The Impacts of mmWave 5G in India

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Contents

mmWave to deliver $150 billion in additional GDP for India over 2025–2040

5G networks offer the potential to transform industrial sectors and deliver significant social and economic benefits in India. Over the period 2023–2040, we forecast that 5G technologies will make an overall contribution of approximately $450 billion to the Indian economy (0.6% of GDP by 2040). The manufacturing sector is set to benefit the most from 5G applications (accounting for 20% of the total benefit), followed by retail (12%) and ICT (11%).

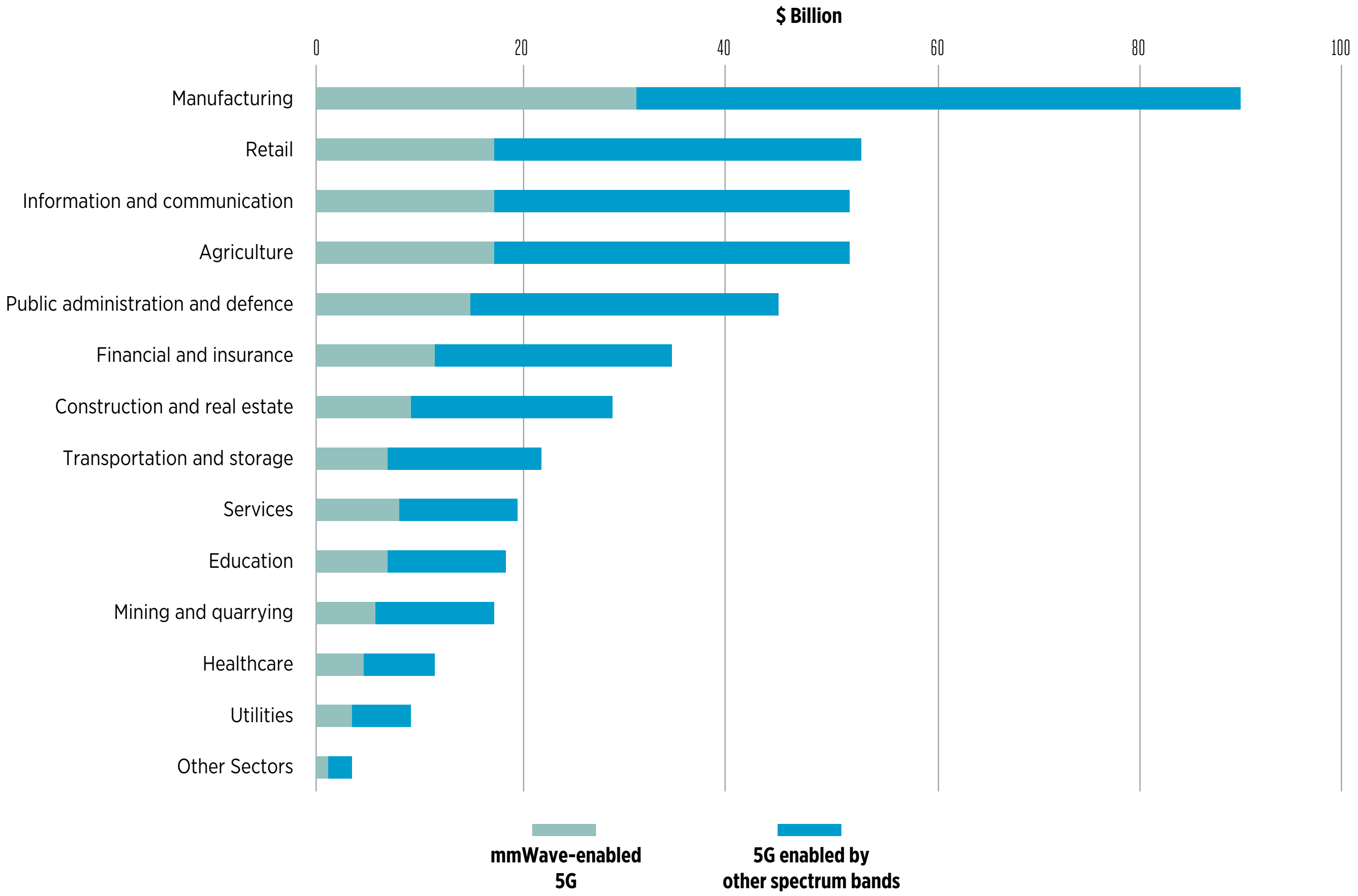
5G networks need a mix of spectrum across low (i.e. sub-1 GHz), mid (e.g. 3.5 GHz) and high (e.g. mmWave) bands. The ITU's minimum requirement is 100 MHz of prime mid-band spectrum and around 1 GHz of spectrum per operator in the high bands.

mmWave spectrum in particular will play a crucial role in enabling the high-speed and ultra-low-latency features required by many 5G applications. India will benefit significantly from mmWave-enabled 5G. Over the period 2025–2040, we estimate that mmWave-enabled 5G will deliver $150 billion in additional GDP for India. The manufacturing sector will see the greatest impact, accounting for about a fifth. The healthcare sector will also benefit greatly from mmWave-enabled 5G, with an impact of approximately $4 billion. These two verticals are explored in our case studies.

FIGURE 1

Source: GSMA Intelligence based on data from UN, IMF and OECD

5G and mmWave: economic impact in India by sector (2023–2040)



A challenging environment, but mmWave can offer opportunities

The Indian market faces key challenges that are hindering operators' capacity to invest in new technologies. While smartphone adoption has soared in the past three years and India is forecast to become the second largest smartphone market in the world by 2025, the market has some of the lowest ARPU levels globally and operators some of the highest levels of debt.

5G will enable new use cases not possible with previous technological standards. Our forecast focuses on four main areas: enhanced mobile broadband (eMBB), massive Internet of Things (MIoT), fixed wireless access (FWA) and ultra-reliable, low-latency communications (URLLC). We expect mmWave to be important in enabling eMBB and FWA.

Recommendations

Stakeholders in India need to focus on the following to maximise the socioeconomic benefits of mmWave-enabled 5G:

- The Indian government should initiate the process of including the new mmWave bands in the National Frequency Allocation Plan (NFAP) and make the timeline for spectrum release available to industry stakeholders as soon as possible.
- India should consider assigning mmWave spectrum bands to operators as soon as possible and in sufficiently large contiguous blocks. This will ensure they are able to deliver the low-latency, high-speed and high-capacity capabilities of 5G.
- Licensed spectrum should be the core 5G spectrum management approach.
- Spectrum set-asides need to be carefully considered, as they could jeopardise the success of public 5G services and may prove to be an inefficient use of spectrum. Sharing approaches such as leasing are better options where verticals require access to spectrum.
- Indian regulators should avoid inflating mmWave spectrum prices as it risks limiting network investment and driving up the cost of services. This includes excessive reserve prices or annual fees, excessive obligations and poor auction design. In particular, cost associated with obligations, if any, should be deducted from the final price.
- The Indian government and regulators can encourage high levels of investment by adopting the following two policies:
  - Support for exclusive, long-term 5G mobile licences
  - Ensuring all mobile licences are technology neutral to speed up wide-area 5G rollouts and encourage improved spectrum efficiency.

1. Indian market overview

The combination of 5G, artificial intelligence, smart platforms and the Internet of Things can deliver significant benefits for consumers, enterprises and society at large. The Indian government and policy-makers support this vision for the future; the 5G High Level Forum clearly articulates: "5G technology has the potential for ushering a major societal transformation in India by enabling a rapid expansion of the role of information technology across manufacturing, educational, healthcare, agricultural, financial and social sectors."[1]

1. Making India 5G Ready, 5G High Level Forum, prepared by the Steering Committee, 2018

India's National Digital Communications Policy (NDCP) similarly presents a positive vision for the industry and country, with the plan to invest $100 billion to enhance India's digital infrastructure and support the next generation of digital services. The aim is to allow India to realise the potential of its digital economy and reach the $1 trillion milestone set out by the Digital India plan.

The government intends to achieve this objective by scaling up 30 digital themes across nine key areas, based on its vision of providing citizens with ubiquitous and affordable internet and digital access.

Mobile will play a central role in realising these ambitions and is crucial in achieving the NDCP's goals to connect, propel and secure India.

India's powerhouse mobile economy

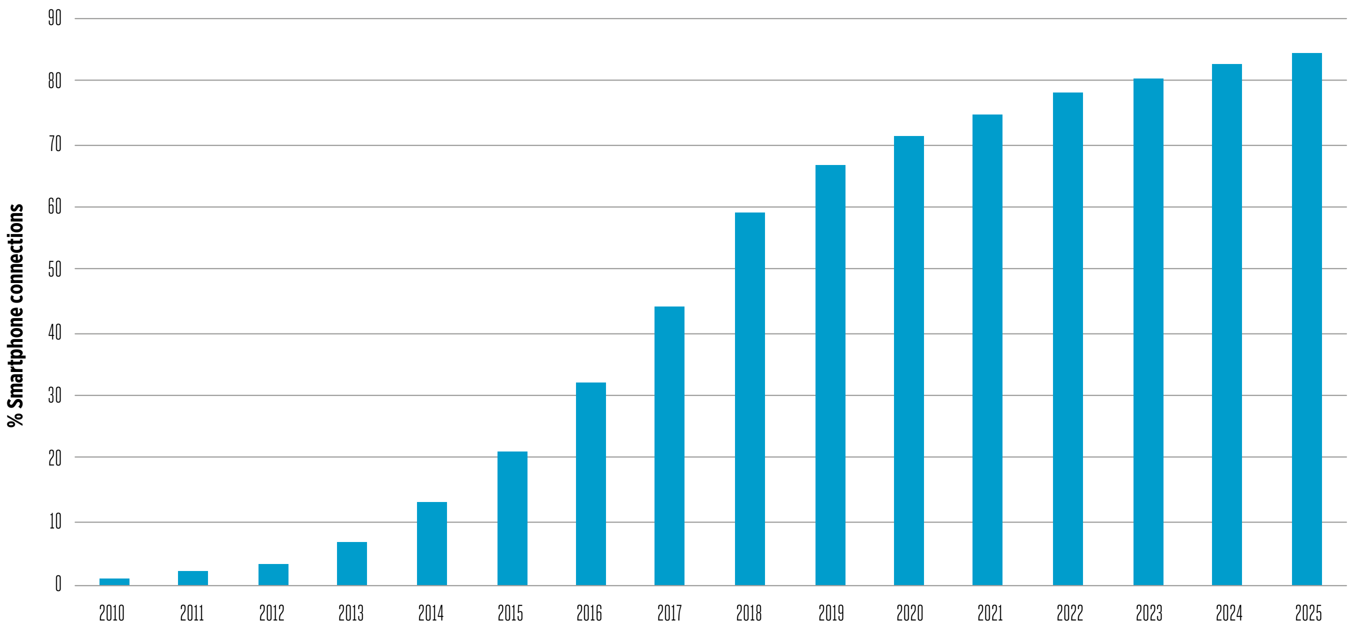
India had 731 million unique subscribers as of the end of 2019, and another 100 million will be added by 2025. That amounts to more than a fifth of the forecast growth in subscribers globally.

India is also seeing rapid migration to mobile broadband. 4G connections have grown from 9% of the total connections base in 2016 to 56% in 2019, and are forecast to reach 82% in 2025. This ongoing shift to 4G reflects the rapid adoption of smartphones in India. Between 2016 and 2019, smartphones as a share of total connections more than doubled, from 32% to 66%. By 2025, India is projected to become the second largest smartphone market in the world. GSMA Intelligence forecasts that another 190 million mobile internet users will come online by 2025.

FIGURE 2

Source: GSMA Intelligence

Smartphone connections as a share of total connections in India, 2010–2025



2. India's Trillion-Dollar Digital Opportunity, Ministry of Electronics and Information Technology

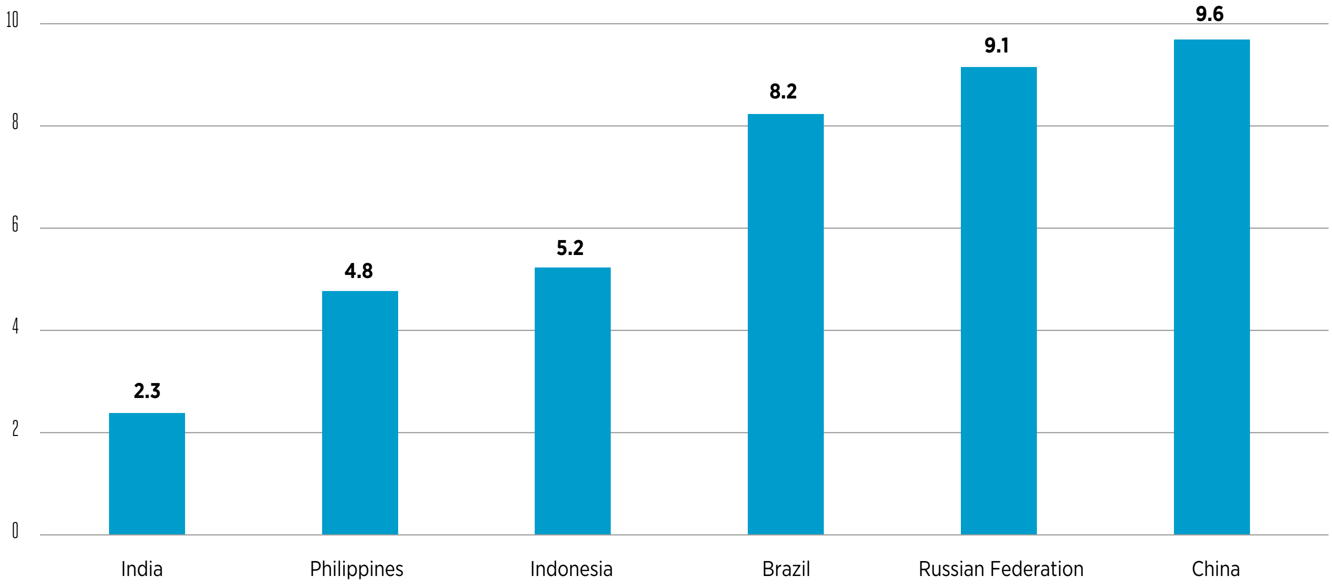
Subdued financials for operators despite growth in subscriber base

India is one of the least expensive mobile markets in the world, but this means it has some of the lowest ARPU levels in dollar terms. According to the GSMA's Mobile Connectivity Index, which tracks countries' progress across several enablers of mobile connectivity, including affordability, in 2018 India recorded the lowest mobile tariff in the world for a medium data consumption basket of 500 MB.

FIGURE 3

Source: GSMA Intelligence

Average monthly revenue per unique mobile subscriber ($, 2019)

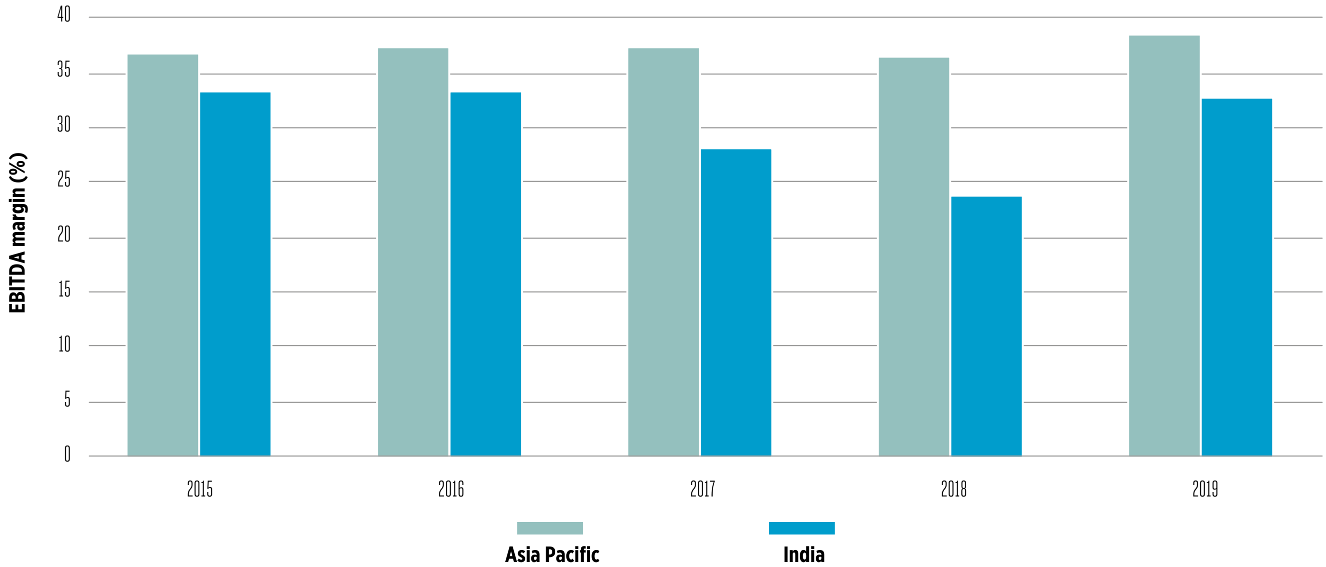


The low ARPU levels in India have mainly been driven by intense competitive pressures reflecting several dynamics, including the fact that India was for several years a highly fragmented market. The super-competitive nature of the market has further compounded pressures on profitability; Indian operators' profit margins have been consistently lower than regional peers, though they have now started to recover from the levels of 2017 and 2018.

FIGURE 4

Source: GSMA Intelligence

Average operator EBITDA margins

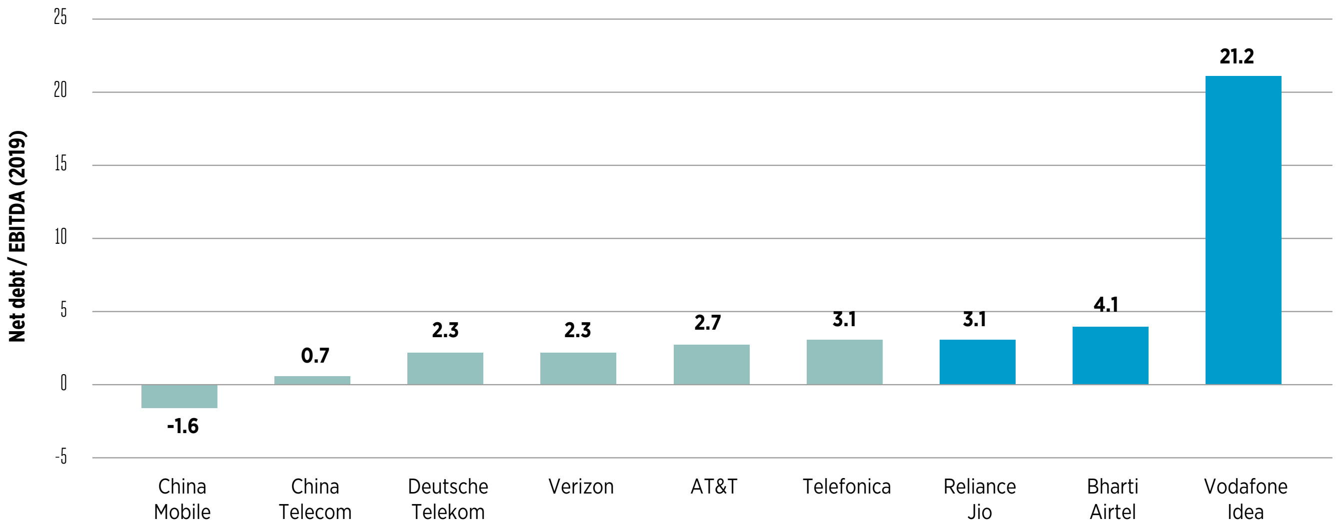


High levels of network investment, the costs of recent market consolidation and deferred spectrum liabilities have left the industry with significant debt levels that hinder operators' ability to invest in new technology.

FIGURE 5

Source: Thomson Reuters, GSMA Intelligence, Market Screener

Net debt/EBITDA by operator



Indian operators are now looking to 5G to expand beyond their traditional telecoms businesses and explore new revenue streams amid a fast-changing competitive landscape. A key challenge, however, will be funding the investments needed to deploy 5G.

5G in India

India is a price-sensitive market, and the long-term sustainability of India's mobile industry is under threat. 5G presents an opportunity to propel the country to the next generation of digital connectivity and generate new revenue streams. Policy-makers can make the most of this by providing timely access to the right amount and type of affordable spectrum, under the right conditions. Networks need a mix of spectrum across low (i.e. sub-1 GHz), mid (e.g. 3.5 GHz) and high (e.g. mmWave spectrum) bands. The ITU's minimum requirement is 100 MHz of prime mid-band spectrum and around 1 GHz of spectrum per operator in the high bands.

Each range offers distinct performance characteristics that will help India deliver on its vision for 5G. The assignment of 5G mmWave spectrum – with the 26, 28 and 40 GHz bands as priorities and, in years to come, the 50 and 66–71 GHz bands – will provide the increased bandwidth and capacity required by 5G use cases. mmWave spectrum is expected to play a key role in meeting demand for enhanced mobile data services as well as new use cases unattainable using alternative spectrum and previous mobile technology generations.

Additionally, to cater for high speeds in the access network, there will be a continual need to raise backhaul transmission capacity, both in the form of more links for new radio sites and additional capacity to support high bandwidth services on the radio sites. For example, the usefulness of backhaul spectrum in the E-band is already widely recognised.

The use cases considered in this study are enhanced mobile broadband (eMBB), fixed wireless access (FWA), massive Internet of Things (MIoT) and ultra-reliable, low-latency communications (URLLC). These will be empowered to different degrees by mmWave spectrum assignments to support their technical requirements.

TABLE 1

Source: GSMA Intelligence

5G use cases and example applications

5G USE CASES	EXAMPLE APPLICATIONS
ENHANCED MOBILE BROADBAND	Data-intensive mobile connectivity AR/VR Broadband for public transport
FIXED WIRELESS ACCESS	Ultra-low-cost networks in rural areas Dynamic hotspots Stationary or near-stationary monitoring networks
ULTRA-RELIABLE, LOW-LATENCY COMMUNICATIONS	Industrial automation Connected vehicles Edge computing
MASSIVE INTERNET OF THINGS	Remote object manipulation Precision agriculture Predictive maintenance

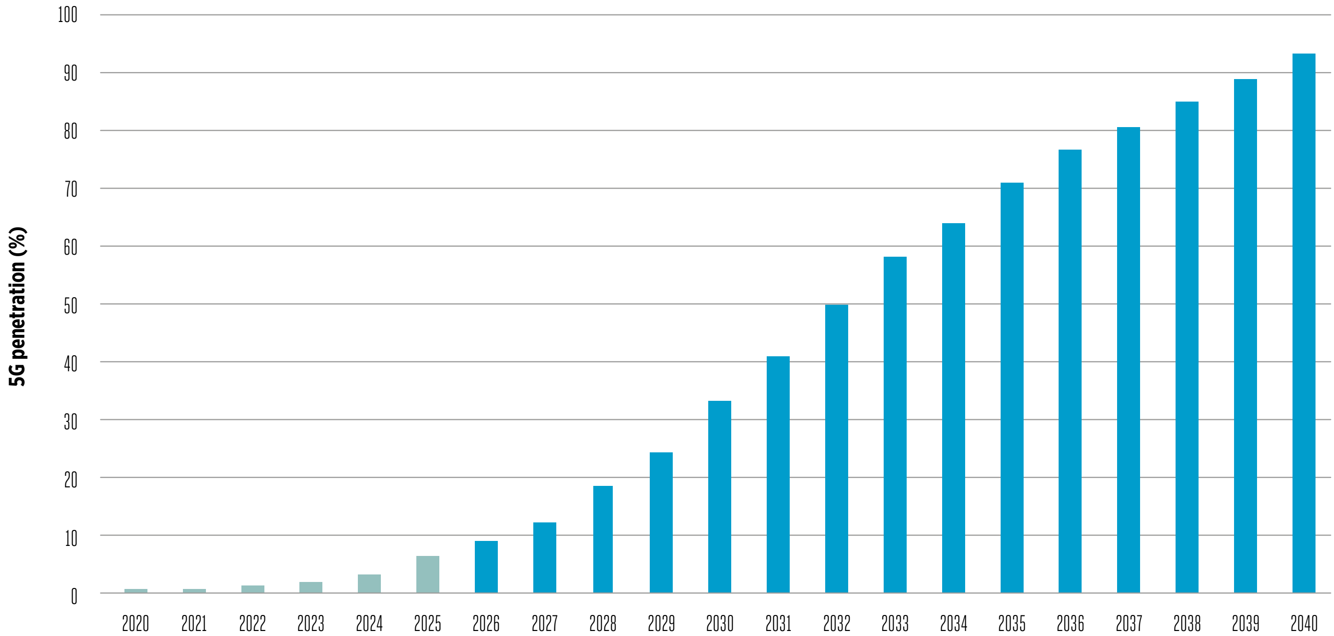
There is growing interest in these applications in the Indian market from both the government and ecosystem players. For example, the New Education Policy (NEP 2020) will bring in a paradigm shift in the use of 5G technology in the field of education. The visionary policy based on the pillars of access, equity, quality, affordability and accountability will benefit from 5G to provide education throughout the country, including in remote areas, and will increase the country's enrolment ratio significantly.

Considering India's interest in 5G and its readiness to adopt the applications, GSMA Intelligence forecasts 5G connections in India to reach 6% of total population by 2025 (72 million) and 93% by 2040.

FIGURE 6

Source: GSMA Intelligence

India 5G market penetration forecast



2. Socioeconomic impact of mmWave in India

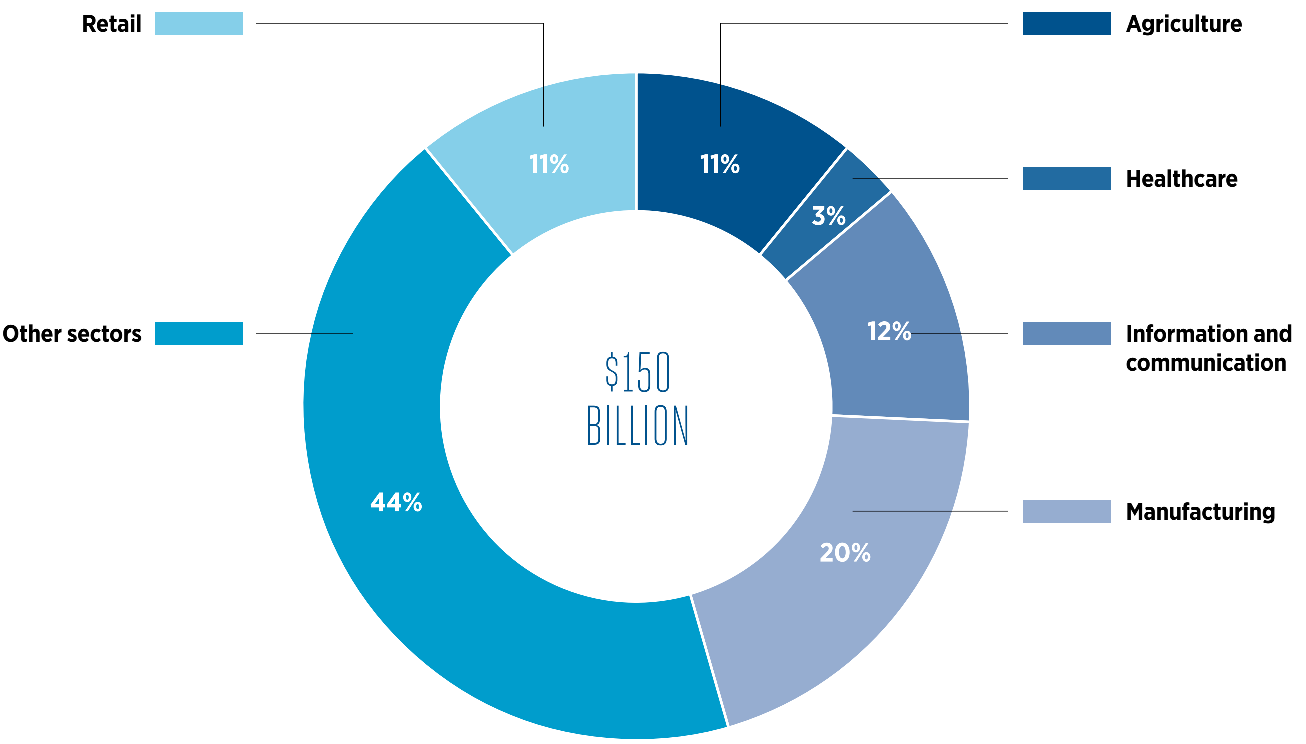
India is expected to assign mmWave spectrum to operators to enable 5G. Over the period 2025–2040, we estimate that mmWave-enabled 5G will deliver $150 billion in additional GDP for India.

The manufacturing sector will account for the largest contribution, reflecting its prominence in the Indian economy and readiness to adopt new technologies to improve productivity levels. By 2040, this sector will account for 20% of the total contribution from mmWave, followed by ICT (12%) and retail (11%). mmWave bands are also expected to provide benefits to the healthcare[3] sector, amounting to approximately $4 billion between 2025 and 2040.

FIGURE 7

Source: GSMA Intelligence, based on data from the UN, IMF and OECD

mmWave: contribution to Indian economy by sector (2025–2040)



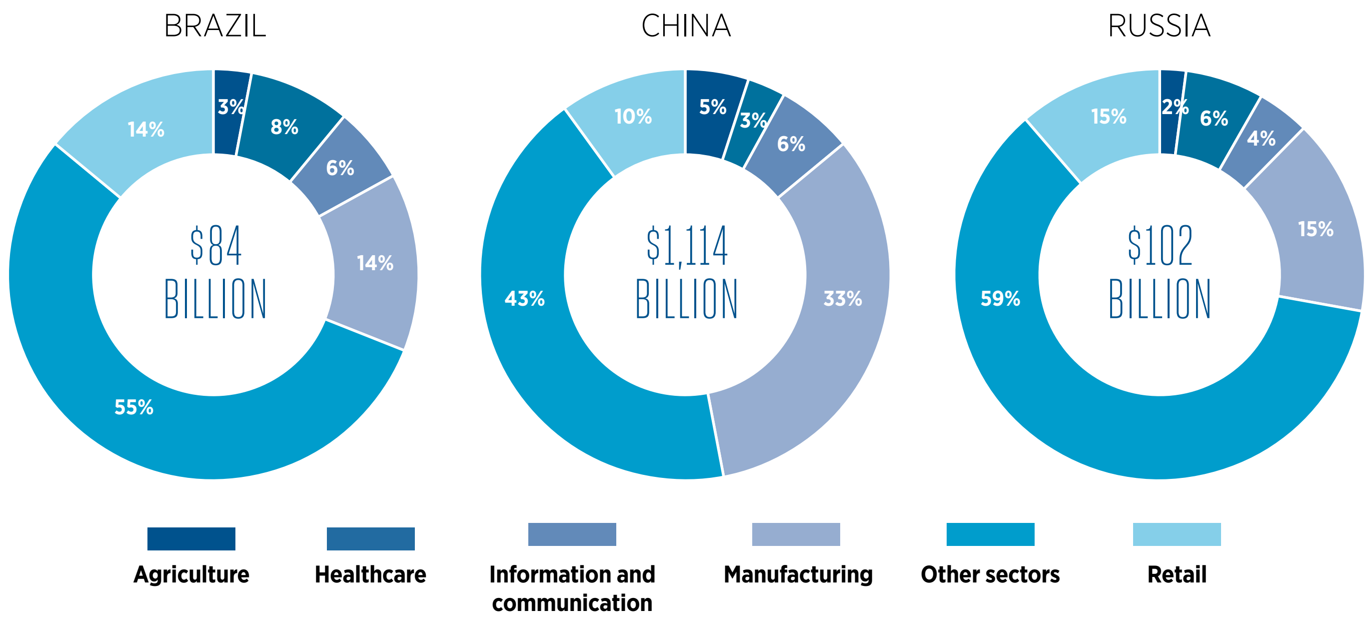
3. The healthcare sector refers to the human health and social work activities sector under the ISIC Rev. 4 classification

Compared to other middle-income countries, India will experience one of the largest impacts, as shown in Figure 8.

FIGURE 8

Source: GSMA Intelligence, based on data from the UN, IMF and OECD

mmWave: contribution to economy by sector for other BRIC countries (2025–2040)

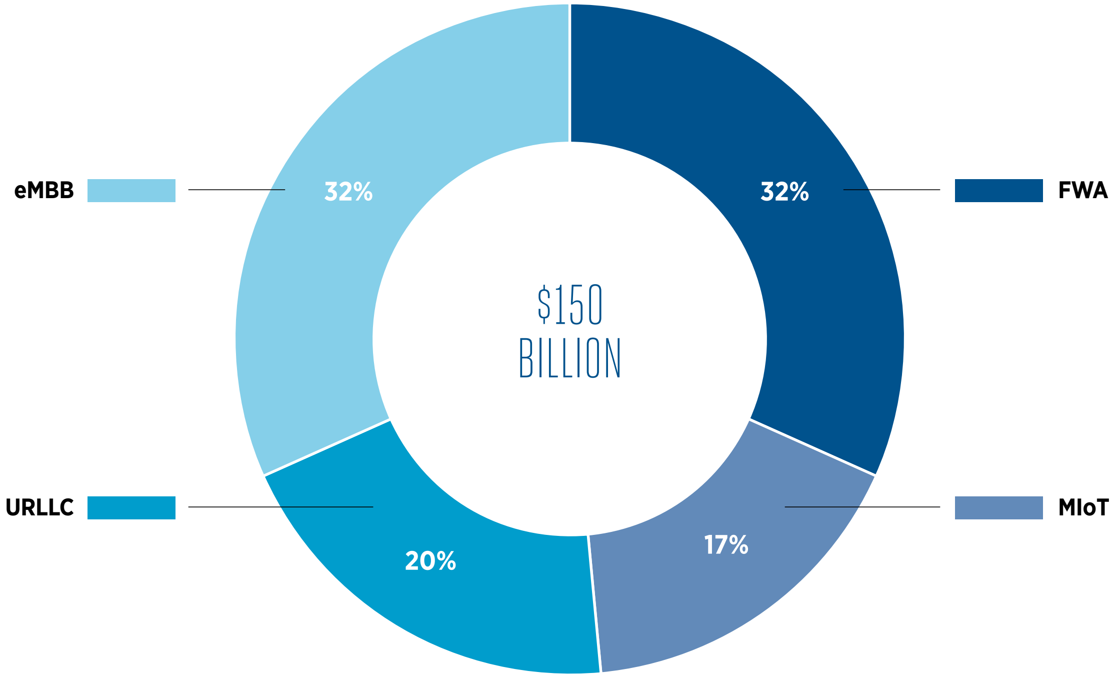


mmWave spectrum will be particularly relevant in enabling eMBB and FWA applications. We therefore expect the overall benefit from mmWave-enabled 5G to be generated primarily by FWA and eMBB.

FIGURE 9

Source: GSMA Intelligence, based on data from the UN, IMF and OECD

mmWave: contribution to Indian economy by use case (2025–2040)



3. Case studies

mmWave spectrum will be key to delivering additional capacity and high throughput in 5G networks. These capabilities will support the data-intensive and low-latency applications expected of 5G. While in some cases the applications could be supported by lower spectrum bands, the potential of mmWave really comes into play when considering the massive scale of connected devices to be supported in specific areas, such as those described in the two industry case studies below.

In manufacturing, widespread implementation of industrial automation will benefit from added capacity due to the higher bandwidth available with mmWave spectrum. In healthcare, maintaining a high-speed, low-latency connection will be critical to enabling the most technologically advanced applications such as remote surgery and telemedicine; these will ultimately help reduce the burden on medical infrastructure through the decentralisation of patient treatment.

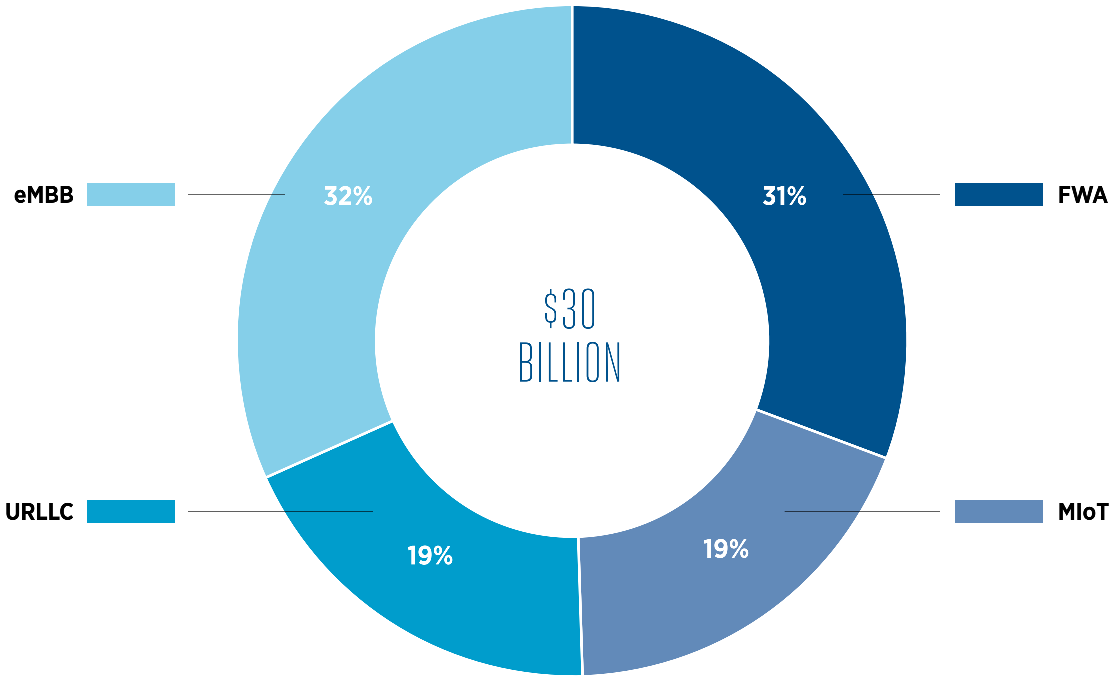
Manufacturing

The manufacturing sector in India will be the largest contributor to the benefit brought about by mmWave spectrum, accounting for 20% of the total impact. We expect eMBB and FWA to account for the greatest shares (see Figure 10).

FIGURE 10

Source: GSMA Intelligence, based on data from the UN, IMF and OECD

mmWave: contribution to manufacturing in India by use case (2025–2040)



The manufacturing sector in India is preparing to adopt new, disruptive technologies to drive improvements in productivity. The Confederation of Indian Industry has tracked 37 Industry 4.0 case studies across the country, in markets including automotive, industrial equipment, food processing and pharmaceuticals.[4]

The government's Make In India and Aatmanirbhar Bharat[5] initiatives are laying the groundwork to enable both small and large companies to develop Industry 4.0 capabilities.[6] Several mmWave-enabled 5G applications can help realise the potential of 5G for Industry 4.0. These include remote control systems, industrial robotics, remote monitoring and quality control, and autonomous factory transport.

4. https://smartmanufacturingindia.com/
5. https://www.india.gov.in/spotlight/building-atmanirbhar-bharat-overcoming-covid-19
6. https://www.makeinindia.com/home

TABLE 2

Source: GSMA Intelligence

Industrial applications for mmWave 5G

Remote-control systems	Remote object monitoring and manipulation can be implemented to increase efficiency and improve safety in smart factories. Industrial processes that involve volatile chemicals or temperature-sensitive materials can be made safer through the remote operation of factory equipment. Efficiency can also be improved by allowing one remote operator to stop, slow or accelerate any of the connected machines, based on real-time feedback to a central control station.
Industrial robots	Industrial robotics allow each piece of machinery in a smart factory to respond almost instantly to requests and directions, enabling a rapid response in production to meet real-time shifts in demand. This also makes the customisation of manufactured products possible at a scale previously unattainable. Communication between connected devices could also increase efficiency.
Remote monitoring and quality control	Real-time data collection and analysis, especially data-intensive processes such as high-speed imaging and virtual and augmented reality applications, can improve production and provide on-the-job training by enabling: • employees to see real-time data on the factory floor and compare the images of defective machinery with those in working order • new employees to be trained through virtual simulations • advisors/specialists to assist remotely when not on the factory floor or put in place an automated process for workers to troubleshoot independently of the specialist.
Autonomous factory transport	As in a broader transport setting, autonomous vehicles in a factory setting (such as carts and cranes) can communicate with a central control or monitoring centre, as well as other machines, devices and broader infrastructure within the factory.

Such industrial applications will result in a large amount of data being transmitted by a vast number of connected devices. The sheer volume of data, along with the critical nature of some of the applications, will require the reliable, high-capacity, low-latency connectivity of mmWave spectrum. The relatively small coverage area of a factory floor, compared to a wider setting, is also well-suited to the propagation characteristics of mmWave spectrum.

Healthcare

Mobile broadband is already transforming the healthcare industry by integrating remote communications into patient-doctor relationships. Adoption of mmWave 5G will enable new use cases, due to its low latency and high speeds.

In India, there is a significant urban/rural divide in access to healthcare, with 80% of the doctors located in urban areas serving only 28% of the population.[7] According to the OECD, India has only 0.5 hospital beds per 1,000 inhabitants, compared to 1.0 in Indonesia, 1.1 in Mexico and 2.1 in Chile. With the recent Ayushman Bharat plan,[8] India has sought to leverage digital technologies to help the poor and isolated access healthcare, laying the foundations for a more digital-intensive public health sector and ultimately delivering the "Healthcare for all" Digital India objective.

We expect healthcare applications to focus on decentralised patient treatment, bringing healthcare professionals to rural areas through remote communication technologies, thus reducing the burden on urban facilities and minimising the need for rural populations to travel to cities for treatment. Medical data collected by massive IoT devices will contribute to advancing scientific knowledge in the field, enabling health professionals to better monitor the health status of their patients and diagnose their conditions.

We forecast mmWave 5G applications in the Indian healthcare sector to provide a socioeconomic benefit amounting to $4 billion over the period from 2025 to 2040. The applications considered in this forecast include precision medicine, telemedicine, remote surgery and VR training in surgical procedures.

TABLE 3

Source: GSMA Intelligence

Healthcare applications for mmWave 5G

Precision medicine	Precision medicine uses a patient's individual specificities, including genetics, to identify tailored healthcare steps. By applying AI to a range of medical datasets, recommendations can be customised to individual patients. IoT devices can be equipped with 5G to provide the speed and accessibility required.
Telemedicine	AR and VR applications can support remote consultations and assessments, providing access to much-needed critical health services for patients and generating cost savings. The next generation of internet speeds will also equip patients' devices with the ability to send their providers real-time data on key metrics such as blood pressure and glucose levels.
Remote surgery	Through 5G, surgeons can operate on a patient via a robotic intermediary, despite potentially being many miles away. Financially restricted patients in rural areas could then be given access to specialist surgery not available at nearby hospitals.
VR training in surgical procedures	VR surgical training tools can be used to train surgeons, allowing them to keep up to date with recent developments in their practice. They can also help train the next generation of surgeons and doctors by connecting them to remote procedures, enabling them to save lives when their turn comes.

7. Report on Healthcare initiatives, KPMG and OPPI, 2016
8. https://pmjay.gov.in/

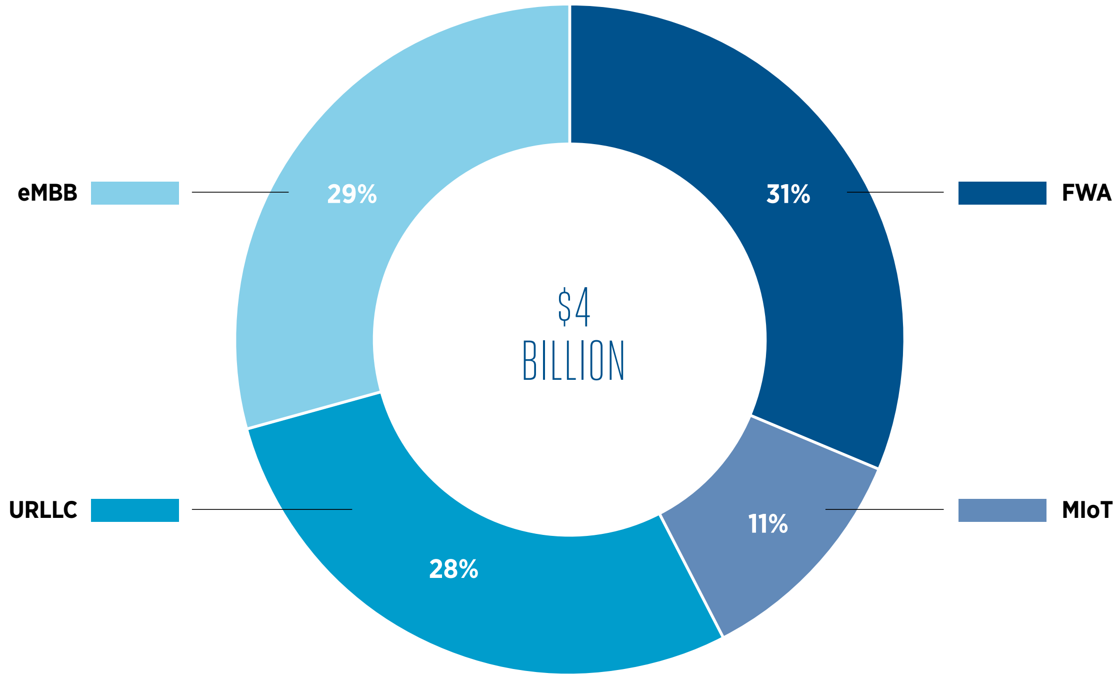
The mission-critical nature of these applications will require the low-latency and high-speed connectivity of mmWave spectrum to ensure dataflows are in real-time and are not interrupted.

Accordingly, we expect URLLC applications to be the largest contributors to the overall 5G benefit in healthcare. However, mmWave spectrum bands are likely to be more relevant to eMBB and FWA applications.

FIGURE 11

Source: GSMA Intelligence, based on data from the UN, IMF and OECD

mmWave: contribution to healthcare in India by use case (2025-2040)



4. Policies to deliver socioeconomic benefits from mmWave

The Indian government has already laid out its 5G ambitions. It has launched a 5G High Level Forum to ensure that 5G can contribute in delivering government initiatives such as the Digital India, Smart Cities and Smart Village missions, and Aatmanirbhar Bharat. It has furthered these ambitions by launching the programme "Building an End-to-End 5G Test Bed" to advance innovation and research into 5G.

More recently, in its 2020 digital infrastructure plan, it has acknowledged the potential of 5G in fuelling industry growth and innovation in India, harnessing the power of emerging technologies such as IoT, cloud computing, AI and big data. In its National Broadband Plan[9], it highlighted the importance of extending broadband access across the country and facilitating the rollout of 5G networks. The government has set out its plans to connect 70% of telecoms towers using fibre in five years. The NDCP envisages overall investment of $100 billion to enhance India's digital infrastructure and reach the $1 trillion digital economy milestone.

As per media reports, operators and vendors are already planning a significant number of 5G trials:

- Reliance Jio has developed its own 5G network solution in India and has recently applied to the DoT for the assignment of 800 MHz in the mmWave spectrum bands to test its solution.
- Bharti Airtel and Huawei have successfully conducted India's first 5G network trial under a test setup at Airtel's network experience centre in Manesar, Gurgaon, achieving user throughput of more than 3 Gbps. Bharti Airtel has signed a memorandum of understanding (MoU) with Nokia and Ericsson to support the company in its preparations for 5G rollout.
- Vodafone Idea has proposed 5G trials with multiple vendors including Huawei and Ericsson.
- Samsung is expected to conduct 5G field trials in New Delhi and is working closely with the Department of Telecommunications (DoT). Samsung is also likely to be one of Jio's partners for 5G field trials.
- BSNL has signed an MoU with Ciena to conduct field trials, with the goal of a commercial launch by 2020. Ciena and BSNL intend to jointly evaluate fronthaul, mid-haul and backhaul transport-based use cases to address resilience requirements and latency concerns. BNSL has also applied to the DoT to carry out 5G trials with ZTE.

In order for India to realise the socioeconomic benefits highlighted above and foster the adoption of the most technologically advanced 5G use cases, stakeholders in the country should focus on the following areas:

- The Indian government should initiate the process of including the new mmWave bands as part of the National Frequency Allocation Plan (NFAP) and make the spectrum release timeline available to industry stakeholders as soon as possible.
- India should consider assigning mmWave spectrum bands to operators as soon as possible, in sufficiently large blocks, to ensure they are able to deliver the low-latency, high-speed and high-capacity capabilities of 5G. In mmWave bands, the GSMA recommends making available around 1 GHz of contiguous spectrum per operator.
- Spectrum set-asides need to be carefully considered, as they could jeopardise the success of public 5G services and may make for an inefficient use of spectrum. Sharing approaches such as leasing are better options where verticals require access to spectrum.
- Indian regulators should avoid inflating mmWave spectrum prices as it risks limiting network investment and driving up the cost of services. This includes excessive reserve prices or annual fees, excessive obligations and poor auction design.
    - Cost associated with obligations, if any, should be deducted from the final price.
    - A recent study by GSMA Intelligence has shown that high spectrum costs lead to negative consumer outcomes by restricting operators' financial ability for network investment. High reserve prices can also result in spectrum going unsold.[10]
    - Countries such as Japan and Hong Kong have taken a novel approach to spectrum pricing to promote investment in mobile technologies by assigning mmWave spectrum at no cost to operators. The Indian government should consider assigning mmWave spectrum with no fees, to entice interest among operators and help realise the benefit that can be achieved in this band.
- The Indian government and regulators can encourage high levels of investment by adopting exclusive, technology neutral and long-term mobile licences to speed up wide-area 5G rollouts and encourage improved spectrum efficiency.

9. India National Broadband Plan, 2019
10. See The impact of spectrum prices on consumers, GSMA Intelligence, 2019

Technical Annex

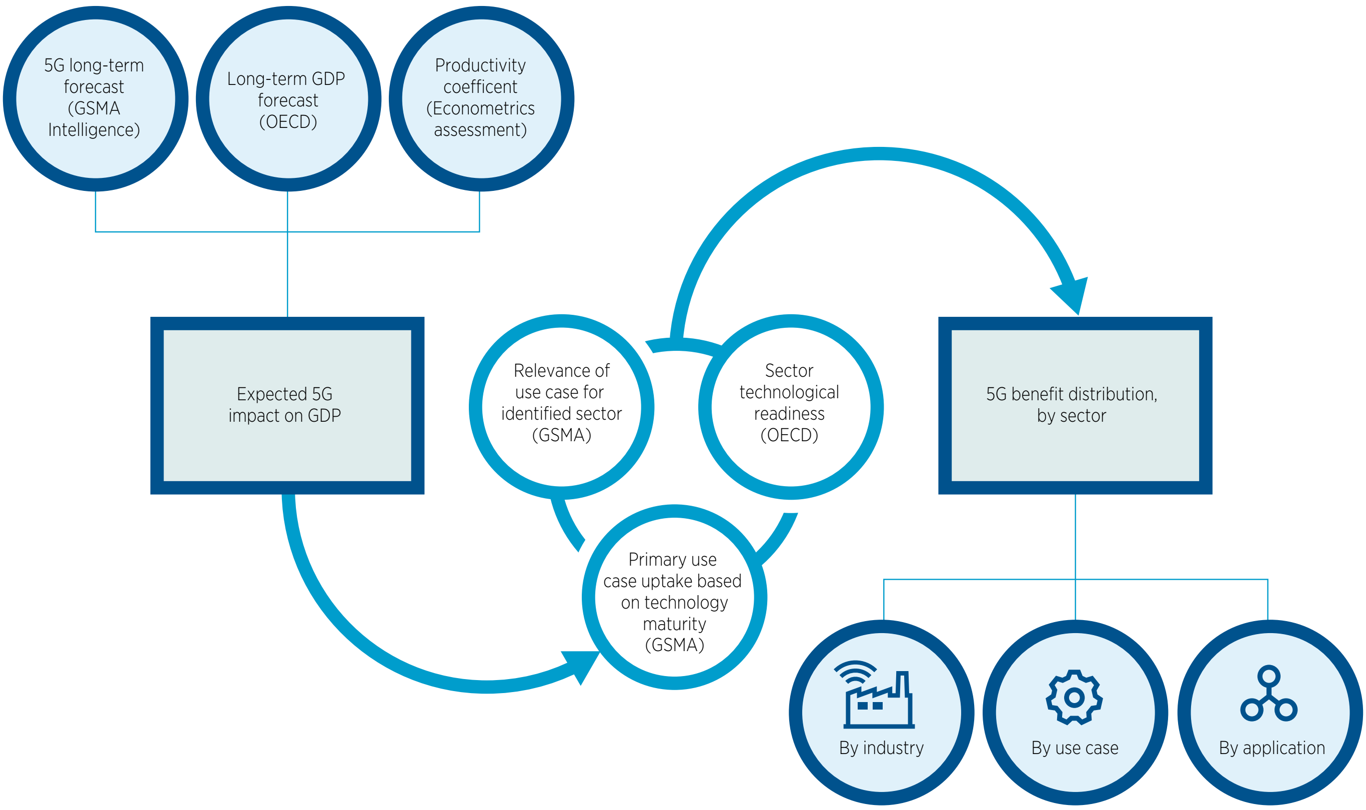
The economic model underpinning this study is designed to assess the benefits of implementing 5G technology and mmWave spectrum in India over the period 2020–2040.

The model is based on two main pillars: the first assesses how different use cases – applications and new/upgraded industrial processes supported by 5G technology – can boost productivity and benefit the economy. The second distributes this productivity impact for each sector of the economy.

FIGURE 12

Source: GSMA Intelligence

5G and mmWave socioeconomic benefits: model overview



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 in India (primarily 4G) to 5G will deliver an economic impact of a similar magnitude to that delivered by previous technology transitions.

A recent econometric study[11] by GSMA Intelligence, based on the most comprehensive dataset used to date and covering the rollouts of 2G, 3G and 4G globally, found that, on average, a 10% increase in mobile adoption increased GDP by 1%. Moreover, it found that the economic impact of mobile adoption increases by approximately 15% when connections are upgraded from 2G to 3G; and by approximately 15% when connections transition from 3G to 4G.

The assumption underpinning the overall 5G benefit is that the transition to 5G in India will deliver macroeconomic impacts on GDP of a similar magnitude to those delivered by the transition from 3G to 4G.

The benefit at the 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

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

In the case of India, the model foresees β = 0.01%, which translates to a GDP increase of 0.1% every 10% increase in 5G penetration rate.

5G long-term forecast

Modelling 5G economic benefits requires forecasting 5G connections over the long term. GSMA Intelligence forecasts for the period 2020–2025 were therefore extended to 2040 based on a stylised trend of historical patterns of new network technology adoption.

GDP long-term forecast

For the period 2020–2024, the GDP forecast by the IMF was used. For 2025–2040, real GDP growth is based on the OECD long-term GDP forecast.[12, 13]

11. Mobile technology: two decades driving economic growth, GSMA Intelligence Economic Research Working Paper
12. https://data.oecd.org/gdp/real-gdp-long-term-forecast.htm
13. This forecast is available for India. Where not available, average expected real GDP growth was assumed according to the level of development of the country.

Technology readiness by sector

Each economic sector in India is attributed an overall benefit according to its importance in the economy and its readiness to adopt new technologies. For example, the agricultural sector has the lowest technology readiness, indicating that the sector is generally not well placed to adopt new technologies.

In the model, the socioeconomic benefit assigned to a given sector is a function of three aspects:

- the importance of each sector in the economy
- its digital intensity score
- the average relevance of use cases considered in the sector, as defined by GSMA technology experts.

The latter two are approximations of the technology readiness of each sector in the economy. The digital intensity score is a proxy of technology adoption readiness, while the average relevance score gives the relevance that use cases are expected to have in each industry vertical.

The weight of each sector in the economy is measured in value-added terms according to the ISIC Rev. 4 classification. The sources used are the United Nations Data Portal[14] and the OECD.[15]

Each economic sector in India is attributed a score based on their readiness to adopt technology, with 0 the lowest readiness and 5 the highest readiness and aptitude to benefit from mobile technology adoption. For example, the agricultural sector has the lowest score, indicating that the sector is generally not well placed to adopt new technology. Conversely, technology-intensive sectors, such as financial services and ICT, are characterised by higher scores.

For this aspect of the model we use the results of the OECD Science, Technology and Industry Scoreboard studies, and in particular the recent paper (2018) *A taxonomy of digital intensive sectors*[16], to identify which sectors are the most prone to technological innovation, with particular reference to mobile.

14. http://data.un.org/Data.aspx?d=SNA&f=group_code%3A204
15. https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE6A
16. https://www.oecd-ilibrary.org/docserver/f404736a-en.pdf?expires=1591106295&id=id&accname=guest&checksum=CF1276987C4C5E924669BFDB7DCE1DF3

TABLE 4

Source: GSMA Intelligence

Technology readiness score by sector

SECTOR	TECHNOLOGY READINESS SCORE
Agriculture, forestry and fishing	1.3
Construction and real estate	1.6
Accommodation and food service activities	2.0
Utilities	2.0
Transportation and storage	2.3
Mining and quarrying	2.3
Education	2.4
Public administration and defence; compulsory social security	2.6
Human health and social work activities	2.8
Arts, entertainment and recreation	3.0
Manufacturing	3.1
Retail	3.2
Services	3.3
Financial and insurance activities	3.6
Information and communication	3.8

Relevance of the use case for each sector

Finally, the average relevance of 5G use cases for each sector is assigned a score from 0 (not relevant) to 6 (strongly relevant), defined by GSMA technology experts.

The 5G applications considered are classified according to four primary use cases.

TABLE 5

Source: GSMA Intelligence

Use cases and example applications considered

PRIMARY USE CASE	EXAMPLE APPLICATIONS
ENHANCED MOBILE BROADBAND	Data-intensive mobile connectivity AR/VR Broadband for public transport
FIXED WIRELESS ACCESS	Ultra-low-cost networks in rural areas Dynamic hotspots Stationary or near-stationary monitoring networks
ULTRA-RELIABLE, LOW-LATENCY COMMUNICATIONS	Connected vehicles Edge computing Industrial automation
MASSIVE INTERNET OF THINGS	Remote object manipulation Precision agriculture Predictive maintenance

As an example, URLLC applications are expected to be weak in terms of relevance in the agriculture, forestry and fishing sector but have strong relevance in the transportation and storage sector.

Some use cases are expected to be implemented earlier than others. Use case scores were therefore adjusted to reflect changes in relevance over time. In general, the model considers two different periods of analysis, 2020–2029 and 2030–2040. Over the first period, eMBB and FWA are expected to be more relevant than MIoT and URLLC. Over the second period, MIoT and URLLC are expected to be more relevant.

TABLE 6

Source: GSMA Intelligence

Use case relevance by sector (2020–2029)

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

TABLE 7

Source: GSMA Intelligence

Use case relevance by sector (2030–2040)

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

The overall 5G benefit is then assigned to each sector according to a normalised weight reflecting the three aspects above (importance of the sector in the economy, digital intensity and use case relevance).

Impact by use case

The economic impact linked to specific use cases is a function of their relevance in each sector over the two periods 2020–2029 and 2030–2040. For a given sector, the relevance by use case was normalised to allocate the overall impact for the use cases. For example, over the period 2020–2029, the share of the benefit linked to eMBB applications in the agricultural sector is their relevance in this sector (5) divided by the sum of the relevance scores in the sector (5+5+4+1).

mmWave impact

A panel of GSMA technology and spectrum experts provided an assessment of mmWave relevance for each sample application across the four primary use cases. mmWave was defined from 0 (not relevant) to 5 (strongly relevant). This relevance was used to inform the average 5G penetration rate associated with mmWave spectrum for each primary use case.

As mmWave spectrum has yet to be assigned in India, we assumed that its benefits will materialise from 2025. The mmWave economic impact is then calculated as the impact associated with each use case multiplied by the average penetration rate enabled by mmWave.

TABLE 8

Source: GSMA Intelligence

mmWave relevance

PRIMARY USE CASE	EXAMPLE APPLICATIONS	mmWAVE RELEVANCE (0 TO 5)	PENETRATION RATE ASSOCIATED WITH mmWAVE
eMBB	Data-intensive mobile connectivity	5	50%
	Augmented reality	5	
	Virtual meeting/augmented reality/broadcast-like services	5	
	Broadband for public transport	5	
FWA	High-speed broadband in the home/office	4	33%
	Low-cost networks in rural areas	3	
	Dynamic hotspots/stationary or near-stationary monitoring networks	3	
URLLC	Next-generation transport connectivity	3	38%
	Healthcare	4	
	Collaborative robots/complex industrial automation	5	
	Edge computing	3	
MIoT	Remote object manipulation	5	30%
	Precision agriculture	2	
	Predictive maintenance/energy	2	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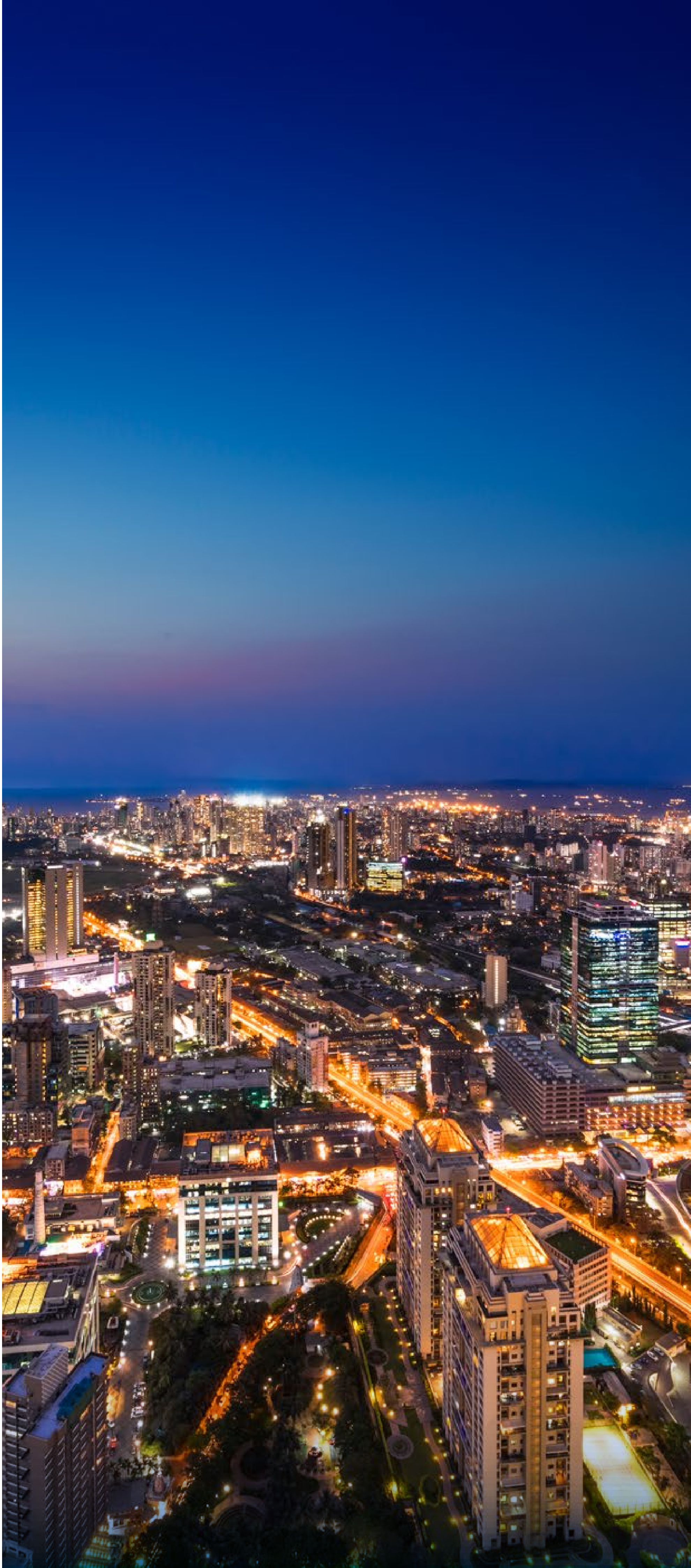

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