The Socio-Economic Benefits of Mid-Band 5G Services

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Executive summary

A new perspective on the impact of mid-band 5G spectrum

5G networks bring substantial improvements over 4G networks, including higher connection speeds, greater capacity and low latency. With this increased performance, 5G networks can enable new use cases and applications that will positively impact many industry sectors.

Spectrum plays a critical role in realising the full extent of these new capabilities. 5G's full socio-economic impact depends on access to a variety of spectrum resources, including spectrum in both lower mid-bands (i.e. 1500 MHz, AWS, 1800 MHz, 1900 MHz, 2100 MHz, 2300 MHz and 2600 MHz) and upper mid-bands (i.e. 3.3–4.2 GHz, 4.5–5.0 GHz and 5.925–7.125 GHz).

Mid-band spectrum is necessary for the increases in bandwidth and capacity that 5G applications will require. It will play a key role in meeting the demand for mobile data services. New mobile broadband use cases such as enhanced mobile broadband, fixed wireless access, IoT and Industry 4.0 depend on mid-band spectrum. These use cases will grow the impact of mobile services on society and economies.

To date, mid-band spectrum has been the most commonly used around the globe to launch 5G networks. The available evidence suggests that the need for mid-band spectrum will continue to strengthen beyond initial 5G launches. By 2030, an average of 2 GHz of additional spectrum will be needed in mid-bands to deliver 5G services at a performance consistent with the ITU's IMT-2020 (5G) requirements.[1]

The socio-economic benefits of mobile services and broadband connectivity enabled by previous mobile technology generations have been studied extensively.[2] While some papers have also considered the potential economic impact of 5G, the specific contribution of mid-band 5G spectrum is less well understood. This study estimates for the first time, at the global and regional levels, the socio-economic benefits that can be delivered through mid-band spectrum.

The analysis leverages the extensive research to date on the expected benefits of mobile broadband, the implementation of 5G and the role of mid-band in implementation. Through unique access to operators and mobile ecosystem data, economic statistics and a proprietary economic model, we forecast the contribution of mid-band 5G spectrum to gross domestic product (GDP) by 2030, providing insight into the role it will play in helping deliver global economic growth.

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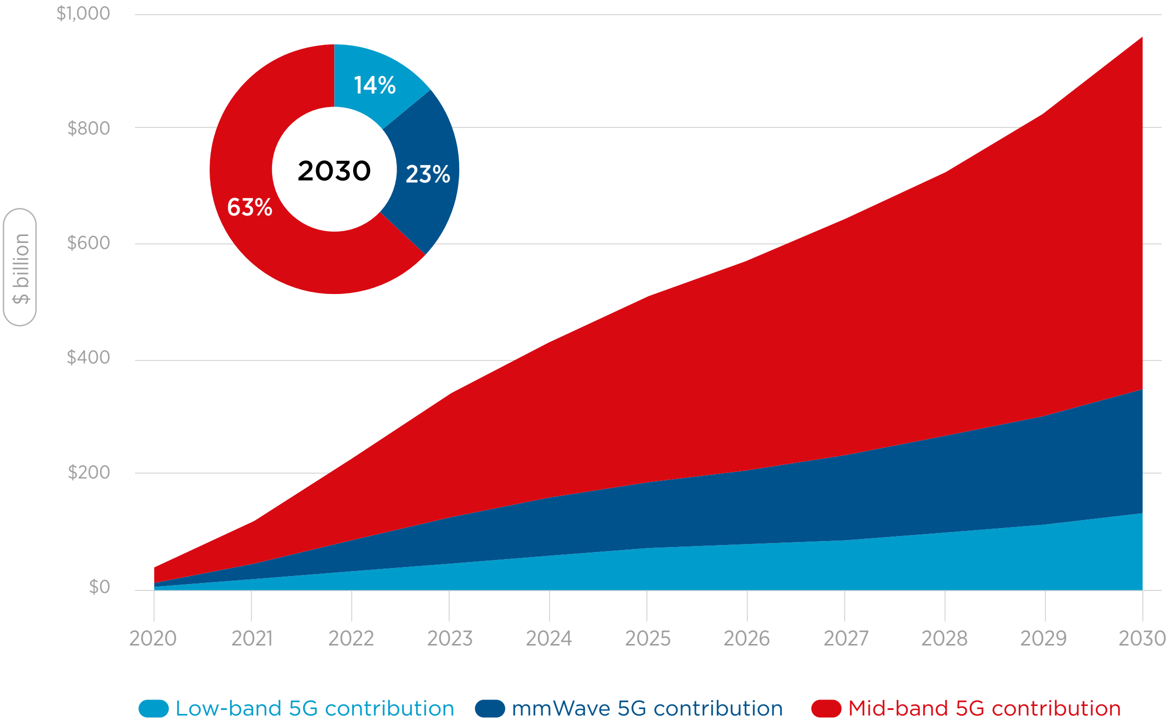
[1] Estimating the mid-band spectrum needs in the 2025-2030 time frame, GSMA and Coleago Consulting, 2021

[2] Mobile technology: two decades driving economic growth, Working Paper, GSMA Intelligence, 2020

An increase of more than $610 billion in global GDP in 2030

Based on conservative assumptions, mid-band 5G spectrum will drive an increase of more than $610 billion in global GDP in 2030, accounting for almost 65% of the overall socio-economic value generated by 5G (see Figure 1).

Figure 1: Annual impact of 5G on GDP, by band, 2020-2030



Source: GSMA Intelligence

A priority for economic development strategies

In 2030, 5G is expected to generate $960 billion in GDP, with the majority of benefits driven by mid-band spectrum. As well as the measurable socio-economic impact of mid-band 5G technology and services, further benefits are expected, such as improved access to healthcare and education, increased public security and response times, safer driving conditions, and reduced pollution.

To realise the potential benefits highlighted in this study, countries should plan accordingly for the timely availability of spectrum for mobile services, as it is a key factor for 5G coverage and capacity. Without additional mid-band spectrum assigned to operators, the full potential of 5G may not be achieved, with a potential loss of around $360 billion.

Governments should consider prioritising the assignment of mid-band spectrum in their economic development strategies. Focus should be given to the following:

- Ensure that existing mid-bands such as 1500 MHz, 1800 MHz, 2300 MHz and 2600 MHz are fully assigned to mobile operators on a technology-neutral basis, allowing them to be used for 5G.
- Make 3.3–3.8 GHz available for 5G.
- Plan for the use of 3.8–4.2 GHz, 4.8 GHz and 6 GHz for further development/rollout of 5G.

The impact of mid-band 5G spectrum will vary by region

- Asia Pacific, the Americas and Europe will account for the greatest share of the total global contribution to GDP generated by mid-band 5G over the period of analysis.
- In Asia Pacific, the East Asia and Pacific region will drive most of the benefits associated with 5G mid-band spectrum, with the biggest economies (China, Japan and South Korea) delivering most of the regional benefits, supported by extensive 5G network deployment.
- In the Americas, while North American countries will drive most of the overall benefit, Latin American countries are expected to benefit the most when considering percentage of GDP.
- In Europe, the largest economies (e.g. Germany, the UK and France) are expected to account for almost 50% of the overall 5G mid-band benefit.
- The Middle East and North Africa (MENA) region is expected to start benefiting from 5G mid-band deployment from 2025, with benefits increasing significantly during 2025–2030.
- Countries in the Regional Commonwealth in the Field of Communications (RCC) are also expected to start benefiting from mid-band 5G technology from 2025. The benefits are expected to account for a significant share of regional annual GDP in 2030, mostly driven by deployment in the Russian Federation.
- Countries in Sub-Saharan Africa are expected to benefit from 5G deployments using mid-band spectrum towards the end of decade. Although deployments will vary, 5G is expected to positively impact the economies of countries such as South Africa, Nigeria and Angola by 2030. The contribution of mid-band 5G as a percentage of GDP will be similar to the impact in Europe and North America.

Figure 2: **Regional overview in 2030: GDP contribution generated by mid-band 5G**

North America

GDP
$122bn

Percentage of GDP
0.36%

Latin America and the Caribbean

GDP
$41bn

Percentage of GDP
0.50%

Asia Pacific

GDP
$285bn

Percentage of GDP
0.51%

East Asia and the Pacific

Sub-group of the Asia Pacific region

GDP
$218bn

Percentage of GDP
0.52%

Europe

GDP
$121bn

Percentage of GDP
0.38%

RCC*

GDP
$14bn

Percentage of GDP
0.51%

Middle East and North Africa

GDP
$16bn

Percentage of GDP
0.35%

Sub-Saharan Africa

GDP
$13bn

Percentage of GDP
0.37%

Source: GSMA Intelligence
*Regional Commonwealth in the Field of Communications, which includes eleven countries from the former Soviet Union.

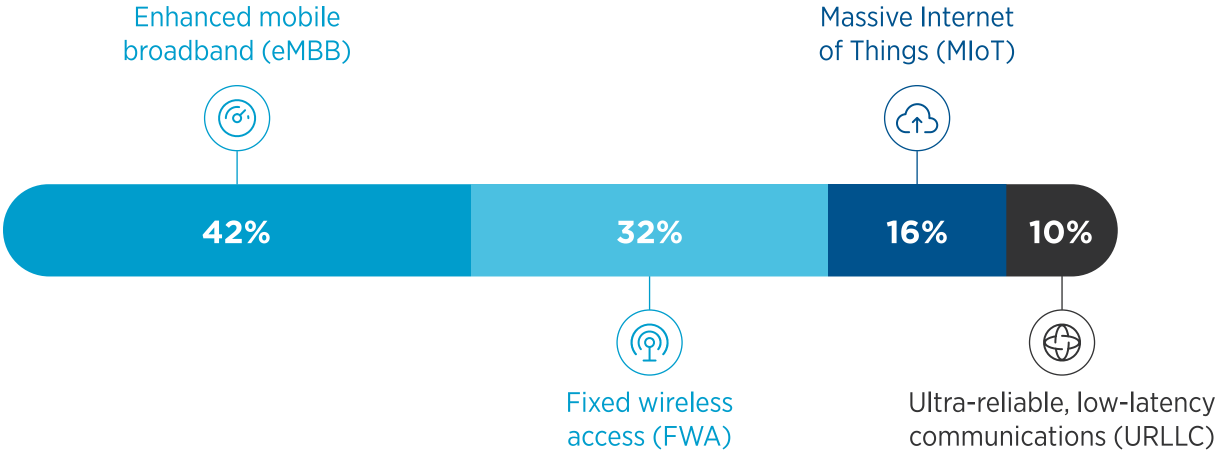
Applications and use cases are set to spur innovation across sectors

Over the next ten years, several applications will be the main drivers of the contribution of mid-band 5G to GDP. These include e-health and advanced manufacturing, which will help increase productivity. New applications such as realtime cloud gaming, 360-degree video and VR/AR devices will also offer new potential revenue streams.

The economic model used for this analysis assesses the growth attributable to each 5G use case and sector by focusing on two main aspects:

- The relevance of mid-band technical features (in terms of coverage and capacity, for example) to the particular needs of each use case.
- The relevance of future 5G applications to different economic sectors, based on pilot projects, feedback from experts and the overall propensity for technical innovation in each sector.

Figure 3: **Projected global contribution of mid-band 5G spectrum to GDP, by use case**



Source: GSMA Intelligence

As shown in Figure 3, for the period 2020–2030, almost 75% of the benefits of mid-band 5G will come from eMBB and FWA use cases and related applications. MIoT and URLLC will start providing benefits at a later stage, as applications such as remote object manipulation and vehicle-to-vehicle communication reach maturity later in the decade.

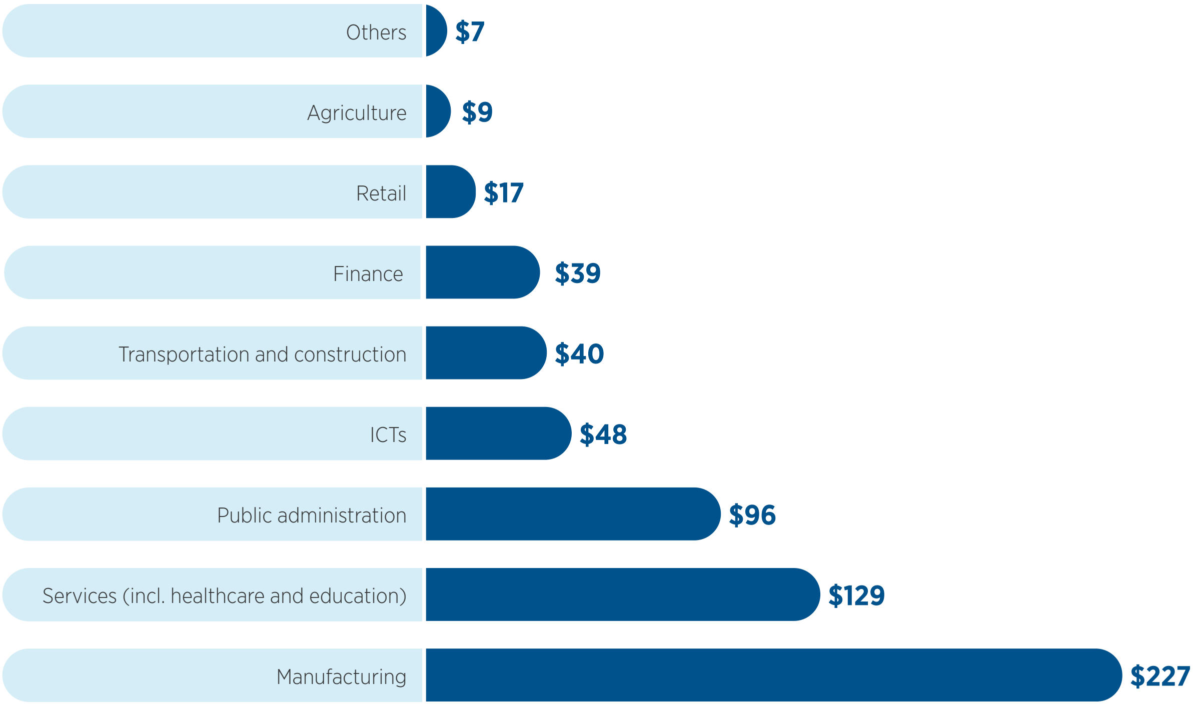
The manufacturing, public administration and services sectors will benefit the most from the 5G technology, as shown in Figure 4. Applications including smart factories, smart cities and smart grids will drive a boost in productivity and the creation of new revenue streams.

Almost all economic sectors will be positively affected by 5G deployment, including the use of mid-band spectrum. Once 5G is widely available to the global population, applications currently being developed in pilot projects will become available to the general public. New applications will include those in smart agriculture, enabling the monitoring of crops and livestock health, and healthcare, providing reliable and high-quality smart and remote patient monitoring.

5G deployments will also bring benefits beyond an uplift in GDP. Mobile broadband plays a significant role in poverty reduction,[3] improving education[4] and increasing well-being.[5]

Figure 4: **Estimated global contribution of mid-band 5G spectrum to GDP by sector, 2030**

($ Billion)



Source: GSMA Intelligence

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3 The poverty reduction effects of mobile broadband in Africa: Evidence from Nigeria, GSMA, World Bank, 2020
4 Reading in the Mobile Era: a Study of Mobile Reading in Developing Countries, UNESCO, 2014
5 The Impact of Mobile on People's Happiness and Well-Being, GSMA, Gallup, 2018

01

5G spectrum bands

Low, mid- and high bands

Mobile networks today operate across an evolving range of technologies, from 2G to 5G. Each technology carries with it a spectrum need relative to the role it plays in benefitting society. 2G voice applications, for example, use small tranches of spectrum compared to the much wider channels required for high-throughput 5G usage. Governments can support mobile growth by ensuring they have laid out a long-term vision of the spectrum access mobile operators will receive.

5G launches began in early-adopter markets in 2018 and have accelerated since. While some used low-band UHF or high-band mmWave spectrum, 78% launched using mid-band spectrum.[6] In most cases, the 5G launch band has been within the 3.5 GHz range (3.3–4.2 GHz).

5G needs a variety of spectrum bands to support a range of applications and services. Low bands provide coverage and indoor reach; mid-bands provide a balance of coverage and capacity; and mmWave or high bands can provide capacity in densely populated urban areas and in factory settings, for example.

Table 1: **The characteristics of different 5G spectrum bands**

Low bands	Mid-bands	High bands
Wide coverage area	City-wide coverage area	Small area/hotspot coverage
Limited capacity	High capacity	Ultra-high capacity

Source: GSMA Intelligence

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[6] Spectrum Navigator, Q3 2021, GSMA Intelligence, 2021

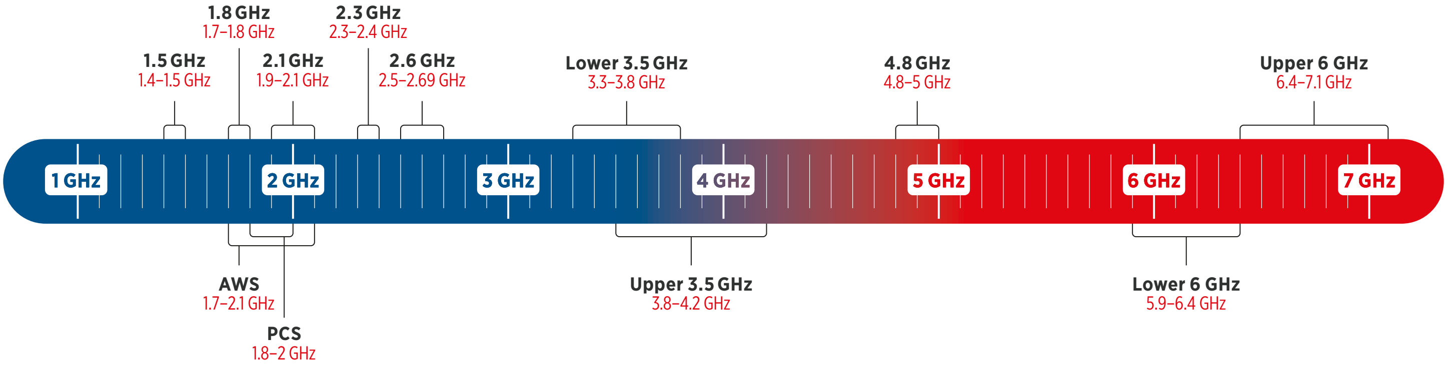
Mid-band spectrum

Mid-band spectrum will continue to play an important role in the future of 5G. Analysis shows that an average of 2 GHz of mid-band spectrum will be required[7] to fulfil the ITU requirements for 5G of 100 Mbps downlink and 50 Mbps uplink. This has led to governments in the most developed markets increasing their mid-band spectrum assignments beyond those in the ITU's Radio Regulations.

Each new generation of mobile technology is more efficient than the last and can use spectrum to provide greater connectivity. Spectrum refarming, dynamic spectrum sharing[8] and other mechanisms support the use of existing bands for new technologies. However, the capacity demands on 5G networks will be a step-change from previous mobile generations. This is driven by the larger number of connected devices as well as growth in data traffic per user. Additional spectrum needs are driven by the growth in demand for connectivity, outweighing the efficiency gains of the next generation of technology.

Generally, lower mid-band spectrum is already in use (or planned for use) for 4G, while upper mid-band spectrum is used for 5G. However, there are cases of refarming or sharing between the two technologies in lower mid-bands.

Figure 5: **Lower and upper mid-band spectrum**



Source: GSMA Intelligence

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[7] Estimating the mid-band spectrum needs in the 2025-2030 time frame, GSMA and Coleago Consulting, 2021

[8] Dynamic Spectrum Sharing: a problem halved for 5G?, GSMA Intelligence, 2021

Mid-band harmonisation at WRC-23

The future availability of mid-band spectrum will be the subject of discussion at the World Radiocommunication Conference 2023 (WRC-23). Spectrum harmonisation through WRCs has created economies of scale for existing generations of mobile networks, making mobile services and handsets more affordable. Harmonisation of mobile spectrum is once again being considered at WRC-23.

The mobile industry sees Agenda Items 1.1, 1.2 and 1.3 at WRC-23 as opportunities to expand affordable mid-band capacity, lower 5G costs and increase digital inclusion. The 2023 Conference will differ from its predecessors in that many of the bands it is likely to harmonise, such as 3.6–3.8 GHz and 4.8 –4.99 GHz, have already been developed for mobile and are in use today, while 6 GHz is already under development. Early-adopter markets needing to assign spectrum faster than the WRC process is a symptom of rapidly rising demand.

WRC-23 also differs from its predecessors in terms of the application of regional variation to the Agenda Items. However, existing allocations in the Radio Regulations mean that wide harmonisation for all mid-bands can still be achieved after WRC-23 concludes.

Table 2: Mid-bands at WRC-23

Band	Agenda Item
3.3–3.4 GHz	1.2
3.6–3.8 GHz	1.2, 1.3
4.8–4.99 GHz	1.1
6.425–7.125 GHz	1.2

Source: ITU

3.3–3.8 GHz

As the 3.5 GHz range is the launch band for 5G in most countries, it has the largest equipment ecosystem and most affordable devices. This band is regarded as the starting point for launching 5G services.

4.8–4.99 GHz

The 4.8–4.99 GHz band is seen by the mobile industry as an option for supplementary mobile spectrum. This band could expand the capacity of future networks and is already being considered in China, the US and Russia, where it is being tested in pilot zones. It also joins nearby assignments in Japan.

6.425–7.125 GHz

The 6 GHz range is seen by the mobile industry as the principal target for 5G expansion and the main means of meeting the average of 2 GHz of mid-band spectrum needed for 5G and its evolution.

02

Economic contribution of 5G and mid-bands

The economic benefits of mobile have been investigated and quantified in various studies. A recent GSMA paper[9] found that mobile technology accounted for approximately $10 of every $100 increase in income per capita over the period 2000–2019. Furthermore, the analysis found that the additional services and functionalities enabled by upgrades from 2G to 3G networks, and further innovation from 3G to 4G, generated significant increases in the benefits that economies reap from mobile technology.

This study focuses on the impacts of 5G associated with mid-band deployment. It draws on many of the conclusions from previous studies in order to forecast the benefits for economic activity, namely in terms of GDP uplift. However, it solely examines the impact of a particular spectrum band (mid-band) for a specific generation of broadband deployments and applications (5G).

Global results

5G is expected to yield more than $960 billion in additional GDP value-add to the global economy, or approximately 0.70% of global GDP forecast, in 2030.

- Mid-band 5G will account for an uplift of more than $610 billion to global GDP in 2030 (approximately 65% of the total 5G benefit).
- Low-band 5G is expected to account for $130 billion (14% of the total 5G benefit).
- High-band 5G adds another $220 billion of GDP uplift (23% of the total 5G benefit).

Further information on the methodology used in the study can be found in the Annex.

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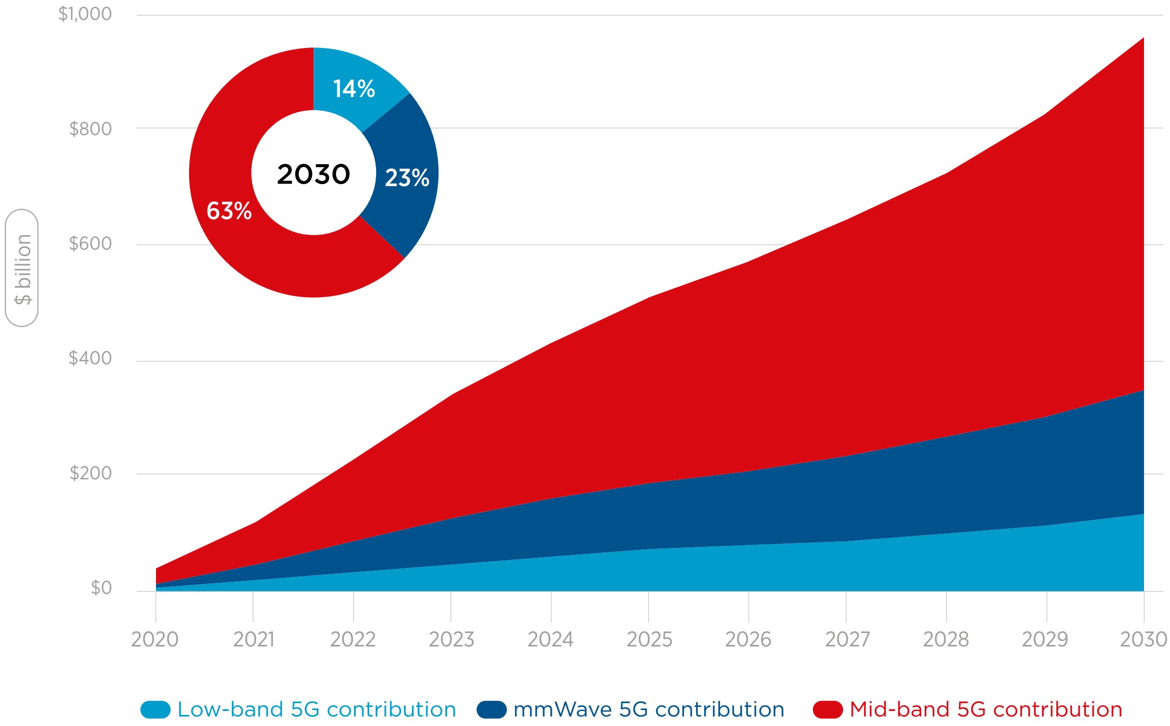
[9] Mobile technology: two decades driving economic growth, Working Paper, GSMA Intelligence, 2020

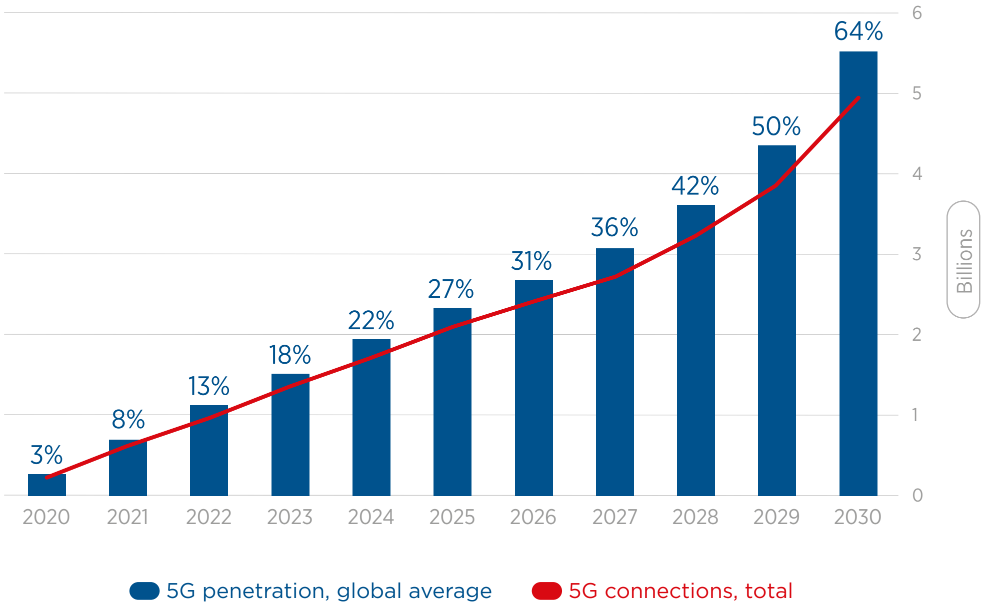
Figure 6: Annual impact of 5G on GDP, by band, 2020-2030



Source: GSMA Intelligence

5G benefits will be directly determined by the rate of 5G penetration by 2030. Figure 7 shows a forecast for the period studied. 5G penetration is forecast to reach more than 60% globally by 2030, with approximately 5 billion connections by the end of the decade.

Figure 7: Global 5G connections and market penetration, 2020–2030



Source: GSMA Intelligence

A second element that will directly impact 5G benefits is how use cases can be applied to different economic sectors. This depends on a number of factors, including overall ecosystem readiness and the degree of available technologies and related skills among workers. For example, Massive Internet of Things (MIoT) related applications are expected to play an important role in the digital transformation of the manufacturing sector, increasing productivity and reducing costs.

The sector has historically been relatively quick to adopt new technologies. We therefore expect the sector to be highly affected by 5G MIoT-related applications. In contrast, MIoT-related applications in agriculture, though available and being developed, are expected to play a smaller role in boosting productivity over the coming years. Technology adoption in the agricultural sector has historically occurred at a slower pace than in other sectors. We therefore expect the impact of MIoT to be evident much sooner in the manufacturing sector than the agricultural sector.

For the period 2020–2030, eMBB and FWA use cases (and their associated applications) are expected to drive most of the 5G benefit. This is particularly the case for mid-band spectrum.

Each of the four core 5G use cases is expected to benefit from one or more particular characteristics of the new technology. Depending on the specific requirements of the associated 5G use case application, different bands are used. For example, a smart city MIoT solution will require wide coverage, so mid- and low bands will be preferred for deployment. Meanwhile, a factory floor is expected to require lots of capacity but will be less concerned with coverage, due to limited/confined space, highlighting the relevance of mid- and high bands for the related applications.

For this study, the distribution of 5G benefits across low, mid- and mmWave bands is based on the coefficients presented in Table 3. Further information on the methodology can be found in the Annex.

Table 3: 5G use cases and relevance of spectrum band

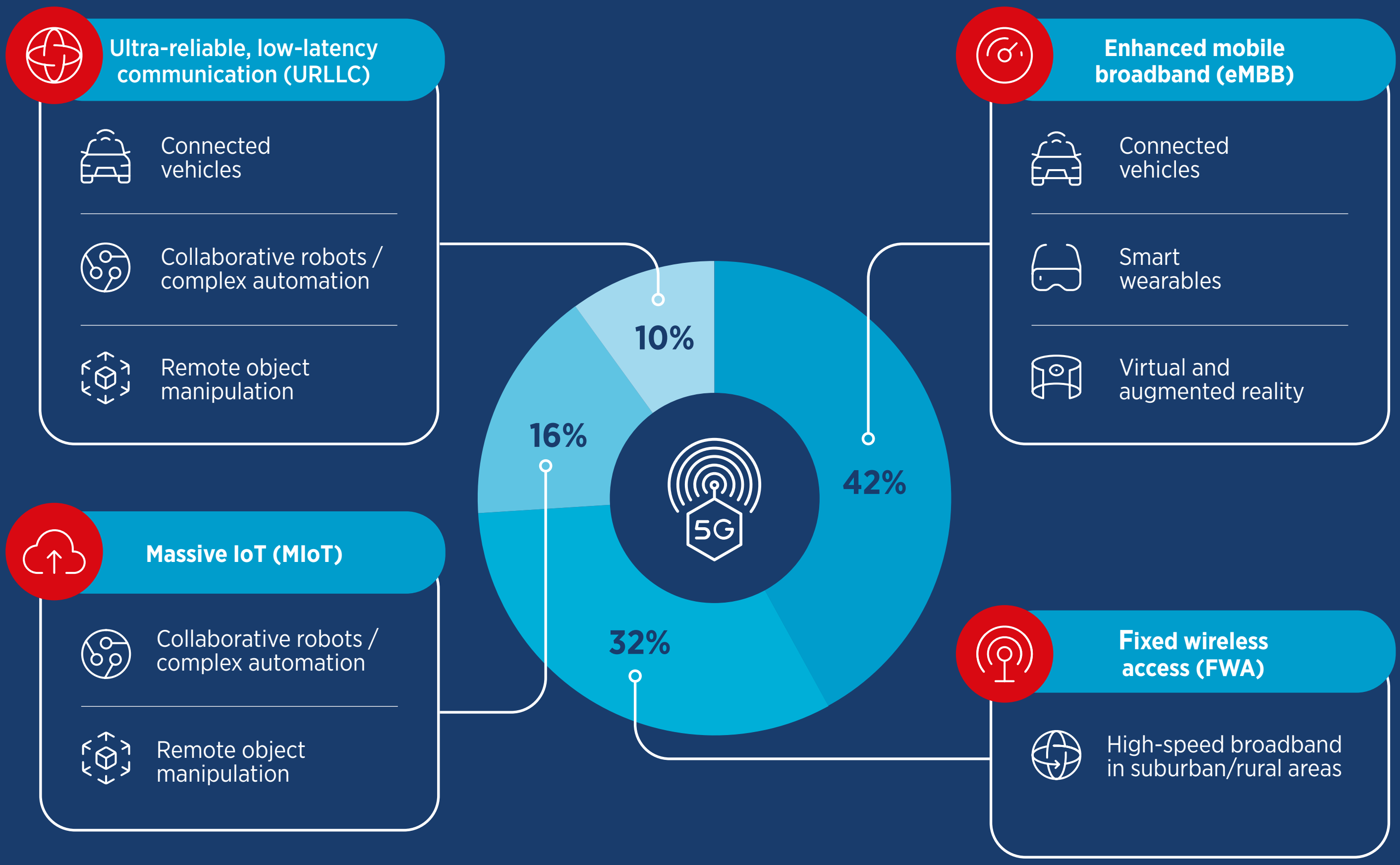
Use case	Low bands	Mid-bands	mmWave bands
eMBB	10%	80%	10%
FWA	10%	60%	30%
MIoT	40%	60%	0%
URLLC	0%	40%	60%

Source: GSMA Intelligence

Global results by use case and vertical

The distribution of mid-band 5G benefits between the four main 5G use cases is shown in Figure 8. eMBB and FWA will be the largest use cases over the period to 2030. These encompass a variety of applications. Some are already available (HD videoconferencing, HD streaming, e-health), while others are being developed. Most economic sectors will be affected by 5G mid-band, with those particularly impacted by technological innovation expected to benefit the most.

Figure 8: **Distribution of 5G mid-band benefits, by use case, with selected 5G applications**



Source: GSMA Intelligence

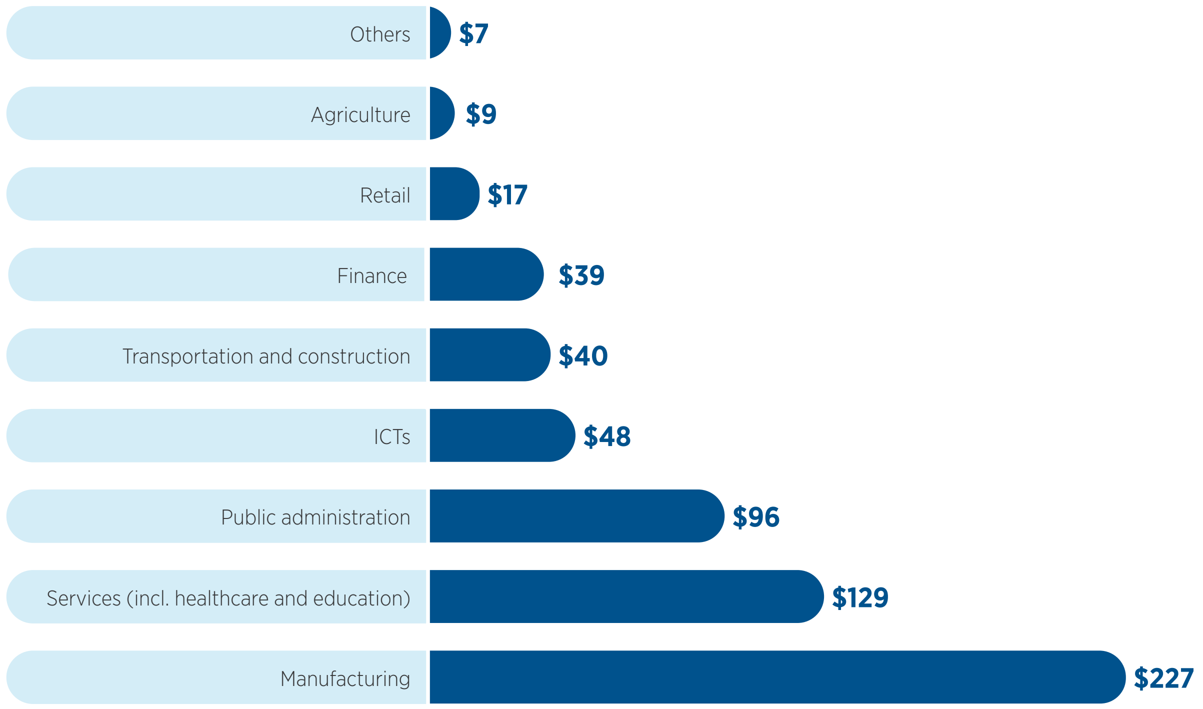
Table 4: **5G use case description and associated applications**

Use case	Description	Business need	Verticals
Fixed wireless access (FWA)	5G will allow network operators to deliver ultra-high-speed broadband to suburban and lower-density areas, supporting home and business applications where fibre is prohibitively expensive to lay and maintain. This will allow more communities to be connected to the internet via an ultrafast, reliable connection, bringing applications such as telemedicine and remote education to more people. 5G FWA can therefore provide the benefits of fibre-like connectivity to rural communities.	• Alternative to fibre connection	Education, healthcare, public administration, utilities
Enhanced mobile broadband (eMBB)	5G will provide the capacity to handle growing data traffic, and grant operators an opportunity to develop new and improved services to consumers. This will enable a new range of applications, including reliable mobile internet services for mass gatherings and sports events (where current mobile technology is often stretched to its limits) and AR/VR applications that improve the customer experience in retail, for example, by supporting or replacing traditional showrooms.	• Immersive experience (AR/VR) • 4K/8K streaming on mobile • Increased service capacity	Retail, public administration, arts and events
Ultra-reliable, low-latency communication (URLLC)	Low latency and high reliability will enable new applications in manufacturing, logistics, health and transportation. These include autonomous driving, connected robotic applications, AR/VR, drones and remote surgical/medical operations.	• Autonomous driving • Safety-critical applications • Remote manufacturing • Remote healthcare	Manufacturing, utilities, oil and gas, transport, healthcare
Massive IoT (MIoT)	5G will be able to facilitate a large network of IoT devices, supporting the creation of smart cities, smart infrastructure and, in the utility sector, smart grids capable of self-identifying issues on networks. In the agricultural sector, farmers will benefit from the potential of a vast collection of sensors located in fields that are able to identify with pinpoint precision which areas need water, have disease or require pest management.	• Remote control of crop conditions • Advanced manufacturing • Smart cities	Agriculture, utilities, manufacturing, public administration

Source: GSMA Intelligence

Figure 9: **Estimated global contribution of mid-band 5G spectrum to GDP by sector, 2030**

($ Billion)



Source: GSMA Intelligence

The manufacturing sector, together with the public administration and services sectors, is expected to drive most of the benefits associated with mid-band 5G spectrum. However, 5G will also drive innovation across other sectors, including retail, agriculture and transportation.

5G mid-band applications for the manufacturing sector

The manufacturing sector is continually looking to improve the productivity of its processes, reduce costs and remain competitive on the global stage. An area of potential is expanding the deployment of 5G and the ensuing services and opportunities that arise from pervasive and ubiquitous connectivity. 5G has unique properties and attributes, including high data rates, greater system capacity, reduced latency and massive device connectivity, that can facilitate and improve manufacturing processes. The impact that mid-band 5G will have on the increased contribution of manufacturing to global GDP is therefore expected to be high.

The current supply-chain disruption created by the Covid-19 pandemic means future factories will need to develop their ability to be reconfigured for different production lines depending on sudden shifts in demand. 5G can help realise a modular factory where machinery can be quickly reconfigured to optimise production, as it does not require wiring or any type of cable communication.

A promising technology that could be transformed by 5G is extended reality (XR), referring to technologies including virtual reality and augmented reality where digital objects appear and can be manipulated in the real world. XR is expected to play an important role in sectors such as construction and manufacturing, where participants need to see detailed models of complex machinery. Manufacturers can present data and information on machinery in spatially relevant ways, which in turn can aid workers in maintenance, repair and training. Currently, the downside of this technology is the need for an XR device to be connected to a Wi-Fi or cable connection. The capacity for high volumes of data offered by 5G will enable augmented and virtual reality to be delivered over mobile networks, including 4K/8K video, and replace fixed broadband, extending the usability of such devices.

Manufacturing plants could also implement the use of 5G to enable predictive maintenance. Balancing the maintenance needs of a production line with the need to minimise downtime is a complex issue. Using connectivity, IoT capabilities and data analytics to predict maintenance requirements means downtime and maintenance windows can be effectively planned, while the risk of unplanned downtime due to machines breaking down is minimised. The productivity and performance of the factory can therefore be optimised.

For effective predictive maintenance, several things must be in place, including accurate, granular, realtime and historical data gathered by IoT sensors, and support for condition-based monitoring of machine and production line performance. 5G-era mobile network support for Massive IoT makes it more economical and less complex to connect machinery down to the component level than comparable technologies, providing a cost-effective solution to enterprises.

Machine vision for plant management is a further 5G-enabled application expected to revolutionise the manufacturing sector. High-resolution cameras offer a low-cost, reliable way to monitor broad areas of a manufacturing site's operations. From security through to monitoring complete production cycles, cameras offer a flexible and good general-purpose sensor with many applications that complement and enhance the data derived from 'traditional' IoT sensors. A current challenge with plant management is that while high-resolution cameras are widely available, they require expensive network support infrastructure. 5G networks offer enhanced bandwidth, massively increased over previous generations. This will allow a much more flexible, cheaper and reliable way to transfer the video data captured by cameras across the plant to a main control centre, reducing costs and increasing overall efficiency.

5G in manufacturing

XR
Extended reality can present data and help modelling

Predictive maintenance
IoT and data analytics can predict maintenance requirements

Machine vision
5G can enhance network support for high-resolution cameras

5G mid-band applications for smart cities

In smart cities, sets of connected sensors and devices are strategically placed around the city to generate large amounts of data. This is aimed at improving transparency and efficiency within the city's infrastructure, resulting in a more cost-effective public administration.

A smart city can involve the use of many connected devices, including:

- Traffic cameras
- Parking garage sensors
- Utility meters
- Public transport vehicles
- Streetlights
- Buildings

Cellular networks and IoT are crucial to realising the smart city vision, as they provide the necessary network infrastructure to enable the systems to work. 5G deployments, especially in the mid-band, are expected to significantly improve the efficiency of such infrastructure, thanks to higher connectivity speeds, increased capacity and lower latency.

A key feature of a smart city is an intelligent traffic system (ITS), designed to limit congestion on roads. Such systems monitor traffic and use AI and machine learning to identify patterns and change key elements (e.g. traffic-light cycles at certain times of the day) to reduce congestion. 5G's high bandwidth allows the use of high-quality video for realtime analysis, as well as the possibility of using multi-access edge computing (MEC) for video processing and 5G for uplink to a cloud-based analytics engine.

Smart metering is a further aspect of smart cities, allowing precise, up-to-date monitoring of public and private electricity consumption, increasing overall grid efficiency and resulting in cost savings and increased environmental sustainability. 5G in mid-band spectrum, thanks to the balance between coverage and capacity, will provide a secure, reliable network; IoT devices will not be limited by low capacity, as is currently the situation for 3G-based devices.

03

The importance of spectrum availability

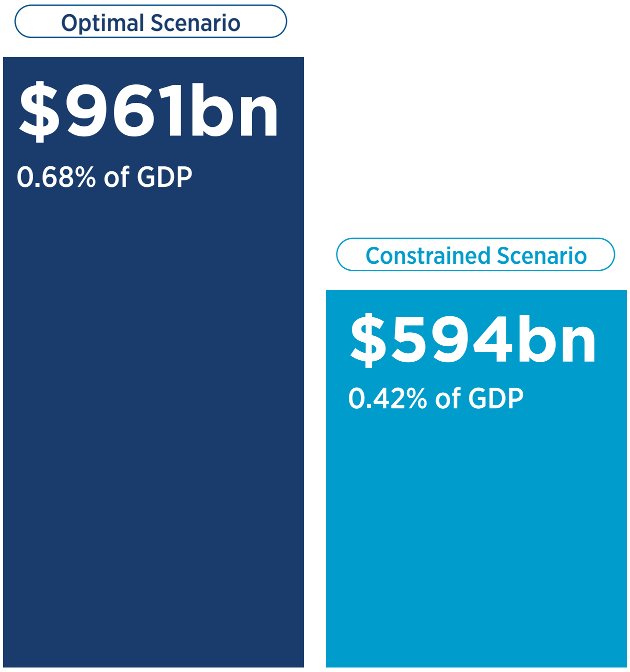
The results presented in this study are based on the assumption that regulators will make mid-band spectrum available in a timely and affordable manner, so that operators are able to meet the exponential increase in data demand with additional capacity.

However, as concluded in the GSMA and Coleago report[10] current and planned mid-band spectrum allocations to mobile operators by 2025 will not be sufficient to satisfy demand for 5G services in 2030.

To better understand the economic loss that a lack of adequate mid-band spectrum entails, we assess a scenario where sub-optimal spectrum allocation impacts the 5G consumer experience, reducing download and upload speeds. Further information on the methodology used can be found in the Annex.

The global economy could lose up to 40% of the expected 5G benefits if no additional mid-band spectrum is allocated to mobile services. In such a scenario, global 5G benefits by 2030 could decrease from 0.68% of GDP (around $960 billion) to 0.42% of GDP (less than $600 billion).

Figure 10: Impact of sub-optimal mid-band spectrum allocation on total 5G economic benefits, globally, 2030



Source: GSMA Intelligence

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[10] Estimating the mid-band spectrum needs in the 2025-2030 timeframe, GSMA and Coleago Consulting, 2021

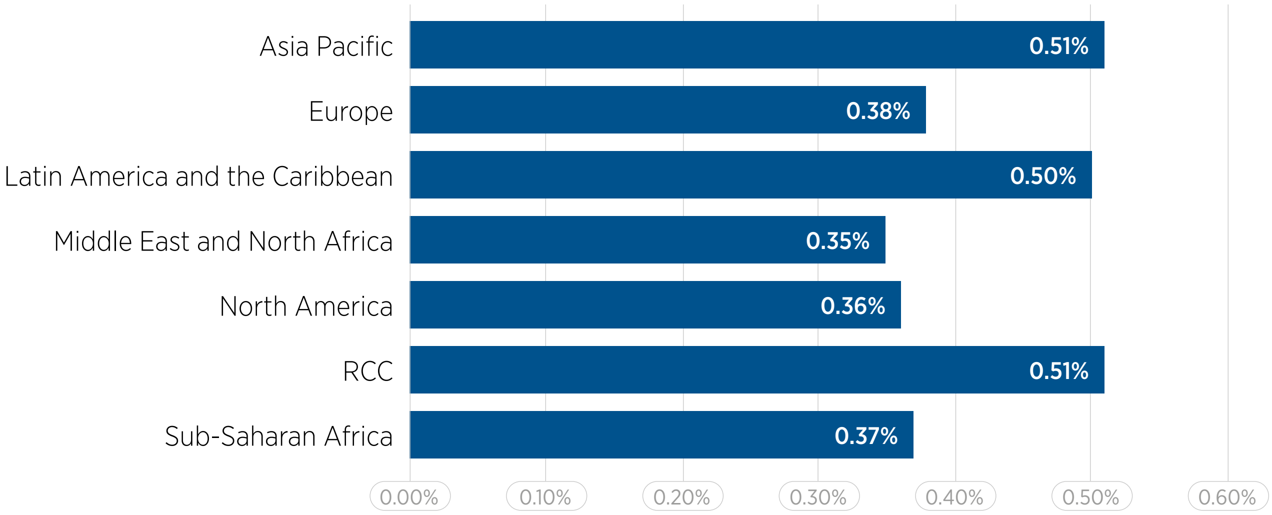
04

Results by region

The key factors outlined earlier (the evolution of technology supporting use cases, the readiness of an economy to adopt use cases, the structure of the economy and the reliance of use cases on mid-band spectrum) also explain the regional differences in the overall economic impact. The four factors differ on a country-by-country basis, leading to different projections of the impact for each region.

However, despite macroeconomic differences between the regions, the impact of mid-band 5G is evenly felt between different regions in terms of percentage of GDP. Figure 11 shows the regional breakdown of the impact of mid-band 5G services as percentage of GDP. While the largest economies of North America, Europe and East Asia will account for the most significant portions of the overall total, mid-band will give all regions a GDP boost of around 0.35%-0.5%.

Figure 11: Regional breakdown of the GDP contribution (%) generated by mid-band 5G in 2030



Source: GSMA Intelligence

The larger and most developed economies are the main drivers of the contribution from mid-band 5G over the study period. It is in these markets where the highest degrees of 5G penetration and uptake of 5G applications will initially occur. Nevertheless, in the second half of the decade, countries in MENA, Latin America and Sub-Saharan Africa will start benefiting from 5G and the associated benefits; their growth will continue into the 2030s. It is important to underline that these benefits are forecast based on the condition that adequate spectrum is assigned to operators in the regions in a timely manner to avoid a capacity crunch due to the exponential rise in data demand expected over the coming years.

Americas

The Americas region, including North America and Latin America and the Caribbean (LAC), is a large, diverse market, characterised by different degrees of economic development and forecast 5G penetration.

It is helpful to understand the specific benefits of the North America and LAC regions separately. North America is expected to account for $122 billion of the overall GDP impact of $163 billion in 2030 as a result of mid-band 5G technology, with LAC accounting for the remaining $41 billion.

Figure 12: **Americas: GDP contribution generated by mid-band 5G, 2030**

North America	GDP contribution **$122bn**	Percentage of GDP **0.36%**
Latin America and the Caribbean	GDP contribution **$41bn**	Percentage of GDP **0.50%**

Source: GSMA Intelligence

At the country level, the US is predicted to account for 92% of North America's overall contribution to GDP from mid-band 5G. For the LAC contribution of $41 billion, Brazil and Mexico are expected to account for 43% and 15%, respectively.

Figure 13: **North America: structure of GDP contribution generated by mid-band 5G, 2030**

Percentage of total sub-regional contribution	
US	**92%**
Canada	**7%**

Source: GSMA Intelligence

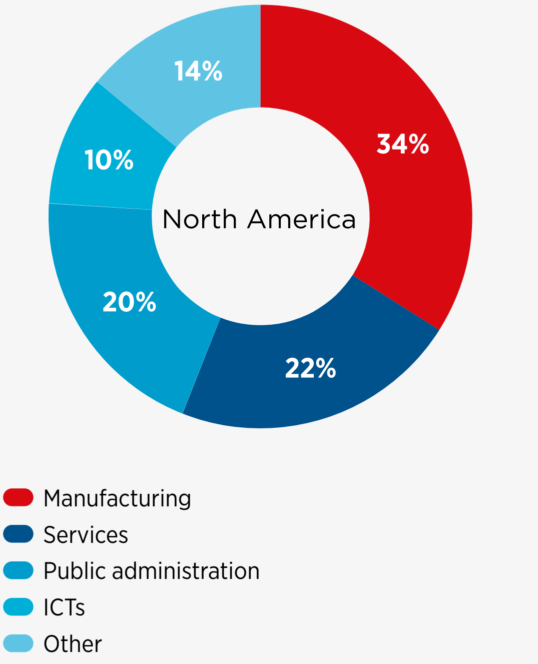
Figure 14: **LAC: structure of GDP contribution generated by mid-band 5G, 2030**

Percentage of total sub-regional contribution	
Brazil	**43%**
Mexico	**15%**
Argentina	**9%**

Source: GSMA Intelligence

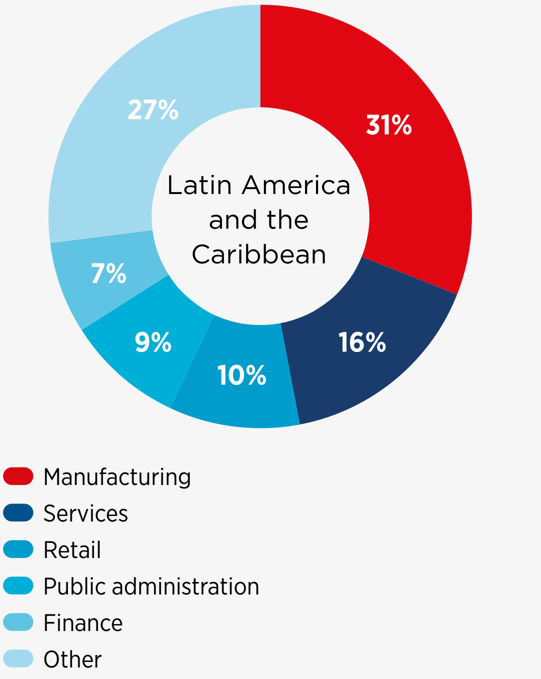
In terms of economic sectors, 5G mid-band applications will primarily benefit manufacturing, public administration/services, ICT and retail services. The retail sector will account for a significant proportion of benefits in LAC due to applications such as VR/AR and smart devices, which are expected to increase productivity in retail outlets as well as create new revenue streams.

Figure 15: **North America: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector**



Source: GSMA Intelligence

Figure 16: **LAC: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector**



Source: GSMA Intelligence

Asia Pacific

In a similar way to the Americas, certain markets in Asia Pacific are expected to drive a large proportion of the 5G mid-band economic benefits. Economies in East Asia and the Pacific are expected to account for approximately 80% of the region's contribution to GDP, due to the higher level of 5G penetration.

East Asia and the Pacific is expected to contribute $218 billion of the overall region's GDP impact of $279 billion in 2030 as result of mid-band 5G technology, with South Asia and Southeast Asia accounting for the remaining $61 billion.

Figure 17: Asia Pacific: GDP contribution generated by mid-band 5G, 2030

	**Asia Pacific**	GDP contribution **$285bn**	Percentage of GDP **0.51%**
	**East Asia & the Pacific**	GDP contribution **$218bn**	Percentage of GDP **0.52%**
	**South Asia**	GDP contribution **$32bn**	Percentage of GDP **0.38%**
	**Southeast Asia**	GDP contribution **$35bn**	Percentage of GDP **0.64%**

Source: GSMA Intelligence

At the country level, the largest economies of each sub-region are expected to drive most of the region's overall contribution to GDP from mid-band 5G. In terms of overall Asia Pacific contribution, China, Japan and South Korea are the major contributors, due to the high level of 5G penetration that will be reached by 2030 in these countries.

Figure 18: East Asia and Pacific: structure of GDP contribution generated by mid-band 5G, 2030

Percentage of total sub-regional contribution	
China	**78%**
Japan	**11%**
South Korea	**4%**

Source: GSMA Intelligence

Figure 20: Southeast Asia: structure of GDP contribution generated by mid-band 5G, 2030

Percentage of total sub-regional contribution	
Indonesia	**41%**
Thailand	**18%**
Malaysia	**13%**

Source: GSMA Intelligence

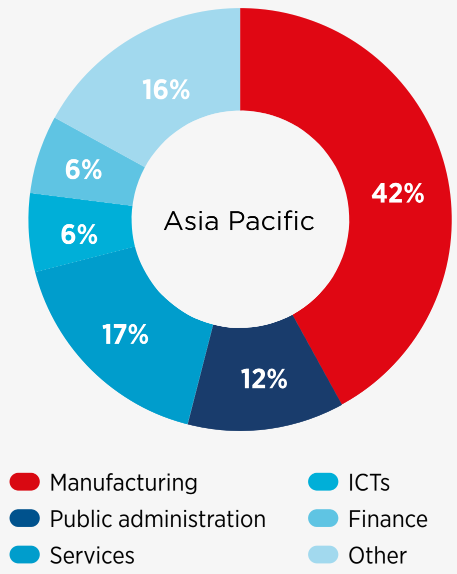
Figure 19: South Asia: structure of GDP contribution generated by mid-band 5G, 2030

Percentage of total sub-regional contribution	
India	**84%**
Bangladesh	**9%**
Pakistan	**5%**

Source: GSMA Intelligence

In terms of economic sectors, 5G mid-band applications will mostly be used by and benefit the manufacturing, public administration/services, ICT and retail sectors across Asia Pacific. The manufacturing sector, in particular, is expected to benefit from 5G, as the region presents a rich environment of high-tech manufacturing companies that will rapidly integrate new 5G applications into their businesses.

Figure 21: Asia Pacific: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector



Source: GSMA Intelligence

Europe

GDP in Europe is expected to benefit greatly from mid-band 5G, with a $121 billion GDP uplift in 2030 – around 0.4% of regional GDP.

Figure 22: **Europe: GDP contribution generated by mid-band 5G, 2030**

Europe	GDP contribution **$121bn**	Percentage of GDP **0.38%**

Source: GSMA Intelligence

At the country level, Germany, the UK and France are forecast to drive most of the 5G mid-band benefits in the region. However, the relatively high level of 5G penetration forecast by 2030 across the region will result in significant benefits across all countries.

Figure 23: **Europe: structure of GDP contribution generated by mid-band 5G, 2030**

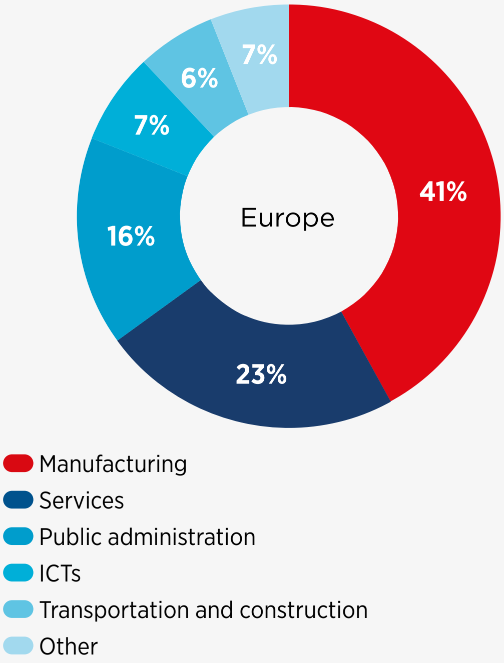
Percentage of total regional contribution	
Germany	**19%**
UK	**14%**
France	**12%**

Source: GSMA Intelligence

In terms of economic sectors, 5G mid-band applications will mostly be used by and benefit the manufacturing, public administration/services, ICT and transportation services across the region.

Public administration and services, benefiting from applications such as smart cities and smart utility grids, are two sectors expected to boost GDP in European countries in particular.

Figure 24: **Europe: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector**



Source: GSMA Intelligence

RCC

(Regional Commonwealth in the Field of Communications)

For the countries in the RCC region, 5G mid-band benefits are expected to contribute almost $14 billion to regional GDP in 2030 – more than 0.5% of annual GDP. As the largest economy in the region, the Russian Federation is expected to drive the bulk of the overall regional benefits, followed by Kazakhstan.

Figure 25: **RCC: GDP contribution generated by mid-band 5G, 2030**

RCC	GDP contribution **$14bn**	Percentage of GDP **0.51%**

Source: GSMA Intelligence

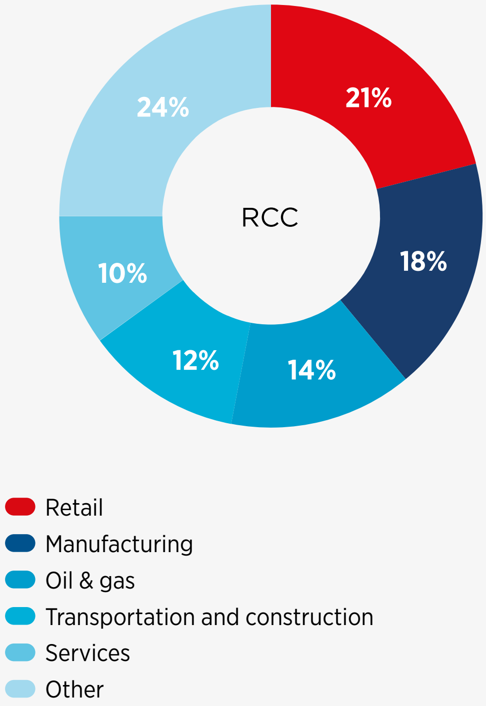
Figure 26: **RCC: structure of GDP contribution generated by mid-band 5G, 2030**

Percentage of total regional contribution	
Russian Federation	**79%**
Kazakhstan	**12%**

Source: GSMA Intelligence

In terms of economic sectors, 5G mid-band applications will mostly benefit the retail, manufacturing, oil & gas and transportation services sectors. Particularly relevant to the economy of the region, due to its exposure to the oil and gas sectors, will be a number of 5G applications expected to improve the safety and productivity of oil and gas plants, thanks to remote control of devices, smart monitoring and 5G-enabled AI, capable of reducing maintenance intervals.

Figure 27: **RCC: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector**



Source: GSMA Intelligence

Middle East and North Africa

Mid-band 5G will contribute $16 billion in additional GDP in 2030.

Figure 28: MENA: GDP contribution generated by mid-band 5G, 2030

MENA

GDP contribution
$16bn

Percentage of GDP
0.35%

Source: GSMA Intelligence

At the country level, Saudi Arabia, UAE and Egypt are expected to account for most of the 5G mid-band benefits in the region.

In terms of economic sector contribution, 5G mid-band is expected to drive significant benefits in manufacturing, public administration and oil & gas.

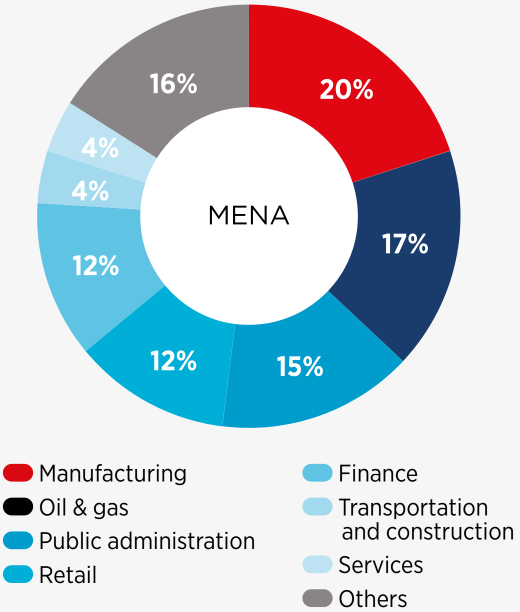
Figure 29: MENA: structure of GDP contribution generated by mid-band 5G, 2030

Percentage of total regional contribution

Saudi Arabia	13%
UAE	6%
Egypt	6%

Source: GSMA Intelligence

Figure 30: MENA: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector



Source: GSMA Intelligence

Sub-Saharan Africa

Mid-band 5G contributions in Sub-Saharan Africa are expected to be impacted by the fact that 5G development will still be progressing during the period of the study. Nevertheless, through early adopters, mid-band 5G is expected to bring up to $13 billion to the regional economy, or around 0.4% of GDP by 2030. While 5G penetration may be lower, its overall impact by 2030 will be higher as a percentage of GDP than in, for example, Europe and North America.

Figure 31: **Sub-Saharan Africa: GDP contribution generated by mid-band 5G, 2030**

Sub-Saharan Africa	GDP contribution **$13bn**	Percentage of GDP **0.37%**

Source: GSMA Intelligence

At the country level, South Africa is forecast to account for 43% of the region's overall contribution to GDP from mid-band 5G, followed by Nigeria and Angola.

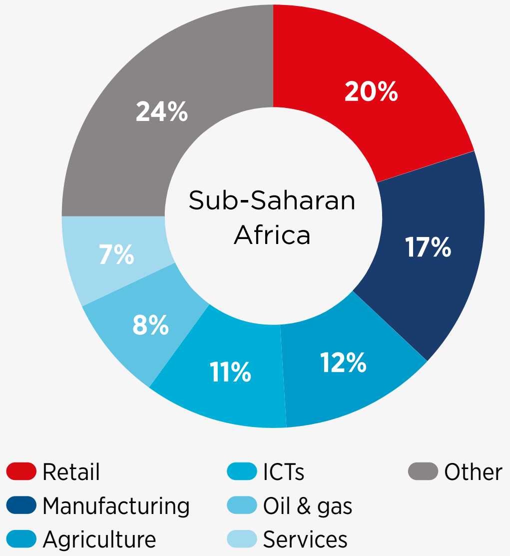
Figure 32: **Sub-Saharan Africa: structure of GDP contribution generated by mid-band 5G, 2030**

Percentage of total regional contribution	
South Africa	**43%**
Nigeria	**13%**
Angola	**5%**

Source: GSMA Intelligence

In terms of economic sectors, 5G mid-band applications will mostly be used by and benefit retail, manufacturing and agriculture. Mid-band 5G is expected to enable a large set of applications in smart agriculture/smart monitoring. Countries in Sub-Saharan Africa, with high level of exposure to the sector, are expected to benefit greatly from this.

Figure 33: **Sub-Saharan Africa: GDP contribution generated by mid-band 5G spectrum, 2020–2030, by sector**



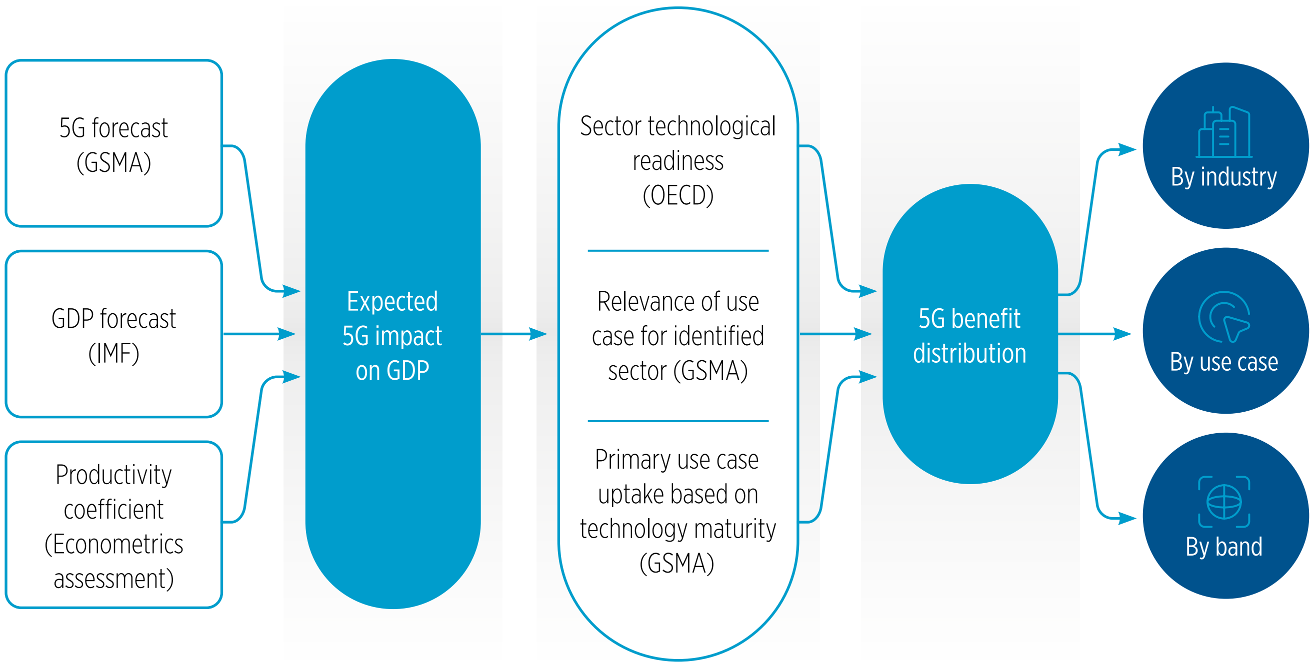
Source: GSMA Intelligence

Annex: modelling the economic impacts of mid-band 5G spectrum

The economic model underpinning this study is designed to assess the benefits of implementing 5G technology over 5G mid-band spectrum across the globe during 2020–2030.

The model is built on two segments: first, it models the impact of 5G-based technologies on productivity and economic growth of the overall economy. Second, it distributes the benefits across sectors based on a number of elements, including the sector's technology readiness and the expected impact of 5G technologies on the sector. Together, the two segments allow the model to forecast the impact on each sector of the economy.

Figure 34: **High-level overview of methodology**



Source: GSMA Intelligence

Economic impact of 5G on GDP

To predict the macroeconomic impact of 5G technology on GDP, we assume that the transition from existing network technologies (primarily 4G) to 5G will deliver an economic impact per mobile connection of a similar magnitude to that delivered by previous technology transitions.

A recent econometric study,[11] based on the most comprehensive dataset used to date and covering the rollouts of 2G, 3G and 4G globally, finds that on average a 10% increase in mobile adoption increased GDP by 1%. Importantly for our analysis, it also finds that the economic impact of mobile adoption increases by approximately 15% when connections upgrade from 2G to 3G and from 3G to 4G. As a consequence, the higher the mobile technology adoption, the higher the benefit with respect to GDP.

We therefore assume that the transition from 4G to 5G will deliver macroeconomic impacts per connection on GDP of a similar magnitude to those delivered by the transition from 3G to 4G, adjusting for differences in the adoption of each technology – that is, the economic impacts of a connection on 4G increase by 15% for each connection that transitions to 5G.

The benefit at a country level is calculated as a function of the 5G penetration rate, as follows:

t = time
i = country
α = 5G penetration rate
β = 5G productivity impact

$$Total\_Benefit_{it} = GDP_{it} * (\alpha_{it} - \alpha_{it-1}) * \beta$$

For most of the developed economies, the α parameter is based on the 5G long-term forecast, while for the β parameter, the model assumes a GDP increase of 0.08% to 0.2% for every 10% increase in 5G connections uptake. This value is calculated based on the results of the GSMA Intelligence working paper.[12]

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[11] Mobile technology: two decades driving economic growth, Working Paper, GSMA Intelligence, 2020

[12] Mobile technology: two decades driving economic growth, Working Paper, GSMA Intelligence, 2020

Technology readiness by sector

Each economic sector of a country is assigned a score based on its readiness to adopt technology, with 0 the lowest readiness and 5 the highest readiness and aptitude to benefit from mobile technology adoption compared to other sectors. For example, the agricultural sector has the lowest score, indicating that the sector is generally not well placed to adopt new technology. In contrast, technology-intensive sectors, such as finance and information & communication, are characterised by a higher score.

Scores are informed by the results of the OECD Science, Technology and Industry Scoreboard studies[13] to identify the sectors most prone to technological innovation, with particular reference to the mobile sector.

Table 5: **Technology readiness coefficient, by sector**

Sector	Score *(OECD average)*
Agriculture	**1.3**
Construction and real estate	**1.6**
Accommodation and food	**2.0**
Utilities	**2.0**
Transport	**2.3**
Oil and gas	**2.3**
Education	**2.4**
Public administration	**2.6**
Healthcare	**2.8**
Arts, entertainment and recreation	**3.0**
Manufacturing	**3.1**
Retail	**3.2**
Services	**3.3**
Finance	**3.6**
Information and communication	**3.8**

Source: OECD 2018

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[13] A taxonomy of digital intensive sectors, F. Calvino, C. Criscuolo, L. Marcolin and M. Squicciarini, 2018

Relevance of 5G use cases by sector

5G use cases are classified into four main groups.

Table 6: 5G use cases

Primary use case	Example applications
Enhanced mobile broadband (eMBB)	Data-intensive mobile connectivity
	AR/VR
	Broadband for public transport
Fixed wireless access (FWA)	Ultra-low-cost networks in rural areas
	Dynamic hotspots
	Stationary or near-stationary monitoring networks
Ultra-reliable, low-latency communications (URLLC)	Connected vehicles
	Edge computing
	Industrial automation
Massive Internet of Things (mIoT)	Remote object manipulation
	Precision agriculture
	Predictive maintenance

Source: GSMA Intelligence

Using input provided by a panel of GSMA 5G experts, we associate a score for each use case, based on its relevance to the sector, assigning a score of 0 in the case of no relevance and 6 in the case of maximum relevance. For example, URLLC is considered to be of limited relevance to the agricultural sector (low score), but very relevant to the manufacturing, utilities and financial sectors (high scores).

The model considers two different periods of analysis, in which different use cases are responsible for the 5G economic benefit in each sector. Some use cases will be ready to be implemented earlier than others. The scores are therefore adjusted to reflect changes over time to the potential impacts of each use case.

Table 7: Sector use case matrix, 2020–2030

Sector	eMBB	FWA	mIoT	URLLC
Agriculture, forestry and fishing	5	5	4	1
Construction and real estate	3	3	3	2
Accommodation and food service activities	5	5	2	0
Utilities	3	3	3	4
Transportation and storage	4	2	4	4
Mining and quarrying	5	5	4	3
Education	6	6	0	4
Public administration and defence; compulsory social security	5	5	4	3
Human health and social work activities	5	5	2	4
Arts, entertainment and recreation	6	6	0	0
Manufacturing	6	6	4	4
Retail	5	5	4	2
Services	6	6	0	0
Financial and insurance activities	5	5	0	4
Information and communication	6	6	3	3

Source: GSMA Intelligence

Distributing 5G benefits between spectrum bands

The study focuses on the benefits of 5G associated with mid-band. This is one of the three ranges together with low and high bands, that are suitable to provide 5G services.

To quantify mid-band as a share of the total benefits, we looked at the relevance of each band for the deployment of the four main 5G use cases.

Table 8: 5G use cases and spectrum band relevance

Application	Low band	Mid-band	mmWave band
eMBB	10%	80%	10%
FWA	10%	60%	30%
MIoT	40%	60%	0%
URLLC	0%	40%	60%

Source: GSMA Intelligence

The coefficients presented in Table 8 have been informed by the following.

Looking at the four main 5G use cases, for the period 2020–2030, it is expected that eMBB and FWA will be responsible for the greatest share of the total benefits, as MIoT and URLLC associated applications are still in a premature stage of development.

Over the period 2020–2030, eMBB applications (multimedia access, streaming, emailing, HD video-calling) are expected to be mostly based on the use of mid-band spectrum, as the band provides a balance of coverage and capacity.

For FWA, mid-band spectrum is also expected to play the greatest role, although pilot projects on the use of mmWave bands to deploy FWA in suburban and rural areas suggest mmWave may play a greater role in the future.

MIoT applications encompass smart readers, smart sensors and all IoT devices that are expected to be deployed, for example, in smart cities. For MIoT, coverage will be an important aspect, hence the relevance of low bands (as well as mid-bands) for this type of application.

For URLLC, encompassing new applications requiring extremely low latency and high bandwidth (for example, smart robots, smart manufacturing devices, remote object manipulation), mid-band and high bands are expected to be the main bands used, given their low latency and high capacity.

Assessing the impact of sub-optimal mid-band spectrum allocation

This research looks at the overall benefits that mid-band 5G spectrum can provide with sufficient spectrum assignments. To counter-balance this, we also look at a scenario where mid-band spectrum is constrained to current levels. Since spectrum adds to mobile network capacity, whenever mobile traffic demand exceeds capacity and spectrum availability is constrained, mobile operators generally face two choices. They must either densify their network to meet traffic demand and/or accept a degree of quality degradation in the performance experienced by users:

- Network densification generally entails higher rollout costs for mobile networks and therefore impacts both operators and consumers (if part of the cost increase is passed on to consumers in the form of higher prices).
- Quality degradation impacts subscribers of the service, since they would experience poorer network performance. Higher densification, as described above, can also lead to interference and therefore poor quality of service.

The actual outcome is likely to be a combination of the two impacts. However, site densification in a given area is constrained by the risk of interference and the need to obtain relevant permissions from local authorities and landlords, as well as the financial constraints operators face in terms of investment, which are usually set as a fixed percentage of revenues.

The model for this report proposes a quantification strategy that is based on two alternative scenarios:

- A first scenario where mobile operators would not densify their networks to meet traffic demand, so any capacity gap that arises would be absorbed by subscribers in terms of lower speeds. Since some subscribers would experience lower speeds than the minimum required for 5G as per ITU IMT-2020 Minimum Requirements, they would not subscribe to 5G services because the service provided would not be 5G, therefore impacting 5G adoption. This leads to a methodology based on quality degradation. In the current assessment, the model looks at a scenario where the number of base stations is based on an optimal spectrum allocation, as suggested by the GSMA and Coleago,[14] against a baseline scenario where available mid-band spectrum is based on current assignments and/or identifications up to and including WRC-19 for mobile spectrum.
- A second scenario where mobile operators would not accept any degree of quality degradation and would densify their network to cover any capacity gap, so the loss in unit capacity due to lower bandwidth availability would be absorbed in the form of higher rollout costs. It can be expected that some of these higher rollout costs would be passed on by operators to consumers in the form of higher prices, eventually resulting in consumers delaying their subscription or not adopting 5G services at all. This leads to a methodology based on cost increase and pass-through to consumers.

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[14] Estimating the mid-band spectrum needs in the 2025-2030 time frame, GSMA and Coleago Consulting, 2021

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