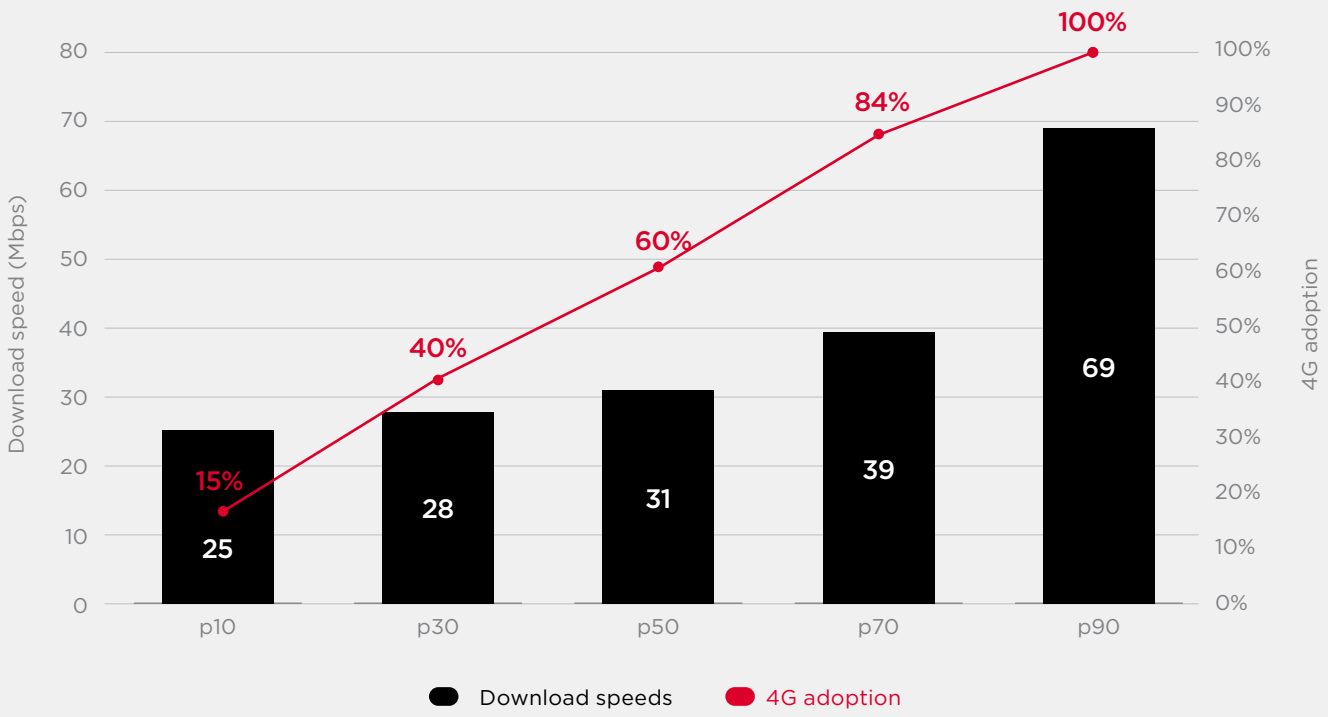
14 GSMA Intelligence conducted analysis of each of the regressors using as a baseline specification a set composed of capex per capita, GDP per capita, market concentration measured through the HHI (both in levels and squares) and the share of population living in rural areas.

Taking each of these main factors in turn:

- **Adoption of new mobile network generations** – The increase in penetration of different technology standards (3G, 4G and 5G) is critical to explaining mobile QoS trends over the last 10 years. Over this period, while the number of 3G connections per capita in Asia Pacific remained stable, 4G connections increased from 5% to more than 60%. This growth in 4G connections was responsible for an increase in download speeds of more than 50% over the period. Figure 10 shows that, in 2023, global mobile download speeds were 52% higher than they would have been if there had been no technology upgrades since 2011. Figure 11 shows that – everything else being equal – a country that can increase 4G adoption from low levels of 15% to high levels of 100% can expect download speeds to increase 2.5×.

Figure 11

Estimated impact on download speeds from increasing 4G adoption in Asia Pacific, 2023



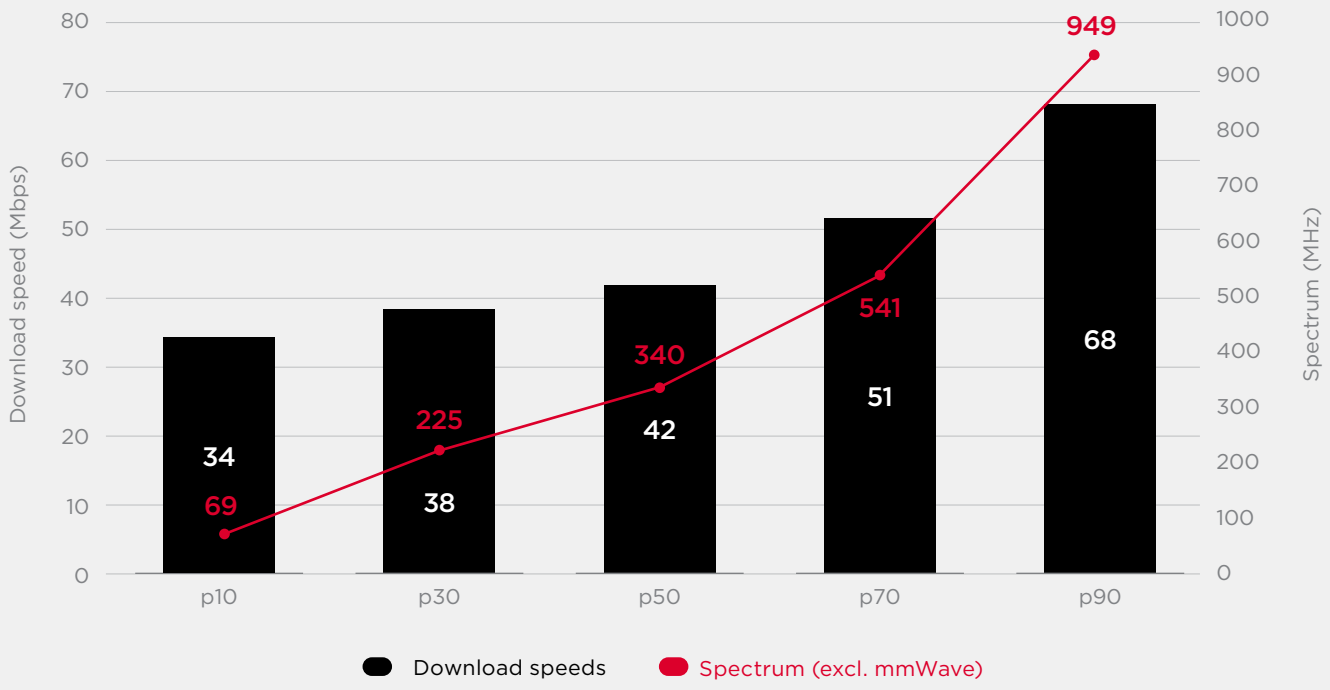
Note: each bar represents the same "average" country in Asia Pacific. The only difference between the bars is the level of 4G adoption. This is simulated at different levels (percentiles 10, 30, 50, 70, 90) to fully isolate the impact of 4G adoption on download speeds. On the x-axis, p10, p30, p50, p70 and p90 represent the percentiles 10, 30, 50, 70, 90 of download speed in Asia Pacific in 2023, respectively.

Source: GSMA Intelligence

- **Smartphone adoption** – The adoption of smartphones has had a significant, positive impact on QoS in Asia Pacific. During 2015–2023, smartphone adoption surged from 50% to 85%, driving an increase in download speeds of 12%, everything else being equal.
- **Spectrum availability** – Spectrum policies are critical to meet increased demand but also to enhance the QoS offered. In addition to spectrum being a key enabler for the launch of new mobile network technologies, the amount of spectrum available has a further significant impact on download speeds. If the amount of spectrum (excluding the mmWave band) available in Asia Pacific had not increased (by an average of approximately 150 MHz per country), mobile QoS would be significantly lower, by approximately 20% (Figure 10). Figure 12 shows that increasing the amount of spectrum available in a country in 2023 from relatively low levels (e.g. just over 200 MHz) to high levels (just under 1000 MHz) has the effect of increasing download speeds from 38 to 68 Mbps.

Figure 12

Estimated impact on download speed from increasing the amount of spectrum available in a country in Asia Pacific, 2023



Note: each bar represents the same "average" country in Asia Pacific. The only difference between the bars is the amount of spectrum available. This is simulated at different levels (percentiles 10, 30, 50, 70, 90) to fully isolate the impact of this factor on download speeds. On the x-axis, p10, p30, p50, p70 and p90 represent the percentiles 10, 30, 50, 70, 90 of download speed in Asia Pacific in 2023, respectively.

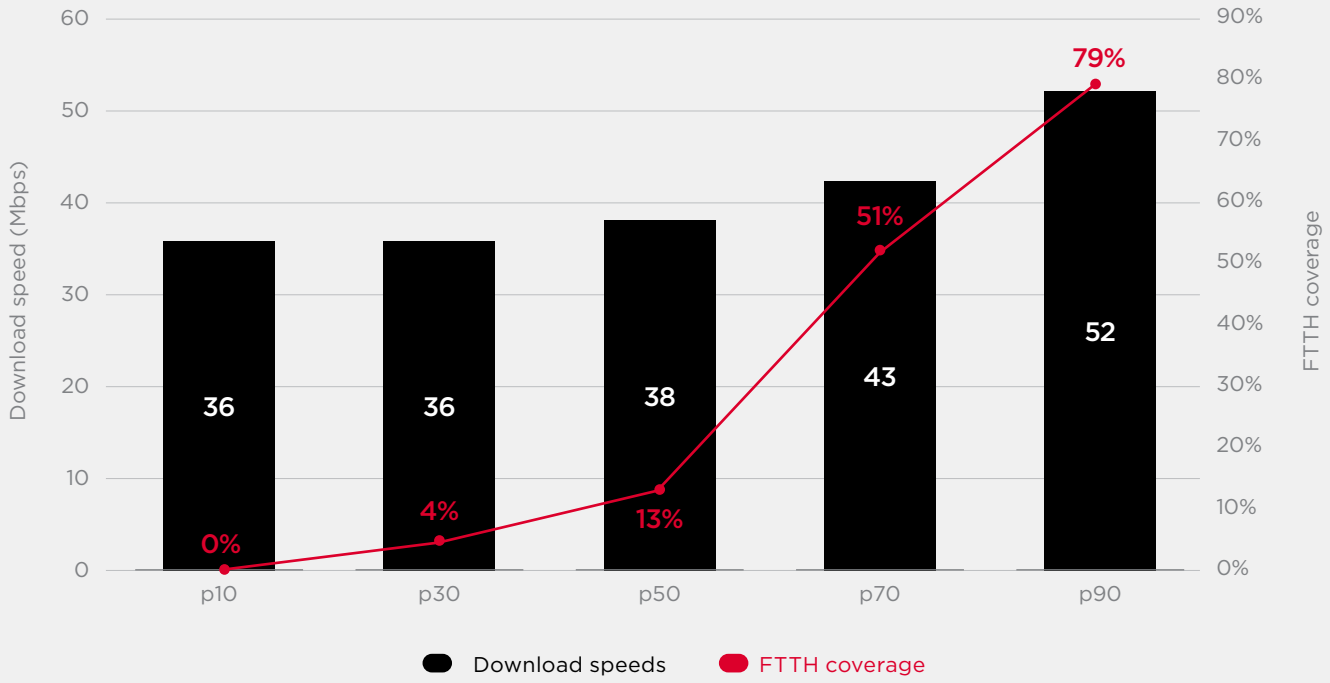
Source: GSMA Intelligence

- **Electricity infrastructure** – Some countries suffer from shortages in the quality and extension of electricity infrastructure, as well as bureaucratic problems accessing it. Such situations can translate into a degradation of mobile performance quality. The econometric results provide some evidence that coverage of the electricity grid and intensity and frequency of power outages can have an effect on mobile QoS.

- **Fibre infrastructure** – The use of high-capacity fibre links for mobile backhaul can be particularly relevant to mobile QoS performance. The results indicate that a 10 pp growth in the coverage of a fibre network results in download speed improvements of 5 pp. Over the whole period, with FTTH increasing from 2% to 24%, the effect on download speeds was an increase of 16%. Figure 13 further illustrates the effect, by showing how download speeds are impacted with increases in population coverage of FTTH in Asia Pacific countries.

Figure 13

FTTH coverage impact on download speed by percentile in Asia Pacific, 2021



Note: each bar represents the same "average" country in Asia Pacific. The only difference between the bars is the population coverage of FTTH. This is simulated at different levels (percentiles 10, 30, 50, 70, 90) to fully isolate the impact of this factor on download speeds. On the x-axis, p10, p30, p50, p70 and p90 represent the percentiles 10, 30, 50, 70, 90 of download speed in Asia Pacific in 2021, respectively.

Source: GSMA Intelligence

- **Broader regulatory quality and investments** – A more stable institutional and regulatory framework can provide certainty for investors and consumers, facilitating the large and long-term technology deployments and investments needed for mobile communications. These in turn yield better QoS performance. A 10 pp improvement in the score of the National Regulation Index[15] was linked to a 3 pp improvement in download speeds.

15 The National Regulation Index from the Worldwide Governance Indicators measures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

4.2 Are QoS obligations improving mobile QoS?

In addition to quantifying the contribution of individual factors to the improvements observed in mobile QoS trends in the region, this study sought to understand specifically whether the introduction of direct mobile QoS obligations played a role in driving further QoS improvements.

As presented in Chapter 2, there is significant variation among countries in Asia Pacific, with approximately half having introduced QoS regulations. Did those countries that introduced QoS obligations deliver better QoS to consumers as a result?

To robustly answer this question, the study compares QoS trends after the introduction of QoS regulations with the evolution QoS would have had in the absence of QoS regulations. As the latter is not observable, we rely on advanced causal inference techniques to estimate the effects.[16]

The results show that the imposition of specific QoS obligations did not have a statistically significant effect on mobile network performance (download speed, upload speed, latency).[17] In contrast with the expectation of regulators that introduced these, the evidence strongly indicates imposition of QoS obligations has not been successful in enhancing the performance of mobile communications services.

Figure 14 presents the impact of the introduction of QoS obligations in Asia Pacific. The results clearly indicate there is no statistically significant effect at any period after the introduction of regulation, meaning the introduction of the regulation did not impact QoS.

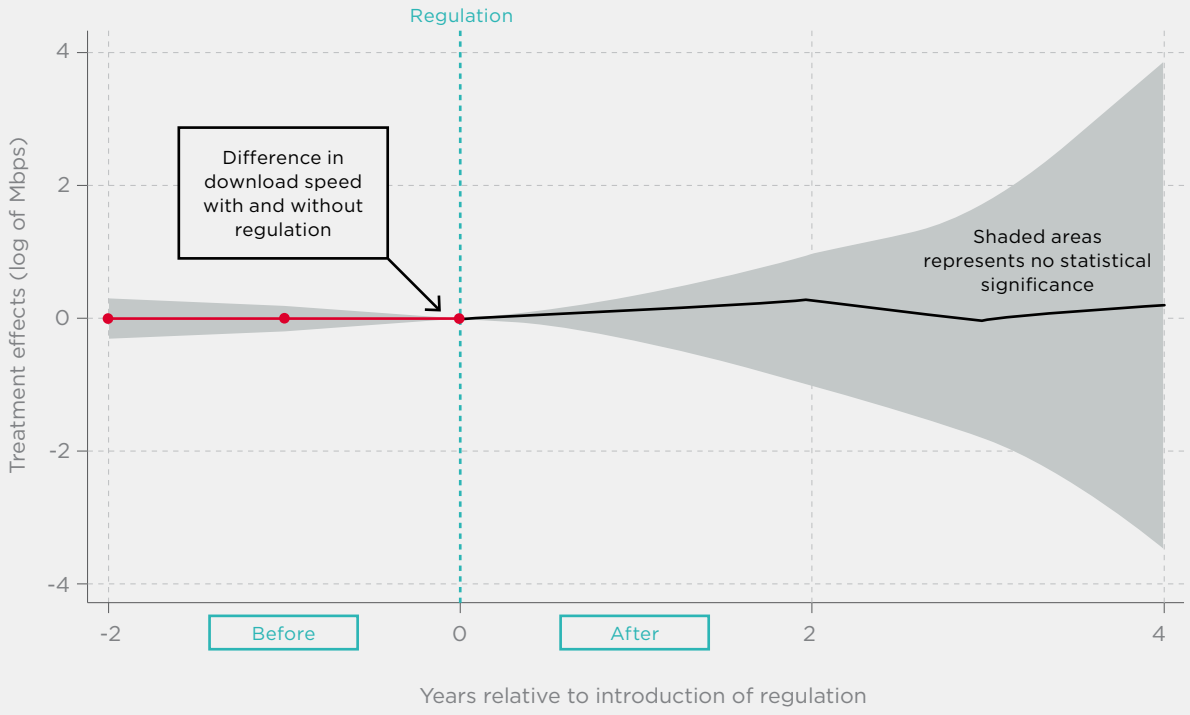
In combination with the key market drivers discussed earlier, the results suggest policymakers that are pursuing improvements in QoS as a policy priority should focus on the key supply and demand factors discussed in the previous section rather than the introduction of direct QoS obligations.

16 The expected evolution of QoS in the absence of the introduction of the QoS regulation (also known as the counterfactual) is estimated with the difference-in-differences (DiD) method, which compares the changes before and after the introduction of QoS, while taking into account the effect of other factors that can influence QoS as discussed above, such as spectrum amounts, smartphone adoption, capex per capita or rural population.

17 We also analysed the impacts on dropped calls, finding unconclusive results – that is, some regressions showing negative impacts, others showing positive impacts, while others showed no effect. In the round, we interpret this as an indication that the effects will be country/regulation specific; there are no generalisable findings.

Figure 14

Effect of the introduction of QoS obligations on download speeds — Asia Pacific



Note: event study presented for the estimation that includes controls
Source: GSMA Intelligence

4.3 Unintended consequences from mobile QoS regulation

While not having an effect on QoS, the imposition of QoS requirements on mobile operators often has significant compliance costs, as discussed in Chapter 3. There can also be additional unintended consequences if QoS levels are set at levels not economically sustainable in a competitive market. With regulation increasing costs and reducing overall returns of infrastructure deployments, this can lead to reduced aggregated investment levels. Even if these do not vary, it can produce an internal reallocation of resources to fulfill QoS requirements at the expense of delaying the introduction of new mobile generations or restricting coverage expansion plans.

To understand any potential negative effects arising from the introduction of QoS regulations, this study conducted an evaluation of the effects on investment and coverage levels. Table 3 summarises the results of the introduction of QoS obligations on investment and coverage.

Table 3:
Effects of QoS regulation on investment and coverage

Outcome variable	Results	Interpretation
Investment • Capex per capita • Capex / revenue • Capex per connection	No significant effects of the imposition of the regulation on capex per capita and capex per connection, neither for the global sample nor for Asia Pacific. Negative effect for the capex / revenue ratio, though only for the global sample.	QoS regulation did not lead to greater investment or enhanced network quality. These were instead driven by operator investment and consumer adoption of new technologies and the assignment of new spectrum bands. For some countries, the imposition of stringent QoS regulations may have reduced investment, which can lead to slower coverage and/or slower network quality growth.
Coverage levels* • 4G coverage	Limited evidence of negative effects from the imposition of regulation on 4G coverage for the global sample only. No significant effects for the Asia Pacific sample.	

* 3G and 5G are not included because of the lack of variability over time, with the former replaced by more advanced technologies and the latter recently introduced in most markets.
Source: GSMA Intelligence

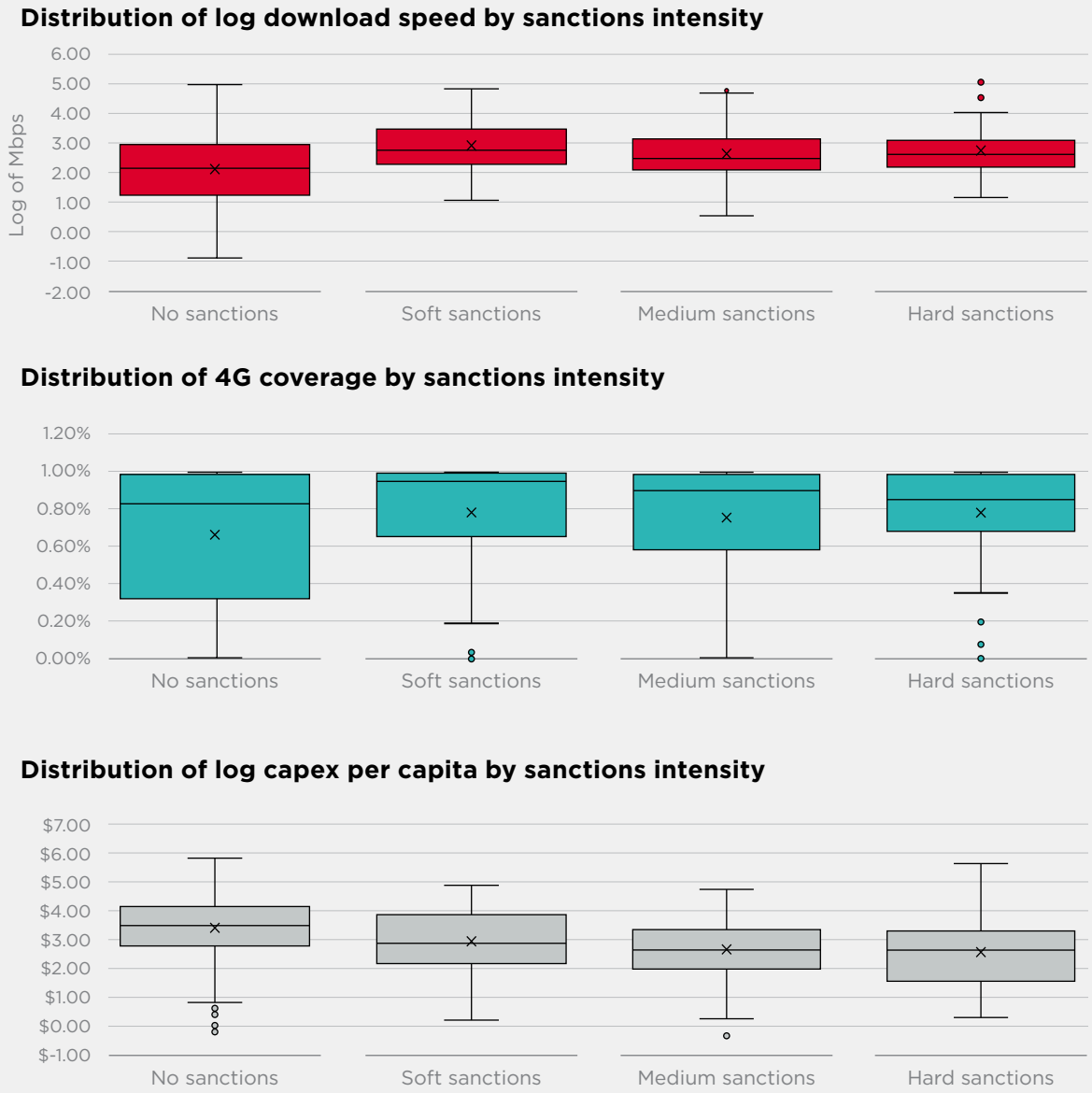
The study also considered whether the enforcement of a more stringent regime of sanctions to guarantee compliance with QoS regulations results in any effects on the QoS enjoyed by consumers.

A sanction intensity indicator was built, taking four possible values, from softer to harder: 0 when no QoS sanctions are imposed; 1 when sanctions include publicising failures or other non-monetary sanctions; 2 when sanctions include fines and other monetary penalties; and 3 when there is regulation and sanctions include licence suspensions or criminal prosecutions.

The results indicate that increasing the severity of sanctions did not have an effect on mobile network performance (see Figure 15). Moreover, the study finds a negative and significant effect on coverage levels. This suggests that the harder the sanctions become, the more likely it is that unintended consequences materialise – for example, resources destined to invest in coverage are relocated to ensure the imposed QoS requirements, to the detriment of coverage levels.

Figure 15

Distribution of log download speed, 4G coverage and log capex per capita by sanctions intensity



Source: GSMA Intelligence

5.
How to improve mobile QoS in Asia Pacific

5.1 The need for a different approach

Quality of service in mobile connectivity has significantly improved over the last decade, both globally and in Asia Pacific. This rapid evolution is by and large a reflection of the strong market drivers already in place for QoS to increase. For example, consumers' growing demand for advanced digital services implies the need for better QoS, with mobile operators responding with large investments in new generations of networks that bring greater network performance capabilities.

The state of mobile QoS in Asia Pacific is diverse across countries, with significant differences across the region. The evidence developed in this report shows that these differences in QoS are primarily explained today by just a few critical supply and demand factors:

- **Network generation:** Upgrading from 15% to 100% 4G adoption can increase download speeds by 2.5×. Newer network generations offer higher bandwidth and better data transmission capabilities.
- **Spectrum availability:** Increased spectrum allocation boosts download speeds. For example, those countries that made most spectrum available to mobile operators almost doubled download speeds as a result. Spectrum availability is crucial to enable faster connections and data transfer.
- **Fibre infrastructure:** Using high-capacity fibre links for mobile backhaul improves QoS. A 10% increase in fibre coverage correlates with a 5% speed improvement. Fibre-optic cables offer significantly higher data transmission capacity than traditional copper cables, resulting in faster and more reliable connections for mobile users.

These critical factors should be considered top priorities by regulators looking to improve QoS in mobile communications.

As tempting as directly regulating or mandating mobile QoS might be, the empirical analysis shows this approach is far from being a 'silver bullet' to improve mobile network performance. The empirical findings strongly suggest a different approach to direct QoS regulation is needed.

Where QoS obligations are introduced, the evidence shows they generally have no discernible effects on QoS. If anything, they can impose significant compliance costs on mobile operators and heighten the risk of unintended consequences. For example, resources destined to invest in coverage are relocated to ensure the imposed QoS requirements are met, to the detriment of coverage levels.

Mobile QoS is the result of a complex and multidimensional reality that places significant direct responsibility on governments, the mobile ecosystem (mobile operators, device makers and digital platforms) and consumers. This highlights the need to move towards a collaborative framework across these players that delivers real QoS progress – one that protects the interest of consumers, promotes fair competition and choice, and encourages investment in network infrastructure and services.

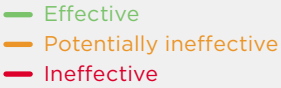
Alternative approaches such as consumer-focused regulations and co-regulations can often offer a better balance by delivering on policy objectives but minimising compliance costs. Consumer-focused regulations provide consumers with tools to compare offers and services from service providers (speed testing tools, coverage maps) as well as channels to provide feedback and complaints about poor services. Co-regulation approaches are a further approach, with the regulator working with service providers to set minimum QoS performance targets, based on analysis of the factors impacting QoS. Any shortcomings identified in the market are tackled through agreed actions by all players (both private and public).

5.2 Key considerations for regulators

- Regulators should consider frameworks that include all players in the ecosystem responsible for delivering voice, data and video to consumers.
  - Providers of voice services over the internet are rarely subject to QoS obligations. Similarly, digital platforms are not subject to mobile data QoS regulations – even though they play a fundamental role in determining quality of voice and video streamed over their platforms.
  - Both digital platform players and device makers can be included to work towards the most efficient solution identified to resolve specific areas for improvement.
  - Consumer perceptions of and complaints about service often fall within QoE rather than QoS. As QoE is inherently subjective, QoS regulations will not necessarily deliver QoE improvements.
- Monitoring and reporting of QoS should leverage where possible existing QoS information, such as that already available to operators or available from crowdsourced data.
  - Compliance costs can be particularly challenging for mobile operators when they do not contribute to achieving the key objective of protecting consumer interests. An example is cost that can be incurred from the requirement for more frequent reporting, which channels resources from potential investments to improve actual network quality, to more administrative functions around testing and reporting. In India, for example, the regulator intends to implement new QoS regulations from October 2024 that will require monthly, rather than quarterly, reporting.
- Regulators must work closely with operators and relevant stakeholders when developing parameters and benchmarks. They should also consider several factors outside the control of operators and establish whether it is feasible to set specific targets that are largely dependent on factors outside of operators' control.
- Conducting a regulatory impact assessment before enforcing or introducing regulations can be a good way to weigh up any benefits from the introduction of the obligations against their costs.
- Any sanctions need to be proportionate and used as a last resort. The number of countries where severe QoS sanctions are applied is significant, including monetary penalties as well as licence suspensions or criminal prosecutions. However, the empirical analysis indicates that more financially stringent sanctions are not found to be more effective. If anything, they can have negative consequences elsewhere in the form of reduced investments in expanding coverage.

Figure 16

Effectiveness of different approaches to driving QoS objectives



QoS factors	Impact on QoS	Impact on network investments
Effective spectrum management	Effective	Effective
Promote smartphone adoption	Effective	Effective
Resilience of broader infrastructure	Effective	Effective
Direct QoS regulations	Potentially ineffective	Potentially ineffective
QoS regulations + severe sanctions	Potentially ineffective	Ineffective
Collaborative QoS frameworks	Effective	Potentially ineffective

Source: GSMA Intelligence

5.3 A new, collaborative approach

Consumer-focused frameworks and co-regulation can be effective approaches for balancing policy objectives with minimal compliance costs. This requires collaboration between all stakeholders:

- **Governments:** These can play a crucial role by facilitating efficient spectrum allocation, streamlining infrastructure deployment processes, and fostering an environment conducive to network investment.
- **Mobile operators:** Operators can continue to invest in new network technologies, expand coverage and optimise existing infrastructure to improve service quality.
- **Device makers:** By developing and manufacturing devices that are compatible with – and optimise the use of – the latest network technologies to support faster speeds, device makers can contribute to improved QoS.
- **Digital platforms:** Collaboration with mobile operators and investment in new solutions that make efficient use of the network are essential to ensure smooth delivery of content and minimise buffering or interruptions for users of video streaming services or voice over IP.
- **Consumers:** Consumers can be provided with tools to compare offers and services from providers (speed testing tools, coverage maps) as well as channels to provide feedback and complaints about poor service. Informed consumers who understand factors affecting QoS can make considered choices about service providers.

Appendix 1: Methodology

Table A1:
Datasets used to estimate drivers of QoS and impact of regulation

Outcome variables	Policy variables – first part	Policy variables – second part	Control variables
Network quality metrics (in logarithms of download speed, upload speed and latency) (Ookla and GSMA Intelligence, 2024)	Spectrum available by band: - spectrum below 1 GHz - between 1 and 3 GHz - between 3 and 6 GHz - mmWave spectrum (GSMA Intelligence, 2024)	QoS regulation of mobile broadband services[18] (ITU, 2024)	Logarithm of capex per capita (GSMA Intelligence, 2024)
4G population coverage (GSMA Intelligence, 2024)	Technology generation (3G, 4G, 5G adoption) and devices (smartphones %) (GSMA Intelligence, 2024)	QoS sanction intensity (ITU, 2024)	Logarithm of GDP per capita (WB-WDI, 2024)
Investment (capex per capita, capex / revenue, capex / connection in logarithms) (GSMA Intelligence, 2024)	National ICT infrastructure (international bandwidth per capita, FTTH coverage) (ITU, WDI-WB, 2024 – CAF / TAS, 2024)		Herfindahl-Hirschman Index (HHI) (GSMA Intelligence, 2024)
	Non-QoS regulation (ICT regulation, national regulation) (ITU, 2024)		Rural population (WB-WDI, 2024)
	Bureaucracy and rights of way at municipal, national and other entity levels (ITU, 2024)		

Source: GSMA Intelligence

18 Binary indicator constructed from the ITU database, taking the value of 1 when answers include "mobile broadband services" or "all regulated services", and 0 otherwise. Unfortunately, this variable presents an important number of missing values, so we have to rely on an unbalanced panel.

Appendix 2: List of countries

Table A2:
Countries included in the global study

Afghanistan
Albania
Algeria
Andorra
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo
Congo, Democratic Republic
Costa Rica
Côte d'Ivoire
Croatia
Cyprus
Czechia
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia
Eswatini
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kiribati
Korea, South
Kuwait
Kyrgyzstan
Laos
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Luxembourg
Macao
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Micronesia
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
North Macedonia
Norway
Oman
Pakistan
Palau
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Rwanda
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
Somalia
South Africa
South Sudan
Spain
Sri Lanka
Sudan
Suriname
Sweden
Switzerland
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Tuvalu
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States of America
Uruguay
Uzbekistan
Vanuatu
Venezuela
Vietnam
Yemen
Zambia
Zimbabwe

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