Broadband and Cloud Development Index Identifies Global Leaders and Best Practice

WORLD BROADBAND ASSOCIATION

This report introduces the WBBA's new Broadband and Cloud Development Index (BCDI). The BCDI quantifies and ranks the performance of the two segments in major countries to identify leaders and best practices in an effort to help industry stakeholders—including policymakers, regulators, service providers and suppliers—support the development and growth of the broadband and cloud industries in their countries.

Additional WBBA members: Telecom Egypt

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SUMMARY

The global broadband and cloud computing markets combined are worth more than $656bn, but their indirect impacts may be even greater because they are two of the key foundations of the digital economy. Next-generation broadband connectivity together with advanced cloud computing support a wider range of advanced applications and services that in turn drive increased innovation, efficiency, and growth.

The vital importance of broadband and cloud computing in driving economic growth and wider social benefits has led the World Broadband Association (WBBA) to develop a unique new benchmark evaluating the impact and performance of these two key engines of digital growth in major countries worldwide. The benchmark combines coverage of broadband, which is the gateway to the internet and digital economy, and cloud computing, one of the key enablers of digital applications and services worldwide, including those of leading cloud providers such as Amazon, Microsoft, Google, and Alibaba.

The WBBA Broadband and Cloud Development Index (BCDI) quantifies and ranks the performance of the two segments in major countries to identify leaders and best practices in an effort to help industry stakeholders—including policymakers, regulators, service providers and suppliers—support the development and growth of the broadband and cloud industries in their countries.

The BCDI also allows stakeholders to identify shortcomings in the broadband and cloud markets in their countries, so they can to resolve these by implementing the policies and investments to improve digital infrastructure and drive economic growth and broader social benefits.

Through the creation of the BCDI and analysis of its results, the WBBA has also developed recommendations to support the development of the broadband and cloud industries in all countries, based on global best practice and the challenges providers are facing in some regions.

The WBBA is also committed to updating the BCDI annually to create an industry benchmark to support the advancement of the broadband and cloud value chains worldwide by assessing and quantifying performance in major countries, identifying leaders and challenges, and sharing best practices to drive innovation and growth.

KEY FINDINGS

- New applications and services are continually emerging in areas ranging from smart living and Internet of Things (IoT) to digital transformation and beyond, driving demand for investment in next-generation broadband infrastructure and cloud computing.
- As consumer and enterprise adoption of digital devices, applications, and services continues to accelerate, it has become clear that although basic broadband access is vital, it is only a first step. Countries that invest in advanced broadband and cloud infrastructure see benefits across their economies and society, as consumers and enterprises adopt more advanced digital applications and services, which in turn drive greater demand for broadband and cloud infrastructure.
- The BCDI examines the development of the broadband and cloud markets across 21 countries from five continents, representing over half of the world's population and over three-quarters of global GDP. It is designed to identify best-in-class performance at the country level, highlighting the most critical drivers for the continued development of the sector and making clear the investment case for broadband and cloud infrastructure.
- The BCDI aims to provide new insight and examples for broadband industry stakeholders – including legislators, policymakers, investors, vendors, service providers, and enterprises – to address and drive forward the goals of democratizing broadband and cloud access to enable broader economic and social benefits.
- The results of the BCDI include scoring and ranking of countries. The intention of the ranking is not to criticize countries based on their scores or rankings, but rather to identify best practices in countries throughout the index, which all stakeholders can then use to improve the performance of the broadband and cloud markets in their countries.

- It is difficult to directly compare the results of one country to another, given the wide variety of countries in the index, their different stages of development, and the many unique characteristics of their broadband and cloud markets. Given that, the BCDI organizes the countries into the following three clusters:
  - **Cluster 1:** Countries where both the broadband and cloud markets have above-average scores in the BCDI. The countries in this cluster are the US, China, South Korea, Japan, France, Finland, Canada, and the UK.
  - **Cluster 2:** Countries where either the broadband or cloud market has an above-average score in the BCDI, but the other market does not. The countries in this cluster are Sweden, Singapore, Spain, Germany, Switzerland, Netherlands, Italy, and India.
  - **Cluster 3:** Countries where both the broadband and cloud markets have scores that are average or below average in the BCDI. The countries in this cluster are Australia, Brazil, Mexico, South Africa, and Indonesia.
- The US ranks first in the BCDI, powered by its leading performance in the cloud and strong showing in broadband. Although the US has not traditionally led developments in the global broadband market, government funding to expand access has increased dramatically since the COVID-19 pandemic, and it is the clear global leader in the cloud market.
- China ranks second in the BCDI and stands out as the only country to achieve a top ranking despite having a GDP per capita well below the index average. It has benefited from successful government and industry initiatives that have made it a leading broadband and cloud market.
- Germany, which is ranked 12th overall in the BCDI, is one of the countries in Cluster 2 due to its below-average score in broadband, which leads to its ranking of 14th in the segment. Its performance in broadband is a concern given it is the fourth-largest economy in the world, with a GDP per capita of $46,846.
- Brazil is an interesting case to explore because its FTTH broadband household penetration is particularly high for a developing market at 35%, but due to other challenges it ranks 17th in broadband out of the 21 countries in the BCDI.

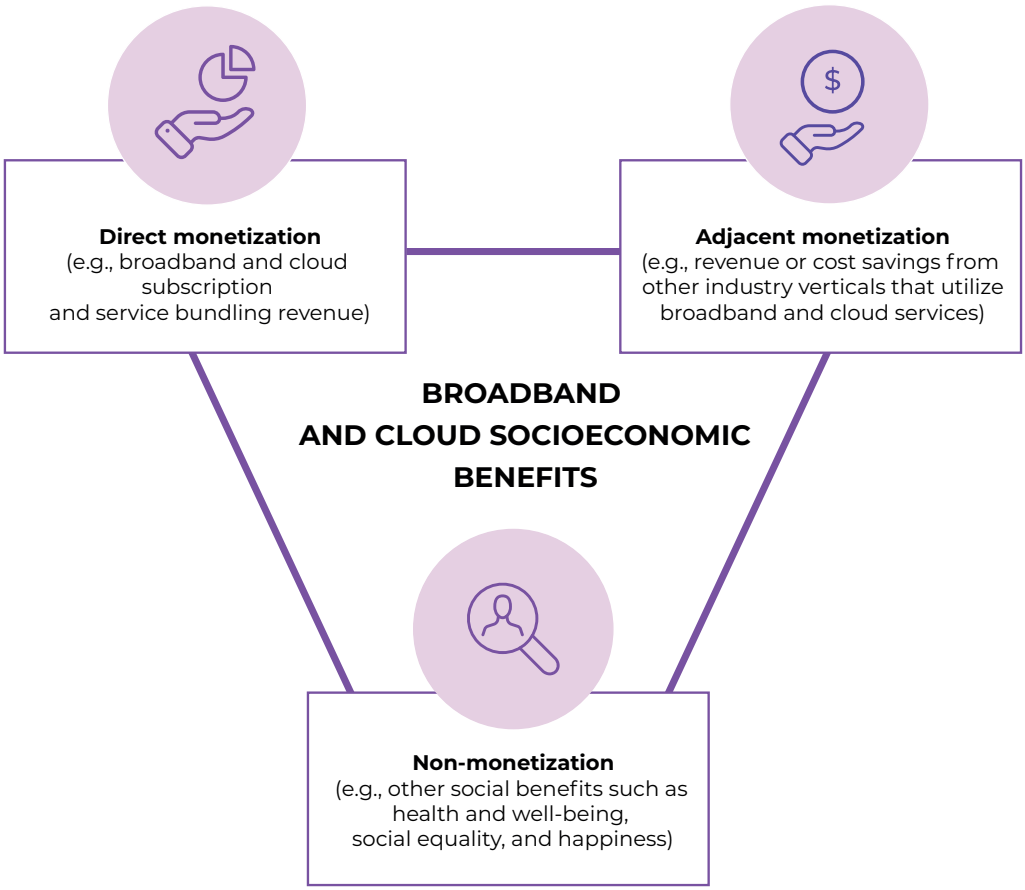
SOCIOECONOMIC BENEFITS OF FIXED BROADBAND AND CLOUD

BROADBAND AND CLOUD INVESTMENT BRINGS WIDESPREAD BENEFITS

The direct economic value of the global broadband and cloud markets is clear, with the global broadband subscription market alone worth more than $356bn and the global cloud services market valued at close to $300bn.

However, the benefits of broadband and cloud services extend well beyond their direct economic impact because they are the foundations of the digital economy, and as such support an increasing array of economic, social, and other activities carried out every day by consumers, businesses, and governments worldwide (see **Figure 1**). Although these broader socioeconomic benefits of broadband and cloud are difficult to quantify, it is intuitively the case that they are as important – if not more important – than the direct economic benefits, given the vital importance of high-quality connectivity and services to our digital economies and societies.

FIGURE 1: BROADBAND AND CLOUD SOCIOECONOMIC BENEFITS ARE WIDESPREAD



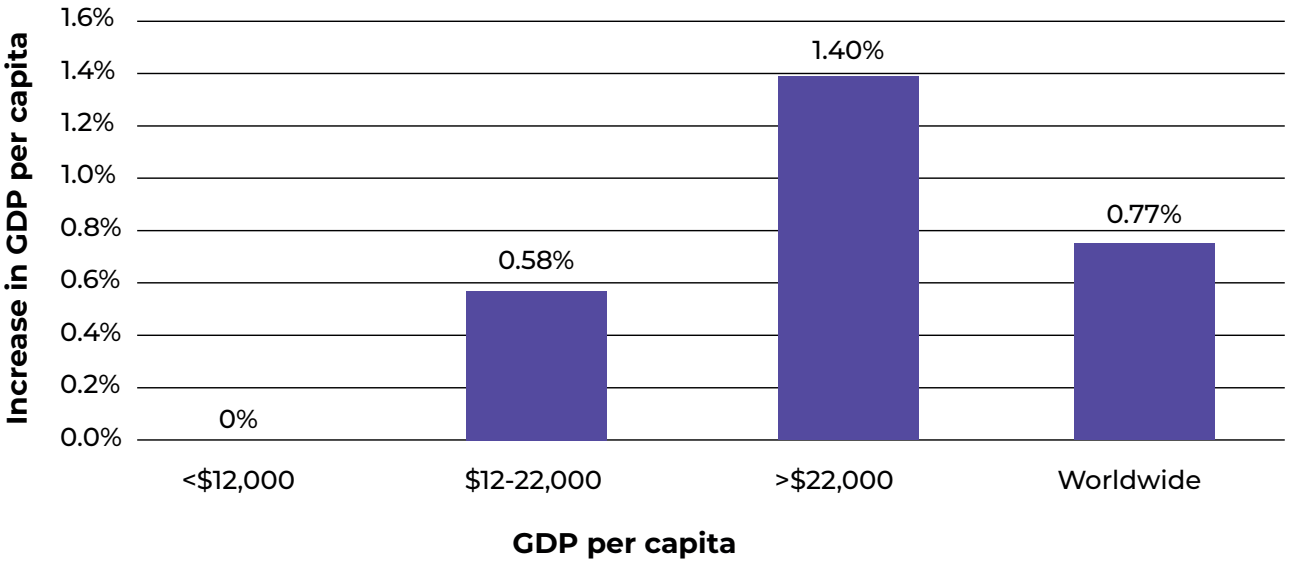
SOURCE: WBBA

INCREASING BROADBAND PENETRATION BOOSTS GDP

There have been a number of studies examining the correlation between fixed broadband penetration and GDP, including the ITU's November 2020 report titled How broadband, digitization and ICT regulation impact the global economy. The report, which is based on econometric analysis of 139 countries from 2011 to 2017, finds that across all the countries, a 10% increase in fixed broadband penetration will lead to a 0.77% increase in GDP per capita.

However, the research also finds that the impact of higher fixed broadband penetration is much greater in countries with higher GDP per capita (see **Figure 2**). The ITU finds that in countries with GDP per capita over $22,000, a 10% increase in fixed broadband penetration increases GDP per capita by 1.4%, while in countries with GDP per capita below $12,000, the same increase in fixed broadband penetration has no impact on GDP per capita.

FIGURE 2: IMPACT ON GDP PER CAPITA OF A 10% INCREASE IN FIXED BROADBAND PENETRATION

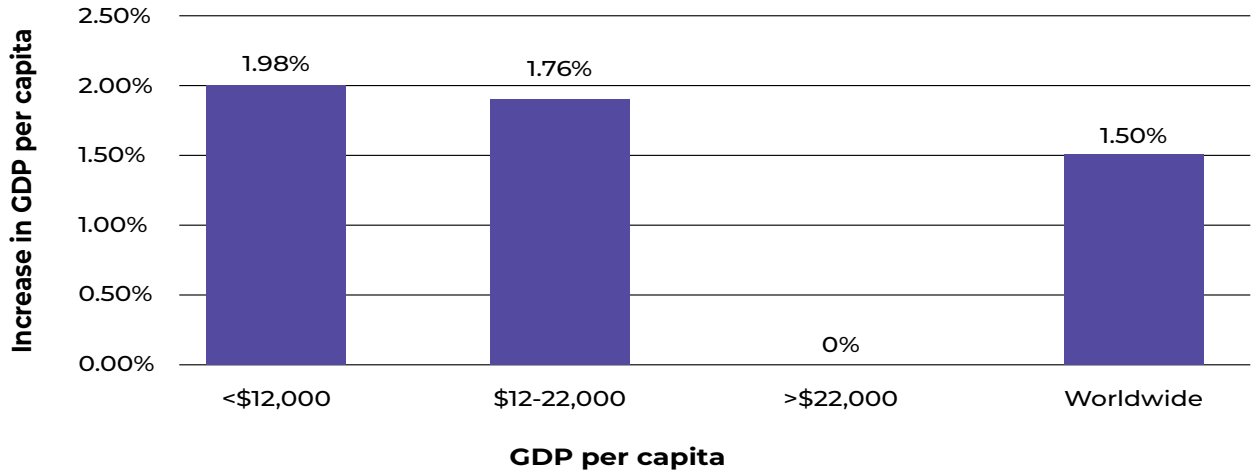


SOURCE: ITU

According to the ITU, the main reason for the different impacts in countries with different levels of GDP per capita is that fixed broadband infrastructure and penetration need to reach a certain scale before they start to have a significant impact on the economy. After reaching that level, increasing broadband penetration has a growing impact on the GDP per capita; as more individuals and businesses are connected, more applications and services can run on those connections, and the value of those applications and services increases along with greater adoption and usage.

This is not to say that broadband overall does not have a positive impact in countries with relatively low GDP per capita. The ITU also researched the impact of mobile broadband penetration on GDP per capita and found that it can be seen as complementary to the economic impact of fixed broadband penetration. This is because increasing mobile broadband penetration has a bigger economic impact in countries with lower GDP per capita, and a smaller impact as GDP per capita increases. Specifically, the ITU found that in countries with a GDP per capita below $12,000, a 10% increase in mobile broadband penetration will increase GDP per capita by 1.98%. In contrast, in countries with GDP per capita over $22,000, a 10% increase in mobile broadband will have no impact on GDP per capita (see **Figure 3**).

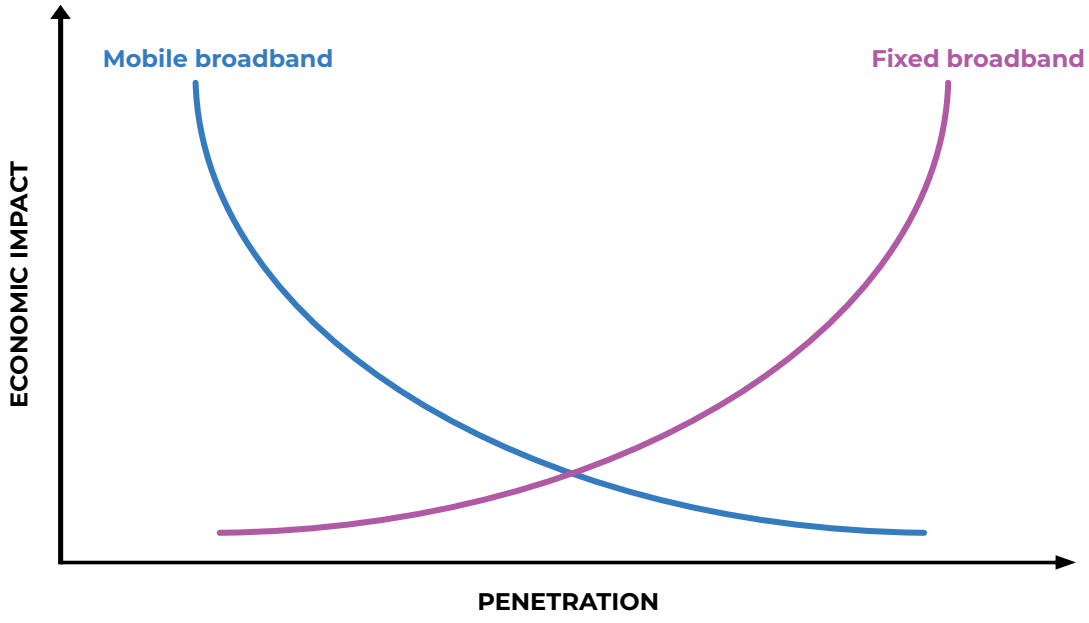
FIGURE 3: IMPACT ON GDP PER CAPITA FOR A 10% INCREASE IN MOBILE BROADBAND PENETRATION



SOURCE: ITU

There are several reasons for this, the ITU finds, with one being that mobile broadband penetration has a bigger impact in countries with lower GDP per capita because fixed broadband penetration tends to be low in those countries. This means that mobile broadband is the only or main option for connectivity, which leads it to have a bigger economic impact. In contrast, countries with higher GDP per capita typically have high penetration of both fixed and mobile broadband services, so the economic impact of mobile broadband suffers from diminishing returns, partly due to competition from fixed broadband services (see **Figure 4**).

FIGURE 4: ECONOMIC CONTRIBUTION OF MOBILE VERSUS FIXED BROADBAND



SOURCE: ITU

This shows both the importance of the different types of broadband, and their complementary economic impacts. It also helps to explain why the WBBA's BCDI focuses on the fixed broadband market, rather than on both the fixed and mobile broadband markets. As Figure 4 illustrates, as fixed broadband penetration increases, it has a bigger positive impact on the economy, in part due to the myriad applications and services enabled by advanced broadband networks. As covered in more detail later in this report, those applications and services are rapidly migrating to the cloud, which is the other key component of the BCDI.

THE IMPACT OF DIGITIZATION AND CLOUD ADOPTION

It is well documented that increased broadband investment, adoption, and development enables greater adoption of a wide range of digital technologies, applications, and services. The benefits of this phenomenon, known as digitization, are so widespread that it can be difficult to quantify. In an effort to measure the economic impact of digitization, the ITU developed the Digital Ecosystem Development Index (DEDI), which is based on eight digital segments and 64 indicators. One of the headline results of the ITU Index is that digitization has a significant positive impact on economies, with a 1% increase in digitization increasing GDP by 0.1331%. That increase in GDP is actually greater than the comparable positive impact of fixed broadband. According to the ITU, a 1% increase in fixed broadband penetration increased GDP by 0.07715%. In addition, the ITU found that 10% digitization boosts labor productivity by 2.62%.

While the ITU DEDI is an industry benchmark for quantifying the positive economic impact of digitization, it is a broad index designed to capture the widespread economic impacts of digitization across the following eight pillars:

- Institutional and regulatory
- Connectivity
- Infrastructure
- Factors of production
- Household digitization
- Competition
- Digitization of production
- Digital industries.

While acknowledging the relevance and value of the ITU approach, the WBBA has developed its more focused BCDI to highlight the impacts seen in leading countries as a result of investment in, and adoption of, broadband and cloud. This is based on the role of broadband as the gateway to the digital economy, and cloud as one of the key enablers of digital applications and services. Certainly, it is no accident that hyperscalers such as Amazon, Microsoft, Google, and Alibaba have leveraged the infrastructure they developed to support their own digital services into cloud computing businesses enabling the digitization of enterprises and consumes worldwide.

Although the narrower focus of the BCDI has limitations compared to broader benchmarks such as the ITU's DEDI, it does have the advantage of providing more detailed insights to stakeholders about the countries seeing the biggest positive socioeconomic impacts from broadband and cloud development, and the policy and market initiatives enabling them.

APPLICATIONS AND SERVICES DRIVING DEMAND FOR NEXT-GENERATION BROADBAND

OVERVIEW

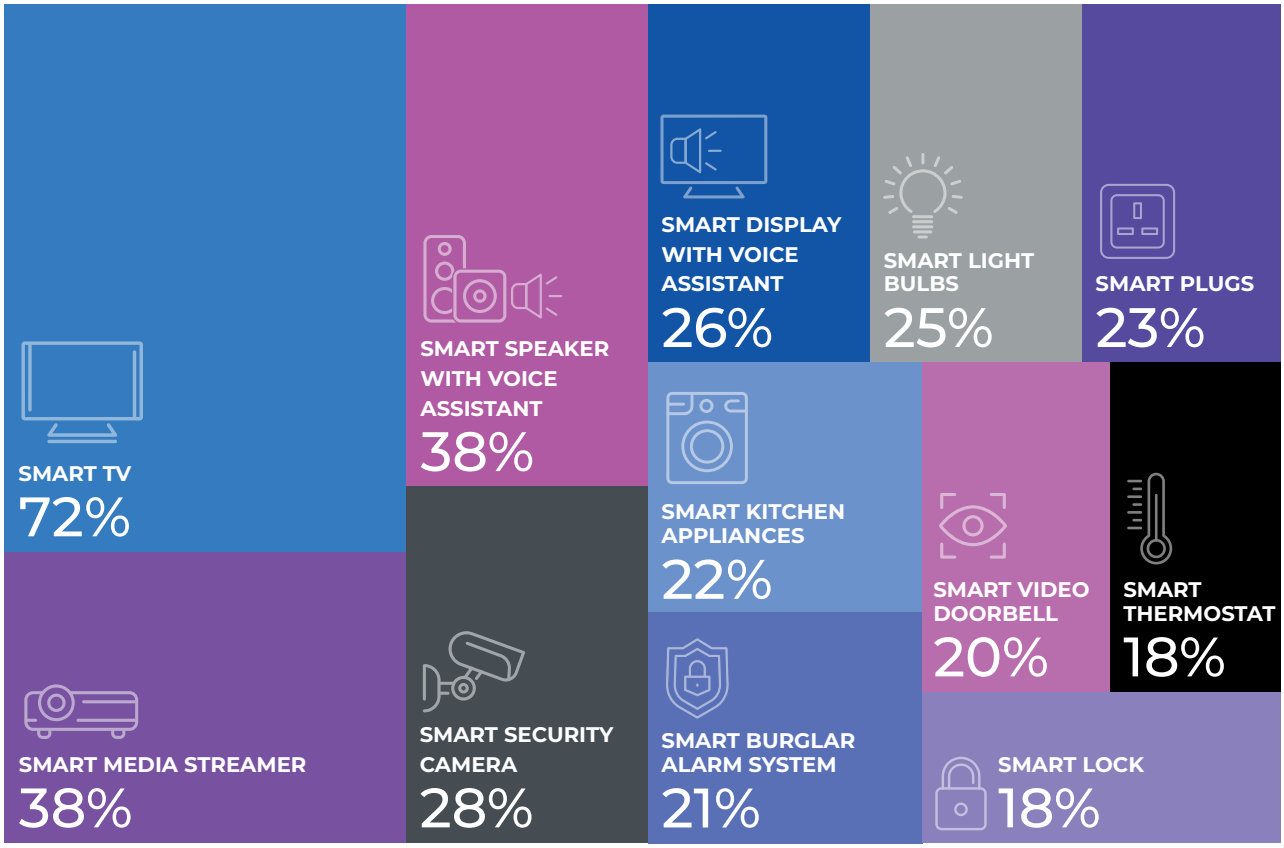
The three-year COVID-19 pandemic accelerated the adoption of digital services by individuals and businesses, increasing demand and usage of broadband and cloud networks. According to the United Nations Broadband Commission, the global internet user base grew by 11% in 2020, which is the fastest growth in two decades. By the end of 2022 there were 5.3 billion internet users worldwide, representing 66% of the global population, an increase of 12% from 2019, before the pandemic. Usage is also continually increasing as new applications and services emerge in areas ranging from smart living and IoT to digital transformation and cloud computing, driving demand for investment in next-generation broadband infrastructure.

SMART LIVING

Consumer demand for internet-enabled products and services seems insatiable – not only in terms of the number of products and services but also the amount of bandwidth each requires. One example is the huge growth in working from home and video calling, initially driven by the pandemic but continuing afterwards, which has significantly increased demand for high-quality broadband and cloud infrastructure. Video calling – particularly when in high definition – requires not only a high-quality broadband connection with robust speeds and low latency and jitter, but also advanced cloud infrastructure to host video calling applications with widespread and growing usage.

Consumers are also increasingly adopting smart home applications and the devices enabling them, as seen by Omdia's Digital Consumer Insights Survey 2022, which was conducted in Australia, Brazil, China, France, Germany, Indonesia, Malaysia, Mexico, South Africa, Spain, the UK, and the US. The survey of 12,178 consumers across the 12 countries found that 72% of respondents have a smart TV, 38% have a smart speaker with voice assistant, and 38% have a smart media streamer (see **Figure 5**). Just taking the example of smart TVs, such widespread adoption drives demand for high-resolution video streaming such as 4K, which in turn drives demand for high-speed and high-quality broadband and cloud networks.

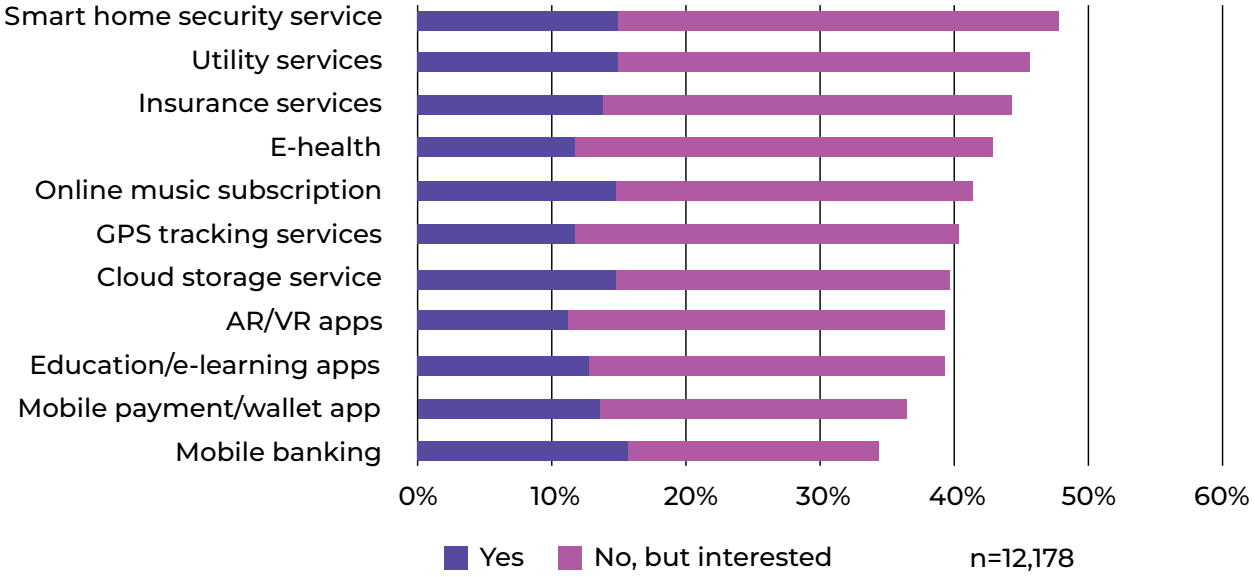
FIGURE 5: WHICH CONNECTED DEVICES DO YOU CURRENTLY HAVE?



SOURCE: OMDIA'S DIGITAL CONSUMER INSIGHTS SURVEY 2022

The survey also finds that consumers are starting to adopt a host of other applications and services, including some such as AR/VR that place heavy demands on broadband and cloud networks. The survey found that 11% of respondents use AR/VR apps on their home broadband service, and another 28% are interested in those apps (see **Figure 6**). Other applications that could drive demand for broadband and cloud investment include education and e-learning apps, used by 12% of respondents, and cloud storage services, used by 14%.

FIGURE 6: DO YOU TAKE ANY OF THE FOLLOWING SERVICES OR APPLICATIONS AS PART OF YOUR BROADBAND SERVICE?



SOURCE: OMDIA'S DIGITAL CONSUMER INSIGHTS SURVEY 2022

Another aspect of the survey results worth noting is the wide variety of applications and services consumers are using today, and the significant number of consumers interested in using them in the future.

INTERNET OF THINGS

With over 450 million Internet of Things (IoT) devices shipped in 2022, according to Omdia's Cellular IoT Market Tracker, and double-digit growth projected through to 2027, IoT is a key driver of demand for connectivity and cloud computing. IoT applications and use cases by industry include:

- **Healthcare:** Remote patient monitoring enables automated monitoring of chronic disease conditions of patients in their homes.
- **Manufacturing:** Smart factories include machine motion control, communication between different industrial controllers, mobile robots, and wired-to-wireless link replacements.
- **Automotive:** Location-based services use GPS/GNSS connectivity to provide a range of services based on the vehicle's location and driving profile, such as stolen vehicle recovery, teen driver monitoring, roadside assistance, crash alerts, usage-based insurance, and boundary alerts.
- **Utilities:** Smart meters enable utilities to automatically collect consumption, status, and diagnostic data from remotely placed electric, gas, water, and heat meters, and transfer that data back to a central database for billing and analysis.
- **Logistics:** Fleet management entails fit-for-purpose OEM or aftermarket solutions to manage fleets of vehicles efficiently.

IoT, combined with advanced analytics, provides companies with opportunities to introduce new products and services, as well as increase operational efficiency. Although not all IoT devices require broadband connectivity, the share of IoT devices requiring broadband is increasing, driven by the demands of more advanced IoT applications and services.

DIGITAL TRANSFORMATION

Digital transformation has accelerated to a point where it is becoming an engine of global economic growth. Enterprises in both developed and developing economies see digital transformation as vital for improving and disrupting traditional production methods, reshaping industrial development patterns, and promoting economic and social development. With the use of cloud computing, big data, artificial intelligence (AI), and IoT in the digital transformation of industries, the requirements for network transmission speed, data storage capacity, and computing power continue to grow. Some examples of digital transformations by industry include:

- **Retail:** Omnichannel commerce, where physical stories are integrated with digital channels like e-commerce, mobile-commerce, and social media.
- **Utilities:** Smart grids, which deploy advanced metering infrastructure through smart meters and communications networks. Smart meters can track and transmit real-time data such as temperature and wind direction.
- **Manufacturing:** Advance robots can greatly improve productivity by performing increasingly complex tasks with higher precision and speed.
- **Logistics:** Asset tracking allows organizations to understand assets' location, condition, maintenance status, and performance, having access to all collected data in centralized storage.
- **Healthcare:** Telehealth services enable patients to receive timely care from healthcare professions through videoconferencing technologies, increasing convenience and reducing the need for physical infrastructure.

Digital transformation is increasingly pervasive as digital technologies have shown their potential to deliver value across industries. Given the rise in enterprise use cases relying on AI and advanced analytics, the demand for digital technologies, powered by broadband access and cloud computing, continues to grow.

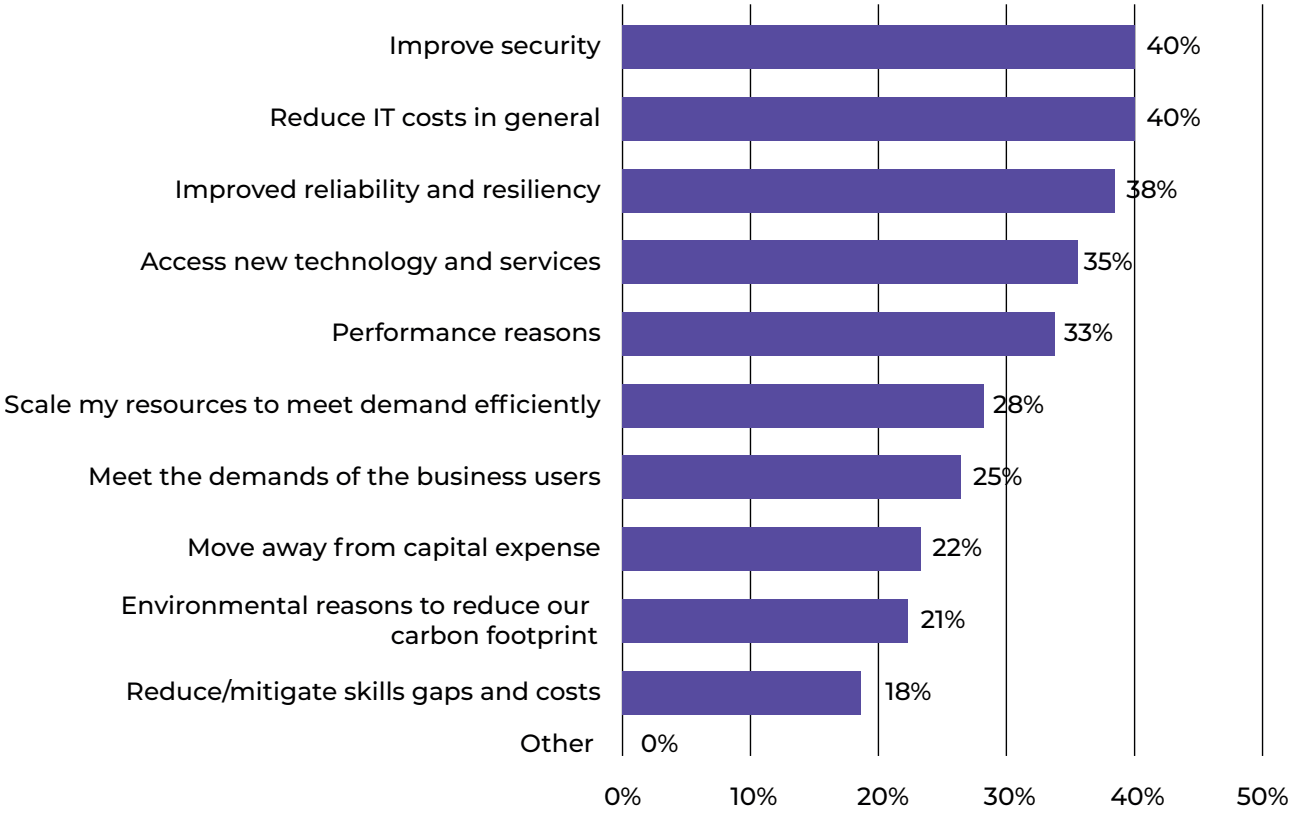
CLOUD COMPUTING

Cloud computing, which relies on high-quality broadband infrastructure, at its core involves the use of the internet to access remote computer servers, and the myriad applications and services running on them. It removes the need for enterprises and consumers to invest in their own digital infrastructure. More importantly, cloud computing enables organizations to increase efficiency, reduce costs, and provide new digital applications and services to customers. Cloud computing benefits include:

- **Scalability and flexibility.** Cloud computing gives organizations more flexibility to scale resources and storage to meet business demands quickly without having to invest in physical infrastructure. For example, the e-commerce channel of an airline can provide compute resources to adapt quickly to changes in demand such as an increase in website traffic and sales around holidays.
- **Increased security.** Cloud computing can strengthen organizations' security because of the depth and breadth of security features, automatic maintenance, and centralized management provided by the cloud service provider.
- **Greater accessibility.** Cloud storage enables organizations to make data available anywhere and anytime.
- **Greater efficiency.** The cloud provides organizations with a central location for all their applications and digital services, making it far easier to keep users across the system connected and aligned with one another.
- **Improves customer service.** Cloud computing makes it possible for users to connect with stored information from any device that is connected to the internet.

The cloud has been growing rapidly in recent years in terms of its breadth and depth, and many organizations have migrated to improve security, reduce IT costs, improve reliability and resiliency, and access new technology and services (see **Figure 7**). This has laid the foundations for a shift where cloud computing is set to become the dominant technology for the next 10 years. In fact, the cloud market is at a major inflection point, where adoption is moving from serving a significant minority of workloads to a position where most organizations have a clear cloud-first strategy.

FIGURE 7: WHY DO YOU PREFER USING PUBLIC CLOUD SERVICES?



Note: n=159 enterprises in North America, EMEA, and Asia & Oceania

SOURCE: OMDIA'S CLOUD SERVICES END-USER SURVEY – 2023

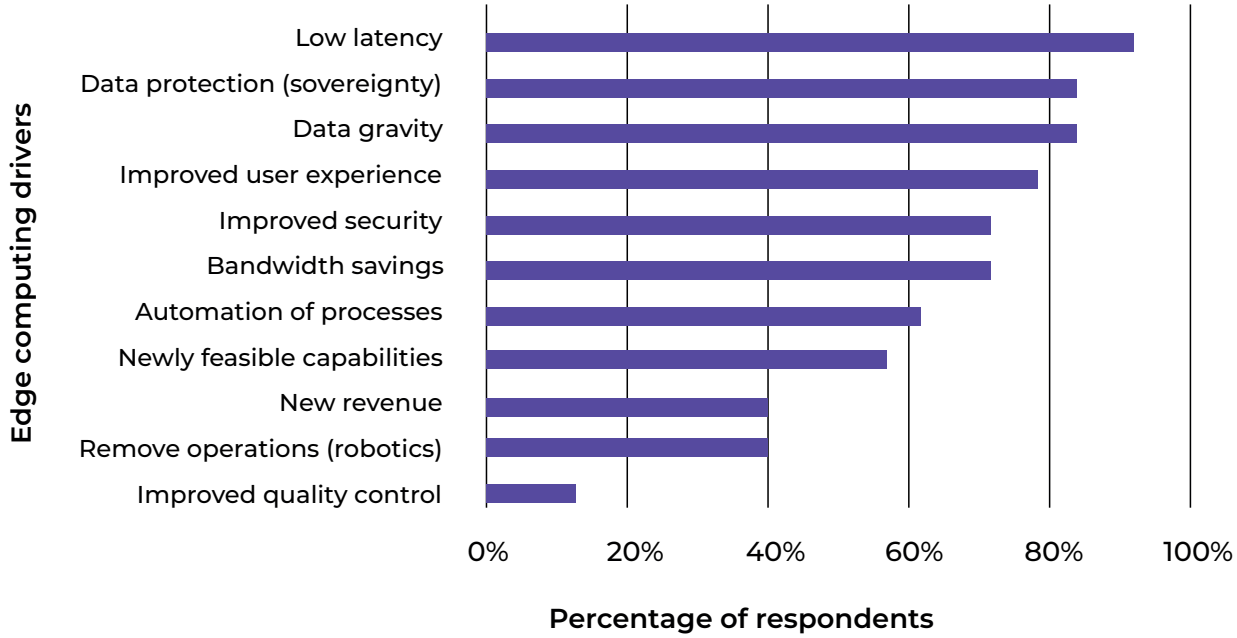
Analysis of IT department infrastructure spending provides further evidence of the move to cloud. In 2019, the average percentage of IT budget spent on server and storage was 4.65%, compared to 7.85% spent on cloud (including infrastructure as a service [IaaS], platform as a service [PaaS], and software as a service [SaaS]). In 2021, the spending was 4.49% on servers and storage and 9.04% on cloud, and Omdia forecasts this gap will widen as IT budgets in enterprise organizations reduce spending on physical infrastructure, a trend accelerated by the COVID-19 pandemic.

EDGE CLOUD COMPUTING

The development of new devices and software technologies in response to a growing requirement to improve business processes, relieve humans of repeatable tasks, and make life more fun is accelerating the global computing demand. The nature of devices and applications is also changing, where the collection and real-time processing of data are becoming increasingly important. As a result, latency and bandwidth are becoming key performance determinants and are driving the need for better telecom networks and more computing power to be placed closer to end users and machines. Security and data volume are also factors that can influence end users to place more compute at the edge.

The key drivers for adoption of edge computing are split between technical features and privacy concerns. The highest rated driver cited by 94% of respondents to Omdia's 2021 Edge Computing Survey was low latency. The latency driver is not a surprise as the concept of edge is that the compute is moved closer to the point of need so that real-time analysis/actions can be taken. The challenge of low latency is also top of mind for the network providers, where 28% of telcos state that they will increase spending by 6% or more on network optimization (according to Omdia's Telecoms – ICT Enterprise Insights 2021 Survey).

FIGURE 8: KEY DRIVERS OF ADOPTION OF EDGE COMPUTING



SOURCE: OMDIA'S 2021 EDGE COMPUTING SURVEY. N=18.

This twin focus on reduced latency by the network providers and the compute sector demonstrates that it is a top concern. For example, the top use case for edge computing is manufacturing process automation, and latency exposes the frustrations of manufacturers with the current technology available. According to Omdia's Industrial IoT Devices Database - 2019, over 3.5 billion IoT devices were shipped, yet only 2.3% of these were industrial IoT enabled. The ability to connect these sensors to cloud gateways and provide real-time responses is limited by the lack of industrial wireless technology. Industrial wireless technology remains a huge untapped market that could be addressed by developments in cellular technology, hence the increased spending by communications service providers and the rise of 5G.

Enterprises, telecom network providers, and cloud service providers have adopted edge computing strategies. For example, Amazon launched Outpost and Microsoft launched Azure Stack. Both approaches are based on the premise of deploying hardware to the edge that is connected to, and compatible with, the core cloud solution offered by the cloud provider. Google, with its Anthos technology, offers a different approach, effectively making the Google Cloud Platform (GCP) the control plane for any edge device, with the only caveat being that the edge device must support the Google software platform. In addition, Alibaba provides a cloud edge service through more than 2,800 edge nodes around the world, and China Telecom offers its China Telecom Cloud Smart Edge Cloud to deliver localized cloud services to end users.

While cloud computing growth is continuing, it can sometimes be limited by the speed, latency, quality, and other characteristics of the underlying broadband network. For example, enterprise customer cloud computing looks set to become the dominant technology, with more than 50% of the workloads executing in some form of public cloud by 2025. However, the ability of the network to deliver the latency demanded for real-time applications, and in particular the growth of AI inferencing using ChatGPT, will further challenge it. Omdia has seen the edge and hybrid cloud emerge, partly due to the lack of adequate network capability to support the business demand. It is clear that the network is the key to digital transformation and supporting the growing demand for cloud-based services.

Service providers have started to address this challenge by converging the broadband and cloud networks at the edge. This can be done by deploying broadband-enabled edge cloud gateways that integrate the network and computing power needed to support the most advanced and demanding applications, such as cloud AI, AR/VR, and gaming.

CLOUD AND NETWORK CONVERGENCE

Advances in network technology in areas such as virtualization, cloudification, service orchestration, and open-network architectures have the potential to help service providers unlock value pools from their network. To meet evolving customer demands and growing competition, service providers need to transform the capabilities of their network by:

- **Ensuring a standardized and open network.** Open-network architectures will be the mainstay for next-generation network services. To facilitate rapid onboarding and integration with third-party systems for faster time to market, service providers must ensure standardization and openness of network interfaces and application programming interfaces (APIs).
- **Building a single pane of glass for cloud and network services.** The next-generation network system will have multiple operator data centers, cloud data centers, and transmission networks. Manual operations across network silos will be increasingly impossible to navigate and manage. It is important to build a consolidated view in real time across all technology and cloud domains to help operators optimize the potential of digital services.
- **Developing end-to-end network orchestration capabilities.** Network orchestration refers to actions a network controller performs in setting up devices, applications, and services in the network to achieve service objectives. The end-to-end orchestration of the network allows service providers to optimize the use of finite network resources to meet specific business objectives.
- **Leveraging AI technology to enhance network automation.** Advances in machine learning and big data technology allow the network controller to translate business needs into network requirements, set up the network to deliver on those requirements, and monitor (and self-correct) it to help ensure that business needs are being met.
- **Establishing ubiquitous connections across air, space, earth, and sea.** Advance use-cases and applications in areas like smart transportation, maritime surveillance, and disaster rescue requires end-to-end collaboration of multiple connection methods, such as combining wireless networks, the Internet of Things and satellite networks with fiber-optic fixed networks. Managing these multiple connection methods requires many challenges to be addressed in this new paradigm, such as network topology management, resource management, service management and mobility management.
- **Building a zero-trust endogenous security system.** Digital transformation, onboarding new partners and developing new applications are essential for scaling, but they also expand the organization's attack surface. There is a need to develop an adaptive, autonomous, and self-growing endogenous security, which is capable of prevention/prediction, detection, response, and recovery. This will allow the cloud-network system to protect confidentially, ensure integrity and maintain availability of the network.

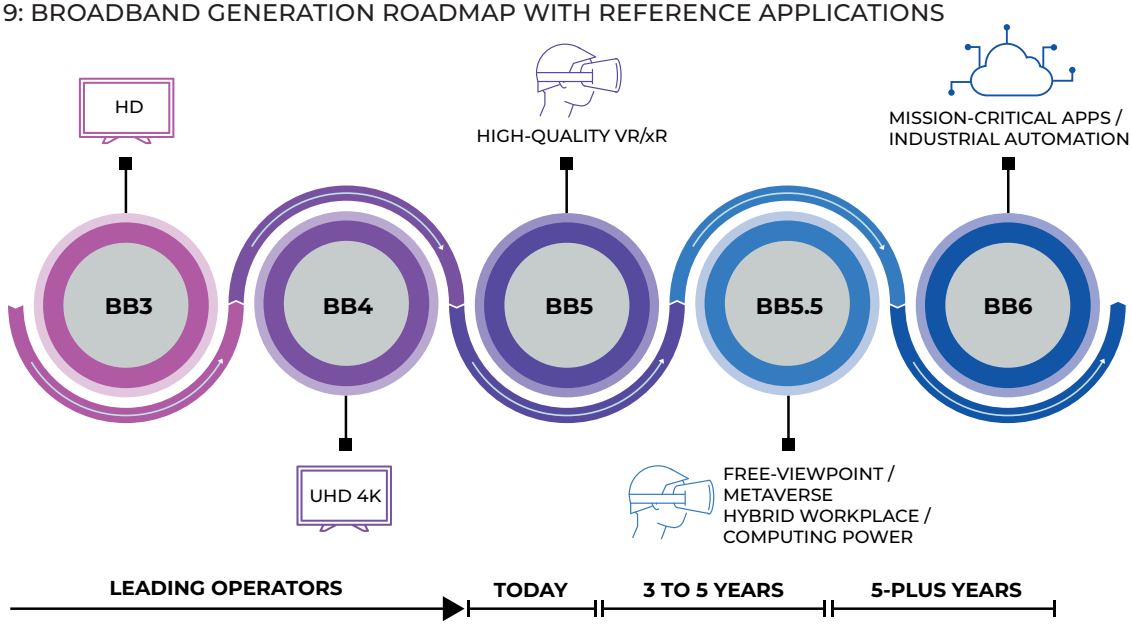
Developing these six capabilities will allow service providers to move from providing bandwidth to delivering experiences. These capabilities are needed to enable the development and adoption of advanced digital applications and services.

NEXT-GENERATION BROADBAND ROADMAP

As consumer and enterprise adoption of digital devices, applications, and services continues to accelerate, it has become clear that although basic broadband access is vital, it is only a first step. As the results of the WBBA Broadband and Cloud Development Index illustrate, countries that invest in advanced broadband and cloud infrastructure see benefits across their economies and society, as consumers and enterprises adopt more advanced digital applications and services, which in turn drive greater demand for broadband and cloud infrastructure.

The WBBA details this in its next-generation broadband roadmap, which is illustrated in **Figure 9**.

FIGURE 9: BROADBAND GENERATION ROADMAP WITH REFERENCE APPLICATIONS



SOURCE: WBBA

The graphic shows the different generations of broadband, illustrated by reference applications and deployment timelines for broadband operators. The timing of the different generations (BB3 to BB6) is difficult to project and depends on local market conditions, the localized business case, and the applications requested by customers. However, the assumption is that generation BB5 is being deployed today by early-adopter operators. The expectation is that BB5.5 will be deployed by advanced operators in the 2025–27 timeframe, and BB6 might be deployed by early adopters in the 2030-plus timeframe.

The next-generation roadmap also categorizes broadband in more detail across the following six dimensions: ultra-enhanced speeds, greater intelligence, ultra-reliable and consistent, trustworthy and green, enhanced connectivity, and greater sensing capability. Ultra-enhanced speeds refers to continual enhancements in speeds across backbone networks, passive optical network (PON) access networks, and home Wi-Fi networks. The greater intelligence dimension is based on the integration of computing into the network and its level of autonomous operation. Ultra-reliable and consistent refers to metrics such as latency, jitter, and packet loss, which will be particularly important as optical networks are extended to industrial locations, for example. A trustworthy and green network is one that is secure, with rapid problem detection and response, and energy efficient. Enhanced connectivity is focused on the entire all-optical network that is divided into backbone, metro, access, and data center interconnect (DCI) optical networks, as well as fiber use for a growing number of IoT connections. Finally, greater sensing capability in the network means enabling network awareness of its surrounding environment, with one example being early sensing of earthquakes through optical submarine cables.

The specific characteristics of each broadband technology generation across these six dimensions are shown in **Table 1.**

TABLE 1: BROADBAND GENERATION NETWORK CHARACTERISTICS

	BB3	BB4	BB5	BB5.5	BB6
RESIDENTIAL SPEED	Up to 30Mbps	Up to 100Mbps	Up to 1Gbps	Up to 10Gbps	Up to 50Gbps*
ENTERPRISE SPEED	Up to 1Gbps	Up to 10Gbps	Up to 100Gbps	Up to 400–800Gbps	Up to 1.6–3.2Tbps
INTELLIGENCE	No automation	Partially autonomous (L2)	Conditionally autonomous (L3)	Highly autonomous (L4), fast provisioning times	Fully autonomous
RELIABILITY & LATENCY	99.9% / n/a	99.99% / 10ms	99.999% / 5ms consistent latency / low jitter	99.999% / 1ms latency (hard guarantee) / very low jitter	Deterministic reliability / <1ms latency (hard guarantee) / very low jitter
TRUSTWORTHY & GREEN	n/a	2× better per bit energy efficient	5× better per bit energy efficient	10× better per bit energy efficient, fast problem detection and response (minutes)	10×-plus better per bit energy efficient, very fast problem detection and response (seconds)
CONNECTIVITY	Copper to the home	Fiber to the home	Fiber to the room/desk, slicing in Gbps granularity	Fiber to the machine, fine granular (Mbps level) slices, 10 times IoT connections	Fiber sensors, 10 times more IoT terminals
SENSING CAPABILITY	n/a	n/a	n/a	Sensing for optimized O&M, application and computing awareness, AI	Fiber sensing for applications, application and computing awareness, AI

Note: *Speeds listed are speculative given the timeframe, and further work by the WBBA will explore this in more detail in future reports.

SOURCE: WORLD BROADBAND ASSOCIATION

As detailed later in this report, the countries that invest in advanced broadband and cloud infrastructure are the ones that achieve high rankings in the WBBA's BCDI.

The BCDI country rankings, along with the technology trends outlined in this chapter, highlight that broadband access alone is not enough – a more nuanced view around the provision of broadband infrastructure needs to be developed. With the outsize role that the internet will play in the coming decade, it is important for governments and service providers to act more decisively to support the development of high-quality broadband infrastructure.

BROADBAND AND CLOUD DEVELOPMENT INDEX: OVERVIEW AND METHODOLOGY

OVERVIEW

The Broadband and Cloud Development Index (BCDI) tracks and benchmarks the development of both broadband and cloud computing by country. Research by the ITU and others has shown that increasing broadband penetration and digitization drives socioeconomic benefits such as GDP and productivity growth. The aim of the BCDI is to quantify the performance of the broadband and cloud markets by country to identify global best practices for developing these two key drivers of digital development, which in turn enable broader economic and social benefits.

As such, the BCDI suggests a country's propensity to bridge the digital divide and take advantage of the growing opportunity that the digital economy presents. Its findings can be helpful to guide service provider strategies for the development and investment direction of broadband and cloud networks in a country. Additionally, it identifies best practice and government policies supporting the growth of these industries and the broader economy.

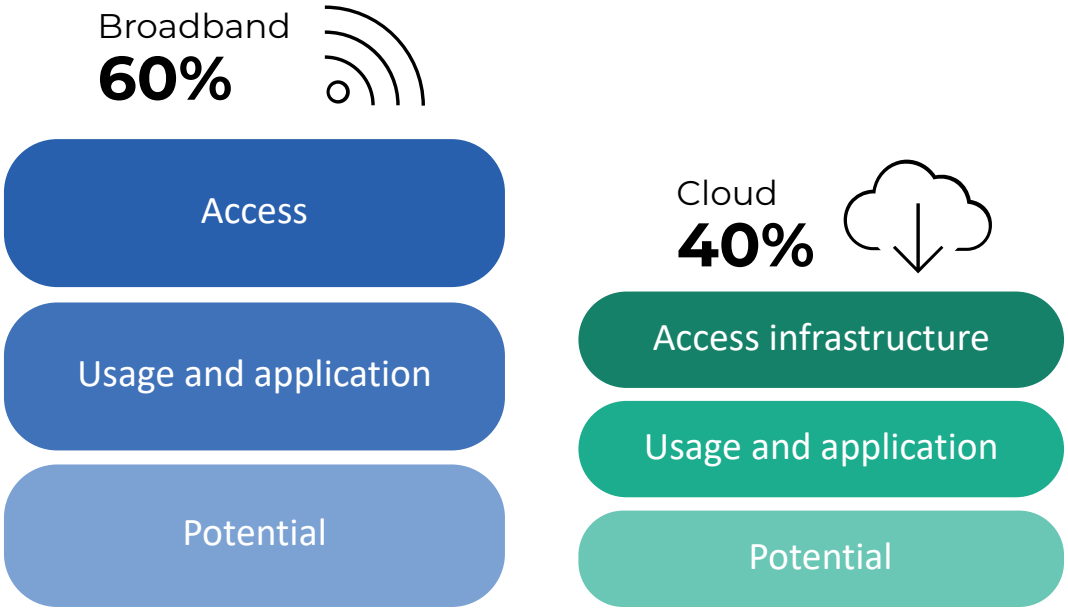
The BCDI is designed to identify best-in-class performance at the country level, highlight the most critical drivers for the continued development of the sector, and make clear the investment case for broadband and cloud infrastructure. The aim is to provide new insight, analysis, and examples for broadband industry stakeholders – whose constituents include legislators, policymakers, investors, vendors, service providers, and enterprises – to address and drive forward the goals of democratizing broadband and cloud access to enable broader economic and social benefits.

METHODOLOGY

The BCDI examines the development of the broadband and cloud markets across 21 countries from five continents, representing over half of the world's population and over three-quarters of global GDP. In finalizing the geographic scope of the first edition of the BCDI, the WBBA included those countries where it had access to enough high-quality data to develop a robust index quantifying the performance of the broadband and cloud markets.

The BCDI is designed to assess the overall performance and impact of the broadband and cloud markets by examining them across three key areas – access, usage and application, and potential (see **Figure 10**). The relative sizes of the broadband and cloud boxes below reflect the WBBA's view that broadband, as the gateway to the digital economy, is more important than cloud, which in turn led WBBA to assign index weightings of 60% to broadband and 40% to cloud.

FIGURE 10: BCDI COVERAGE AND WEIGHTING BY MARKET



SOURCE: WBBA

As the segmentation above shows, the BCDI takes a holistic view of broadband and cloud from the initial access stage, evaluating availability of services, through the usage and application of services, and finally to their potential going forward.

The first step in quantifying the impact of each segment in each market was the selection and validation of the most relevant high-quality input metrics available for all 21 countries in the index. Overall, the BCDI is based on 25 metrics, with four to five in each segment above, adding up to 12 metrics related to the broadband market and 13 metrics related to cloud. The two main sources of the metrics are WBBA members Omdia and Ookla.

BROADBAND METRICS

In the broadband market, the BCDI is built on the 12 metrics detailed in **Table 2**, with four metrics evaluating each of the three key areas – broadband access, usage and application, and potential.

TABLE 2: BCDI BROADBAND METRICS BY SEGMENT

Segment	Metric	Definition
Access	Residential broadband penetration	Residential broadband subscriptions divided by number of households
	Total (residential + business) broadband penetration	Total number of residential and business subscriptions divided by total number of households
	FTTH coverage	Number of residential households covered by the optical fiber network divided by total number of households
	FTTH penetration	The number of FTTH broadband subscriptions divided by the total number of households

Usage and application	Median download speed	Median download speed of broadband services
	High-speed broadband penetration	Proportion of households with broadband subscription tariffs providing 100Mbps or faster speeds
	Online video user penetration	The number of paying subscribers and free trialists across online video platforms like Netflix and Amazon Prime, divided by the population of the country
	Online video views per capita	Total transactional, ad-supported, and subscription views and transactions of content across pay-TV and online video subscription services, divided by the population of the country
Potential	Market competition	One minus the Herfindal-Hirschman Index (HHI) score for the fixed broadband market. The HHI measures the level of concentration within a market and, therefore, the level of competition. It considers two main factors: the number of companies and the market share of each company in that particular market. The index varies from 0% to 100%: the closer to 100%, the more concentrated the market. For the fixed broadband market, HHI is calculated by taking the square of the market share of fixed broadband subscriptions of each company and adding them together.
	Incumbent impact	One minus the market share of the incumbent or largest broadband service provider
	Provider penetration	The number of active internet service providers (ISPs) divided by the number of households
	Broadband affordability	Annual Gross National Income divided by annual broadband average revenue per user (ARPU)

SOURCE: OMDIA, OOKLA

CLOUD METRICS

The BCDI is based on 13 metrics evaluating the cloud market, with four on cloud access infrastructure, four on usage and application, and five on potential (see **Table 3**).

TABLE 3: BCDI CLOUD METRICS BY SEGMENT

Segment	Metric	Definition
Access infrastructure	Cloud spending	The total enterprise spend on cloud in 2022
	Cloud spend proportion	The enterprise cloud spend as a proportion of IT budget in 2022
	Storage spend	The total enterprise spend on storage in 2022. Storage includes the following technologies: 1. Hard-disk drives – standard hard drives that are used to augment or maintain storage area network (SAN) and network attached storage (NAS) systems. 2. NAS filers and arrays – a NAS file server designed and programmed for high-volume data storage, backup, and archiving. 3. NAS gateways – a single gateway that consolidates and aggregates several NAS filers. 4. SAN adaptors and connectors – high-speed networking hardware that is optimized for storage network traffic (e.g., fiber channel). 5. SAN disk arrays – an enterprise storage system that contains multiple disk drives. It is differentiated from a disk enclosure in that an array has cache and intelligence. 6. Tape libraries – a high-capacity data storage system for storing, retrieving, reading, and writing multiple magnetic tape cartridges.
	Data center load capacity (MW)	The maximum power available for IT and mechanical equipment in data centers (2022)
Usage and application	PaaS spending ($m)	2022 spend on PaaS services that combines application development tools, middleware, and runtime services delivered from, or integrated with, an IaaS platform that may or may not be separately available to customers. PaaS can be platform-centric (e.g., IoT or big data), application-specific (e.g., customer engagement or business intelligence), and is typically focused on developer tools and APIs. Customers pay for usage of the services without owning the underlying software licenses and PaaS is designed to make it easier to develop, deploy, and manage applications and cloud-based resources. (External spend)

	SaaS spending ($m)	2022 spend on a usage-based consumption model for runtime applications delivered over the internet or accessed by private network services from multitenant cloud resources hosted externally, either by an independent software vendor (ISV) or by a managed service provider (MSP). With SaaS, the service provider owns the software license not the customer. This includes applications such as sales, marketing, and customer service apps; finance, ERP, and SCM apps; productivity and collaboration apps; and industry-specific operation apps offered "as-a-service." (External spend)
	Percentage of workloads in public cloud	The proportion of workloads in public cloud in 2022. Public cloud is defined by IaaS, PaaS, and serverless services
	Percentage of SaaS workloads	The proportion of workloads in SaaS in 2022
Potential	Cloud spending growth	Year-on-year change in cloud spending (2022 vs. 2021)
	Storage spending growth	Year-on-year change in storage spending (2022 vs. 2021)
	Growth in workloads in public cloud	The difference in proportion of workloads in public cloud between 2022 and 2024 (18 months)
	Growth in SaaS workloads	The difference in proportion of workloads for SaaS between 2022 and 2024 (18 months)
	Share of largest cloud provider	The relative market share of the incumbent (or largest) provider

SOURCE: OMDIA

NORMALIZATION

After selecting, compiling, and validating the 25 metrics for the 21 countries in the BCDI, the next step in the methodology was to normalize all the metrics to a scale of 1 to 100. For metrics in percentages, such as penetrations, the first step in the normalization process is straightforward in that the percentages are simply multiplied by 100. For other metrics, such as spending or revenue data expressed in dollars, log transformation was chosen as the first step in normalization to reduce both the scale differences of the different datasets, and the impact of outliers.

The next step in the normalization process was to define the largest number in a dataset as 100, and then express all the other numbers in that dataset as a proportion of the largest number. Put another way, each number in the dataset is divided by the largest number to get a percentage, and then multiplied by 100 to be on a scale of zero to 100.

WEIGHTINGS

Once all the metrics were normalized onto a common scale, weightings were agreed to reflect the relative importance of each metric within its segment, and each segment within the index overall. The most important decision in this regard was to assign a weighting of 20% to each of the three broadband segments, and 13.33% to each of the three cloud segments (see **Table 4**). This reflects the reality that broadband, as the gateway to the internet, is the foundation of the digital economy, and thus more important than the cloud. This led to the weighting of the three broadband segments combined at 60%, compared to 40% for the three cloud segments taken together.

TABLE 4: BCDI METRIC AND SEGMENT WEIGHTINGS

Segment	Segment weighting within BCDI	Metric	Metric weighting within segment
Broadband access	20%	Residential broadband penetration	25%
		Total (residential + business) broadband penetration	25%
		FTTH coverage	25%
		FTTH penetration	25%
Broadband usage and application	20%	Median download speed	25%
		High-speed broadband penetration	25%
		Online video user penetration	25%
		Online video views per capita	25%
Broadband potential	20%	Market competition	40%
		Incumbent impact	10%
		Provider penetration	10%
		Broadband affordability	40%
Cloud access infrastructure	13.33%	Cloud spending	25%
		Cloud spend proportion	25%
		Storage spend	25%
		Data center load capacity (MW)	25%
Cloud usage and application	13.33%	PaaS spending ($m)	25%
		SaaS spending ($m)	25%
		Percentage of workloads in public cloud	25%
		Percentage of SaaS workloads	25%
Cloud potential	13.33%	Cloud spending growth	20%
		Storage spend growth	20%
		Growth in workloads in public cloud	20%
		Growth in SaaS workloads	20%
		Share of largest cloud provider	20%

SOURCE: WBBA

As detailed above, metrics are also assigned weightings within their segment. The majority of metric weightings within each segment have been assigned equally with the exception of the broadband potential segment, where market competition and broadband affordability were assigned weightings of 40% each, as they were seen as significantly more important than the other two metrics, incumbent impact and active service providers, which were given weightings of 10% each.

COUNTRY INDEX SCORES

The next step in the methodology was to calculate country index scores for each of the six segments by multiplying the score for each metric by its weighting within the segment, and adding the result for all the metrics in a segment to get a total score in that segment. Each segment score is then multiplied by the weighting of that segment within the index (20% for the broadband segments and 13.33% for the cloud segments) to create a total index score for each country.

VALIDATION

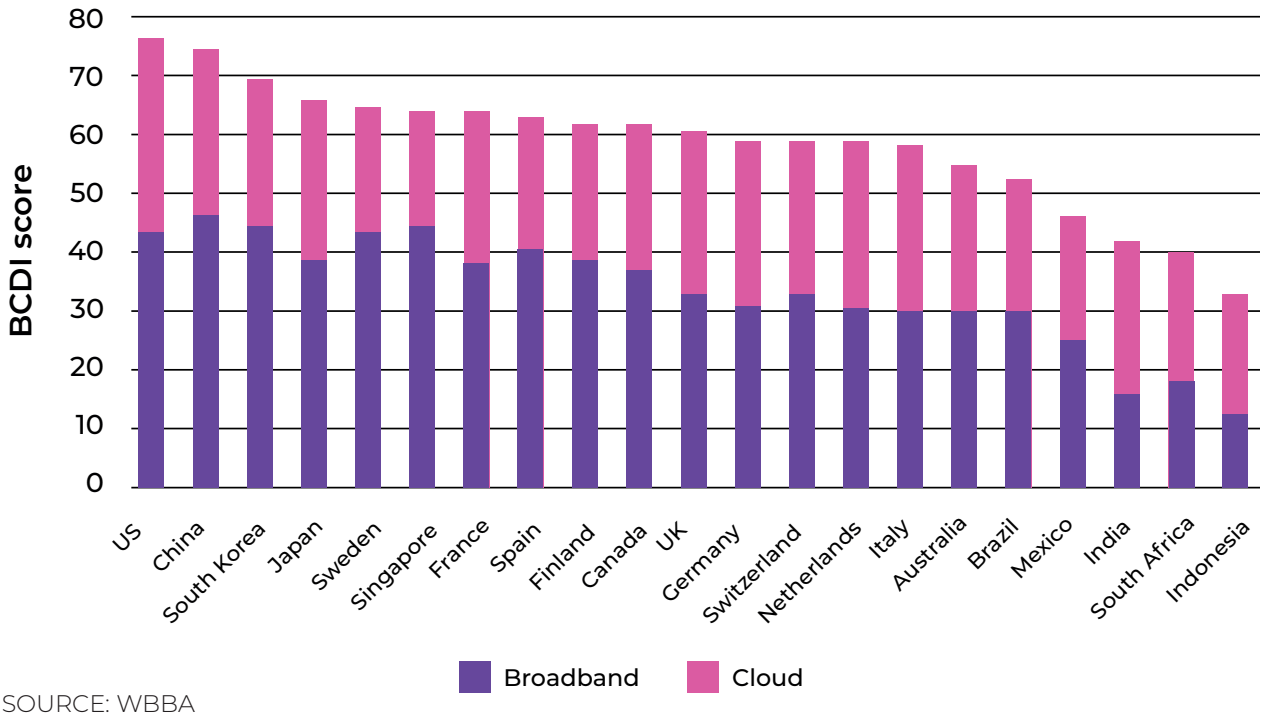
The validation of the index results was extensive and included sensitivity analysis to assess the validity of the results. This included several approaches, such as the adjustment of the metrics in the index, relative weightings of the metrics, and methodology for calculating scores – to gauge the sensitivity of the model to the changes and to arrive at the final methodology that produces the most robust results.

BROADBAND AND CLOUD DEVELOPMENT INDEX: RANKING RESULTS

This chapter presents the results of the BCDI, including the overall scores and rankings for each of the 21 countries. It is worth noting that the intent of the ranking is not to criticize countries toward the bottom, but rather to identify best practices in countries throughout the index, which all stakeholders can then use to improve the performance of the broadband and cloud markets in their countries.

The high-level results of the BCDI are provided in **Figure 11**, which indicates the overall scores by country and the separate contributions of the broadband and cloud segments.

FIGURE 11: BCDI RANKINGS



SOURCE: WBBA

Although high-level analysis of the performance of selected countries will be provided in the next chapter, it is difficult to directly compare the results of one country to another, given the wide variety of countries in the index, their different stages of development, and the many unique characteristics of their broadband and cloud markets.

Therefore, to compare individual results, the BCDI organizes countries into three different country clusters:

- **Cluster 1:** Countries where both the broadband and cloud markets have above-average scores in the BCDI.
- **Cluster 2:** Countries where either the broadband or cloud market has an above-average score in the BCDI, but the other market does not.
- **Cluster 3:** Countries where both the broadband and cloud markets have scores that are average or below average in the BCDI.

It should also be noted that the number of countries in the BCDI does limit the amount of significance that should be given to the clusters. For example, if the number of countries covered in future editions of the BCDI increases, the range of scores will naturally change, along with the average scores by segment. That, in turn, could lead countries to move from one cluster to another simply due to the addition of more countries, rather than due to any changes inherent to national broadband and cloud markets.

CLUSTER 1

The countries in Cluster 1 tend to have either large or highly developed economies, or both (see **Table 5**). The US and China lead the cluster and overall BCDI rankings but achieve their leadership in different ways. The US has the top score in the index in the cloud segment, which is not surprising given the early adoption of cloud services by US enterprises, and the fact that the US is the home market of the world's leading cloud providers. What may come as more of a surprise is that the US has the third-highest broadband score in the cluster and fifth highest in the index overall, even though it has not traditionally been a leader in the global broadband market, particularly for fiber broadband availability and take-up. However the US performance is largely because the BCDI covers aspects of the broadband market that other indexes do not, such as broadband usage and application, where the US scores highly, as detailed in the US case study in the following chapter.

TABLE 5: CLUSTER 1 COUNTRY RANKINGS AND SCORES

Rank	Country	Broadband score	Cloud score	Total score
1	US	42.4	33.0	75.4
2	China	45.1	29.1	74.2
3	South Korea	42.8	26.3	69.1
4	Japan	38.7	28.4	67.1
7	France	38.5	27.1	65.6
9	Finland	37.7	26.2	63.9
10	Canada	37.6	26.1	63.7
11	UK	33.6	28.2	61.8

SOURCE: WBBA

China, in contrast, is an established leader in the global broadband market, so its top score in the segment comes as no surprise. China also ranks second in the cluster and BCDI in the cloud due to accelerating adoption by its large-scale enterprise segment and support from the country's cloud providers, which have established leadership positions in the global market.

CLUSTER 2

Cluster 2, which includes countries with one market segment with an above-average score and the other with a score that is average or below-average, lends itself to analysis of the performance of the countries by segment (see **Table 6**).

The first thing to note in this regard is that the top three countries in the cluster – Sweden, Singapore, and Spain – have above-average broadband scores and below-average cloud scores, while the other five countries – Germany, Switzerland, Netherlands, Italy, and India – have above-average scores in the cloud segment and below-average broadband scores.

TABLE 6: CLUSTER 2 COUNTRY RANKINGS AND SCORES

Rank	Country	Broadband score	Cloud score	Total score
5	Sweden	43.5	23.2	66.7
6	Singapore	44.2	21.6	65.8
8	Spain	39.9	25.5	65.4
12	Germany	30.9	28.1	59.0
13	Switzerland	33.9	25.0	58.9
14	Netherlands	32.0	26.9	58.9
15	Italy	29.4	28.9	58.4
19	India	15.1	28.1	43.2

SOURCE: WBBA

For the advanced European markets of Germany, Switzerland, Netherlands, and Italy, this naturally raises the question of the key drivers of below-average broadband scores. For Germany, that will be evaluated in the case study in the next chapter, but for the Netherlands, one of the main drivers is a lower score in broadband potential, driven by a below-average score in market competition. Italy is impacted by relatively low scores in broadband usage and application and broadband access, where there is room to improve FTTP penetration of 11% of households, and residential broadband penetration of 63% of households.

In the case of Switzerland, its broadband score is affected by a relatively low score in the broadband potential segment. That, in turn, is driven by a broadband affordability score that is below average, which can impact adoption and usage, even in a market such as Switzerland, which has a GDP per capita of $85,706 – the highest in the index.

India stands out for achieving an above-average score in cloud despite having the second-lowest broadband score in the index and lowest GDP per capita. It performs particularly well in cloud potential, where it has the second-highest score in the index due to high year-on-year growth rates across most cloud segments.

CLUSTER 3

The countries in Cluster 3, which are detailed in **Table 7,** have below-average scores in both the broadband and cloud segments. For Brazil, Mexico, South Africa, and Indonesia, this can be explained partly by their status as developing economies. However, the presence of Australia in the cluster requires further consideration, particularly in the broadband segment.

TABLE 7: CLUSTER 3 COUNTRY RANKINGS AND SCORES

Rank	Country	Broadband score	Cloud score	Total score
16	Australia	29.8	25.2	55.0
17	Brazil	27.3	24.6	52.0
18	Mexico	24.7	21.8	46.5
20	South Africa	17.4	23.2	40.6
21	Indonesia	13.3	20.2	33.5

SOURCE: WBBA

Australia's challenges in broadband are widespread, given it has below-average scores in all three broadband segments. The country's broadband access score is pulled down by relatively low FTTP coverage of 26% and FTTP penetration of 17%, although it is helped by 79% of households having broadband service. The low fiber penetration is one of the factors behind the country's low score in broadband usage and application, given that fewer than one quarter of the country's residential broadband connections provide 100Mbps or faster speeds, based on Omdia's analysis. Its broadband potential score, meanwhile, is impacted by below-average broadband affordability.

COUNTRY CASE STUDIES AND BEST PRACTICE

This section provides more detailed analysis of several countries in the BCDI to uncover best practices and other learnings that could benefit broadband and cloud stakeholders. The case studies cover the US and China from Cluster 1, Germany from Cluster 2, and Brazil from Cluster 3.

The country case studies below include analysis of the role selected government policies and investments have played in the BCDI scores and rankings, emphasizing the fact that major industries such as broadband and cloud need the support of governments, policymakers, and regulators to encourage the investment, adoption, and usage that drives economic and social benefits.

COUNTRY CASE STUDY 1: US

The US ranks first in the BCDI, powered by its leading performance in cloud and strong showing in broadband. The result is surprising to a degree because the US has not traditionally led developments in the global broadband market, particularly fiber deployment. However, the US is the clear global leader in the cloud market in terms of both cloud providers and enterprise cloud adoption. The top ranking for the US also highlights how the broader focus of the BCDI on both broadband and cloud can lead to new insights on the wider benefits of broadband-enabled digitization.

TABLE 8: US – SELECTED STATISTICS

Statistic	2022
Population (millions)	333
GDP per capita	$67,359
Fixed broadband household penetration	90%
FTTH household penetration	19%
Public cloud spending (millions)	$27,255

SOURCE: OMDIA, IHS MARKIT

The relatively high GDP per capita of $67,359 of the US means that increasing broadband penetration has a greater positive impact on GDP than in countries with relatively low GDP per capita, based on ITU's analysis in the report, How broadband, digitization and ICT regulation impact the global economy. In fact, the ITU found that in the Americas (including North America), a 10% increase in fixed broadband penetration increases GDP by 1.88%.
Similar to several other countries in the BCDI, the US benefits from high fixed broadband penetration, which stood at 90% of households in 2022. As detailed by the ITU, higher fixed broadband penetration drives more growth in GDP, due to the positive scale and network effects of broadband access.

However, while fixed broadband penetration is high, FTTH penetration remains limited, reaching just 19% of households in 2022. Increased investment in fiber rollouts is therefore critical in order for the US digital economy to drive the next phase of broadband-enabled economic growth in the US.

RANKINGS BY SEGMENT

The trends above are reflected in the US rankings across the broadband and cloud segments of the BCDI (see **Table 9**). The US ranks tenth out of the 21 countries in broadband access, with its score constrained by its relatively low coverage and penetration of fiber broadband, and twelfth in broadband potential, where its performance is impacted by the below-average score in broadband affordability. However, it fares much better in broadband usage and applications, where it ranks first in the index due to the strong adoption and use of online video services, which contributes to the US ranking fifth overall in broadband.

TABLE 9: US BCDI RANKINGS BY SEGMENT

Segment	Rank
Broadband	**5**
Broadband access	10
Broadband usage and application	1
Broadband potential	12
Cloud	**1**
Cloud access infrastructure	1
Cloud usage and application	1
Cloud potential	4
Overall rank	**1**

SOURCE: WBBA

Public cloud spending in the US reached $27.3bn in 2022, which helps to explain its first-place ranking in cloud access. Likewise, US enterprises invest the most in cloud segments, including PaaS and SaaS, leading the US to rank first in cloud usage and application. The US does not lead the cloud potential segment, however, ranking fourth behind countries including India, where growth rates of cloud and storage spending are higher.

FCC EXPANDS BROADBAND ACCESS AND RAISES SPEED TARGETS

The US Federal Communications Commission (FCC) has introduced several major new policies in recent years, often in response to the pandemic, that have helped improve the country's broadband infrastructure. One initiative that could help explain the top rank of the US in the broadband usage and application segment came in July 2022, when the FCC raised the national standard for minimum broadband speeds from 25Mbps downstream and 3Mbps upstream to 100Mbps downstream and 20Mbps upstream.

In 2021, the FCC launched its Emergency Broadband Benefit Program (EBBP) and Emergency Connectivity Fund Program (ECFP) to improve affordability and access to broadband services during the COVID-19 pandemic. EBBP included $3.2bn in subsidies to provide broadband access for low-income groups during the pandemic. ECFP provided $7.17bn in funding for schools and libraries across the US to purchase laptops, tablets, Wi-Fi hotspots, and broadband connections to support online learning for students and teachers.

In November 2021, the US Congress passed the Infrastructure Investment and Jobs Act to improve the country's infrastructure and competitiveness, allocating $65bn to broadband access with most funds being dedicated to deployments in unserved and underserved areas. The FCC has further indicated its preference for full fiber networks to be deployed as part of the Broadband Equity, Access, and Deployment (BEAD) Program funding. First allocations of the $42.5bn BEAD funding were announced in July 2023.

In addition, in December 2021, the EBBP was replaced by the Affordable Connectivity Program (ACP), with a total investment of $14.2bn. The ACP extended the provision of broadband to more families and for a longer time, with the FCC estimating that close to 40% of American households qualify for the program.

NATIONAL CLOUD STRATEGY DRIVES INDUSTRY FORWARD

The US government and Department of Defense have strongly supported the cloud computing industry by creating cloud development strategies for civil and military use, establishing and continuously updating corresponding cloud computing standards, development roadmaps, and technology roadmaps.

The first cloud-oriented policy was launched over a decade ago in 2010, when the White House Office of Management and Budget formulated the "Cloud First" policy, which aimed to accelerate cloud adoption by requiring government agencies to evaluate cloud computing solutions as part of any new investment. Then, in February 2011, the US issued its "Federal Government Cloud Computing Strategy," which was designed to support the development and adoption of cloud computing across the US government and private enterprises. In the same year, the government committed to invest up to $20bn to develop cloud applications. Another milestone came in September 2018, when the US released its "Cloud Smart" strategy to encourage federal agencies to adopt more intelligent cloud solutions by focusing on three key factors – security, procurement, and personnel.

In addition, the US Department of Defense has supported the adoption of efficient, secure, and flexible cloud platforms in the US military by publishing its Department of Defense Cloud Computing Strategy in July 2012, its Department of Defense Cloud Strategy in February 2019, and its US Offshore Cloud Computing Strategy in June 2021.

There is no doubt that the US government's early and strong backing of the US cloud computing industry has helped the country achieve the top BCDI ranking in cloud.

COUNTRY CASE STUDY 2: CHINA

China, which ranks second overall in the BCDI, stands out as the only country in the index to achieve a top ranking despite having a GDP per capita (see Table 10) well below the index average. Although China's position as the world's largest country and second-largest economy makes it something of a special case, there is no doubt that other countries can learn from the successful government and industry initiatives that have made China a leading broadband and cloud market.

TABLE 10: CHINA – SELECTED STATISTICS

Statistic	2022
Population (millions)	1,448
GDP per capita	$11,428
Fixed broadband household penetration	97%
FTTH household penetration	93%
Public cloud spending (millions)	$19,882

SOURCE: OMDIA, IHS MARKIT

As the statistics above show, China has developed a highly advanced broadband market, despite the country's relatively low GDP per capita of $11,428. With a fixed broadband household penetration reaching 97% of households, the third highest in the index, broadband is already contributing significantly to China's GDP.

In addition, China's FTTH household penetration is 93%, the highest in the BCDI. This means that 467 million households across China's vast territory have access to fiber broadband services with the high speeds and low latencies needed to support advanced applications and services.

RANKINGS BY SEGMENT

China ranks first in broadband in the BCDI, and second in cloud, behind only the US (see Table 11). Its top ranking in broadband access is based on its high FTTH household penetration and overall broadband household penetration rates, along with FTTH coverage of 99% of households. That level of FTTH coverage and penetration is notable in a country as large as China, and unique in the BCDI among countries that are large, developing, or both.

China also ranks second in broadband usage and application, driven by its strong performance in broadband speed metrics, including the majority of households in the country having high-speed broadband connections of 100Mbps or faster. In broadband potential it ranks third, partly due to a below-average score in broadband market competition.

TABLE 11: CHINA BCDI RANKINGS BY SEGMENT

Segment	Rank
Broadband	**1**
Broadband access	1
Broadband usage and application	7
Broadband potential	2
Cloud	**2**
Cloud access	2
Cloud usage and application	2
Cloud potential	15
Overall rank	**2**

SOURCE: WBBA

The country reached second place in the BCDI in the cloud segment thanks to cloud spending of $19.9bn, second only to the US, and strong migration of workloads to the cloud. However, it ranks 15th in cloud potential due to relatively low growth rates for cloud spending.

CHINA'S NATIONAL BROADBAND STRATEGY DRIVES RAPID DEVELOPMENT

China continues to be one of the most ambitious countries when it comes to connectivity targets, especially considering its size and population. The government's major support for, and investment in, broadband development in recent years are clearly key drivers of the country's top ranking in broadband in the BCDI.

Between 2016 and 2018, the Ministry of Industry and Information Technology (MIIT) and the National Development and Reform Commission (NDRC) led a three-year action plan for the construction of communications infrastructure, with a budget of CNY1,200bn ($181bn). The plan aimed to support the development of high-speed fiber optics, the construction of advanced mobile broadband systems, and global network facilities. To execute this plan, the government focused on 92 selected infrastructure projects, with a total investment budget of CNY902.2bn ($136.3bn).

In 2015, the State Council also proposed measures to accelerate high-speed broadband network construction and promote speed upgrades and fee reductions. According to MIIT, from 2016 to 2020 broadband tariffs per unit of bandwidth decreased by more than 95% for consumers, and more than 70% for enterprises. The ministry says the tariff reductions have benefited over 1 billion users per year, but for service providers they have meant cumulative foregone revenue of CNY700bn. This resulted in China achieving the second-highest score in the BCDI in broadband affordability, which in turn helped it rank third in broadband potential.

In 2019, the MIIT proposed a "dual-gigabit" plan to promote both fixed and wireless gigabit broadband services. This used 10G PON technology to create a dual-gigabit broadband service featuring both wired and wireless gigabit broadband.

In 2021, China shifted its focus from expanding fiber network coverage to improving the speed and quality of broadband services. In March 2021, the MIIT released a plan to expand the gigabit network to cover 200 million people by the end of the year and 400 million by the end of 2023. The government targeted 10 million gigabit users by the end of 2021—a goal it surpassed, with more than 34 million 1Gbps users at the end of 2021 and just under 46 million by March 2022. As of the same date, 93% of broadband users had access to speeds of 100Mbps, and that increased to 97% in 2023. This successful policy is one of the key reasons China achieved second place in broadband usage and application in the BCDI, given the vast majority of households in the country having high-speed broadband.

CHINA CLOUD INDUSTRY ACCELERATES IN 2015

China's government launched initiatives supporting the cloud industry as far back as 2015, helping to explain the rise of China's global cloud providers and adoption of cloud services by enterprises, which in turn support China's second-place ranking in cloud in the BCDI.

In January 2015, the Chinese government published its top-level design for the development of China's cloud industry in its "Opinions of the State Council on Promoting Innovation and Development of Cloud Computing and Cultivating New Forms of Information Industry." The policy detailed the key tasks to develop China's cloud computing industry, including enhancing cloud services, improving cloud innovation, exploring new models for government cloud computing, strengthening the development and use of big data, coordinating the layout of cloud infrastructure, and improving security. This policy document played an important role in promoting the early development of China's cloud computing industry.

In March 2017, the MIIT issued its "Three-Year Action Plan for the Development of Cloud Computing (2017-2019)." The five key actions in the plan were enhancing technology, developing industry, promoting applications, guaranteeing security, and optimizing for the environment. It then followed up in August 2018 with its "Guidance for Promoting Enterprise Cloud Usage (2018–20)."

Most recently, in March 2022, the "Channel Computing Resources from the East to the West" project was launched to further promote China's cloud computing industry, and in July 2022 China Telecom led the launch of the "National Cloud" to achieve self-reliance, security, and technological leadership in China's digital technology and infrastructure.

At the same time, China's cloud service providers (including Alibaba Cloud, Tencent Cloud ,and Huawei Cloud) and CSPs (including China Telecom, China Mobile and China Unicom) have become the backbone of China's cloud computing industry.

COUNTRY CASE STUDY 3: GERMANY

Germany, which ranks 12th overall in the BCDI, is in Cluster 2 due to its below-average score in broadband, where it ranks 14th. Germany is joined in Cluster 2 by the Netherlands and Italy, which also registered below-average scores in BCDI's broadband segment. However, as the fourth-largest economy in the world, with a GDP per capita of $46,846 (see Table 12), Germany should arguably be performing much better in the BCDI's broadband and overall rankings.

TABLE 12: GERMANY – SELECTED STATISTICS

Statistic	2022
Population (millions)	84
GDP per capita	$46,846
Fixed broadband household penetration	81%
FTTH broadband household penetration	6%
Public cloud spending (millions)	$3,630

SOURCE: OMDIA, IHS MARKIT

Although Germany's fixed broadband household penetration is above average among BCDI countries at 81%, its FTTH broadband penetration of 6% is the lowest in the BCDI, and tied with the levels in India and South Africa. This is a concern for one of the world's largest economies because it could miss out on the economic growth and productivity gains enabled by migration to fiber broadband networks that support the most advanced digital applications and services.

As with the Netherlands and Italy, one of the reasons for Germany's poor performance in broadband is the telecom incumbents' historical investment in upgrades of their legacy copper networks, rather than full-fiber deployments.

RANKINGS BY SEGMENT

Germany has an above-average score in cloud, leading it to rank seventh in the segment, driven by its public cloud spending of $3.6bn in 2022. However, its performance in broadband, and particularly broadband access where it ranks 18th out of the 21 countries in the BCDI, is of most concern (see Table 13). Its score in broadband access is driven down not only by its low FTTH penetration of 6%, but also its correspondingly low FTTH coverage of 21%, which is the third lowest among BCDI countries.

TABLE 13: GERMANY BCDI RANKINGS BY SEGMENT

Segment	Rank
Broadband	**14**
Broadband access	18
Broadband usage and application	14
Broadband potential	8
Cloud	**7**
Cloud access	5
Cloud usage and application	5
Cloud potential	8
Overall rank	**12**

SOURCE: WBBA

In addition, the low levels of FTTH coverage and penetration in Germany help lead to a below-average penetration of households with high-speed broadband, and relatively slow download speeds—both of which cause Germany to rank 14th in broadband usage and application.

The country's rank of eighth in broadband potential is the lone bright spot in the segment, driven by broadband affordability, which is above average in the BCDI.

GERMANY TARGETS NATIONWIDE GIGABIT COVERAGE BY 2030

Germany's policymakers may be aware of the importance of advanced broadband services to the competitiveness of their economy, but their attempts to support it have not always gone to plan. For example, as part of its "Gigabit Germany" initiative, the government set a nationwide target to provide 100% coverage with broadband speeds of at least 50Mbps by the end of 2018. However, the target was missed, with coverage only reaching 88% of households in 2018.

However, the government then updated its Gigabit Strategy 2030 with a new target for fiber network coverage to reach all households by 2030. The strategy also aims to triple the number of fiber-optic connections and extend the coverage of FTTH/FTTB networks to 50% of households and companies by 2025.

In addition, in an effort to close the significant urban-rural broadband divide in the country, in September 2021, the government announced a €12bn ($12.2bn) funding program to expand fiber networks in gray spots; i.e., areas with internet connectivity lower than 100Mbps speeds. From 2023, the plan is to extend the funding to all areas without gigabit coverage.

Germany's performance in broadband in the BCDI can be improved with continued focus on, and investment in, fiber network deployments and the latest government policies are a step in the right direction.

GERMANY SUPPORTS CLOUD ADOPTION AND SOVEREIGNTY

It can be argued that Germany scores significantly higher in cloud than broadband in the BCDI, firstly because cloud is a new segment that is less constrained than broadband by large-scale legacy network investments, and secondly because the government turned its attention to cloud as far back as October 2010, when it announced its Cloud Computing Action Plan. Through this plan, the German government provided technical and financial support to small and medium-sized enterprises to tap into the economic potential of cloud computing.

In addition, in November 2019, the German government announced the Gaia-X European Cloud Plan, stating that it would help Germany regain digital sovereignty and work with other members of the group to create a digital ecosystem to share data. In the following year, the

German government signed a German Cloud Technology Development Agreement with Google. The agreement made T-Systems, a Deutsche Telekom subsidiary, responsible for data management, and established a public cloud operating on infrastructure controlled by the Germany government, in an effort to increase the country's cloud sovereignty.

COUNTRY CASE STUDY 4: BRAZIL

Although not reflected in its relatively low overall rankings in the BCDI, Brazil is an interesting case because its FTTH broadband household penetration is particularly high for a developing market at 35% (see **Table 14**), which ranks seventh in the index. The question then becomes why Brazil's relatively high FTTH penetration does not lead it to rank higher in broadband and the BCDI overall?

TABLE 14: BRAZIL – SELECTED STATISTICS

Statistic	2022
Population (millions)	215
GDP per capita	$9,103
Fixed broadband household penetration	54%
FTTH broadband household penetration	35%
Public cloud spending (millions)	$1,029

SOURCE: OMDIA, IHS MARKIT

The first reason is Brazil's relatively low overall fixed broadband penetration of 54%, which places it 14th in the BCDI, which brings down Brazil's score in the broadband access segment, where it ranks 15th (see **Table 15**).

The second reason is that, although FTTH broadband household penetration stands at 35%, less than 20% of households have high-speed broadband connections of 100Mbps or more, which results in Brazil ranking 17th in broadband usage and application.

The third reason is that broadband affordability in Brazil is well below average in the BCDI, leading it to rank 13th in broadband potential.

TABLE 15: BRAZIL BCDI RANKINGS BY SEGMENT

Segment	Rank
Broadband	**17**
Broadband access	*15*
Broadband usage and application	*17*
Broadband potential	*13*
Cloud	**16**
Cloud access	*17*
Cloud usage and application	*20*
Cloud potential	*5*
Overall rank	**17**

SOURCE: WBBA

One explanation for this is that Brazil is a unique broadband market with over 12,000 regional ISPs, most of which provide FTTH services over their own local fiber networks. Many of these companies were originally dial-up ISPs in areas not served by major operators, and deployed fiber networks and services with limited resources. This means that the networks may not always have been architected to provide high-speed services. This could also be true for parts of the networks of Brazil's major fiber broadband providers.

AMBITIOUS BROADBAND TARGETS NOT ALWAYS ACHIEVED

Although Brazil's National Telecommunications Agency, Anatel, has released a number of ambitious national broadband plans, the targets in the plans have not always been achieved, which helps to explain the country's relatively low broadband rank in the BCDI. This also highlights the point that funding, implementing, and managing broadband policies is vital.

Brazil's broadband strategies include the Smart Brazil national broadband development plan, launched in 2016, which aimed to increase fiber broadband coverage to 85% of towns by 2022, thereby achieving broadband population coverage of 95%. In the same year, the government invested nearly $5bn to enhance the coverage and speeds of broadband services.

In June 2019, Anatel approved its Telecommunications Network System Plan, which aimed to provide fiber broadband access to 75% of the population by 2022, with the remaining 25% of the population to be served by high-capacity wireless broadband networks.

In May 2020, Anatel updated its strategic plan for 2015–24, with its revised goals including increasing broadband household penetration to 91% by 2023, deploying fiber-optic backhaul networks in 4,883 cities nationwide, achieving an average contracted broadband speed of 150Mbps, and increasing rural broadband penetration to 73%.

INDUSTRY CHALLENGES TO ADDRESS

The results of the BCDI highlight not only country leaders and best practice, but also the challenges the industry needs to understand and address to support development in all regions and countries. These challenges are detailed below.

BROADBAND ACCESS ALONE IS NOT ENOUGH

The BCDI rankings highlight that although basic broadband access is vital, it is not capable of supporting the wide variety of cloud-enabled applications and services that are increasingly important to consumers, enterprises, and governments.

Although broadband is increasingly seen as critical infrastructure alongside utilities such as electricity and water, the provision of broadband infrastructure is more complicated because access alone is not enough. A more nuanced view around the provision of broadband infrastructure needs to be developed to encourage stakeholders to support and invest in next-generation broadband infrastructure to enable the digital applications and services vital to economic growth and social development.

The BCDI is designed to help develop this more nuanced view of broadband access by focusing more on broadband speed and quality than access alone. In practical terms, this is why the BCDI includes broadband metrics for FTTH coverage, FTTH penetration, and penetration of high-speed broadband services.

With the outsize role that the internet will play in the coming decade, it is critically important for governments to act more decisively to support the development of high-quality broadband infrastructure.

CLOUD DEVELOPMENT IS UNEVEN

The BCDI results clearly show that while cloud investment and adoption has taken off in leading countries such as the US and China, it is much less advanced in a number of other countries in the index. This creates challenges for policymakers seeking to balance concerns around data security and sovereignty with the desire to encourage the efficiencies and other benefits of cloud computing.

As seen in the previous chapter, some countries are using policies around sovereign cloud as an approach to ensure technology, jobs, skills, and investment are made within their country instead of using cloud resources hosted in another country.

Both broadband service providers and cloud providers have a role to play in helping countries navigate these challenges, in part by deploying edge cloud services that can store customer data locally while also supporting more advanced applications and services.

INFRASTRUCTURE NEEDS TO BE MORE SUSTAINABLE

Broadband and cloud services have clear environmental benefits in that they can drive efficiencies through the economy, including reductions in energy use. One example is the explosion in home working since the pandemic, made possible with broadband connectivity and cloud-enabled collaboration tools, including videoconferencing. This reduces travel, which in turn reduces emissions—in fact, a report by the US National Academy of Sciences recently found that switching from working in an office to homeworking reduces an individual's greenhouse gas emissions by 54%.

However it is also true that broadband and cloud infrastructure consume massive amounts of electricity, with the ICT industry overall estimated to account for 5–9% of global electricity consumption, which means the industry has a responsibility to constantly improve the energy

efficiency of its equipment and services. This includes optimizing the energy efficiency of broadband infrastructure, cloud servers, and data centers, partly by improving the monitoring and management of energy use throughout the industry value chain.

In the broadband market, it should also be noted that deploying fiber not only improves broadband quality and speeds, but also energy efficiency compared to traditional broadband technologies, with some estimating that gigabit PONs can deliver a 12-fold improvement in bits delivered per watt consumed when compared to VDSL.

The industry also needs to work with other stakeholders to support the transition to using more sustainable sources of energy to reduce the negative environmental impacts of digital infrastructure.

BROADBAND AND CLOUD COLLABORATION REQUIRED

Another challenge identified through the BCDI research is a lack of coordination between the broadband and cloud industries as the two converge around the broadband-enabled edge cloud. There is a need for cloud providers and broadband providers to collaborate more at the industry level to support harmonization of relevant standards and product certification. This will support the development of new converged broadband cloud infrastructure and business models, enabling the next phase of digital growth.

WBBA INITIATIVES SUPPORTING GLOBAL BROADBAND AND CLOUD DEVELOPMENT

To address the challenges identified by the BCDI, the WBBA is proposing the following four initiatives.

- **Promote private and public investment in broadband and cloud networks to bridge the digital divide.** WBBA will cooperate with governments and investment institutions such as funds and banks to promote the construction of broadband and cloud infrastructure in underdeveloped countries and regions worldwide to bridge the digital divide. WBBA will also promote broadband investment and construction by publishing development reports and policy initiatives, and advocating for governments to provide policies and funding for universal broadband services.
- **Build an industry ecosystem and platform for exchange.** WBBA will provide forums, summits, exhibitions, and other services for stakeholders to exchange views and best practices to develop broadband and cloud technologies and promote the industry. As part of this effort, WBBA is committed to providing regular thought leadership based on annual updates to its new BCDI to share best practice and support development of the global broadband and cloud industries.
- **Collaborate on scientific and technological innovation to support industrial development.** WBBA promotes the development of next-generation technologies in the broadband and cloud industries through research collaborations with industry participants globally. The association has working groups for researching broadband strategy and evolution, market scenarios and use cases, sustainable development and policies and regulations, and broadband network architecture. In the future, WBBA will also collaborate with leading universities and research institutions worldwide on research projects to enhance and advance broadband and cloud technologies.
- **Support industry standards, product certification, and technology training.** The WBBA plans to support industry standards, provide objective and fair product certification services, and develop innovative technology training. The association will actively seek cooperation with research institutions, universities, and standards organizations to promote the improvement of standards; achieve global broadband and cloud network standardization, integration and coordination; and cultivate talent and expertise for the development of the industry and society.

These initiatives align with the overall aim of the WBBA, which is to help bridge the digital divide by bringing together industry stakeholders to maximize the social, economic, and environmental benefits of broadband and cloud computing. WBBA activities in support of its mission include discussion, promotion, education, and research, including this report detailing the findings of the WBBA's new Broadband and Cloud Development Index.

The WBBA's goals include overcoming challenges in industry development, accelerating the healthy and sustainable development of the broadband industry, promoting the comprehensive supply of broadband networks and services, creating new opportunities for industry participants, and ultimately benefiting consumers and society as a whole. WBBA supports and promotes the interests of stakeholders, including global broadband network operators, suppliers, cloud service providers, governments, financial investors, and vertical industries.

APPENDIX

METHODOLOGY

This report was developed by the World Broadband Association (WBBA) based on research by its member companies including Omdia. The methodology for the WBBA Broadband and Cloud Development Index (BCDI) is detailed in the chapter of this report titled Broadband and Cloud Development Index: Overview and methodology.

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