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Why 5G in Latin America?

A call to action for Latin American operators and policymakers

An Omdia–Nokia research paper

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Foreward: Latin America, 5G, and COVID-19

Increased demand for broadband can only help the 5G business case, especially in fixed wireless access.

The need for better-quality emergency communications will encourage the deployment of network slices, a key feature of the coming versions of 5G.

Without question the most important news of 2020 concerns COVID-19: we face the biggest public health emergency in generations. Governments, businesses, NGOs, communities, and individuals are doing all they can to keep people safe and economies resilient. The pandemic has driven most countries to extreme quarantine measures, which have everyone in their houses, working when their devices, connectivity, and tasks make that possible and on forced vacation when not.

At the time of writing, it is difficult to predict where we as people, societies, and economies go from here. However, this introduction gives a brief overview of current thinking about impacts and some observations about what these might mean for Latin America and how 5G can contribute to improve society and business in the region after the crisis.

The downside

Closed businesses and most people staying inside have had a significant impact on the region's economies. Most of the world, including Latin America, is expecting to have lower growth. It may take weeks or months for quarantine to end, and even economies that can bounce back quickly will find their end users are struggling.

However, the provision of networks and connectivity has never been so important, with peak traffic increasing 40–50% in a few weeks, an increase that typically only occurs over a year. While the crisis could impact the speed at which the recommendations in this white paper are adopted, they should not affect their characteristics: operators will deploy 4G more deeply in their networks, upgrade transmission networks to fiber, and begin to deploy 5G once cheaper 5G-enabled smartphones become available or when enterprises get sold on the need for private networks.

The upside

We will not know what the impact of these extended periods of quarantine will be on people's consumption and working habits for some time. But most observers expect that trends and technologies that were already happening before the quarantine period will speed up. So more remote working and video conferencing will increase the need for better connectivity. The power of 5G and lower latency times will not be abstract terms for the majority of people but will suddenly become critical for everything: digital health, financial trading, virtual classrooms, government, and international diplomacy, for example.

Employers will accelerate their automation, artificial intelligence (AI), and Internet of Things (IoT) plans to allow more remote working. Driverless food trucks, automated deliveries, and advanced medical robotics may suddenly seem like urgent necessities. We may also find we prefer to watch movies or concerts in the comfort of our living rooms.

Two of the consequences will be a better fixed wireless access (FWA) business case (which Omdia believes is important for 5G in Latin America) and significantly higher traffic in residential areas. Both will encourage telecoms operators in the region to deploy 5G sooner rather than later.

The bottlenecks that operators are dealing with today should encourage governments to address current spectrum limitations, which we identify as an issue in Chapter 6. More spectrum will benefit everyone.

Another consequence will be greater funding and greater focus on emergency services, especially those related to health. Much is already predicted for 5G's impact on healthcare, with HD-quality telemedicine and mobile healthcare destined for major advances. But there are technologies currently in use that could potentially be transformed by 5G. Thermal cameras are already in use at airports as a preliminary diagnostic tool. In the future, 5G could take this technology's potential further, enabling greater functionality and, with permission, access to other relevant data that assists prevention and diagnosis.

With today's versions of 4G, emergency services get the same grade of service as any other mobile user. Ambulances compete with cat videos for bandwidth. Network slicing is possible in 4G, but it requires significant manual effort and is very complicated to accomplish end to end. With Release 16 and 17 versions of 5G, this will be a standard feature. Not only can slices be set up for emergency services during normal times but their parameters can be easily modified when there is a short-term crisis.

Manufacturing and supply chain sectors will benefit from 5G adoption. Across manufacturing, we have seen how some companies have switched from making scents to sanitizer, sneakers to N95 masks, and F1 cars to respirators. With 5G, the digitalization of industries will reduce time to design and build and will increase agility in changing production lines with Industry 4.0. A connected enterprise has flexibility to quickly retool and change systems on demand. That "change on demand" can also mean using automation and remote operation to rapidly increase output, improve employee safety, and ensure continuity of businesses that are fundamental to the production and distribution of essential products and services. Rapid deployment of new supply chains and logistic modes will be enabled by 5G, connecting manufacturers with their suppliers faster and more directly.

Conclusion

It is too early to be definitive about how COVID-19 will change behaviors and the patterns of 5G adoption in Latin America.

But it seems clear that increased demand for broadband can only help the 5G business case, especially in FWA for homes and businesses. Because of the pandemic, there is a clear need for digitalization of essential sectors such as healthcare, emergency services, manufacturing, and supply chain.

The need for better-quality emergency communications will encourage the deployment of network slices, a key feature of the coming versions of 5G. In the future of what is often called *Industry 4.0*, a large part of the new value creation will be around the ability for humans to remotely see, understand, manage, operate, fix, and generally interact with all manner of physical systems and machines, and that will be possible with 5G.

1. Summary

To ignore the potential of 5G is to miss a considerable opportunity or leave it to one's competitors. In this report we show the opportunity for Latin America in the mass market, as a fixed broadband substitute, and in the enterprise market.

Omdia estimates that 4G in Latin America is about 52% of lines and 3G about a third (as of year-end 2019). Even 2G remains important at 13%, and it will not disappear until well after 2024.

Commercial 5G launches in the US and South Korea have captured the world's imagination with the promise of mobile ultra-broadband. Accelerated deployments in China and the Middle East show that 5G is not limited to developed countries. By the end of 2019, there were more than 40 5G networks around the world.

But so far, Latin American operators have been relatively silent, apart from some trials, a deployment in Uruguay, and recent soft launches using DSS in Brazil.

This caution is understandable considering the late adoption of 4G. Omdia estimates that 4G in Latin America is about 52% of lines and 3G about a third (as of year-end 2019). Even 2G remains important at 13%, and it will not disappear until well after 2024.

To ignore the potential of 5G is to miss a considerable opportunity or leave it to one's competitors. In this report we show the opportunity in the mass market, as a fixed broadband substitute, and in the enterprise market. The mass-market opportunity is based on the immersive technologies powered by 5G that will take our digital experiences to the next level and beyond. The enterprise opportunity is less familiar because it has not been as important a play in 3G and 4G as Omdia believes it will be in 5G. All Latin American enterprises must explore digital transformation to remain competitive in the rapidly evolving global economy. Latin American governments must transform themselves and, more importantly, encourage digital transformation in their economies to improve productivity and return the region to real growth in income per capita.

So 5G is not an option but an imperative, and this report discusses what service providers and policymakers must do to get ready. There is a brief overview in the Appendix for those who would like to understand more about 5G technology.

What does this report discuss?

Chapter 2 sets the context for this imperative by discussing the region's macroeconomic performance over the past decade and making the case for digital transformation and ultra-broadband, especially 5G.

Chapter 3 describes the problem: a gap to developed nations in broadband penetration that is not going away.

Chapter 4 talks about use cases and the way in which various industries, including entertainment, will be transformed by adopting 5G. This chapter describes why 5G is so important in the mass market, for enterprises, and for government: it shows what can be done with it and how society will be more productive through its adoption.

Chapter 5 is the argument for Latin America: why 5G is essential to the region. It gives concrete examples, country by country for the six largest economies. It shows why 5G will improve productivity in each country's key activities and its impact on the mass market.

Now that we know that 5G is essential, it is inevitable, and Chapter 6 is about getting ready. The first part of the chapter is addressed to service providers, reminding them of where they need to invest to get their networks ready for 5G. The second part is for policymakers, essential to 5G's success because they control the allocation of spectrum and can facilitate (or hinder) 5G deployment.

Finally, Chapter 7 pulls together the conclusions and recommendations from the report.

Recommendations

Consumers will be attracted to the immersive technologies that 5G can provide (cloud gaming, VR, AR, and mixed reality). Gaming is probably for early adopters, but 5G will inspire new modes of experiencing video entertainment, education, shopping, communicating, and even traveling. Operators that successfully bundle these new offers with high-speed connectivity services in a new and immersive experience should see lower churn and better ARPU results. Latin America still has significant areas without fixed broadband coverage, and 5G is a way to address this gap.

In the enterprise market, every country has its unique characteristics. However, based on its analysis, Omdia believes that retail will be the most important enterprise vertical that will be supported by the deployment of mass-market 5G and that ICT and manufacturing will lead for 5G impact, followed by government (smart cities). In Argentina and Brazil, agriculture will also play an important role.

Recommendations for service providers

- **Upgrade 4G to be "5G ready."** Although 5G will not deploy instantaneously to all parts of the network, 5G-ready base stations will help.
- **Expand 4G coverage to support 5G plans.** Except in Colombia, 4G population coverage is good in the region, but if a target vertical (e.g., transportation or utilities) requires broad coverage (e.g., between urban centers), more investment might be required.
- **Push fiber deeper into your network.** A high-capacity, all-IP transport network is required for 5G.
- **Plan the network's future computing architecture** for multi-edge computing (MEC) and to (eventually) accommodate a 5G standalone (SA) core.

Recommendations for policymakers

- **Finish allocating 4G spectrum.** Great strides have been made in all countries in recent years, but 5G requires vast amounts of spectrum and not only in so-called 5G frequencies.
- **Develop a clear spectrum policy roadmap.** Globally and regionally harmonized spectrum brings lower prices through global economies of scale, faster adoption, and a more cost-effective network deployment.
- **Proactively develop an infrastructure policy** to encourage and help the private sector to invest in 5G networks.
- **Promote infrastructure sharing of all kinds of networks and infrastructure on commercially and technically agreed terms.** This could result in substantial cost savings and make investment more attractive.
- **Develop a national digital transformation plan.** A comprehensive national digital transformation strategy plan that includes timeline, objectives, and goals with 5G as an enabler of the digital economy should be a priority for Latin American policymakers.

2. Digital transformation, GDP, and productivity

Argentina and Brazil have seen falls in real incomes, while the other countries saw growth but often at a declining rate.

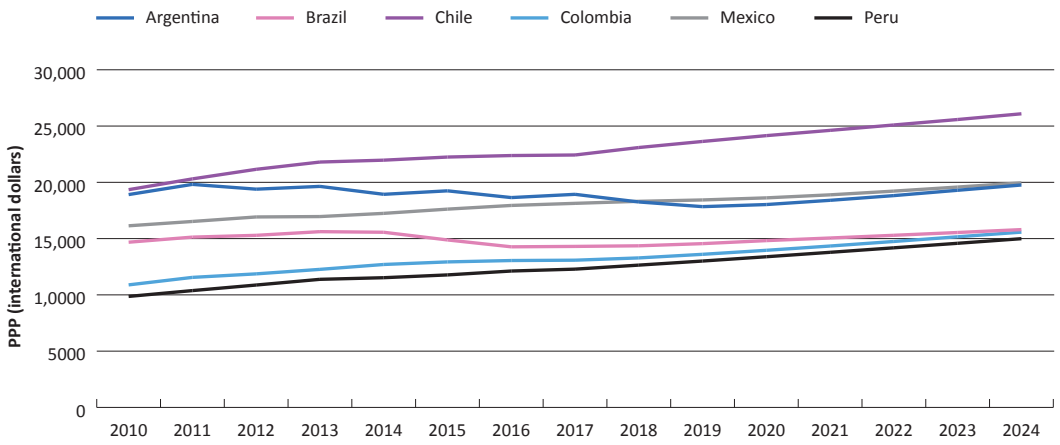
Policymakers and influencers are calling for nothing less than a transformation of the region's economies: a digital transformation to create cleaner, safer jobs that produce more added value for the country.

We have barely passed into 2020 and already commentators are calling the previous decade "lost" for Latin America.

In the first decade of the century, rising commodity prices—driven by demand from China—increased incomes and brought many in the region out of poverty. But the global financial crisis cooled the world economy for several years, and China's hunger for resources stalled, especially in the second half of the decade. As a result, Latin American GDP growth slowed, and some countries even flirted with recession.

Figure 2.1 illustrates the issue for selected large Latin American countries using GDP per capita, a crude measure of individual income, adjusted for purchasing power parity (PPP), which accounts for different price levels in different countries. The PPP adjustment puts all countries at the price level of the US, so a family earning $30,000 on a PPP basis in say, Brazil, has the same purchasing power as a family earning $30,000 in the US. Finally, the effect of inflation is removed by expressing the result in dollars indexed to a particular year, here 2011.

Figure 2.1: Real incomes in Latin America flat over the past decade



Source: Omdia

Argentina and Brazil have seen falls in real incomes, while the other countries saw growth but often at a declining rate.

Crudely, income per capita grows as the difference between real GDP growth (i.e., taking out inflation) and the growth in population. There is not much that can be done about population growth (which has been declining in these countries for decades anyway), but governments and

central banks do try to influence the rate of real economic growth. That, in turn, has to do with increasing the productivity of all sectors of the economy and shifting the mix of sectors toward those that generate more added value.

There is widespread agreement among academics, policy thinktanks, and regional governments that while natural resources and agriculture will continue to be important for some time, Latin American countries must diversify their sources of income and jobs into activities with more value added. Activities such as mining and manufacturing must become more productive, and sectors that raise political and social concerns with citizens must be safer and less polluting.

Policymakers and influencers are calling for nothing less than a transformation of the region's economies: a digital transformation to create cleaner, safer jobs that produce more added value for the country.

What is digital transformation?

Although it is a well-used term, there is no standardized definition that one could call the definition of digital transformation.

Wikipedia says "Digital transformation … is the use of new, fast, and frequently changing digital technology to solve problems."

Omdia likes this one from Salesforce: "Digital transformation is the process of using digital technologies to create new—or modify existing—business processes, culture, and customer experiences to meet changing business and market requirements ... It transcends traditional roles like sales, marketing, and customer service."

While the goal could be seen as the elimination of humans from the value chain—and in some cases that is the objective—the broader interpretation is making humans more productive, raising efficiency and/or quality, and increasing economic value added and, hence, real income growth.

Chapter 5 goes into specific cases in more depth, but mining illustrates the broader points very clearly, and it is an important economic sector for several countries in the region, especially Chile, Peru, Brazil, and Mexico.

With digital transformation of mining, the goal is definitely to apply "digital technologies to create new … business processes," but the main purpose is to move humans out of harm's way not to eliminate them. Driving vehicles around an open-pit mine or deep underground is inherently dangerous. In an open pit, the routes are narrow and constantly changing as the mine expands. In both kinds of mine, walls are fragile and might collapse, trapping miners and drivers beneath tons of rubble. The disaster in Chile a few years ago, where, fortunately, many miners were saved after a long ordeal, convinced major companies that the social, public relations, and financial cost of an accident was more than their shareholders wanted to bear. Autonomous or remotely managed trucks and excavators became the priority.

In this case, trading human operators in the mine for digital or remotely located operators might or might not save direct cost. But the benefits in terms of safety (fewer accidents, fewer lives affected by accidents) and public image outweigh any direct cost penalty.

The net benefits from any one such digital transformation project might be difficult to translate into change at the national accounts level. But the cumulative effect of many projects should be visible in total factor productivity and real GDP.

Digital transformation and 5G

While the link to IT in digital transformation is obvious, for many projects the relationship to 5G is just as clear.

Digital transformation means machines making decisions as fast as humans or with the same ability as humans to process information instantaneously. It will mean complex computing resources that humans will either wear or have very close by that are orders of magnitude more complex than at present. It will also mean having the flexibility to remain connected to such resources as humans move around or as the equipment they use moves around. Think of the mining machines described previously: augmented reality glasses to stream information to a technician, pick-and-pack robots that move around a warehouse floor, or the complexity of a flexible factory that can be reconfigured on the fly to accommodate new products or different processes.

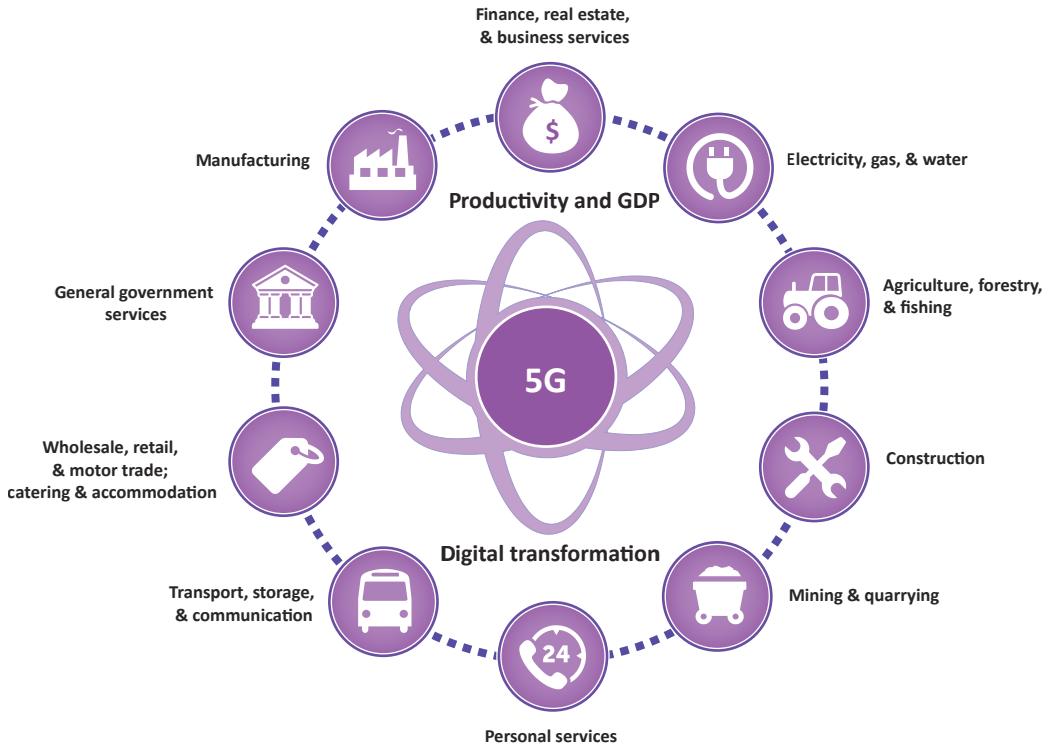
In the past, such solutions would have to drag cables around after themselves. Cabled networks are fast but inflexible; 5G will give comparable performance or even better performance (higher bandwidth, lower latency) than Ethernet or fiber with the important benefit that the sender or the receiver does not have to be fixed in place.

While motion is a feature of some applications such as autonomous or remotely controlled vehicles, simply having the flexibility to move devices from place to place easily can significantly change the productivity of a solution. Wi-Fi has provided this for decades now, but as we will see, 5G brings important benefits in performance characteristics such as bandwidth or managing reflections as well as better traffic management and quality of service (QoS) guarantees.

Consumer or mass-market 5G will enhance people's lifestyles by bringing new information and entertainment options on the move. Using 5G as a replacement for fixed broadband will enhance their experience in the home and help connect the unconnected.

But 5G-enabled digital transformation will increase productivity, raise incomes, and help to bring Latin Americans into greater economic parity with other regions.

Figure 2.2: 5G an enabler of digital transformation



Source: Omdia

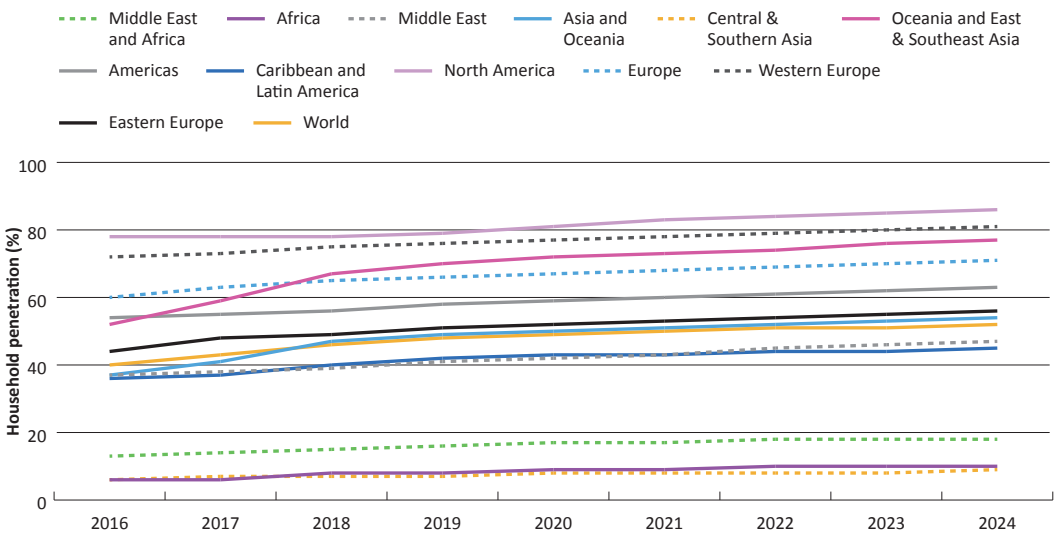
3. Broadband in Latin America

Despite growth in fixed and mobile broadband, the digital divide persists and will widen if nothing changes from a policy perspective.

Fixed broadband

Without a doubt, broadband penetration has increased in the region. Greater prosperity after the resource boom and increased investment by telcos have made more, higher-speed services available to more people at a more reasonable cost than was the case a decade or so ago. However, the digital divide with respect to developed countries persists. According to Omdia's forecast, the gap will widen if nothing changes from the current policy scenario.

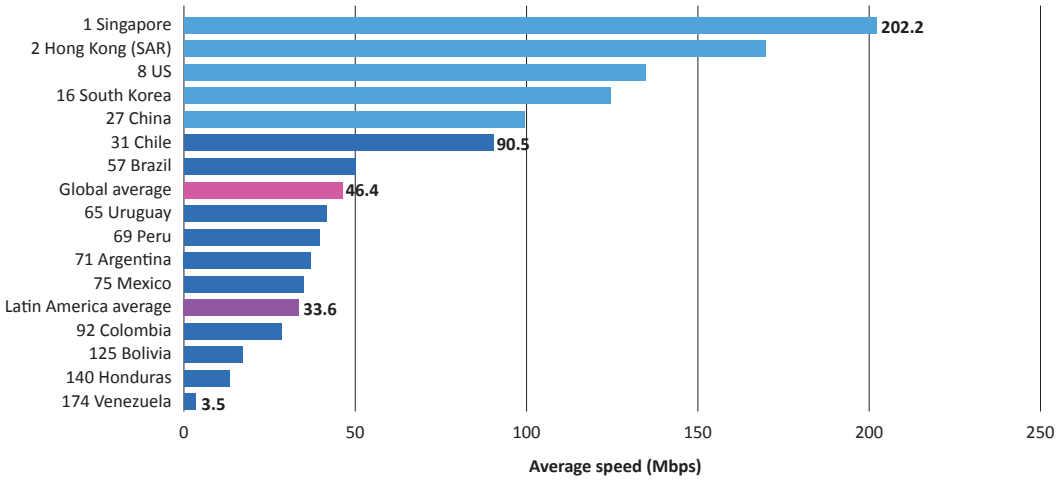
Figure 3.1: Fixed broadband penetration forecast by region (2016–24)



Source: Omdia

Latin America also lags its peers with respect to broadband speed. In the latest Ookla Speedtest Global (December 2019), Chile registered 91.5Mbps but was the only large Latin American country with an average download speed above the global average fixed broadband of 73.6Mbps, although Panama was also above average at 84.4Mbps.

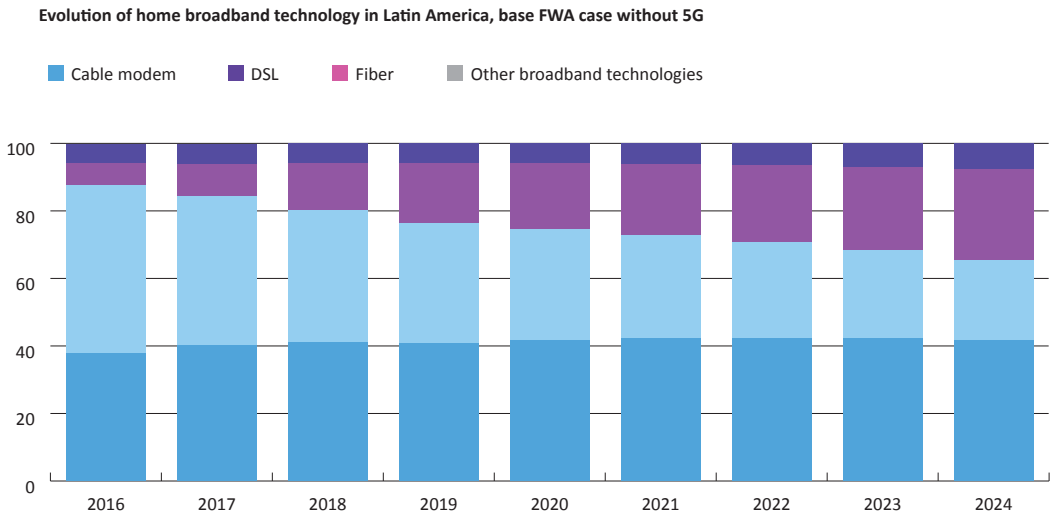
Figure 3.2: Selected countries, fixed broadband average speeds ranking



Source: Ookla Speedtest Global Index May 2019

Low fixed broadband speeds are mainly due to the low penetration rate of fiber in Latin America. Only 14% of current fixed broadband subscriptions use fiber.

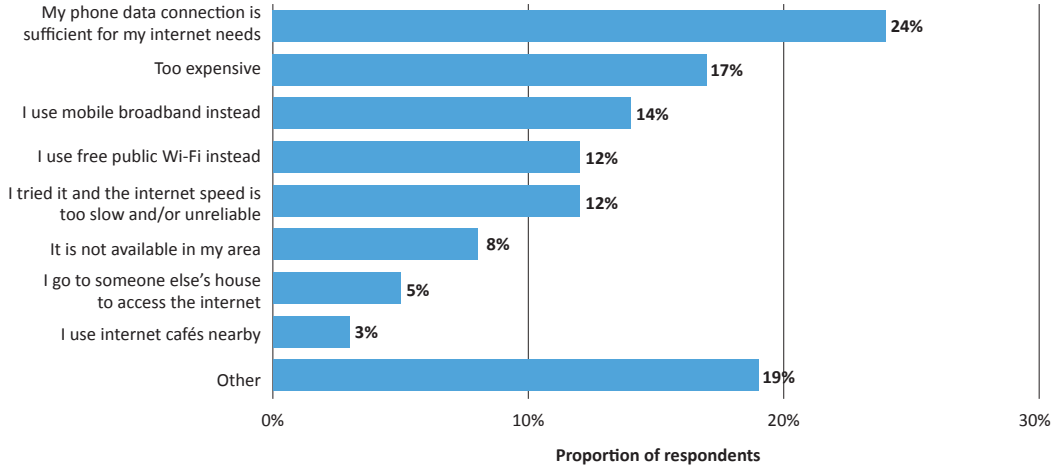
Figure 3.3: Latin America, fixed broadband technology mix



Source: Omdia

Figure 3.4 is taken from Omdia's Digital Consumer Insights survey. For a variety of reasons, more than half of Latin American smartphone internet users do not contract fixed broadband service. Not having the service available in their area or bad service connection was mentioned by 20% of the respondents.

Figure 3.4: Why smartphone users do not have fixed broadband

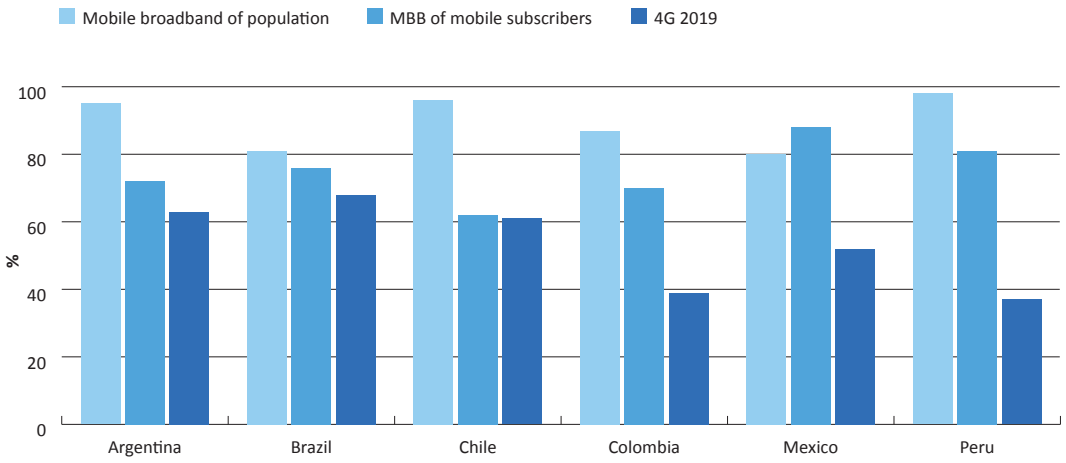


Source: Omdia Digital Consumer Insights 2018: Latin America

Mobile broadband

Mobile broadband penetration is already substantial in the region as Figure 3.5 illustrates.

Figure 3.5: Latin America, mobile broadband penetration, 2019

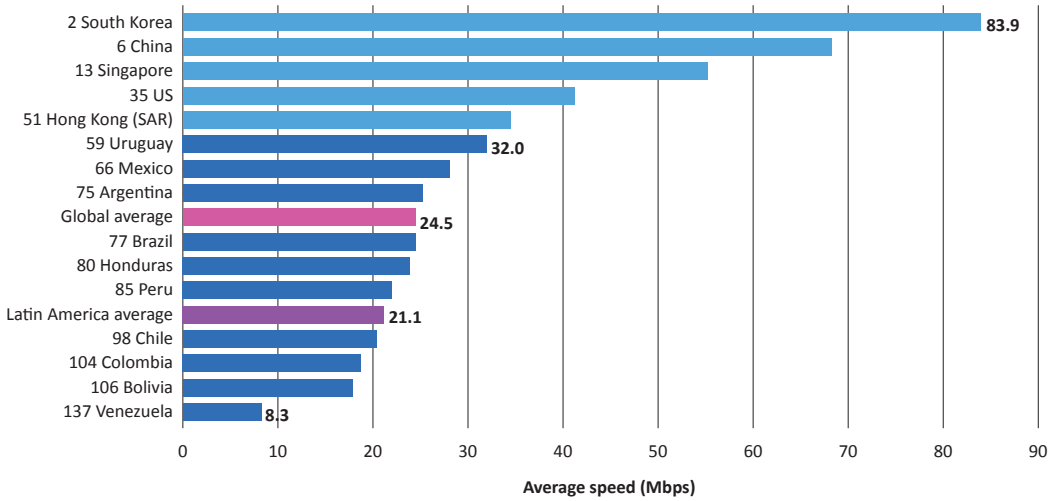


Source: Omdia

However, the chart also shows that 4G device penetration is lower than mobile broadband penetration, except perhaps in Chile, and considerably lower in the cases of Peru, Colombia, and Mexico. This means that mobile broadband includes a lot of 3G in these countries, which these days would give a rather poor customer experience.

This is reinforced by the mobile broadband speed data from Ookla shown in Figure 3.6.

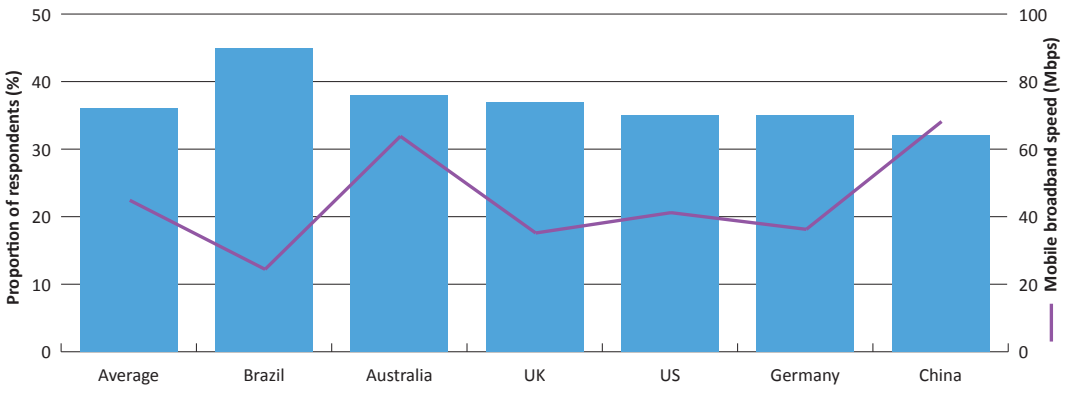
Figure 3.6: Selected countries, mobile broadband average speeds ranking



Source: Ookla Speedtest Global Index May 2019

These lower mobile internet speeds in Latin America have an impact in terms of higher Wi-Fi usage. Although it is a widespread phenomenon that some users prefer Wi-Fi to cellular networks, in Latin America (Brazil in particular) the preference is even greater for staying on Wi-Fi almost all of the time at 45% of respondents versus a global average of 36%. While quality can be better in some cases, and Latin American mobile users prefer to use Wi-Fi because it is perceived to be free, this usage also has a direct relationship to mobile network speeds.

Figure 3.7: Selected countries, users using Wi-Fi almost all the time vs. mobile broadband speed

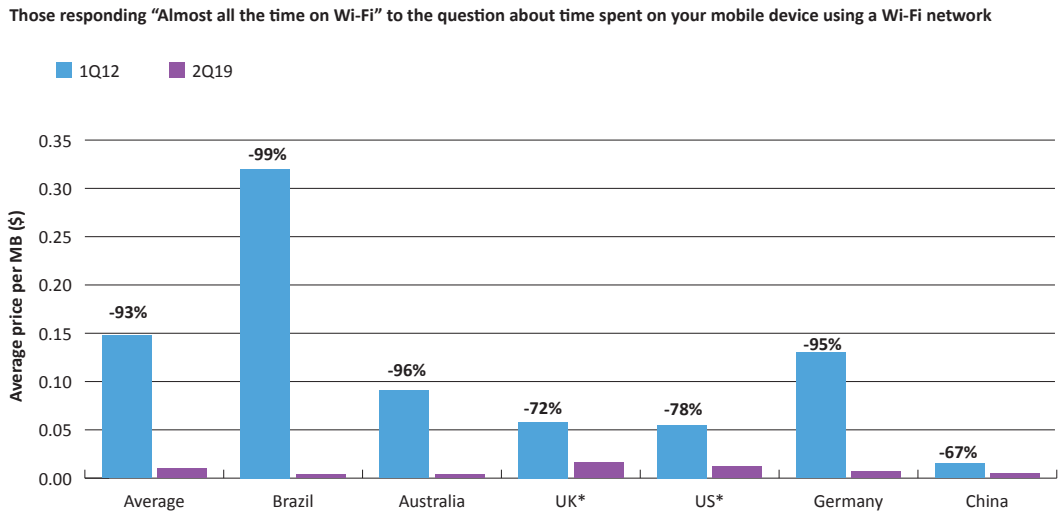


Source: Omdia Digital Consumer Insights 2018: 5G, Mobile-Only, and Multiplay

When those that spend more than half their internet time on Wi-Fi networks are considered, Latin America stands out with 72% of respondents, surpassed only by China, where 84% of users spend more than half their internet time on Wi-Fi. Latin American network quality and coverage are part of the explanation, but historical mobile data pricing is a barrier to using the mobile network.

Historically, Latin American data pricing used to be higher than the global average, and users tend to move to Wi-Fi to avoid high prices. This has changed in the last years: Figure 3.8 shows that Brazil mobile data pricing per megabyte fell by 99% in seven years and in 2019 had an average price per megabyte lower than in the US, the UK, or Germany. Users became accustomed to connecting to Wi-Fi "automatically" because of the perception that mobile pricing was too high and speeds too low. This is probably not necessary any more, and in many cases, using the mobile LTE network would be better.

Figure 3.8: Selected countries, average price per MB, 1Q12 vs. 2Q19



Source: Omdia Broadband Pricing Interactive Tracker: 2019

While the current challenges of mobile broadband in the region serve as a cautionary tale, they also show the opportunity of 5G, at least for countries such as Chile, Argentina, and Brazil, which already have high levels of 4G mobile broadband penetration. For Mexico, Colombia, and Peru, 5G represents a vastly more compelling broadband offer than 3G or 4G, and its greater efficiency should allow equivalent or even better prices, drawing more clients.

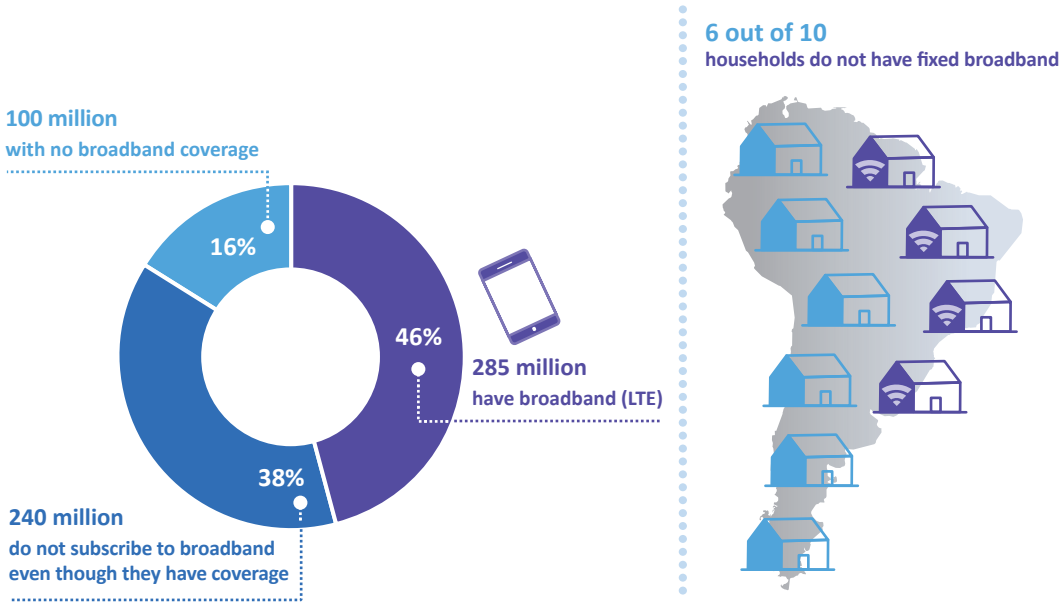
Latin America connectivity challenges

To summarize the previous data, Latin America faces two major issues:

- Increasing broadband speeds and network quality
- Connecting the unconnected: expanding network coverage to reach the uncovered 100 million inhabitants (supply side) but also increasing adoption by the 211 million Latin American inhabitants that do not have service despite coverage (demand side)

High Latin American cellular telephony penetration means most of the population have access to voice, text, and basic text-related services. But there is a huge gap to address: half of Latin Americans do not have access to internet broadband despite increasing broadband adoption.

Figure 3.9: Latin America, broadband digital divide

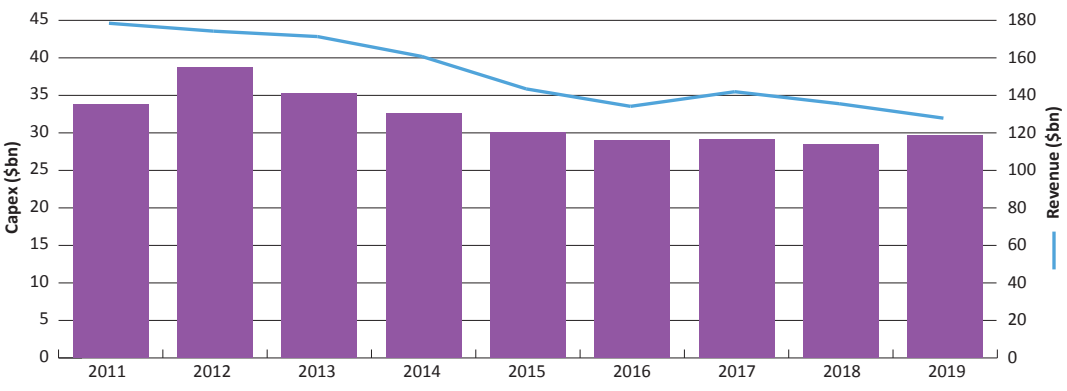


Source: Omdia. Note: total population of Latin America=625 million (8.5% of the world population), December 2019

While the digital divide is most apparent in rural and remote areas, the largest digital divide is in cities or semiurban areas. The region is experiencing a massive migration from rural areas to urban centers, fueling the growth of cities, which had 40% of the population in 1950 and have 80% today, making Latin America the world's most urbanized region.

Despite these gaps and Latin America's falling behind more advanced regions, operator network capex has been almost stable during the last decade, and revenues have been declining.

Figure 3.10: Latin America, communications providers' annual revenue and capex, 2011–19

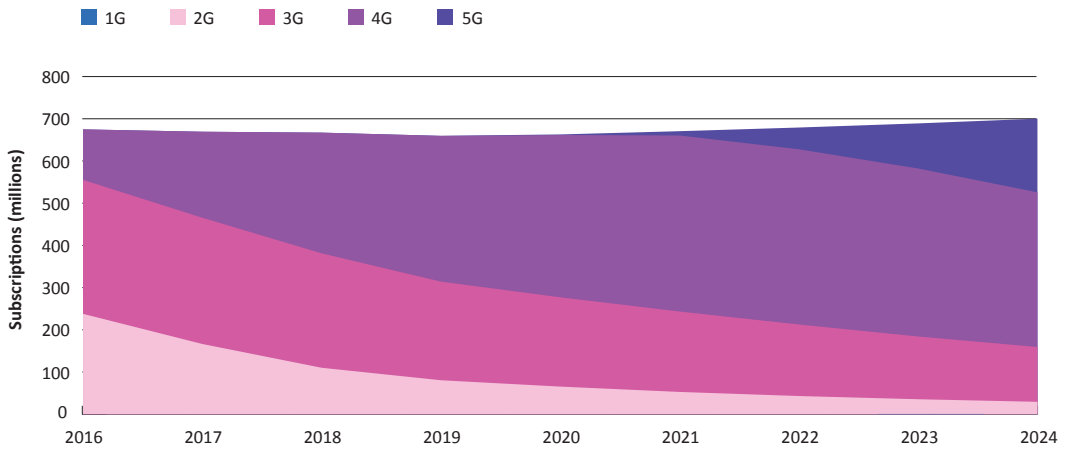


Source: Omdia Communications Provider Revenue & Capex Tracker

Mobile and fixed operators invested about $30 billion annually in Latin America over the past decade. But this has declined since 2012 as currency devaluation has lowered revenue in US dollars, the currency of capex in most companies' budgeting systems.

According to Omdia's forecasts, 4G/LTE will be the principal technology with over 440 million subscriptions, or 60% of total connections (Figure 3.11) by 2024.

Figure 3.11: Latin America, mobile subscriptions by technology generation, 2016–24



Source: Omdia

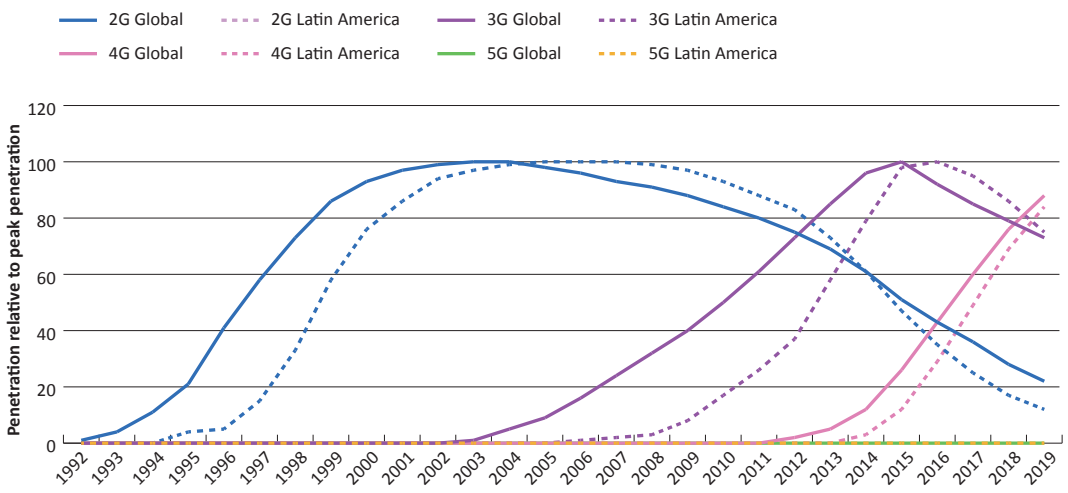
Omdia's World Telecom Information Service shows that Latin America launched 2G, 3G, and 4G around three years after the global trendsetters did. Later adoption delays the benefits, but handsets would have ridden the experience curve to lower prices, becoming more accessible to the regions' consumers, and markets tend to grow faster, replacing old technologies more quickly.

However, Latin America must continue investing in 4G while preparing for 5G. Building a high-quality LTE network is a prerequisite for 5G, because 4G is the foundational technology for the next generation.

While this chapter has focused mainly on coverage, operators must also be concerned with speed and capacity. The rapid growth of video traffic, driven by social networking and video calling, is stressing operators. The fact that adding sites is increasingly complicated in urban areas for social reasons is only adding to the challenge.

Latin American operators will be motivated to migrate to 5G, if only for its greater spectral efficiency and more effective management of small cell networks, to deal with today's constraints as well as tomorrow's opportunities.

Figure 3.12: Global and Latin America, mobile penetration relative to peak penetration, by generation, 1992–2019e



Source: Omdia Forecaster

4. Use cases for 5G

The killer app for 5G is human impatience.

Marcus Weldon, CTO and President, Bell Labs, Nokia

The uniqueness of 5G lies in the wide variety of use cases it is designed to support, spanning consumer and enterprise segments. Every vertical has special needs, and there is a 5G application for each.

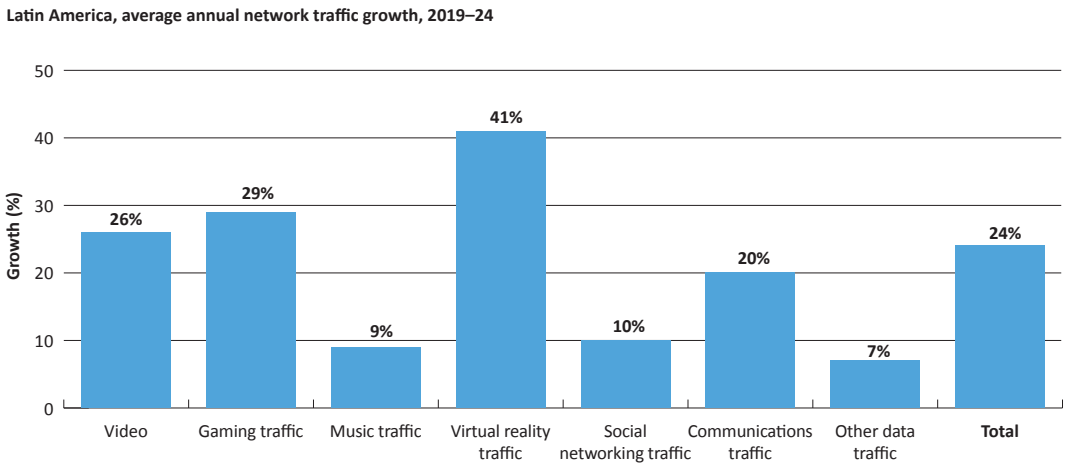
Consumer

Video

The fundamental consumer application is the same one that has fueled the growth of data in 3G and 4G: the consumption of video. As Nokia's Marcus Weldon has frequently said, "The killer app for 5G is human impatience," meaning that the main source of 5G demand, at least in the consumer segment, will be our desire to get the same content we have today but faster, in HD, 8K, or maybe 3D.

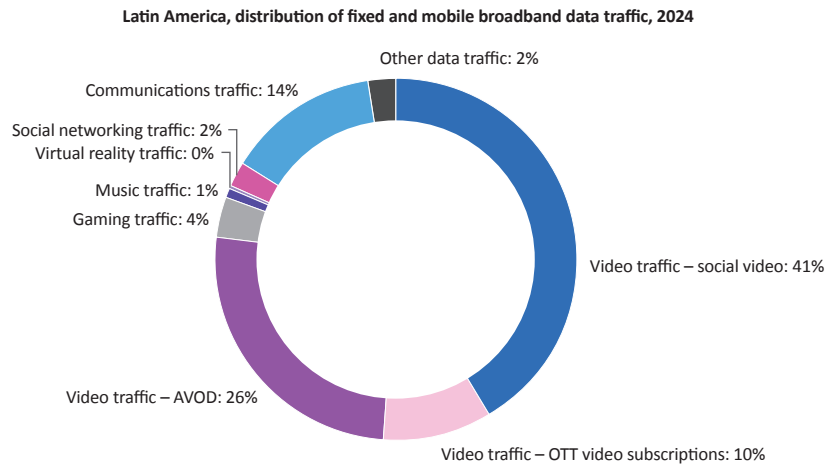
Figures 4.1 and 4.2, taken from Omdia's latest Global Network Traffic Forecast, illustrate this well. They show both mobile and fixed broadband traffic.

Figure 4.1: Latin America, network traffic growth



Source: Omdia Network Traffic Forecast: 2019–24

Figure 4.2: Distribution of global network traffic in 2024

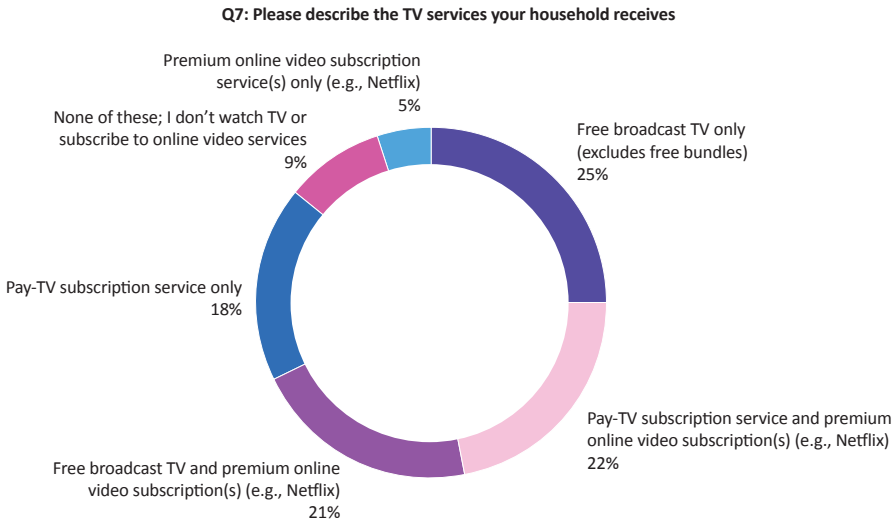


Source: Omdia Network Traffic Forecast: 2019–24

Virtual reality (VR) traffic is expected to grow faster than video traffic, but VR is growing from such a small base that it is forecast to remain less than 1% of total traffic even in 2023. Video will not only be the largest category; the overwhelming majority of network traffic will be video.

Latin Americans have adopted video streaming, as Figure 4.3 graphically illustrates. According to this data, 47% of households surveyed use an online service in some combination to satisfy their video consumption needs (with pay TV, with free TV, only online). While 9% say they consume no video, more than half of the video households say they subscribe to an online service.

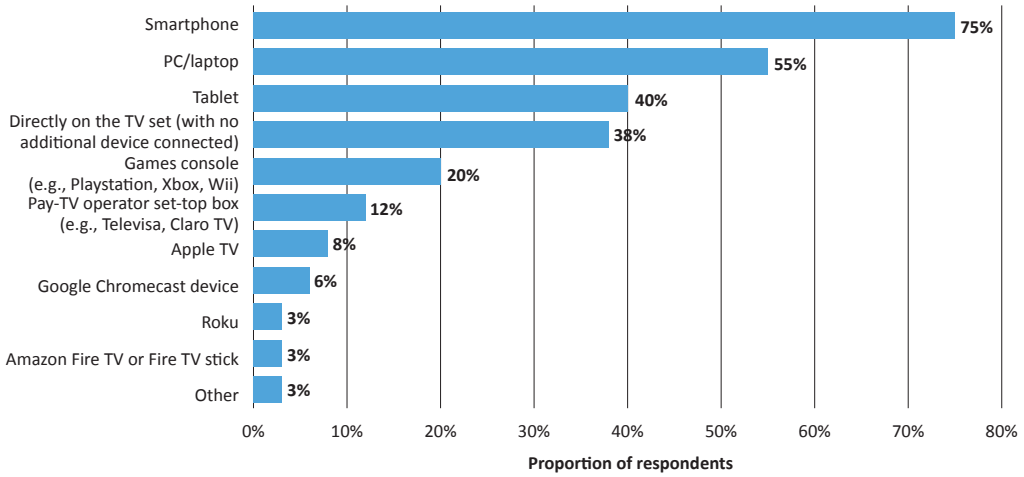
Figure 4.3: Latin America, TV services received



Source: Omdia Digital Consumer Insights 2018: Latin America

Figure 4.4, from the same source, shows that 75% of Latin Americans surveyed said they use their smartphone to access and view online video services.

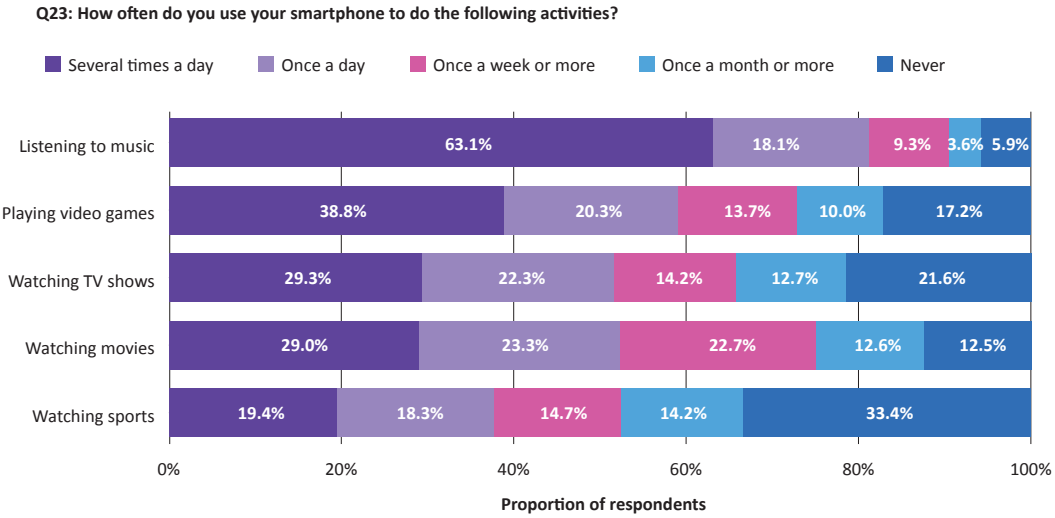
Figure 4.4: Users use smartphones, laptops, and tablets to view video



Source: Omdia Digital Consumer Insights 2018: Latin America

Finally, the survey shows that these behaviors are not casual or infrequent but part of daily life. Figure 4.5 shows that 81% of those surveyed used their smartphone to listen to music at least once a day, and more than 50% used it to watch video or TV programs daily.

Figure 4.5: Consuming music or video on a smartphone is a daily activity



Source: Omdia Digital Consumer Insights 2018: Latin America

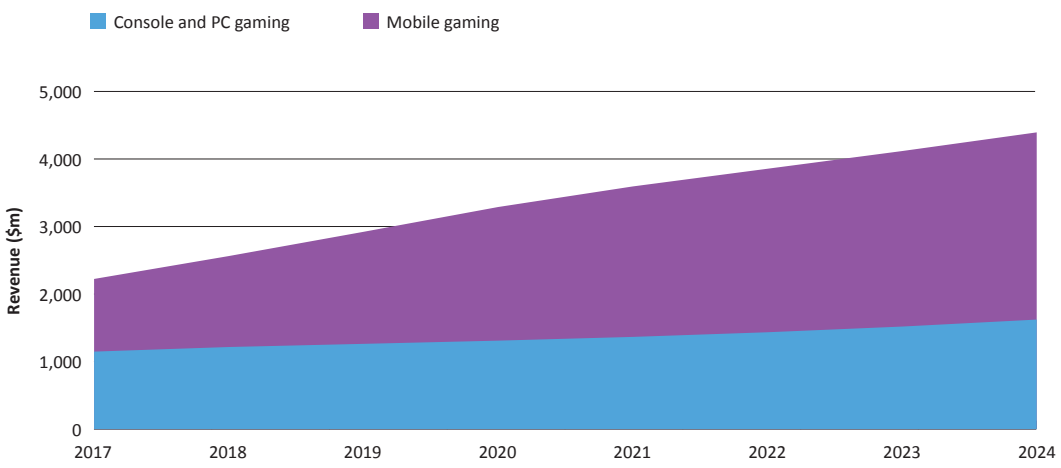
Gaming

Omdia forecasts that gaming revenue will grow 7.2% annually between 2019 and 2024 but that mobile-gaming revenue will grow 50% faster at 10.8%, allowing it to grow its share of total revenue from 36% to 43% by the end of the period. Omdia forecasts negative growth for physical distribution of games (e.g., disks or cartridges) and double-digit growth for distribution via the internet. No wonder Omdia's data traffic forecast has gaming traffic growing at 42% annually.

Although gaming traffic is forecast to remain a small proportion (4%) of the total, it is important for telecoms operators because, Omdia believes, it can be more easily monetized than many other

streams. Gamers will do anything to get an "edge," and some are prepared to pay to achieve it. Chinese and Hong Kong operators have shown the way by creating special, high-priced gaming subscriptions that give priority to their traffic, meaning much lower latency and less chance that network limitations will cause them to lose.

Figure 4.6: Mobile gaming has rapidly outgrown traditional gaming in Latin America



Source: Omdia Video Games Revenue Forecast: 2019–24

Esports is a growing subcategory of gaming where fans watch expert gamers compete against each other, whether online, on television, or even live. Omdia predicts that the consumer contribution[1] to this business in Latin America will grow at 20% between now and 2024 and that esports will become a business worth nearly $80 million (including other sources of revenue).

As smartphones and app stores became ubiquitous over the course of the last decade, a new and rapidly growing casual gaming segment emerged. Playing video games was no longer restricted to dedicated game consoles, PCs, or laptops; millions of smartphone owners in Latin America became gamers. Simple "match-three" and strategy titles such as *Candy Crush* and *Clash of Clans*, which dominated the app stores, were the first ever gaming experiences for many consumers. It is therefore unsurprising that mobile-gaming revenue is rapidly outgrowing that of traditional gaming.

As mobile technologies have evolved, so has consumer appetite for enhanced mobile-gaming experiences. The upsurge of "battle royale" games in Latin America, namely *PlayerUnknown's Battlegrounds (PUBG Mobile)* and *Garena Free Fire*, highlights the demand for premium games offering enhanced graphics and gameplay that in the past would only be found on consoles or PCs.

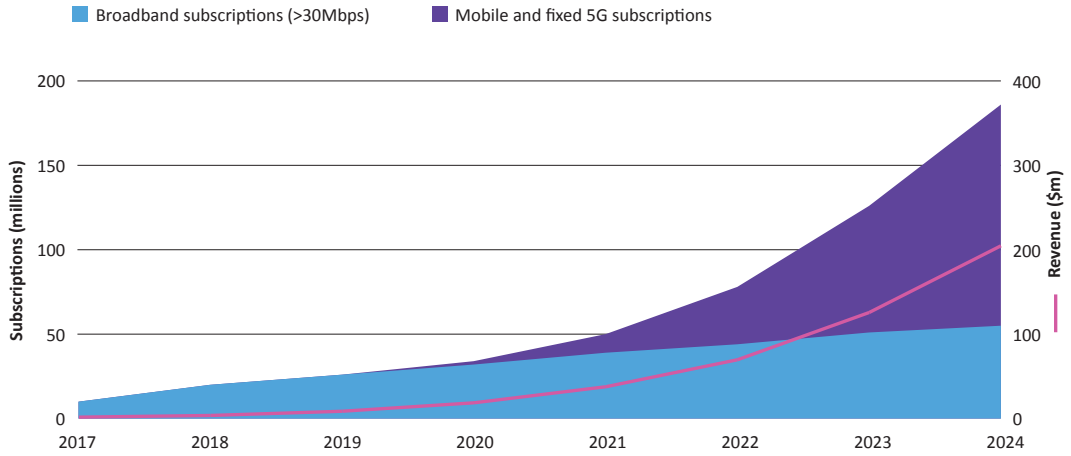
Networks are having to adapt to these new data-hungry games, which feature multiplayer elements and require constant and reliable connectivity to support the gameplay. Unfortunately, low-latency and high-bandwidth requirements increasingly risk confining mobile gaming to Wi-Fi. Add the fact that in the Caribbean and Latin America mobile gaming is set to generate $2 billion in 2020 (as much as subscription video on demand), and it is unsurprising that mobile network operators are heralding premium mobile gaming as one of the leading use cases for 5G.

The buzz around cloud gaming has reached fever pitch with many leading network, hardware, technology, and content players ramping up investments and establishing partnerships in this area. Existing game-streaming services have so far failed to attract large numbers of gamers, but Google's and Microsoft's involvement with their respective Stadia and xCloud services is gaining gamers' attention. Their immense network infrastructure and consumer offerings such as YouTube and Xbox could see them succeed where others have fallen short.

1. Consumer contribution: Revenue from consumer spend on compendiums for esports events or battle passes for virtually attending esports events. Examples include the digital compendium released each year for Dota 2's The International tournament.

In conjunction with increasing internet speeds worldwide, cloud gaming is set to democratize premium games, meaning anyone with a smartphone can enjoy a premium, console-type gaming experience. Omdia forecasts gradual uptake of cloud gaming, reaching an inflection point in 2023. Refined business models, improved cloud technology, and importantly, faster global internet access thanks to 5G will make accessing premium gaming frictionless and more immediate than ever before (see Figure 4.7).

Figure 4.7: More 5G and fast broadband subscriptions will fuel cloud-gaming adoption



Source: Omdia

New opportunities are opened up by 5G for tech vendors and network operators, which can now play a key role in the future of video games. Partnerships between cloud-gaming technology providers and network operators have a big potential to be mutually beneficial: cloud gaming is predominantly delivered as a premium, subscription-based service and is well suited for bundling. Meanwhile, network operators' existing billing relationships with customers are appealing for service vendors. Underpinning the future success of cloud gaming will be operators' core network and 5G infrastructure, which can move cloud-computing capabilities closer to users and provide the best possible gaming experience.

Entertainment

Entertainment is an interesting sector for specific 5G applications and, of course, consumer services. There are specific areas of interest such as 5G stadiums that will transform sports and concerts with a totally new experience. Fans will be able to gain access to instant replays from multiple angles through a dedicated app on their smartphones and share with friends in social networks. It will also unlock the potential of immersive reality and make it possible to make a sport match or a concert experience the same for the person in the back row or outside the venue as for the person in the front row. The gaming industry is also generating multiple opportunities where high bandwidth and low latency are key components. Argentina is recognized for its creative power in the arts, so adding 5G capabilities will generate opportunities for exports and international audiences.

There are two potential impacts of 5G. The first is to enhance a customer's experience with existing services when they migrate from 4G; ultra-high definition (UHD) video on mobile phones falls in this category. The second is all the 5G-only services, those that can only be provided over a 5G connection; some of the first examples in the consumer market are augmented/virtual reality (AR/VR) services.

Events such as concerts and sports are obvious targets for 5G-powered use cases. Early examples include UHD video, broadcasting of live events, video capturing with wireless 360-degree cameras for an immersive VR experience, and use of AR in m-commerce and education/

training videos. Features of 5G such as high speed, low latency, and network slicing can provide the right combination for such services. For instance, 5G will not only virtually eliminate poor viewer experience caused by video buffering but can also bring new forms of interaction between audience and TV shows, delivering perceptibly better experience and introducing more sophisticated interactivity options.

Among the several use cases being studied for 5G, these consumer services have the advantage, for the service providers, that they can be among the first to be deployed: they fit well in service providers' existing business models, and all that they need is 5G equipment based on Release 15. For these reasons, the first operators to launch 5G services in the US and South Korea did so with a host of video and AR/VR services. Verizon, for instance, is adding 5G coverage at NFL stadiums; LGU+ has dedicated video channels for the South Korean Baseball League, K-Pop bands, and a series of video classes using AR services. Strategically, success for service providers with these services will be important to validate investment in 5G while the other use cases are still under development.

Why 5G for consumer use cases?

We do not want to wait for the next video to start when scrolling through a social network, miss a split second of a football match, have a glitch in the middle of our favorite song, or have the screen lock up just as we are about to defeat the villain, so we hunger for faster and faster broadband.

Furthermore, we want richer experiences, higher-resolution displays, and more complex software, which developers are happy to supply as our handheld devices become more and more capable, catching up with our laptops and game consoles.

But why is 5G the answer for Latin American consumers? Will 4G not be sufficient? Or Wi-Fi? Do gamers not mostly play at home where fiber or advanced cable or DSL will be enough?

No doubt 4G, especially advanced versions colloquially known as 4.5 or 4.9G, will be sufficient for some users and for some time. But the reality is that whenever we thought a particular bandwidth was "enough," consumers demonstrated their "impatience," as Marcus Weldon says, and demanded more. Luckily, 4G is a prerequisite for 5G non-standalone (NSA), so operators can expand 4G coverage and upgrade earlier LTE systems to be ready when the demand comes.

Fiber would certainly meet the performance characteristics required for any of these consumer services and, combined with Wi-Fi, could serve the increasing need for untethered connectivity in the home or in the street. Wi-Fi is not a speed bottleneck because it is faster than most commercial home fiber services (3.5Gbps in commonly available varieties and 9.6Gbps in Wi-Fi 6, which is just rolling out).

But Wi-Fi is a best-efforts technology that lacks the network management and quality management capabilities of 3GPP mobile networks such as LTE and 5G. Raw speed might overcome some of the glitches but not all of them, and there would be reliability issues with gaming and other latency-sensitive applications.

There is currently no way to configure a Wi-Fi slice that would give gamers a guaranteed quality of service. That is a feature of upcoming releases of 5G that will bring unique service capabilities to all 5G users.

Usually configured by the homeowner or by a low-grade installer, security can also be a Wi-Fi challenge, something important to consumers with today's heightened appreciation of privacy and something that cannot be taken for granted in a public mobile network.

In short, while 4G or fiber and Wi-Fi can serve customers' needs today, maybe even next year, these alternatives will soon run up against performance, security, or network management issues that mean they will not be sufficient for the growing demands of high bandwidth, low latency, and high reliability.

All in all, 5G will positively impact several aspects of the consumer mobile market: from the infrastructure perspective it delivers a better experience than previous cellular generations and Wi-Fi, even its newest version; from the services perspective it will enable new services and will improve existing ones; and finally, from the service providers' strategy perspective, these consumer services offer a relatively easy path to scale up the 5G base while other use cases are still maturing.

Industrial, mining, and energy

Digital transformation of industry is a great hope for economic growth. However, the scope is extremely broad, so we will pick a few illustrative examples that show 5G's power and importance.

These examples are based on a dedicated, so-called private wireless network to serve the individual site. There are two ways to achieve this:

- A truly dedicated network that only operates within the site, using either spectrum set aside for industrial use (as in Germany), spectrum rented from a licensed operator, or unlicensed spectrum
- A slice of a public network that allows the site to have unique performance characteristics and be free from interference with other users, consumer or industrial

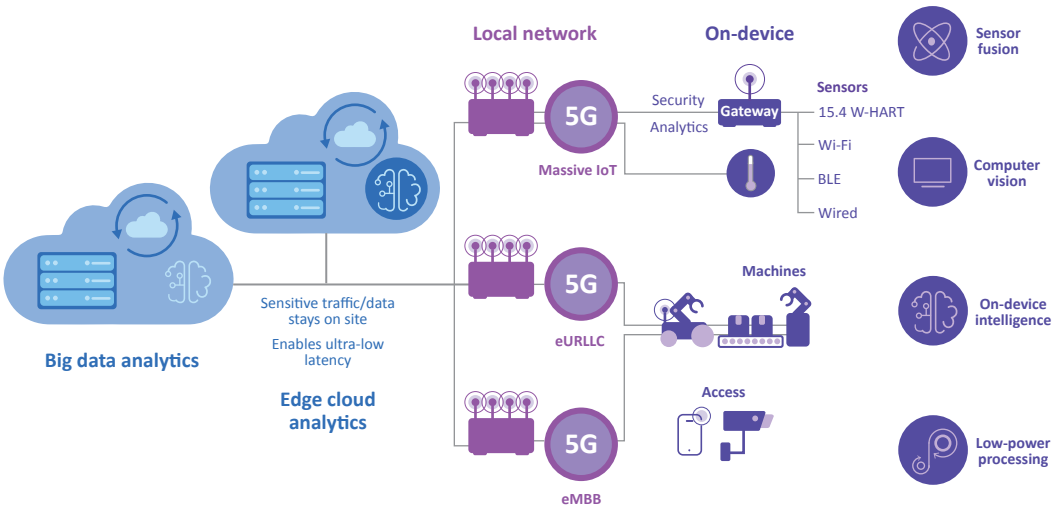
The opportunity for a network operator is to sell a network slice to such industrial clients. Regulation or spectrum availability may dictate in some cases that this is the only legal solution. In other cases, clients may see benefits in getting an expert (the mobile network operator) to manage the difficult task of running a private network. However, some clients may prefer to have their own dedicated network under their own control.

The decision between these options depends heavily on spectrum availability and regulation, but skills availability, pricing, and corporate strategy also play a role.

The emphasis will be on 5G in the following sections because Omdia believes this is where such networks will eventually evolve.

But there is no reason why private networks could not be adopted today using LTE (especially advanced levels of LTE) for applications that are less dependent on low latency. Industrial, mining, and energy companies often start transforming their communications infrastructure based on a single application, usually an existing one such as asset tracking or internal voice and data communications. Almost by definition, today's needs can be satisfied with existing network designs based on 4G/LTE.

Figure 4.8: Industrial IoT in 5G



Source: Omdia, Qualcomm

Later, as the company transforms itself digitally and puts more demands on its basic applications (lower latency, higher sensor density, etc.), it will have to migrate to 5G, but the fundamental

architecture and many fundamental operational and infrastructure components can already be in place.

Although they are not yet widespread in Latin America, around the world there are a number of examples from which we can learn. A common occurrence is that there is an initial application that drives the deployment of a private network. Later, companies find other uses for the capacity already installed for other transformations, consolidating ever-increasing amounts of traffic onto the private network. In the discussion that follows we will refer to the initial application, which is what has been observed to be the primary justification for a private network, and then discuss subsequent applications for the other uses of the existing capacity.

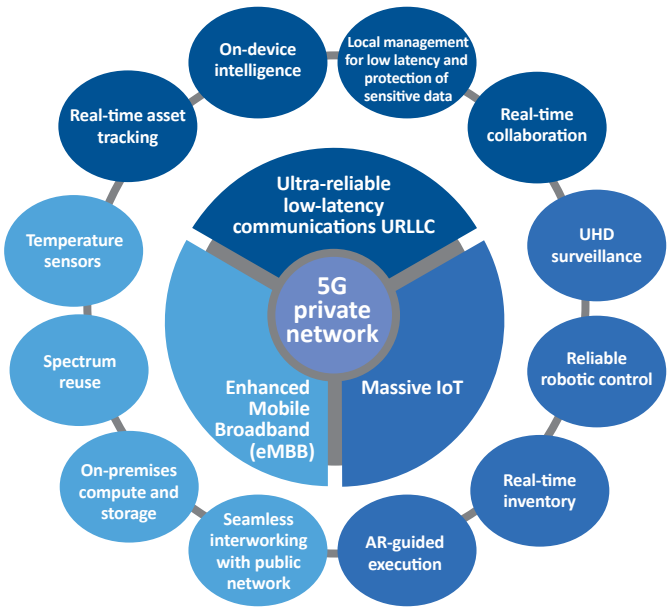
Industry

The manufacturing industry is on the brink of change to be brought about by 5G. Through unprecedented speed, low latency, and bandwidth capacity, 5G can enable manufacturers to do more with the mega expansion of the IoT, to collect more data, and to analyze more information faster to make better business decisions. It can also be an innovation catalyst, both in the creation and quality of products and in how these products are delivered into the supply chain.

Because manufacturing plays such a key role in the global economy, every manufacturer has the potential to affect companies in other industries, such as transportation, retail, healthcare, and many others. Since 5G will eventually help make it possible for companies to adopt new and emerging technologies, including advanced robotics, vision systems, AR, and AI, it can help achieve enhanced efficiency and reliability of manufacturing. The volume, security, and reliability that Wi-Fi cannot provide can all be addressed by 5G.

Thanks to 5G, manufacturers will be able to achieve new levels of factory optimization through AR and VR. These technologies can display overlays to help to guide workers through production steps for intricate assembly processes. Integrating video-based technology with IoT will add another layer of analytics to industrial manufacturing. Manufacturers can improve safety protocols with more sensitivity and insight into anomaly detection that can help reduce defects, improve efficiency, and reduce costs. Automated guided vehicles and industrial mobility technologies are clearly game changing, providing cost reduction, productivity gains, and increased safety. A 5G-connected factory is the only way to be competitive in a global economy.

Figure 4.9: Dedicated 5G private networks for targeted needs



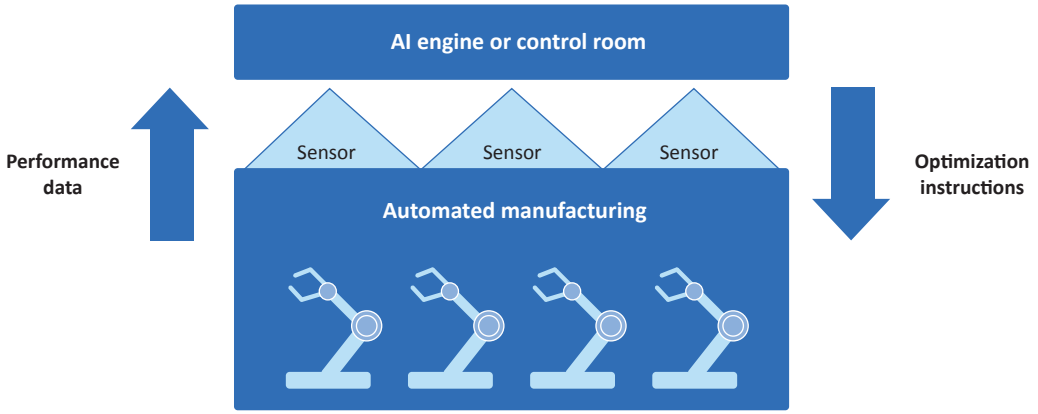
Source: Omdia

Perhaps the prototypical example of a private network application is a large factory. Modern factories are already highly automated, requiring communications networks within them. So-called Industry 4.0 initiatives imply putting sensors on virtually everything to measure and optimize operations in real time, increasing the communications requirements.

Industry 4.0 is the umbrella term for a wide range of smart factory ideas including the Industrial Internet of Things (IIoT), AI applied to manufacturing, extreme automation, robotics, and so on. The initiatives are sometimes referred to as *cyberphysical*, being the integration of physical systems (such as assembly robots) and IT (or cyber systems).

Figure 4.10 shows the main components of an Industry 4.0 system.

Figure 4.10: Main components of an Industry 4.0 system



Source: Omdia

A company with an automated manufacturing system in its factory (here represented by a series of robotic arms) installs sensors (video, tactile, temperature, pressure, chemical properties, etc.) that communicate back to a control function (perhaps human, perhaps an automatic controller that has some sort of AI within). The controller sends back messages to the automated manufacturing system to adjust the operation as required for optimal performance.

Omdia calls the central core of this application—the automated manufacturing, sensors, and control—operations technology, or OT, to distinguish it from information technology, or IT. IT may be involved—an AI-based controller has to run on some sort of server, performance data will be saved for analysis, and the history of optimization will be stored for audit purposes—but the core of the smart factory is OT, and OT vendors are normally at the center of their implementation.

The role of the private network is to send performance data from the sensors to the control function and optimizing instructions from the control function to the automated manufacturing equipment.

The application described above is the initial driver for some sort of broadband communications network in a factory.

Eventually all factory communications can be migrated to the private mobile broadband (P-MBB) network including

- Voice and text communications between employees
- Video sensors
- Physical security systems including cameras
- Asset tracking
- Autonomous guided vehicles (AGV): robots for the distribution of raw materials or tools

These represent a mix of narrow and high-bandwidth traffic demands that can be accommodated easily if the original design was high bandwidth but that might be hard or even impossible to simply graft onto a narrowband solution.

Mining

Another prototypical private network situation is a large mining complex.

The fundamental issues are tracking and communicating with vehicles and often employees in a complex environment. However, it is important to distinguish between two important subcases: open-pit mines and underground mines. The applications can be slightly different, and the radio challenges are absolutely different.

Multinational mining companies are increasingly turning to autonomous or remotely controlled mining equipment to solve two challenges: efficiency and safety.

With few exceptions, the mining industry's products are commodities and so can suffer from low prices and (virtually) identical quality. Profitable operation in the face of wildly varying and often uncontrollable prices implies having the absolutely lowest-cost operation. As with other Industry 4.0 applications, the mining industry has found that autonomous or remotely controlled equipment is more cost-effective, even for low-skilled labor such as dump-truck drivers.

Global mining companies are pursuing such solutions even in emerging markets such as Chile, Peru, or Africa, where traditionally it has been thought that low wages made automation business cases hard to justify.

Safety is the other industry demand for autonomous or remotely controlled equipment. Mining is an inherently dangerous business. In open-pit mines the main issues are the collapse of fragile pit walls, driving on narrow roads to get heavy trucks out of the pits, and accidents between vehicles and employees. Underground mines have the same issues, but there are additional dangers (e.g., poisonous gases), and rescue issues are more complex.

For 69 days in 2010, the world was gripped by the Copiapó mining accident in Chile. It took 17 days just to discover that 33 miners were still alive and trapped in a partially collapsed tunnel. The cost of the rescue (estimated at more than $20 million) and, more importantly, the human cost (although the 33 were saved) implied a significant impact on the mining company and its investors.

Since mining accidents are almost inevitable, the long-term strategy is to minimize the number of humans at risk.

Mining equipment manufacturers such as Caterpillar and Komatsu have developed autonomous or remotely controlled mining equipment to excavate the ore and robots to load the material into autonomous or remotely controlled dump trucks.

This is not as complex a problem as, say, an autonomous taxi. There are fewer moving obstacles, the obstacles are more predictable (often other guided vehicles), and the routes are fewer and more predictable. But it is still a considerable data and communications challenge, requiring low-latency, high-bandwidth communications.

The plastic nature of mines—the constantly changing shape of open-pit mines as material is excavated or, in underground mines, the opening of new tunnels and the abandonment of others—means that cabled solutions are inflexible. In any event, the machines, especially the trucks, are themselves mobile, and wireless solutions are the only recourse.

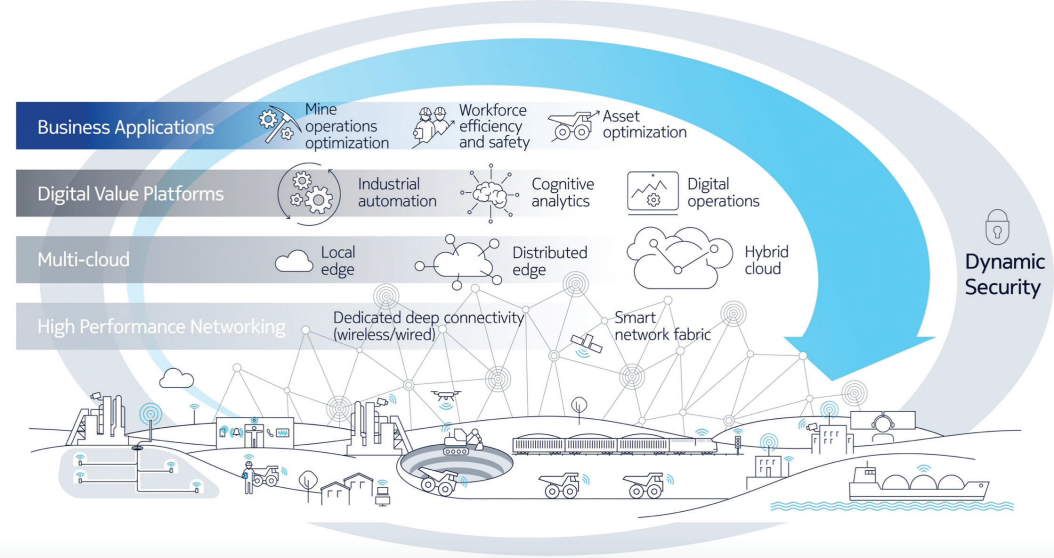
Once the high-bandwidth P-MBB network has been built to connect the autonomous or remotely controlled vehicles, other existing and future applications can be migrated onto the new platform. These include

- Traditional push-to-talk (PTT) and push-to-transfer (PTX) communications between employees
- Physical security systems including cameras
- Geo-tracking of employees and equipment
- Remote operation of several mines from a central site

The first is narrowband and the second is a typical broadband application. The fourth is also broadband and requires low latency to ensure that the round-trip time to detect, decide, and respond is short enough to avoid accidents.

While geo-tracking in open-pit mines can use traditional GPS technologies, signals are blocked in underground mines. The only solution is 3GPP based, which naturally provides location information and manages reflections of signals through tunnels.

Figure 4.11: 5G for mining can create an intelligent, dynamic network that increases safety, productivity, efficiency, and responsiveness



Source: https://www.nokia.com/networks/industries/mining/

Energy

Energy extraction comprises a wide range of activities including oil and gas production, solar farms, and windmills. Technically, it should include coal mining, but that has already been discussed.

The common factor to these disparate activities is a complex industrial process requiring precise measurement and optimization and, often, remote operation.

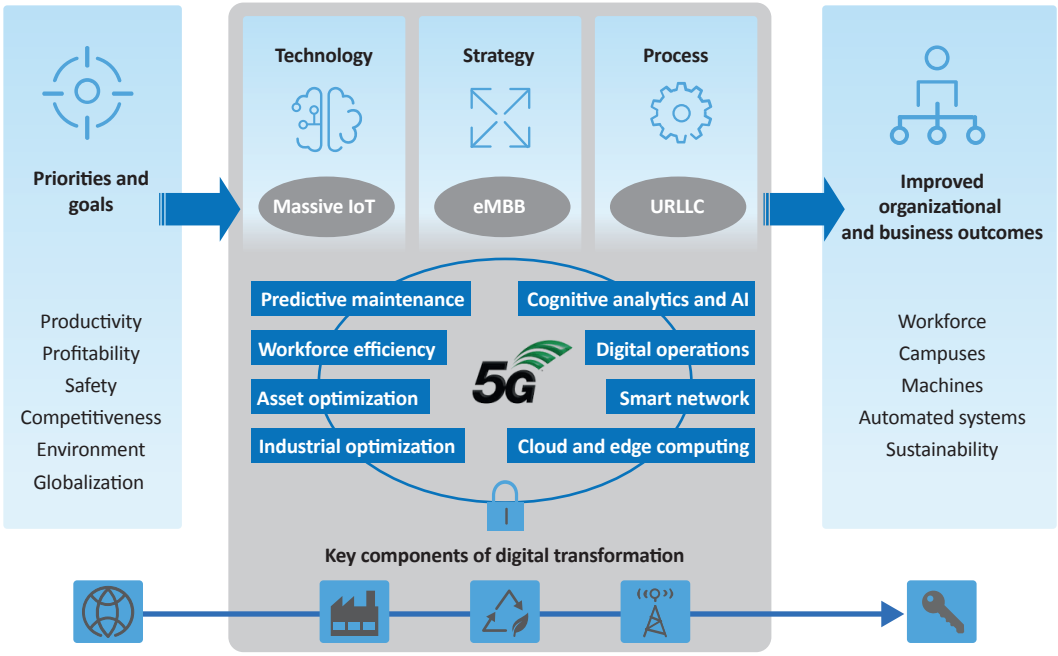
Oil and gas are not found in the center of a city (and if they were, environmental laws would prevent their extraction). "NIMBYs" and finding reliable wind currents mean wind farms have to be located far from where people live. Solar farms need lots of space, and land values mean they have to be well out of high-priced urban areas.

On the complexity issue, modern energy extraction is, in many respects, a particular application of Industry 4.0 principles to industrial processes that have been around for some time. Solar power generation goes back only a few decades, but oil has been pumped out of the ground for over a century: natural gas extraction dates to 1859. The first windmills were found in ninth-century Persia.

Like the smart factory described earlier, today these processes require significant sensor arrays to monitor all aspects of production, a detection function to determine whether the process is running at an optimal level (and in the case of oil and gas production to detect potential hazardous events), and a control function to take action and return the process to a safe, optimal level.

The sensors are different for each application (pressure is the key variable in oil and gas production, blade pitch is critical for a modern windmill), but the basic characteristics required for the application are the same. Multivariate sensor data has to be transmitted in real time, at low latency, to a central, often remote point. Round-trip time for the detect, decide, respond cycle has to be short for both efficiency and safety reasons.

Figure 4.12: 5G framework: oil and gas in 5G enables a converged network that uses the best mix of advanced technologies converging robust and reliable services for critical applications



Source: Omdia

These elements are not in motion, but the people and vehicles that work there are. Clients may prefer the flexibility of using wireless solutions because it is easy to add or delete elements (windmills, solar panels) or even whole sites (oil and gas wells eventually run dry).

Additional applications depend on specific implementation.

Wind farms and solar farms are generally unmanned and may need no more communication (beyond the sensor/control system) than infrequent access to corporate communications for maintenance personnel. Since one of the objectives of applying Industry 4.0 principles to energy production is to minimize the need for expensive maintenance, this connectivity cannot be a driving design principle.

Onshore oil fields are normally much larger (hundreds or thousands of hectares) but with minimal staff in the production phase. Again, they may need only minimal connectivity beyond the core application.

However, offshore oil platforms are miniature floating cities. The Deepwater Horizon had a crew of 130. Royal Dutch Shell is building a floating gas liquefaction barge 500m long by 74m wide. These create the need for intraplatform communication and for connectivity to wider-area corporate and even public networks.

Why 5G for industrial, energy, and mining use cases?

Obviously, these examples have quite different characteristics in quite different environments. They do, however, share some common features:

- Massive amounts of sensors transmitting multivariate data in real time, implying high bandwidth
- The need for very fast detect, decide, respond round-trip cycles that imply low latency
- Elements in motion or elements that need to be rapidly reconfigured
- Assets that are often worth millions of dollars
- Severe and expensive consequences of failure, damage, or even momentary downtime.

Often there is an existing Wi-Fi network, but as the communications demands become more complex, this becomes inadequate, unreliable, or both, leading to the need for a more robust, 3GPP-based solution.

In a traditional factory, a wired solution is conceivable. But modern manufacturing requires more flexible arrangements including the ability to reconfigure productive lines for new products or special runs of existing products. Industrial robots trailing cables behind them are hardly the image of agile manufacturing, and the cables are subject to accident and wear.

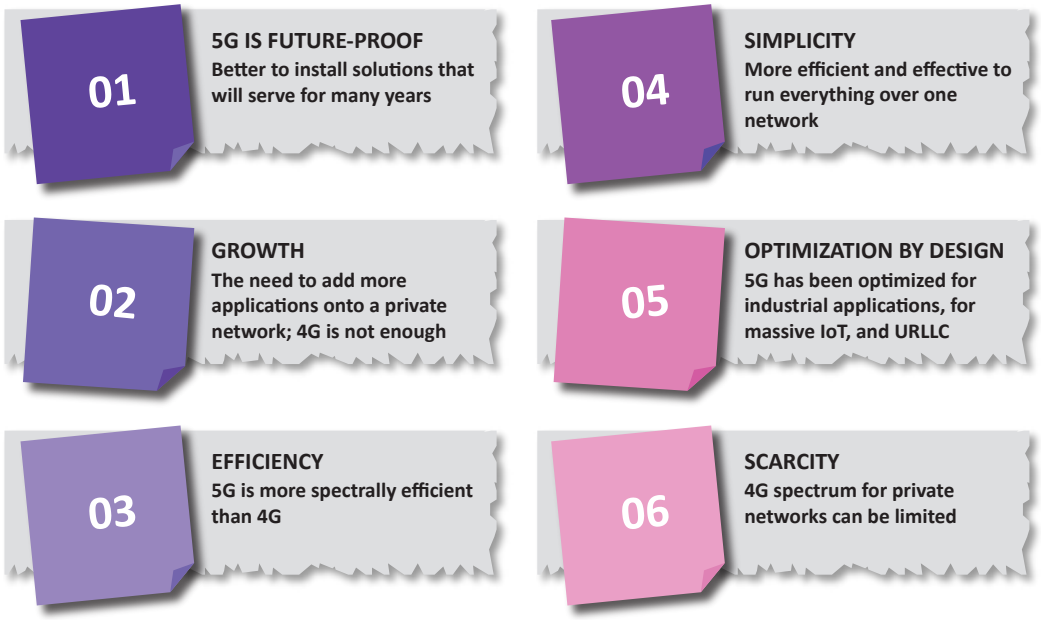
Thus a modern factory is, in a real sense, mobile. The factory itself does not move, but its components do.

In a mine, not only are the devices in movement but the physical space the network has to cover is also moving (albeit slowly). There are similar considerations in energy: the issue is not so much that the sensors are in motion but that they are distributed over a large, constantly changing space as new elements (wells, solar panels, windmills) are added to the facility and others are retired.

Common characteristics are that the right communications solution has to be high bandwidth, low latency, untethered, and have ultra-high reliability. Wi-Fi 6 can meet some of these requirements, but as discussed previously, it lacks the reliability and security of 3GPP solutions.

Bandwidth and latency will determine whether 5G is absolutely necessary or 4G is sufficient. However, Omdia recommends “rounding up” to 5G in these cases for several reasons:

Figure 4.13: 5G benefits vs. 4G



Source: Omdia

- It is future-proof: it is better to install solutions that will serve for many years.
- We know from existing examples that companies will add more and more applications onto a private network as they figure out what they can do with the capability; if 4G is enough today, it will not be in the near future.
- It is more spectrally efficient than 4G, and the spectrum available for private networks, even those sliced out of public networks, can be limited.
- On a related note, while some of the applications might not require 5G, it will be more efficient and effective to run everything over one network than to maintain several overlapping ones.
- Especially in Releases 16 and 17, 5G has been optimized for industrial applications, massive IoT, and ultra-reliable low latency.

Smart cities, e-government/e-society, education, and health

The e-government and e-society applications of 5G have to do with the digital transformation of government in the broadest sense, ranging across national, regional, and local governments and including the internal processes of the bureaucracy, those that interact with citizens, and the services that governments provide to their "clients."

Not all digital transformation of government and society requires ultra-broadband. Simple queries and forms can run comfortably over narrowband, although the citizen experience is enhanced by the almost instantaneous responses that these platforms will provide with broadband. Even within broadband, here is another case where 4G is better than no G, and for some applications, 5G will be better than 4G.

Here we concentrate on use cases that require broadband, the faster the better.

Smart cities

According to the Smart Cities Council, worldwide, cities account for

- One percent of land use
- Fifty-five percent of population
- Seventy-five percent of energy use
- Eight percent of emissions

The United Nations Department for Economic and Social Affairs says that in 2018, an eighth of the world's population lived in 33 megacities (defined as having more than 10 million inhabitants) and "By 2030, the world is projected to have 43 megacities … most of them in developing regions." Of the 30 largest cities globally in 2020, five will be in Latin America, more than any other region except the geographically extensive and more populous Asia Pacific.

Clearly, making all cities more effective at delivering services to their citizens, at less cost, with greater energy efficiency and less pollution, will be the central challenge of this century. The Smart Cities Council defines a smart city as one that "… uses information and communications technology (ICT) to enhance livability, workability, and sustainability," that is, to address these fundamental challenges.

The *workability* concept is defined as "cities that provide the enabling infrastructure—energy, connectivity, computing, essential services—to compete globally for high-quality jobs."

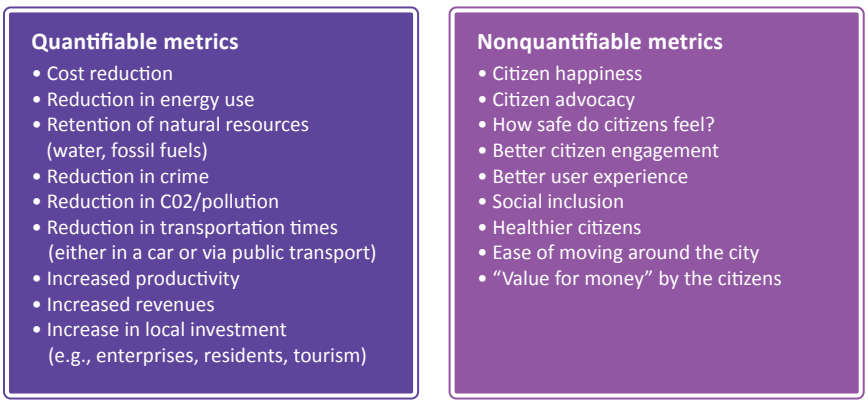
Although connectivity appears as but one of the four essential enabling infrastructures, in fact, broadband connectivity, based on fiber, is critical to the other three as well.

- **Energy.** Greater energy efficiency is all about understanding the nature of demand, shaping it when possible, and delivering the necessary resources at the right time. That means effective measurement and low-latency measure-decide-act loops in the energy management system. Low-latency communications demand fast broadband, either fiber or high-speed 4G or 5G services.
- **Computing.** Today's cloud-based computing architecture is enabled by high-bandwidth fiber communications. Without ultra-broadband, remote storage and processing simply do not deliver as required. "Competing globally for high-quality jobs" means robust international fiber connectivity but also high-speed connectivity within a city to allow distributed workplaces that promote livability (often fiber but 4G or 5G for untethered applications or to deal with low user density).
- **Essential services.** These include municipal responsibilities such as water, waste processing, traffic control, and street lighting. It certainly includes mission-critical services such as police, firefighting, and disaster response. Depending on the social and political structure, the concept might also include education and healthcare. Like energy, the foregoing all depend on measure-decide-act control loops requiring low-latency systems. Modern mission-critical systems live on top of advanced wireless networks, and it would be hard to conceive of modern education and healthcare systems without high-bandwidth connectivity.

In many cases, the most effective medium to connect to a device such as a sensor, a traffic light, a surveillance camera, or the terminal in a police car is high-speed wireless, that is, advanced versions of 4G or, eventually, 5G. A police car is mobile and so has to be wirelessly connected, but even fixed devices such as cameras or sensors can benefit from the flexibility of not being physically attached to an immobile interconnection point. Wireless devices are easier to move around to different locations, less affected by wind or rain (the connector is often the most vulnerable point), and easier for maintenance workers to swap out for repair or upgrade.

A city also plays an important role in educating its citizens, promoting the value of digitally transformed utility services, and encouraging the use of e-government capabilities. This grows the capabilities of the city's inhabitants and expands the digital ecosystem. Growing this ecosystem is essential for fulfilling the municipality's responsibility to "compete globally for high-quality jobs."

Figure 4.14: Smart city business case metrics



Source: Omdia

Table 4.1: Smart city business case metrics mapped onto smart city applications		
Smart city application	**Primary business case metrics**	**Secondary business case metrics**
Smart street lighting	• Cost savings through a reduction in energy use • Cost savings/increased productivity of maintenance teams (lower fault rate, quicker detection)	• Sustainability targets (due to lower energy consumption) • Reduction in crime (better/responsive lighting) • Increase in local area business investment (e.g., lighting often associated with district regeneration
Smart parking	• New revenue generation • Increased utilization of parking spaces • Reduction in manual labor costs to monitor parking spaces/issue tickets	• Reduction in CO2/pollution, • Reduction in transportation times • Increase in local area business investment • Reduction of driver stress
Public security & CCTV	• Reduction in crime • Increased productivity of emergency services • Greater resilience • Increased public safety	• Increase in local area business investment (if area made safer) • Less quantifiable metrics such as how safe citizens feel, overall happiness, desire to live and work in that area
Traffic management	• Reduction in transportation times (often linked to emergency services response times) • Reduction in congestion • Reduction in CO2/pollution	• Reduction in maintenance costs (quicker fault rate detection) • Reduction of driver stress • Increase to local economy (improved logistics for local businesses & more people likely to visit city)
Smart urban transport	• Increased revenues (from more citizens using public transport) • Reduced congestion • Reduction in CO2/pollution • Reduction in consumption of natural resources (electric vehicles/car pools/shared bikes)	• Reduction in costs long term (electric vehicles) • Increase in local investment (making it easier for citizens to travel to specific destinations) • Less quantifiable metrics such as citizen happiness, better user experience, and ability to move around city
Environment & infrastructure management	• Cost reduction, increased productivity/efficiencies (waste management) • Sustainability, CO2 reduction, retention of natural resources (environmental monitoring)	• Citizens' sense of "value for money" • Increased citizen advocacy rates • Improved citizen health • Citizen happiness
Source: Omdia		

Education

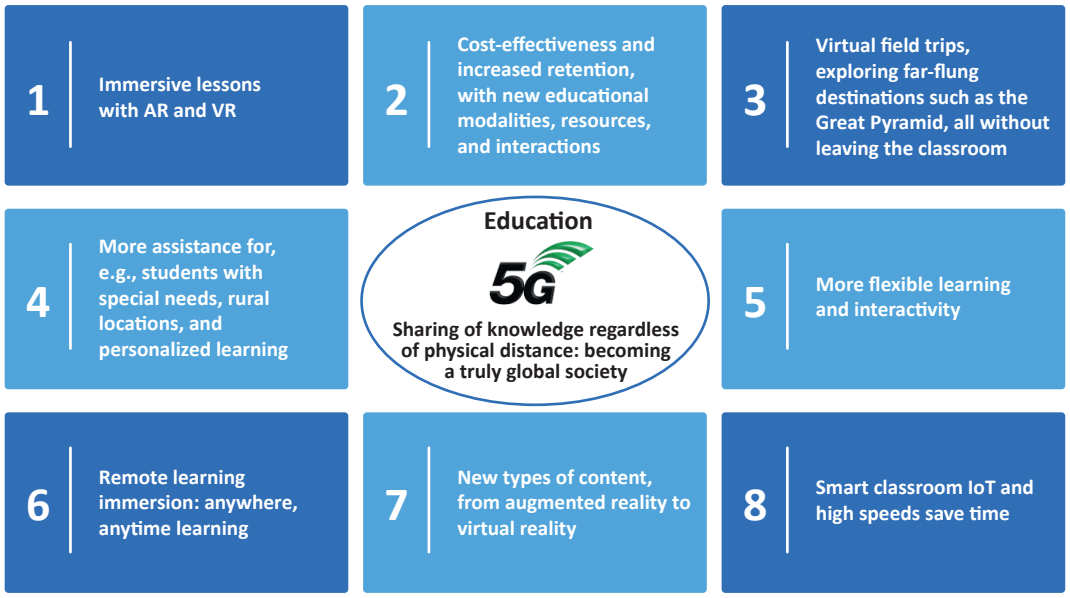
A number of NGOs and think tanks point to Latin America's poor educational record as a contributor to poverty and inequality. The Inter-American Development Bank says Latin American nations "are on average 2.5 years of schooling behind the average for the OECD,"[2] and Educando, an NGO, says "Approximately 50% of Mexicans, Colombians, and Brazilians do not have the skills necessary to solve simple math equations or to explain basic scientific phenomena."[3]

All agree that access to scarce high-quality teaching resources is critical, and STEM (science, technology, engineering, and mathematics) training requires access to specialized facilities. For more than a decade, governments have been experimenting with distance education solutions to bring good teachers to a much broader audience and allow students to interact virtually with specialized tools. The recent COVID-19 crisis brought home the importance of distance education even for urban households as schools closed and, in some countries, children lost their academic year.

2. https://blogs.iadb.org/ideas-matter/en/latin-america-the-caribbean-and-pisa-the-long-road-ahead/

3. https://educando.org/education-latin-america/

Figure 4.15: 5G in education



Source: Omdia

Remote lecturing is yet another video application and requires the same tools discussed in the consumer use-case section. But remote use of specialized tools opens new use cases including the so-called *tactile internet*, controlling sensitive machines remotely or AR and VR simulations of the equipment.

As discussed in the consumer section, 5G mobile and 5G FWA will bring faster downloads and higher quality to all video applications. But the second application requires ultra-broadband speeds and ultra-low latency. Only 5G can do this untethered, which is the natural topology in a classroom setting.

Healthcare

The challenges in healthcare are often greater than those in education. Not only is there a lack of qualified doctors, especially far from the lucrative urban centers, but rural clinics lack sophisticated diagnostic equipment.

The COVID-19 crisis gave rise to new applications for mobile networks including remote healthcare in urban areas and geo-tracking those identified with the virus to find those they may have contaminated.

Ultra-high-resolution video (4K, 8K) is part of the answer, allowing doctors to diagnose remote patients based on simple diagnostics, a patient interview, and looking at the patient for visible symptoms.

AR and VR applications are clearly relevant to remote healthcare, creating a virtual bond between doctors and specialists in urban centers and nurses or medical technicians in faraway locations.

There is much interest and high expectations for remote robotic surgery, leveraging the low latency of 5G to provide almost instantaneous response between the remote doctor's hand and the robotic knife. A number of demonstrations have been held that show promise. There is much work to do on the robotics side, but little doubt that the promise will be realized. The ultra-reliable low-latency communications (URLLC) features of 5G Release 16 and 17 will be essential to making this work.

Why 5G in e-government?

Smart cities comprise multiple applications with vastly different network requirements, from narrowband to ultra-broadband and from naturally tethered to naturally mobile, passing through those that, like the modern factory, are tethered today but would benefit from an untethered architecture for fast and flexible reconfiguration.

Some citizen-facing use cases will benefit from the rise of consumer 5G, providing faster response times and richer video and graphic detail in smartphone-based applications. This benefit will come automatically.

But with the multiple networks that governments will manage in the future (smart cities, high-bandwidth video for education and healthcare, tactile internet, and AR and VR), a single layer of connectivity for all use cases will be simpler to manage than multiple technologies. With its ability to deliver fiber-like performance in fixed broadband situations and unmatched performance in mobile, 5G is the obvious candidate for this single layer.

Agribusiness

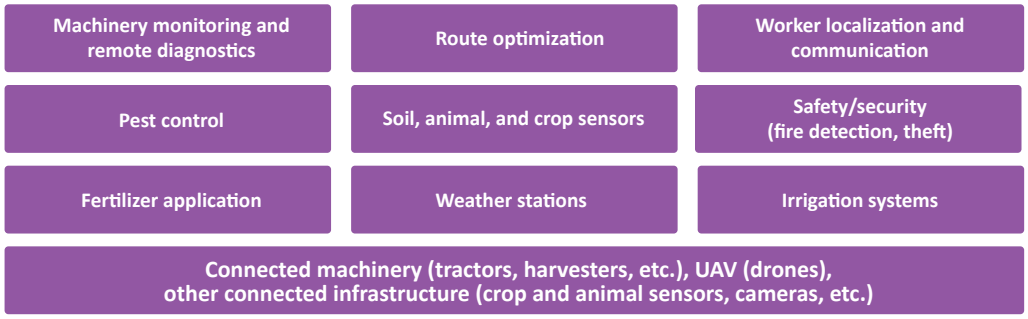
The Food and Agriculture Organization of the United Nations (FAO) estimates that the world's population will reach 9.1 billion by 2050. This growth, coupled with increasing urban populations and income levels, will require a 70% increase in food production by that year. This food production will need to come either from expansion of arable land, potentially putting pressure on forests and other wild areas, or from more productivity. FAO argues that agriculture R&D is one of the most beneficial investments available. Therefore, developing and deploying technologies that improve productivity in farms is a critical path for guaranteeing the food safety of the world's population in the coming decades.

Technology in rural areas can be applied in several steps of the production and can have even more impact in emerging economies, where generally speaking, farmers have had less access to technology, although this is not the case in many export-oriented economies. In recent years, there has been an effort to apply new technologies to agriculture. This use of technology to improve the sector has been called precision agriculture, and 5G fits in this movement.

Nonetheless, given the poor state of wireless connectivity in rural areas, the agribusiness sector is not waiting for 5G to become available and is already implementing different types of technologies, from proprietary solutions to 3G and 4G. Rather than competing with such efforts, investment in 5G will be an evolution. It will bring several innovations and improvements to previous generations' use cases, will enable use cases that are hard, or even impossible, to implement with other technologies, and finally, will unify different use cases in a single connectivity layer.

A simplified overview of the main agriculture activities shows that there are opportunities for the use of technology at every stage of production including preparing the land, planting seeds, growing crops, harvesting, and raising livestock. Furthermore, farmers are continually analyzing, planning, and making decisions about their crops and animals based on information they can get from each phase. However, most of the data is gathered offline, and very few steps of the decision-making process are automated, leaving much room for improvement. This process can be enhanced by 5G: the standard supports a wide range of use cases, and many of them match the different needs from the agriculture sector. Figure 4.16 lists several activities that can be improved or implemented by 5G.

Figure 4.16: Use cases for agriculture



Source: Omdia

Connected machinery

The use of tractors, harvesters, and other machinery is crucial for most farms; however, lack of connectivity means that there are few opportunities to use real-time data in the decision-making process. Applying connectivity and analytics to this infrastructure will open new ways of tackling the challenges in the sector.

Autonomous vehicles are among the most researched technologies in the world. In agriculture that translates to autonomous heavy machinery, with the possibility to control multiple vehicles such as harvesters and trucks. The way it has been planned, vehicle autonomy will have a phased approach, starting with human-driven vehicles just sharing information and going all the way to a fully autonomous fleet. Between these initial and final phases there will be a number of evolutionary steps, including human-driven vehicles sharing information between themselves and the surrounding infrastructure (also referred to as V2X), platooning (leader vehicle operated by human with autonomous vehicles as followers), and autonomous vehicles remotely monitored by humans. Since Release 15, 3GPP has included V2X in 5G, and there are plans to enhance the standard in coming releases.

The main benefits of autonomous vehicles in agriculture include optimizing routes to avoid wasting resources and increasing productive time by allowing machinery to operate under any conditions, day and night.

Unmanned aerial vehicles or drones

The use of unmanned aerial vehicles (UAVs) in agriculture is a relatively new initiative. They are currently used for mapping the land and analyzing soil and crops. However, their use is limited by poor autonomy, relatively low payload capacity and the need for visual line of sight (VLOS) between controller and aerial entity. In some countries, farms cover more than 10,000 hectares of land; therefore, there is a need for more reliable connectivity and autonomy to utilize UAVs at their full potential. The communications between the UAV and its controller and between the controller and a cellular network have been part of 3GPP work since Release 15, and enhancements are roadmapped in subsequent releases. A key feature will be beyond visual line of sight (BVLOS), enabling the flight of a UAV across longer distances while it is remotely controlled from a central site. A 5G-connected UAV will also improve other aspects of UAV operations, particularly higher bandwidth for data transfers, live ultra-HD video streaming, and lower latency.

Also under consideration by 3GPP are even more advanced use cases such as AI-controlled UAVs, which will require high capacity in the up- and downlinks, high reliability, and low latency, all in order to feed high-precision positioning information and other data to the AI system, so it can decide on the course of action, from flight path to the application of fertilizers or pesticides. The

expectation is that 5G networks will be able to simultaneously support such sophisticated cases while also providing Enhanced Mobile Broadband (eMBB) capabilities, thanks to native support for network slicing, which allocates and guarantees resources to each type of use. The types of requirements being studied by 3GPP for UAVs are listed in Table 4.2.

Table 4.2: Features under study by 3GPP

Services	Uplink data rate (UAV to network)	Service control data rate (network to UAV)	Data latency	Control latency	Positioning accuracy	Altitude
8K video live broadcast	100Mbps	600kbps	200ms	20ms	0.5m	<100m
Laser mapping / HD patrol	120Mbps	300kbps	200ms	20ms	0.5m	30–300m
Remote UAV controller through HD video	>=25Mbps	300kbps	100ms	20ms	0.5m	<300m
Video streaming	4Mbps for 720p video	–	100ms	–	–	–

Source: 3GPP

Other infrastructure

Beyond heavy machinery and UAVs, 5G will also be suited to supporting a broad range of other types of infrastructure such as sensors attached to soil, plants, and animals; irrigation systems; smart pest-monitoring systems; cameras; and wearables. All these devices can be connected to a 5G network.

Use cases

There is a broad range of use cases that can be mapped to the infrastructure described above; the list below looks at the most relevant ones, selected by the impact of 5G. The list is not meant to cover every existing use case but to discuss the main cases applied to agriculture:

- **Machinery monitoring and remote diagnostics.** This allows the online monitoring of the operational conditions of the infrastructure as well as determining its location, identifying problems in the equipment, and avoiding the waste of resources. Sensors connected by 5G on tractors and other heavy machinery allow the capture of data about speed, fuel, parts, and productivity among other things. That, in turn, enables remote diagnostics and even preventive maintenance, increasing uptime of the equipment.
- **Route optimization.** This enables the reduction of fuel waste and the elimination of route overlaps or missing areas via dynamic route planning. There are examples of farms where the combine harvesters cover 3,500km per day; the potential saving from optimizing their routes is one of the main gains from IoT projects.
- **Pest control.** The vast majority of pest traps are not connected, which means each one of them needs to be checked periodically by a worker. Smart traps can send high-resolution pictures instead, saving time and providing better measurement of pest proliferation.
- **Fertilizers and pesticides application.** The analysis of crops, soils, weather conditions, and pest infestation fed by high-resolution pictures and HD videos allows a very granular map of the area that guides the application of fertilizers and pesticides with a high level of precision, simultaneously avoiding waste and improving yields.
- **Irrigation systems.** As in the previous use case, water resources can be optimized by analysis of soil, weather, and crop conditions.

- **Soil, animal, and crop sensors.** Parameters such as soil humidity, temperature, and nutrients; plant growth and pest infestation; and animal weight, temperature, and location are measured. Online monitoring of such parameters can guide decisions about timing and the amount of resources to apply in production or help identify eating disorders or detect fertility periods, all with potential impacts on productivity and costs.
- **Weather stations.** One of the most basic inputs in planning agriculture activities is knowledge of the likely weather conditions.
- **Safety/security.** Multilayered security systems, including sensors in gates and fences, movement detection sensors, and cameras, can be connected by 5G. Farms can be particularly vulnerable to events such as theft and fire, so fire detection systems and surveillance equipment powered by AI can identify incidents and trigger corrective action.
- **Worker localization and communication.** Lack of cellular coverage leaves farm workers relying on basic radio communications, but 5G coverage can bring a set of different collaboration tools including voice and video calls and localization.

Why 5G for agriculture?

While some simple sensors may be served adequately by narrowband systems, the most transformative cases described above require massive amounts of complex sensors, requiring broadband capability. The autonomous machinery and UAVs require not only high-bandwidth downloads but uploads as well and at ultra-low latency. But 5G is designed for these kinds of requirements, especially with Release 16 and 17 and their focus on massive M2M and URLLC.

Today's wireless technology cannot support all the use cases described above, or at least, an enterprise would need to manage multiple technologies to cover all the use cases. The flexibility and technical capabilities of 5G makes it an ideal technology to provide a single connectivity layer to cover all the needs of precision agriculture.

Transport/logistics

Transportation

Industry 4.0 applied to transportation means wringing the last penny out of a part of the value chain that is absolutely critical but for which customers are unwilling to pay much of a premium. Maybe customers will pay more for transporting high-value, fragile goods such as fine art or fine wine, but in most cases, they view shipping as a commodity. That means the shipper's objective is to minimize cost.

Minimizing cost obviously implies efficient movement of the goods, minimizing time and energy but also minimizing lost or damaged goods and accidents. Safety is also an important component of this sector.

By definition, the devices in private networks for transportation are in motion, and wireless is the only solution.

For trucking, the initial application is fleet tracking—identifying where all the vehicles in the fleet are at precisely this moment in time—which can be used to derive certain key performance measures such as average speed. The modules used to do this can also pick up maintenance-related information such as oil pressure and gas consumption.

For both trucks and rail, the additional applications include look-ahead traffic information, access to corporate databases such as dispatch, and goods management. Driver monitoring (e.g., using AI to detect sleepiness) is another safety-related application.

Transportation terminals and logistics

Transportation terminals come in two major types: airports and container ports. There are other types of seaports such as bulk commodity ports and cruise ship ports. The former, we assume, are mostly located alongside container ports, so whatever infrastructure is built for containers can be adapted to bulk. Bulk shipping is also an inherently less complex problem because not much can be tracked except volume in / volume out. Cruise ships are not a particularly large opportunity because only a few ports would need to accommodate more than one ship simultaneously, and again, these are often built beside cargo ports and can use part of that network.

Container ports can also be situated inland, although they are normally then referred to as intermodal terminals or intermodal facilities because their primary purpose is to move goods between rail and truck.

Many airports tried to leverage existing Wi-Fi networks originally installed to provide infotainment services to passengers. These proved to be insufficiently robust for coverage outside the airport terminal, where the high-value applications are needed. In particular, Wi-Fi signals are blocked by the metal structure of the airplanes themselves, complicating coverage for maintenance crews working underneath the fuselages.

For a container port, the primary objective is to ensure that containers are received and dispatched correctly. Estimates of how many of these there are circulating vary wildly, but the World Shipping Council says there were 34 million in 2018. Between 1,000 and 2,000 are lost at sea every year, and many more are damaged, lost, or stolen on land. At the very least, the manager of a port needs to prove to a container's owner that the box was received and dispatched according to the waybill.

In airports, the initial application has to provide voice and data communications to cockpit and ground crews. In airports, pilots have to deplane, even on a turnaround, just to get connected and file their flight plans for the next leg. With better connectivity, they could do that from the cockpit. Giving ground crews better data connectivity will improve their administrative efficiency.

For a container port, the initial application is fitting the mobile cranes with cameras to audit the movement of the boxes.

For both, subsequent applications include a host of administrative activities that benefit from better connectivity including PTT voice to access port/airport systems and corporate systems.

Security cameras are another an obvious candidate. Later, operations management can move to tracking all of the vehicles moving around on the tarmac. The objective is primarily safety and thus efficiency. Even a simple accident can tie up a container terminal or airport for hours.

Both types of port often have large numbers of "outsiders" working on site who need restricted access to some systems (to know where other vehicles are) but not to all. They also need access to public networks.

The initial applications described above do not require high-performance networking and so are candidates for an early deployment using 4G/LTE with a clear migration path to 5G.

Energy transport

There are two parts of an energy transportation network (e.g., electricity, gas): the long-haul network from the source to an urban area and the distribution network that connects to individual houses and businesses. Omdia considers the distribution part of the network to be an application in a smart city discussed previously.

That means we are looking here at the long-haul network, which shares many characteristics with a railway network.

The initial application is detecting breaks in continuity and quickly shutting off the flow. The recent bankruptcy of California PG&E is an unfortunate illustration of the catastrophic consequences of fallen electrical lines: the utility is alleged to be at least partially responsible for some of the catastrophic forest fires in recent years. In January 2019, a breach in a Mexican gasoline pipeline killed more than 90 people when the escaping fuel blew up.

Metering at regular intervals can highlight pending (but not catastrophic) maintenance issues such as, in fluids networks, problems with pumps.

There would also be a need for infrequent access to corporate communications by maintenance personnel. Since one of the objectives of applying Industry 4.0 principles is to minimize the need for expensive maintenance, this connectivity cannot be a driving design principle. If the process is truly transformed, the network will not need visits by maintenance people.

Why 5G for transportation and logistics?

Wired solutions are clearly inadequate for transportation, terminals, and energy transformation, because in the first two cases, the items being connected (trucks, trains, containers, forklifts, cranes) are in motion, and while pipelines and energy transmission networks are fixed, the cabled communications can be disrupted when there are faults, the very condition that these sensor networks are primarily trying to detect.

All are wide-area solutions, inappropriate for Wi-Fi, with the possible exception of terminals. In the case of airports, Wi-Fi has already been attempted and found lacking for reliability, security, and propagation reasons. Similar issues make it inappropriate for seaports. The only highly reliable wireless solutions are based on 3GPP.

As discussed previously, bandwidth and latency requirements may suggest that, at least initially, 4G is sufficient. However, Omdia again advocates 5G for the reasons outlined in the section on industrial, mining, and energy cases.

Other services

The services opportunities for 5G are only limited by the imagination of services businesses, which themselves represent the broadest category of economic activity. Depending on how the category is defined, services are 50–60% of GDP and span a variety of activities including construction, IT, retail, and real estate.

Here a few of the major subsectors are described with an eye to those that correspond to economic sectors of importance to Latin America.

Retail

Retail is often not just an important subsector of services but a major GDP category in its own right.

There is a clear trend toward selling experiences, not just selling things. Retail will continue evolving toward rich, experience-based shopping to better compete in an increasingly online world. In order to compete, retailers should evolve to use data and solutions from different types of endpoints to trigger customer-requested targeted marketing, managing the tremendous amounts of data from customers and their behaviors, enabling AI personalization, and creating the optimal fusion of the virtual and physical worlds to create personalized shopper experiences: VR and AR to virtually try on clothing or virtually remodel and redecorate the home. Sensors will also be able to detect how well customers like what they see based on advanced facial-recognition algorithms that can interpret subtle expressions and eye movements and show different wardrobe items that trigger more positive responses. This will all be virtually instantaneous using 5G.

The other aspect of retail that is relevant for 5G is the management of inventory and logistics. Much of this, however, has been discussed above under transportation or is a variation on those same themes.

Finance

As in retail, most finance applications depend on mass-market 5G deployment. Faster consumer applications will speed adoption because of the “human impatience” factor.

Another application is replacing or complementing SD-WAN services that banks use to connect branches, especially kiosks. SD-WAN allows very simple connections to corporate data systems with full access to secure financial systems. As banks look to more flexible retail operations, such as pop-up kiosks for signing up new clients or for customer service, 5G will offer a high-bandwidth secure connection.

Real estate

Although this could be considered a subcategory of retail, there are a number of specific applications that would rely on 5G, particularly around VR such as viewing houses and offices virtually to reduce the number of site visits and avoid traffic.

5. Latin America and 5G

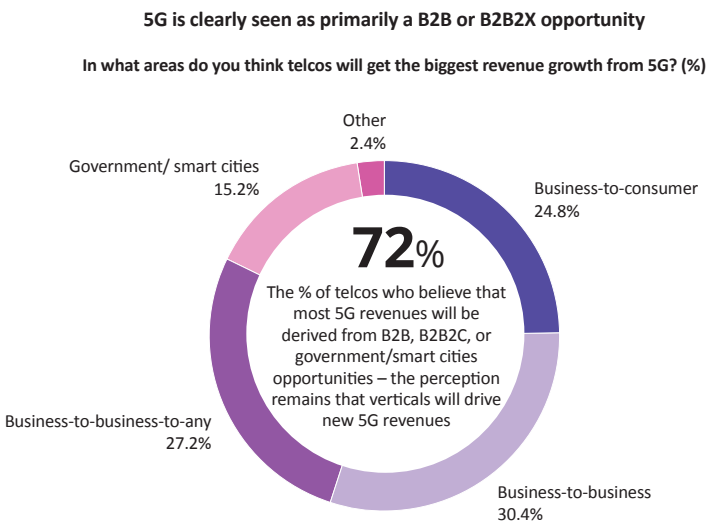
In an Omdia survey, 30% of telcos said their biggest 5G revenue opportunity was in B2B.

Today, the showcase examples of 5G in the world are mass-market focused (e.g., in South Korea, the US), and Omdia estimates that 5G penetration in Latin America will approach 17% by the end of 2024. Apart from a deployment in Uruguay, there are no commercial networks in the region today (2020), but Omdia believes that there are immediate opportunities in very specific geographies and in the enterprise space.

Omdia surveyed 125 mobile operators from around the world and asked where they thought their 5G revenue would come from. Most thought it would be from B2B or B2B2X. Government is also significant; in fact, nearly three-quarters of those responding said something other than consumer, even though the commercial networks today are focused on consumer.

We will use the term mass market to refer to the primarily smartphone-based opportunity that includes consumer but also enterprise-to-consumer and enterprise use on public networks.

Figure 5.1: Global telcos, sources of 5G revenue



Note: n=125

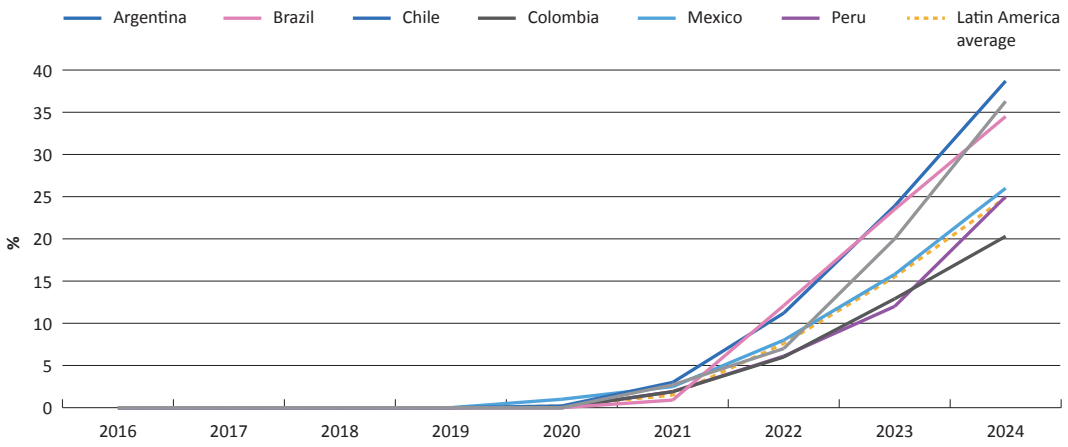
Source: Informa Tech 5G World Series Market Survey 2019

Mass-market eMBB

Figure 5.2 shows Omdia's view of 5G in the major countries of Latin America. By 2024, the average penetration in the region is expected to approach 17%, with some major countries getting to 22%.

This shows that the core smartphone opportunity has gotten more attractive as device prices have fallen. Communications service providers (CSPs) looking for upside will look to FWA and enterprise applications for additional network connections and traffic.

Figure 5.2: Latin America, forecast of devices by mobile-technology generation

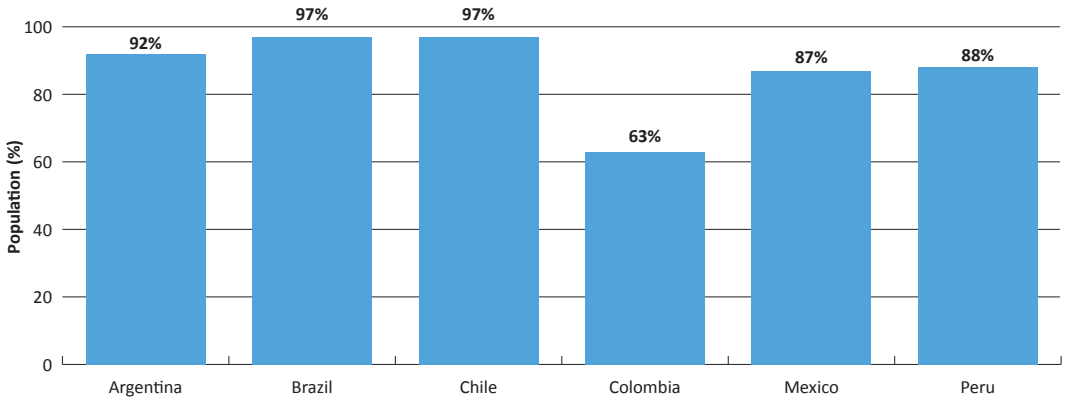


Source: Omdia Forecaster

These impressive penetration numbers (within less than five years) imply a significant population coverage of 5G services, which will facilitate B2C 5G applications, at least in urban areas where traffic is already high. There are consumer applications in video and gaming and B2C opportunities in retail and services.

By mid-decade, Omdia expects a level of 5G population coverage comparable to that seen today for 4G. Figure 5.3 shows that, for the major markets, this ranges from 63% to 97%, showing there is a good starting point for 5G NSA deployment.

Figure 5.3: Latin America, estimated 4G population coverage for major markets



Source: Omdia, based on various sources including regulatory comments, press reports

However, there is considerable variation between urban and rural areas and even between urban areas. Coverage can vary 15 or more percentage points between major cities and secondary or tertiary cities, and there are rural municipalities without any 4G coverage.

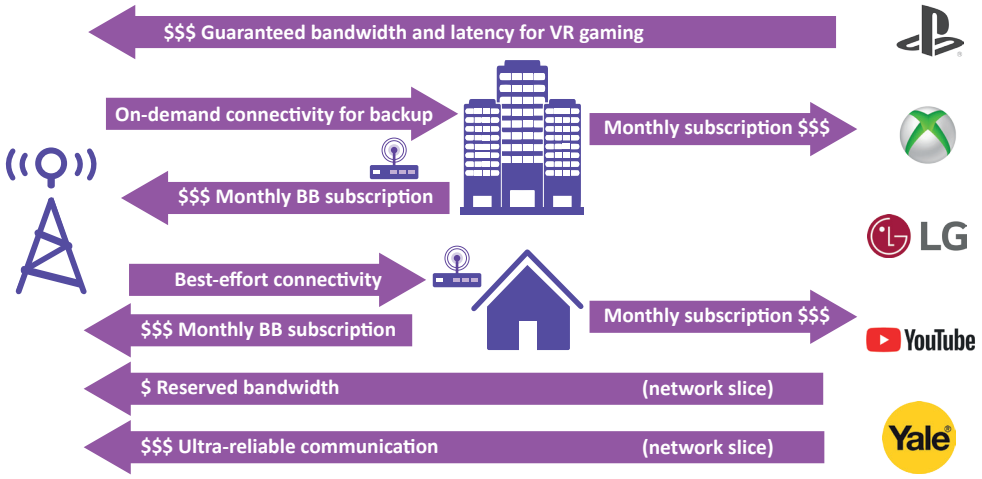
As with most new generations, 5G will roll out quickly in urban areas, but coverage between these centers will be poor for several years. The exception will be in specific areas such as housing developments outside major cities or tourist regions.

Fixed wireless access

Omdia estimates that 50% of Latin Americans are not connected to any broadband service. Network coverage today misses 100 million inhabitants. There are also an estimated 211 million inhabitants who do not subscribe to either mobile or fixed broadband, despite having coverage.

Using 5G eMBB for FWA is attracting growing interest in many countries, especially in emerging markets. Mostly out of necessity, because compatible smartphones were not yet available, AT&T and Verizon launched their 5G offers with wireless hotspot devices that connected to devices such as phones, tablets, laptops, and smart TVs over Wi-Fi and to the internet over 5G. This is proven technology that is already riding the experience curve to lower prices and that can be adopted quickly.

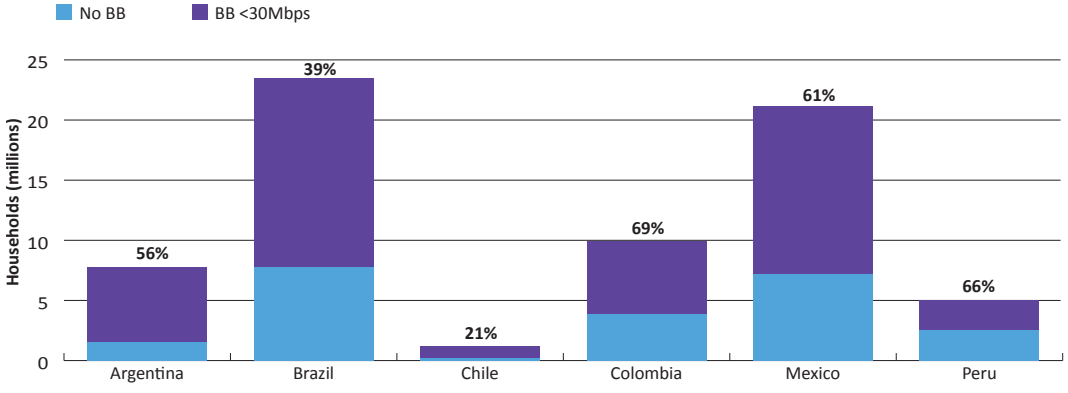
Figure 5.4: Examples of FWA 5G monetization options



Source: Omdia

Figure 5.5 shows Omdia's estimate of the addressable market for 5G FWA in the major markets. We see it as having two components: households without broadband of any type (neither fixed nor mobile) and households with fixed broadband but at a lower speed than that achievable with 5G (lower technology levels of DSL and cable modem). The low value for Chile may surprise some, but the country has the highest fixed broadband penetration and the fastest average speeds in the region. By our definition of addressable market, it was bound to have few potential customers.

Figure 5.5: Major Latin American markets, estimated total addressable market for 5G FWA (household penetration)



Source: Omdia

Some of the households with no broadband are without service for economic reasons, and 5G might eventually have an impact on affordability. Because it is more spectrally efficient, eventually it is expected to have a much lower cost per megabyte.

More importantly, the barrier can be lack of coverage (lack of fiber or 4G), especially for those outside major urban centers. One key difference between 4G and 5G for FWA is the newer technology's vastly superior performance. Although 4G is better than 3G and, depending on the generation, better than much DSL, 5G is better than higher technology versions of DSL or cable modem, and Release 15 speeds are faster than many fiber offers in the region. Households that have not bothered with lower-quality fixed broadband would find a quantum leap in performance from 5G FWA.

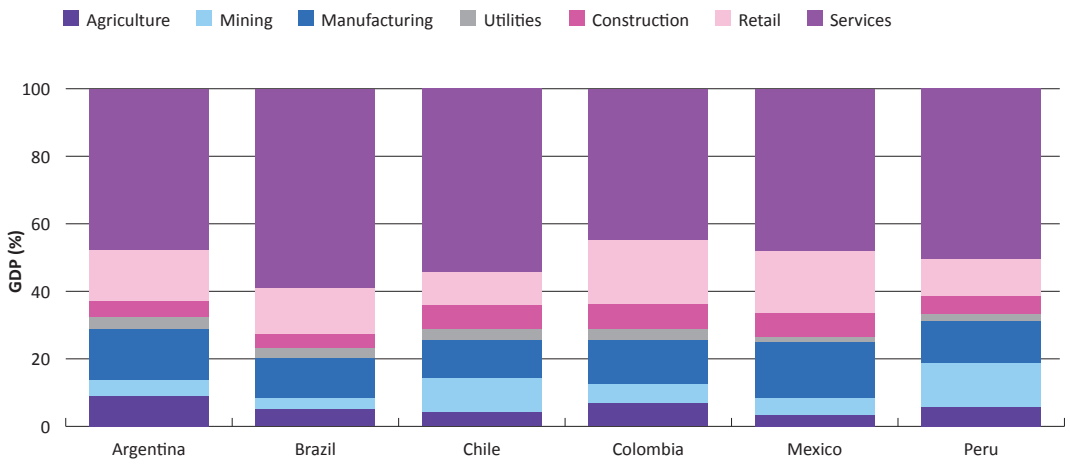
Furthermore, Omdia believes that those who have lower-quality fixed broadband will consider a 5G FWA alternative.

However, 5G FWA using NSA would still require 4G coverage, which varies from country to country and between urban and rural areas. But 5G FWA could be deployed selectively and rolled out neighborhood by neighborhood, town by town. Customers with a smartphone service would expect broad 5G coverage as they move from home to work or home to shopping and entertainment. But for a fixed broadband service, it is only important to have coverage at home or at the workplace.

Enterprise applications

The previous chapter described a number of 5G use cases that were clustered around particular industries. Figure 5.6 shows how GDP breaks down by productive sector in the major Latin American countries.

Figure 5.6: GDP by productive sector



Source: Omdia, based on countries' national systems of accounts

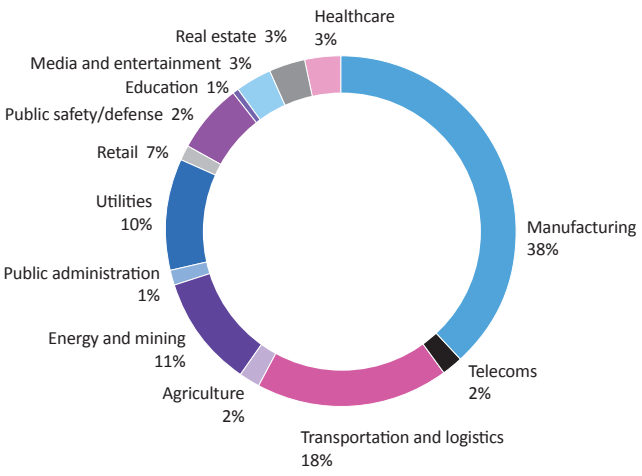
It should come as no surprise that services (including government) are about 50% of these economies because the region has become more sophisticated over the past few decades, following the same path as more-developed countries. Retail (which in these figures includes wholesale) is another 14% on average. Many 5G use cases in these two sectors are B2C applications such as connected cars, using beacons to target ads to individual clients within a department store, or applying VR to selling houses. These require 5G eMBB, normally on a broad basis although some (such as beacons) could be managed with 5G hotspots using FWA.

Apart from services and retail, the so-called productive sectors map fairly well onto the categories of use cases we described in the previous chapter:

- Agriculture (3–9% of GDP)
  - Autonomous, remotely managed or simply smart and connected farm machinery such as tractors and harvesters
  - Managed irrigation and other infrastructure
  - Drones for measurement and spraying insecticides or fertilizers selectively
- Mining (5–13% of GDP)
  - "Hard" mining
    - Autonomous or remotely managed trucks and excavators
    - On-site communications systems
    - Remotely managed drilling equipment
  - Oil and gas
    - Remote sensing equipment, especially for pipelines
    - On-site communications systems
    - Remotely managed drilling equipment
- Manufacturing (11–17% of GDP)
  - Sensors for smart manufacturing systems
  - Autonomous robots
  - A/R maintenance systems
- Utilities (3–7% of GDP)
  - Smart city systems
  - Smart metering and smart energy management systems
  - Remote sensing for pipelines
- Construction (5–11% of GDP)
  - Autonomous or remotely managed cranes and construction equipment

Figure 5.7 is taken from Omdia's *5G Innovation Tracker* and shows how 5G trial announcements map onto industrial sectors. The top five sectors are manufacturing, transportation and logistics, utilities, energy and mining, and public safety.

Figure 5.7: Global, enterprise 5G announcements by industry



Source: Omdia

But is 5G necessary for enterprise applications? Are many needs not served today with Wi-Fi and fixed broadband or cabled networks or even 4G? Some are, yes. But not those that are truly transformative, that will bring the leaps in productivity that the region needs. In Figure 5.8, which comes from Omdia's report *Are you ready for 5G Monetization?*, we map common key application areas onto 5G's main attributes.

Figure 5.8: 5G use cases and key capabilities

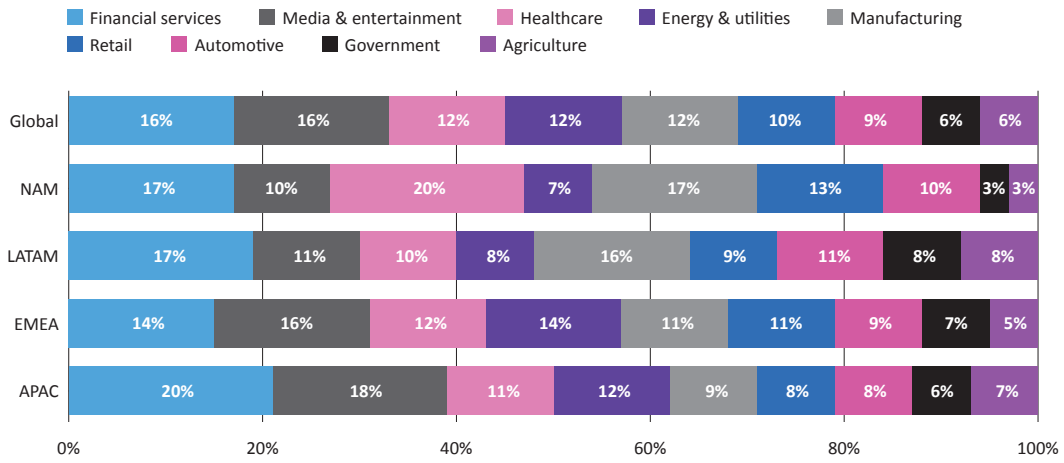
	eMBB	FWA	Scalable IoT	Ultra-low latency	Edge computing	Network slicing	Revenue management
Retail bandwidth on demand	■	■					■
Hybrid MVNO for logistics	■		■			■	■
Private mobile for Industry 1.0	■		■	■	■	■	■
Campus network for healthcare		■	■	■	■	■	■

Note: Colored squares show which capabilities are relevant to each use case.
Source: Omdia

This chart is not exhaustive but does show how transformative applications depend on 5G attributes.

Figure 5.9 shows how CSPs around the world prioritize different industries for 5G solutions.

Figure 5.9: Global mobile operators prioritizing industries for 5G

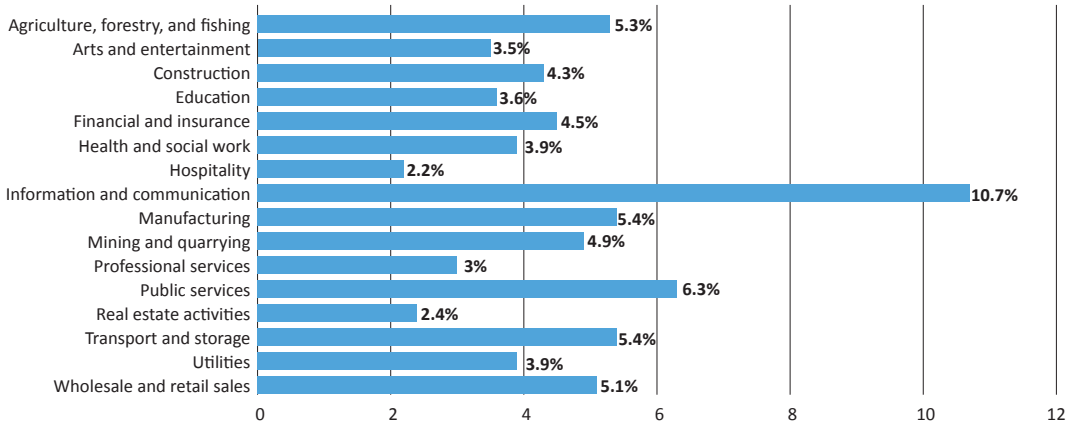


Source: Omdia

In the following sections we will look at each country, identifying which 5G enterprise applications are highest priority based on the economic structure of the country and the opportunity for 5G to impact productivity and thus economic growth.

According to the 2019 Omdia report, *The 5G Economy: How 5G will contribute to the global economy*, an average 5% impact will be enabled by 5G by 2035. Across all different sectors, 5G-enabled sales will have a different impact, starting at 2.2% and rising to more than 10% for ICT revenue (see Figure 5.10).

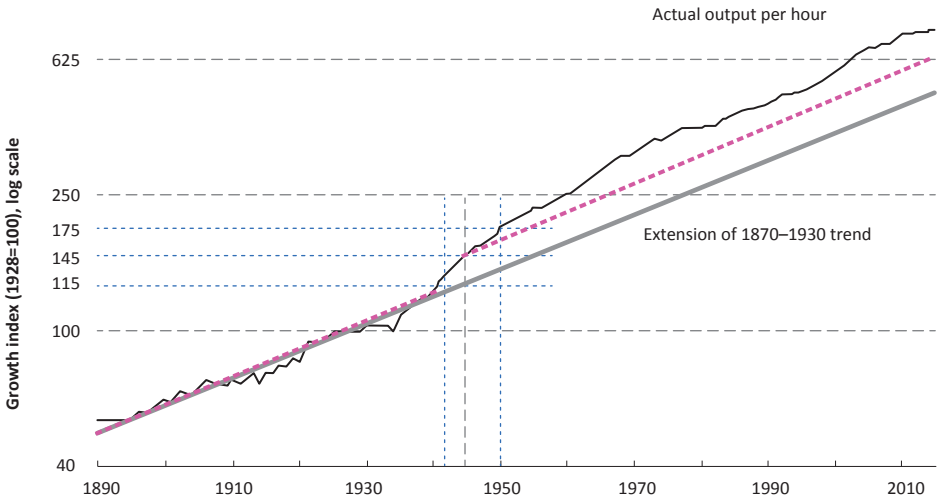
Figure 5.10: 5G revenue growth impact by economic sector, 2020–35



Source: Omdia, The 5G Economy: How 5G will contribute to the global economy, 2019

Bell Labs has identified that 5G could contribute a significant productivity jump during the 2029–35 timeframe when the aggregate for the constituent technologies reaches the tipping point at 51% penetration. Intelligent connectivity, enabled by 5G, will be a catalyst for socioeconomic growth in the fourth industrial revolution.

Figure 5.11: Long-term global productivity

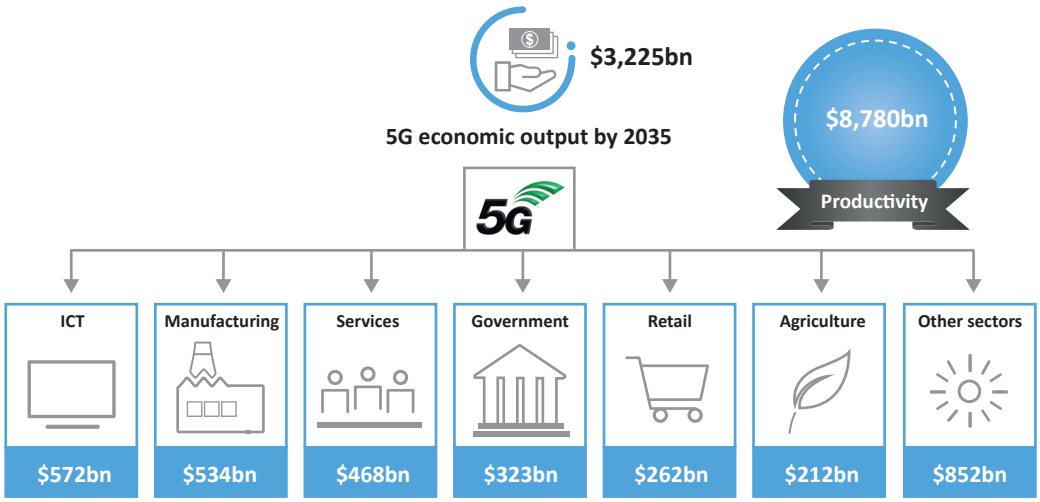


Source: Bell Labs

Combining all these economic effects, Omdia designed a model to estimate the economic and social impact of 5G through 2035 in Latin America, addressing each industry and sector potential.

According to Omdia, the potential economic and social value of 5G in Latin America is estimated to be $3.3 trillion by 2035 (Figure 5.12).

Figure 5.12: 5G economic and social impact by industry, 2020–35



Source: Omdia, based on Omdia and Bell Lab economic models

Table 5.1: 5G economic and social impact by Latin American country, 2020–35

	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Total
Agriculture	33.6	76.8	10.5	15.1	33.7	11.0	180.7
Mining	16.4	48.6	23.8	11.4	43.6	21.6	165.4
Manufacturing	57.9	181.2	29.3	29.5	134.3	22.7	454.8
Utilities	10.2	36.2	6.2	5.4	77.0	2.5	77.0
Construction	14.5	47.9	14.1	13.3	149.1	8.1	149.1
Retail	23.5	88.2	10.4	17.6	75.3	8.1	223.1
ICT	54.8	240.8	40.8	13.9	136.9	–	487.2
Finance	12.7	88.6	11.7	9.7	41.9	0.0	164.7
Real estate	19.8	68.1	10.2	9.8	51.9	0.0	159.8
Other services	34.3	151.2	39.5	9.7	112.8	51.4	399.0
Government	21.2	189.0	9.5	26.3	29.0	0.0	275.0
Entertainment	3.1	0.0	0.0	3.9	2.9	0.0	9.9
Total 5G Economic Impact	**301.9**	**1,216.4**	**206.4**	**165.4**	**730.1**	**125.4**	**2,745.6**
Productivity	**778.4**	**3,083.6**	**517.2**	**574.1**	**2,121.1**	**401.3**	**7,475.9**

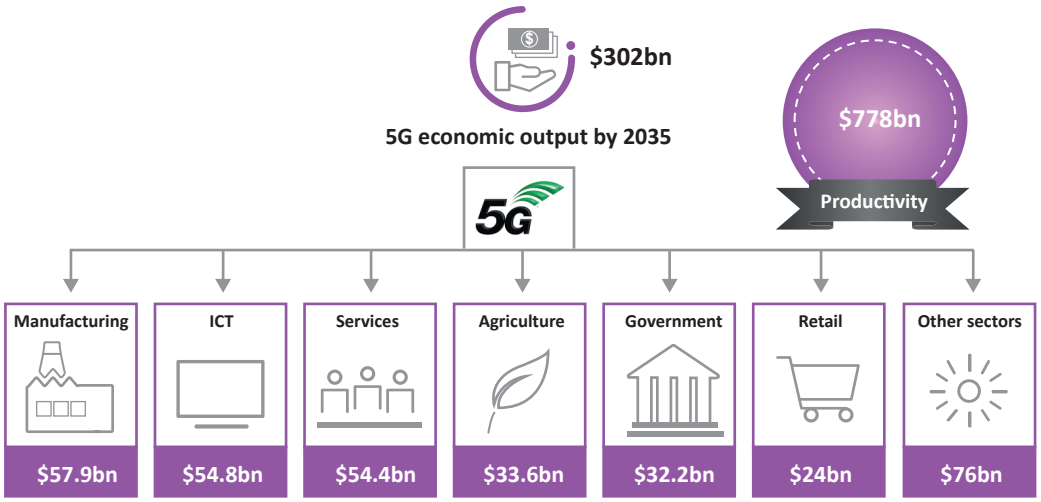
Source: Omdia, based on Omdia and Bell Lab economic models

All countries have their own characteristics, so we discuss them individually in the rest of this chapter.

Argentina

In 2035, 5G will enable $302 billion of social and economic output in Argentina. Manufacturing, ICT, retail, services, and agriculture will be the industries most impacted by 5G.

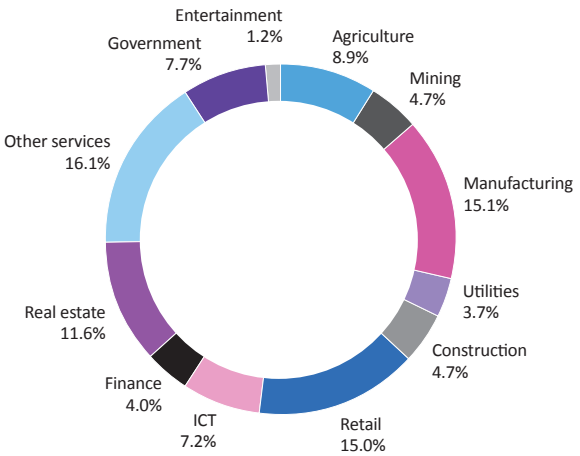
Figure 5.13: Argentina, 5G economic and social value impact



Source: Omdia, based on Omdia and Bell Lab economic models

According to Argentina's breakdown of its sectors by economic impact, we can see the high impact that manufacturing and services have in the local economy. Figure 5.14 shows the structure of Argentina's economy including a breakdown of its services sector into subsectors.

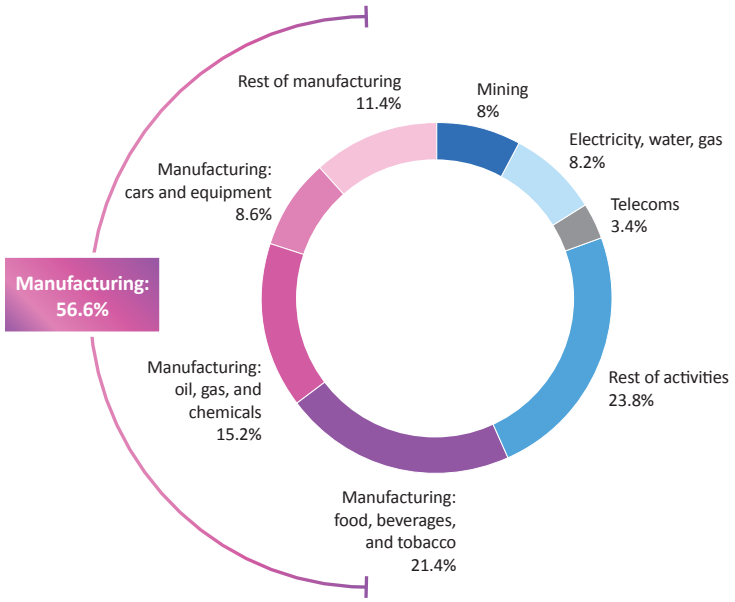
Figure 5.14: Argentina, gross value added by economic sector



Source: Omdia

The majority, 65%, of the 500 largest companies in Argentina have foreign ownership. These 500 large enterprises represent 22% of the GDP according to INDEC (National Statistical Bureau). Industrial 5G is a worldwide trend, and manufacturers will implement 5G in their many facilities, meaning Argentina will be part of this global digital tsunami. International companies are looking for new efficiency levels to provide quality goods to customers and clients, implementing 5G in their different locations around the globe. This is the case for manufacturing, automotive, pharmaceutical, plastics, oil and gas, and all the main economic sectors.

Figure 5.15: Argentina's 500 largest companies by activity



Source: INDEC

Manufacturing is clearly one of the main 5G opportunities with an economic impact of $57.9 billion. Because manufacturing plays such a key role in the economy, every manufacturer has the potential to affect companies in other industries such as agribusiness, which is the engine of Argentina's economy. Argentina's manufacturing industry has historically been related to Argentina's large agribusiness. Food and beverages and local production for agribusinesses are dominated by local companies. Adding value to local production is one of the main opportunities for Argentina to evolve from commodities exports. On the one hand, agribusiness is becoming more sophisticated every day in Argentina, requiring highly developed technical products such as chemical fertilizers, tractors, machinery, and packaging. The country cannot establish a high-value-added, export-oriented manufacturing sector without technology. On the other hand, agribusiness has new demands and will also be transforming with 5G.

The Argentinian agribusiness sector has grown and innovated remarkably in the last three decades, driven by technological change and, over much of the period, by high international agricultural prices. Despite challenges, agriculture is still the country's main exporting sector. Argentina used to be known as "the farm of the world" but needs to improve its productivity to be among the 10 largest food exporters again. There is still room for the industry to grow significantly with the adoption of precision agriculture and cattle farming boosted by 5G. This will assist other related businesses, driving investment and encouraging further technology adoption in the local economy.

The automotive industry is quite developed in Argentina, currently having 11 manufacturing facilities and producing more than 500,000 vehicles annually, with exports to more than 15 markets. The industry has generated more than 500 auto-arts-related companies. Automotive is one of the leading sectors to benefit from 5G, to increase safety, reduce costs, and be able to compete globally. Automated guided vehicles and industrial mobility technologies are clearly game changers. The automotive industry can benefit as well by providing these kinds of vehicles to other industries. A 5G-connected factory is the only way to be competitive in a global economy.

ICT is the next impacted sector, and the one with the highest growth rate. The country rates highly in ICT talent, and three of the nine multi-Latinas in Argentina are technology companies, including Globant, a regional leader. ICT clearly has an impact in all the economic sectors, being the key enabler of the 5G benefits. Retail is the next-largest sector in term of GDP contribution and 5G opportunities with an estimated $54.4 billion impact. Argentina is where the Mercado Libre unicorn, the largest Latin American online commerce and digital payment company, was founded. In order to compete, local and international large retailers should evolve using data and solutions from different types of endpoints to trigger customer-requested targeted marketing, managing the tremendous amounts of data from customers and their behaviors, enabling AI personalization, and creating the optimal fusion of the virtual and physical worlds to create personalized shopper experiences. They have to compete with Mercado Libre and all the international e-commerce marketplaces (Amazon, Alibaba, JD, eBay). Despegar.com is another example of a digital disruptor unicorn founded in Argentina.

The government's role in Argentina has a large impact on the economy, managing the social safety net that is the largest component of the national budget, followed by education, energy (mainly subsidies), and transport (this does not include the interest on the national debt). Government can be a catalyzer of the local economy, adopting 5G as an anchor customer that will boost the rest of the economy. Smart cities using 5G have a key role to play in the national transformation. According to the IESE Cities in Motion Strategies, Buenos Aires is a regional leader, being the smartest city in Latin America with a great potential to boost this capacity with 5G implementation.

Despite its large area, Argentina is a highly concentrated country with 35% of the population living in Buenos Aires and the Greater Buenos Aires area, which generates almost 50% of the country's GDP. Having such a high level of population concentration makes a 5G deployment plan potentially much more efficient, because it can evolve from the current 4G coverage in these highly urban and developed areas. These concentrate the main economic activities: retail, banks, factories, hospitals, and educational centers.

Energy is another key development sector. Vaca Muerta, one of the world's largest shale oil and gas fields, has become a magnet for investment, drawing the interest of oil supermajors and promising to boost Argentina's future economic development. The giant shale formation, which sprawls over 30,000 square kilometers in four provinces, attracted $7 billion in investment in 2019. It is expected that hydrocarbon exports could reach $25.4 billion in 2030 from this development. About 30 companies currently have concessions in Vaca Muerta, with YPF, now controlled by the Argentine state, holding the largest number. Vaca Muerta is the world's second-largest nonconventional gas play and the fourth-largest petroleum play of this type, where 5G has a differential role for productivity and safety. Most of the connectivity required for these large fields is still pending, creating a greenfield opportunity for early 5G deployment.

Argentina has a commitment that renewable energies should account for 20% of the national electrical energy consumption by 2025, so this is another area of interest where 5G can contribute. The Patagonia region has very stable and strong winds throughout the entire year (with average winds of over 9m/s), and in the north of the country, solar energy is developing very quickly. Because this is a high-growth market where new investments are being made, greenfield projects are an area where 5G has a large potential, since there are no legacy technologies. They represent a great opportunity that will provide security, high capacity, and reliability.

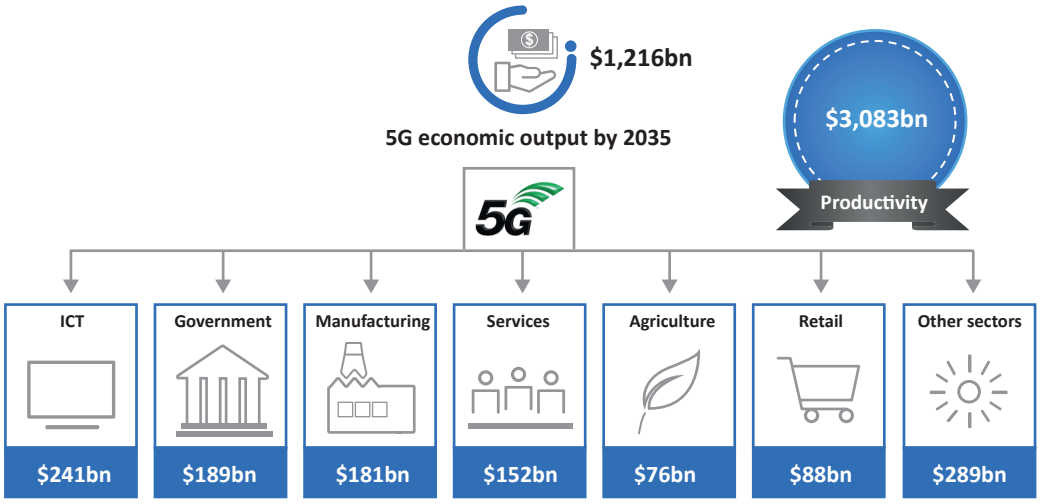
Entertainment is an interesting sector for specific 5G applications and, of course, consumer services. The gaming industry is also generating many opportunities where high broadband and low latency are key components. Argentina is recognized for its creative power in the arts, so adding 5G capabilities will generate opportunities for exports and international audiences. Sports and concerts can be transformed by 5G-enabled stadiums. Argentina boasts some of the best soccer teams in the world, and this is an industry that has great export potential. Providing new experience capabilities to the fans would enable new business models and revenue streams. Although soccer represents only a small percentage of the economy, it would be a quick win to start deploying and multiplying the value of 5G.

Argentina has a great potential in terms of 5G being an early and fast technology adopter in the Latin American region.

Brazil

In 2035, 5G will enable $1,216 billion of social and economic output in Brazil. ICT, government, manufacturing, services, agriculture, and retail will be the industries most impacted by 5G.

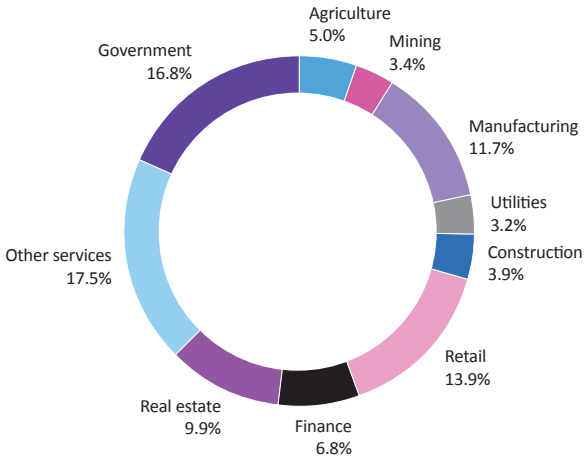
Figure 5.16: Brazil, 5G economic and social value impact



Source: Omdia, based on Omdia and Bell Lab economic models

An analysis of the Brazilian GDP per gross value added per vertical is a starting point for the discussion of 5G's potential impact on the Brazilian economy, because it allows for the selection of verticals for prioritization. Figure 5.17 shows the structure of Brazil's economy.

Figure 5.17: Brazil, gross value added by economic sector



Source: Omdia, based on Omdia and Bell Lab economic models

Government (including public education and healthcare) is one of the main contributors to Brazilian GDP, and not coincidentally, some of the main opportunities envisaged for 5G in the country are in areas where governments at all levels are the main buyers. When it comes to improving connectivity, via both eMBB and FWA, Brazil still has a major challenge in connecting public services to the internet in a significant part of its 5,650 municipalities, especially in rural and remote areas. The country has been struggling to offer public services such as healthcare and education in such places. However, the combination of investment in broad capillarity and robust backhaul with high-capacity 5G network access can enable sophisticated services such as telemedicine, supporting remote diagnosis, treatment, and monitoring of patients and increasing coverage of healthcare services. The Brazilian health ministry estimates that 25% of the population (close to 50 million people) is still not covered by basic medical assistance. The main problem is the lack of medical teams in remote areas, so having audio and video communications could help bridge the gap between such teams and the population. Such services can have an important impact on the population's well-being,

Also linked to governments, smart city solutions can be enabled by 5G. Almost 85% of the country's population live in urban areas, and cities such as Sao Paulo and Rio de Janeiro are among the largest in the world, with several challenges to match their size. Nonetheless, the range of use cases that 5G can enable for smart cities in Brazil is somewhat limited by the chronically poor financial situation of the country's municipalities. In other words, the use cases that have a guaranteed source of funding and/or business models that do not require large expenditures by city governments tend to be the ones with a higher chance of being implemented. With this caveat in mind, the blending of big data and 5G in urban infrastructure can support city administrators in several areas, some of them listed below:

- **Traffic and transport.** The connection of urban infrastructure such as traffic lights, parking areas, and buses would bring benefits such as reduction of downtime, optimization of traffic control, quick identification of free parking slots, and bus location and monitoring. This is one of the most sensitive areas for citizens and corresponds to an important share of municipalities' budgets, making it particularly well suited for cost-saving and efficiency initiatives.
- **Smart lighting.** The latest statistic about the number of street lights in Brazil (14.7 million) dates from 2008, from PROCEL. Although outdated, it shows the opportunity in the sector. There are a growing number of initiatives in the area, and the sector benefits from an exclusive tax paid by citizens for public lighting, making it a rare example of a service that has a defined source of funding. There are new public-private partnerships based on this, which give companies the right to manage cities' lighting systems. These companies are using different technologies to begin Brazil's first smart lighting projects. Once 5G is available, its expanded massive machine-type communications (mMTC) capabilities will create the conditions for it to be a competitive connectivity solution as well.
- **Video monitoring.** Brazil has one of the highest crime rates in the world. Violence ranks high among citizens' concerns, and it is, therefore, a top priority for local governments. For this reason, video-based facial-recognition systems have been evaluated by more and more cities. The use of such systems in dense urban areas is, however, limited by the availability of high-capacity connectivity, so 5G is ideal to address this problem, thanks to the combination of features such as high bandwidth, edge computing, and QoS.

Globally, manufacturing is expected to be one of the main sectors for 5G. In Brazil, sectors such as automotive are dominated by sophisticated multinationals with access to R&D from headquarters. Moreover, this is one of the sectors selected for the National IoT Plan (together with agriculture, healthcare, and government), so the government is orchestrating a national effort to drive innovation in this sector. Another subsector likely to demand 5G connectivity is manufacturing linked to the agribusiness sector, an export-driven area with challenges in managing raw and processed food. A common goal for the Brazilian manufacturing sector as a whole is to improve

productivity levels. Therefore, 5G-enabled use cases such as the implementation of AGVs, applied in smart factories and warehouses, allowing flexible path planning and replacing conveyor belts, need to be among the priorities of the sector. In addition, 5G will enable the location of parts and equipment with a high degree of precision, saving time and optimizing processes.

Although mining and oil and gas are smaller than manufacturing, their particularities, such as the presence of few, but large and sophisticated local and multinational companies and the need to manage high-risk places, make them candidates to be among the first to adopt 5G-enabled services. In fact, some initiatives are already in place using 4G private networks in mines and dams—places that usually do not have cellular coverage. Nonetheless, 5G will bring a higher QoS and will meet stricter latency and speed requirements, allowing more sophisticated use cases such as autonomous vehicles and UAVs as well as automation and remote monitoring of offshore facilities.

Retail is one of the most important economic activities in Brazil. It is a diversified sector, with the presence of large companies, both locals and multinationals. The sector has seen important changes in recent years, and the impact of 5G is likely to be felt quite soon after the technology is available. To begin with, e-commerce represents about 5.4% of total sales of the sector, according to the sector's association e-Camaranet. It is growing at double-digit rates, most of it already originating on smartphones. Therefore, fast speeds enabled by eMBB will improve customer experience with AR/VR services, faster page loading and checkout times, and better customer support including video calls. In the brick-and-mortar retail space, AR/VR will also be implemented, but retail companies will see 5G as another option to connect their stores. Thanks to 5G FWA, operators will be able to offer SD-WAN services without the need to invest in expensive fiber connections all the way to the customer premises. Finally, the same logistics solutions suggested for manufacturing will likely be implemented in the vast warehouses maintained by retail groups in Brazil.

Agriculture in Brazil is a highly productive, export-oriented industry, with important spillover effects in other industries such as manufacturing and services. Thirty percent of the country's land is used for crops and pastures, making Brazil one of the largest food producers in the world. Table 5.10 gives an idea of the importance of Brazil in the area.

Table 5.2: Brazil's ranking in the world's production of selected agriculture products

	Sugar	Coffee	Soya	Orange juice	Corn	Poultry	Beef
Ranking	First	First	Second	First	Third	Third	Second

Source: FAO, Embrapa

The sector includes large and sophisticated local companies, focused on achieving productivity gains in order to compete in international markets. According to IBGE, there are 2,400 farms in Brazil of 10,000 hectares or more, in many cases using highly mechanized, but often offline, production techniques. Opportunities for 5G span the whole process, and many use cases are already mapped in what the sector has called *precision agriculture*, that is, the use of technology in the industry's processes. Chapter 5 discusses in detail each use case in the sector. Nevertheless, 5G has the potential to be the single layer of connectivity necessary to connect such different use cases as connected animal collars, irrigation systems, equipment sensors, cameras, autonomous vehicles, and UAVs (drones). Most farms in Brazil do not have any cellular coverage, so the potential gains from connecting workforce and infrastructure could have a significant impact in productivity in the sector, especially considering the possibility to leapfrog directly to 5G.

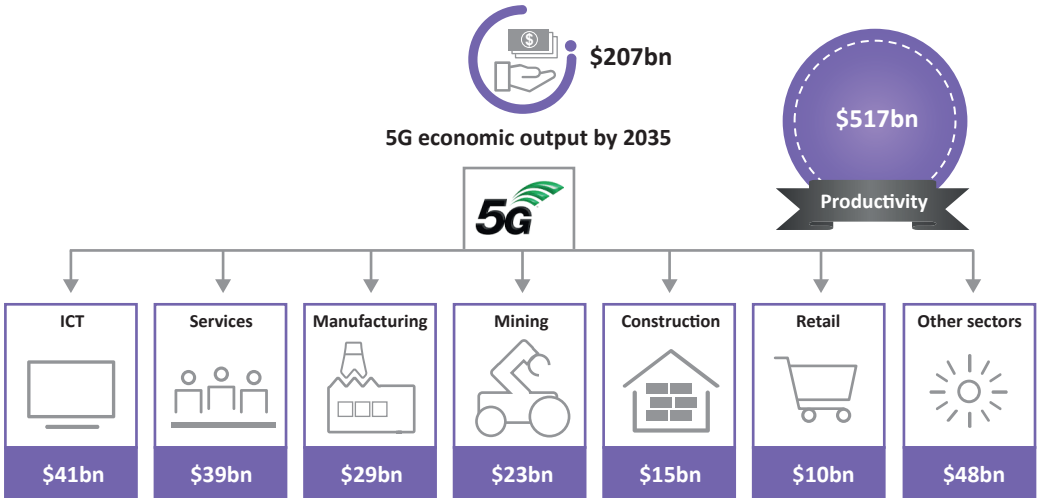
The transportation sector also holds opportunities for 5G. In this case, many of them will come from the upgrade of M2M solutions already implemented in the country. Historically, the transport sector was, together with connecting point-of-sale (POS) machines, the main demand driver for M2M in Brazil. However, the market only offers limited functionalities linked with fleet and cargo tracking, in many cases still using 2G connections. V2X technologies enabled by 5G could change that, allowing safer and more precise operations.

Finance is the main sector in the services market in Brazil. It is a highly commoditized market consuming basic connectivity (in many cases at 3G or below) for POS machines in the payments sector. More sophisticated services will arrive with 5G. First, as in retail, 5G FWA will enable SD-WAN services to connect bank branches and ATM machines. It will also allow faster connections with better QoS for the vast POS market in the country.

Chile

In 2035, 5G will enable $207 billion of social and economic output in Chile. ICT, services, manufacturing, and mining will be the industries most impacted by 5G.

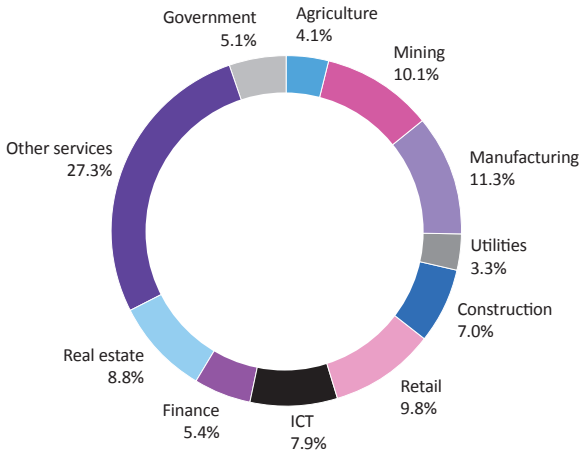
Figure 5.18: Chile, 5G economic and social value impact



Source: Omdia, based on Omdia and Bell Lab economic models

Chile is known for mining and agriculture, but the national accounts show these to contribute only 15% of total gross value added (See Figure 5.19). That is still about 40% of the productive sector; services make up 55% of GDP and retail another 10%. The country is a small market domestically compared with neighbors such as Argentina or economic peers such as Colombia, but its strong export sector makes it an important market to analyze and creates strong incentives to invest in technology. Chile must compete with the rest of the world.

Figure 5.19: Chile, gross value added by economic sector



Source: Omdia

Chile was the first Latin American country to join the OECD, a club of developed nations, and consistently ranks very much higher than its regional peers in studies of competitiveness, ease of doing business, and so on. It is much closer to its fellow OECD members than to any of its regional peers and so is normally an early adopter of advanced technologies.

Chile has a very large services sector, which includes an important ICT subsector. The country rates highly in all surveys of technology adoption—significantly higher than its Latin American peers—so there will be many 5G opportunities, especially when mass-market 5G is deployed.

Although mining is not the largest productive-sector contributor to GDP (that distinction belongs to manufacturing) nor does it rank at the top in our model, it accounts for more than 50% of the country's exports. Copper alone accounted for 25% of exports in 2018.

The country has already distinguished itself for using advanced technologies. In 2008 Komatsu installed its first automated haulage system (AHS) at the Gabriela Mistral copper mine near Calama. Nokia and Komatsu recently announced a joint project to convert AHS to run on private LTE. Given the higher-performance characteristics of 5G, Omdia expects this project to migrate to the new technology very quickly.

Chile's manufacturing is a mixed portfolio with about 59% in primary manufacturing (first-stage transformation of extracted resources) and 41% in secondary or higher-value-added work. Among the country's top 10 exports are wine, wood pulp, and inorganic chemicals. A high proportion of export-oriented manufacturing firms are considered to be "large" (70%). However, an OECD report from early 2018 noted a low level of investment in manufacturing relative to other countries in the organization and a low level of labor productivity. While this shows the opportunity for digital transformation, this same OECD report ranks Chile a distant last in manufacturing R&D, so there are barriers that prevent investment from happening today.

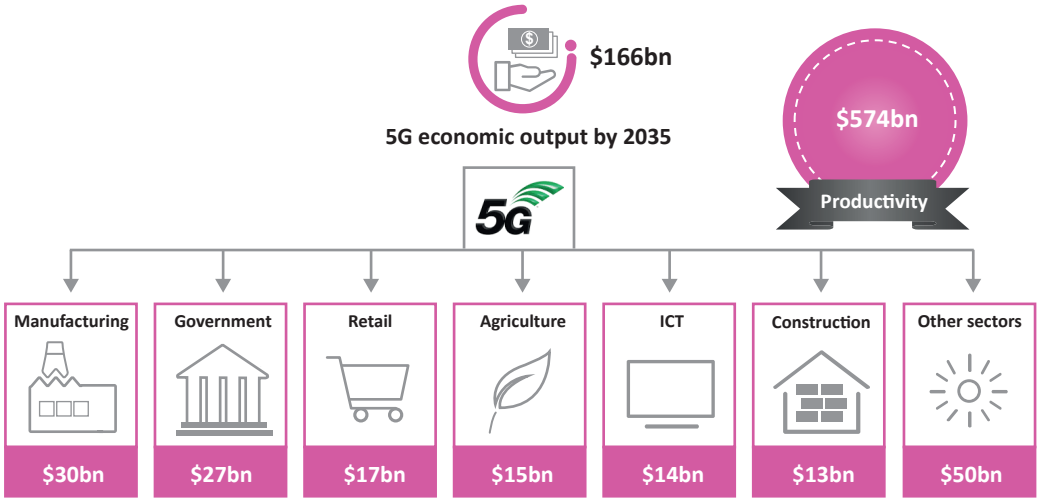
Chile's construction sector has been booming thanks to investment in basic infrastructure, but social unrest in the second half of 2019 has observers such as Fitch Ratings concerned. In the short term, significant construction dollars will shift to repairs to infrastructure damaged during the demonstrations and, in the medium and longer term, Fitch worries that government budget priorities will shift from infrastructure to social spending.

Urban dwellers account for 88% of Chile's population, so it is no surprise that it is often described as one of the most advanced retail markets in the world. Large chains, both local and multinational, dominate the industry. In fact, Chile's national chains have gone out to conquer the rest of South America, acquiring significant market share in the Spanish-speaking countries. For this reason, Omdia believes that retail digital transformation will come first to Chile and then spread to the rest of South America.

Colombia

In 2035, 5G will enable $166 billion of social and economic output in Colombia. ICT, services, manufacturing, and mining will be the industries most impacted by 5G.

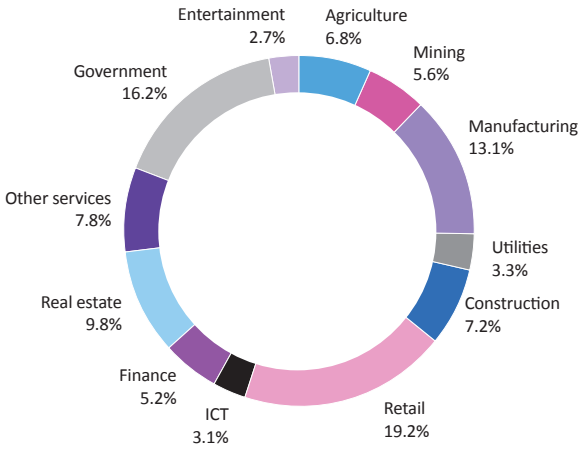
Figure 5.20: Colombia, 5G economic and social value impact



Source: Omdia, based on Omdia and Bell Lab economic models

Figure 5.21 shows the structure of Colombia's economy including a breakdown of its services sector into subsectors.

Figure 5.21: Colombia, gross value added by economic sector



Source: Omdia

Manufacturing comes out on top of our model and is the third-largest contributor to GDP, but the country has struggled with establishing a high-value-added, export-oriented manufacturing sector. Still, the model is telling the truth, because digital transformation of the country's factories will be vital to maintaining the country's heretofore exemplary GDP growth record from the last decade. Low-wage manufacturing was wiped out by a boom in oil and gas prices that revalued the peso and eliminated this advantage. Now the peso is cheap again, but the jobs have already left for Southeast Asia. Only by focusing on productivity will this sector become an engine of growth.

The second-largest contributor to GDP is government services including health, education, and Colombia's significant military sector. All government services would benefit from 5G eMBB. Additionally, the ministries of ICT and health have run telemedicine trials for many years now, and the ministries of ICT and education have held remote education trials, trying to overcome the country's infrastructure deficiencies outside major cities (lack of schools, hospitals, and the roads to get to where such facilities exist).

No mayor has talked about comprehensive smart city solutions, but individual utility networks could see upgrades that leverage 5G in the coming years. Furthermore, most cities in Colombia and, in particular, Bogotá, the country's capital and by far the largest urban area, experience serious traffic and transit infrastructure issues for which a smart city, or at least components of it, would be extremely useful. Since all the utility companies are either owned outright or have significant equity participation by cities or the national government, there is an opportunity to leverage synergies between utility and traffic/transportation networks.

Retail is the largest sector in terms of contribution to GDP and the third most important for 5G impact. Some of the more sophisticated B2C marketing applications will follow the deployment of consumer/mass-market 5G eMBB, but there are logistics opportunities, especially in the major cities, where big-box retailers play a major role. Furthermore, these retailers are subsidiaries of major Chilean chains or global retailers. These multinationals have plans and projects for upgrading their "smart" logistics systems and would no doubt want to bring these to Colombia sooner rather than later.

In agriculture, Colombia has resisted the shift to large-scale industrial farms for a number of political and social reasons, although there are large palm oil, sugar, rubber, and cattle-raising operations. With the possible exception of palm oil and rubber, even the large farms are traditionally run, so Omdia sees less opportunity in this sector over the coming five years.

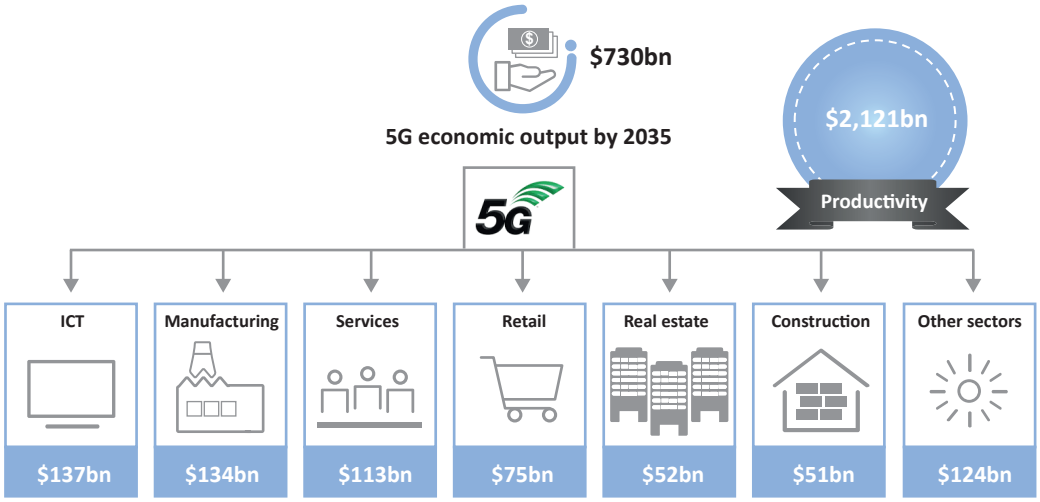
Finally, there are opportunities in the transportation and logistics area. The country suffers from terrible transportation challenges: the commonly repeated story is that it costs more to ship a container from Bogotá to the coastal port of Cartagena than it does to ship it from Cartagena to China. New roads are changing the situation, but the logistics chain must be optimized at every step. Colombia has the fourth and twelfth busiest ports in the region by volume, and both are already highly automated with, for example, remote crane operations. The next step would be to leverage 5G technology even further for container tracking and remote or autonomous forklift systems.

As discussed in the previous chapter, airports present a number of 5G use-case opportunities. Bogotá has the region's busiest cargo airport and third-largest passenger one, both operations continuing to grow faster than the country's GDP. Maintaining the airport's competitive edge will require it to be at the technological forefront, so Omdia expects these 5G applications to appear soon, although not, perhaps, until the mid-part of the decade given conservative planning, especially since runways are shared with a Colombian Air Force base.

Mexico

In 2035, 5G will enable $730 billion of social and economic output in Mexico. ICT, manufacturing, services, retail, real estate, and construction will be the industries most impacted by 5G.

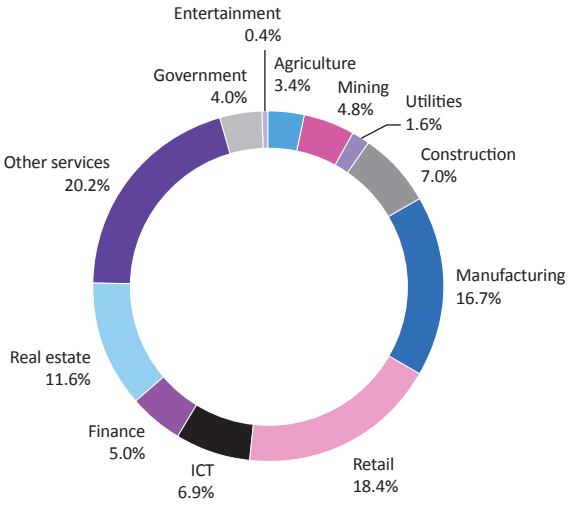
Figure 5.22: Mexico, 5G economic and social value impact



Source: Omdia, based on Omdia and Bell Lab economic models

Looking at Mexico's breakdown of the economic impact of its sectors, we can immediately see the high impact that manufacturing and services have on the local economy. Figure 5.23 shows the structure of Mexico's economy, including a breakdown of its services sector into subsectors.

Figure 5.23: Mexico, gross value added by economic sector



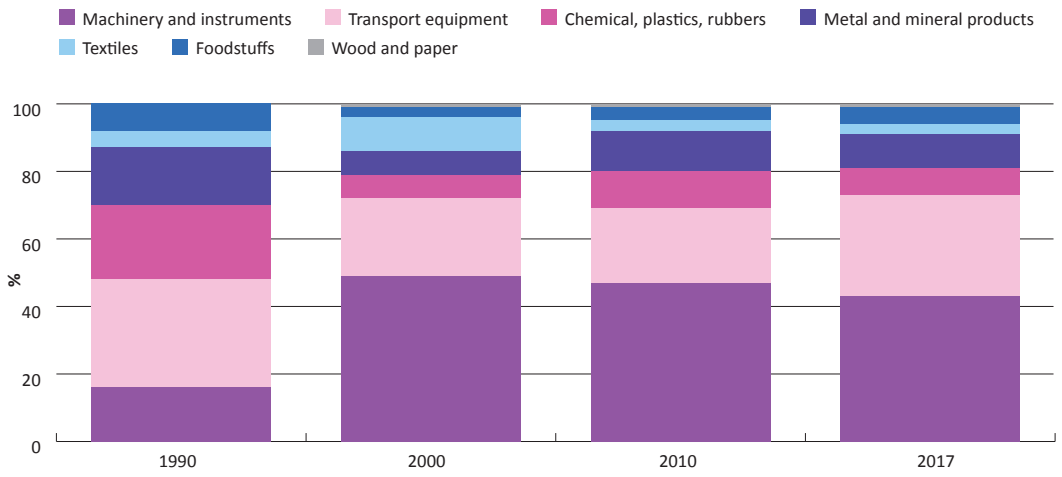
Source: Omdia

Services, retail, manufacturing, and retail are the largest contributors to GDP.

Launching a new technology such as 5G requires a certain scale, so Omdia looked at the largest 500 companies in Mexico. Utilities is the top-ranked sector in terms of revenue, comprising a small group of around 50 companies that could be "foundational" 5G enterprises in the country. Finance is also an interesting activity in terms of scale, but more than a hundred companies are involved. Another consideration is that the third-largest activity is holding companies, and conglomerate companies could be interested in 5G technology to implement in different industries and activities. This is one of the advantages of this multipurpose technology.

Aided by the North American Free Trade Agreement (NAFTA) and by its proximity to the US, Mexico developed into a manufacturing hub by deepening its integration into global value chains, and exports' share of GDP climbed from 19% in 1990 to 38% in 2017. Manufactured goods account for 80% of exports and go mostly to the US. (In total, 76% of Mexico exports go to the US.) While medium-technology products still dominate goods exports, the share of high-technology and more complex goods has been increasing over time. Export growth has been driven by the expansion of current trade relationships, as in other countries, showing the potential to expand manufacturing by implementing 5G because new technologies will drive productivity and growth.

Figure 5.24: Mexico, composition of exports by sector, 1990–2017



Source: Omdia

The most prominent manufacturing industries in Mexico are automotive, aviation and aerospace, medical devices, and transport equipment.

Mexico is Latin America's largest automotive manufacturer with an annual production of close to 4 million units. It is estimated that 82% of these units are exported. Mexico is now the fourth-largest producer of automobiles in the world. Automotive is clearly one of the top sectors where 5G will be introduced to facilitate cost reduction and productivity.

Gone are the days of only simple assembly and low-tech manufacturing in Mexico. Now the country is attracting large multinational manufacturers from virtually every industry. Industries in Mexico now vary across all sectors of business. In fact, Tijuana, Mexico now claims the largest concentration of medical device manufacturers in all of North America. Incorporating 5G will create an advanced industrial hub.

ICT and manufacturing will be the most impacted sectors, mainly because they are catalyzers of all these changes in society and in all industries. Manufacturing will garner almost $135 billion, or

almost 20%, of the $733 billion in sales enablement. This might appear high until one considers that implementing any of the 5G use cases will stimulate, at a minimum, complementary spending on equipment, all of which will be produced by the manufacturing sector. For example, drones will enable sales within the transportation sector, which will require the transportation sector to buy additional drones from the manufacturing sector. Medical use cases will require complementary spending on 5G-ready equipment from the manufacturing sector.

The same line of reasoning applies to the information and communications sector, which will see the first large share of 5G-enabled economic activity at almost $137 billion. Implementing any of the 5G use cases will require spending on communication and content services. ICT includes telecommunications, broadcasting, and video. It is itself the core of 5G and an enhanced broadband connectivity enabler to make all these changes possible. Streaming of UHD, AR/VR, video telepresence, and tactile internet would be facilitators. These will enhance existing communications solutions and encourage new ways of interacting. This will affect a broad range of professional service industries and the overall ICT industry.

Information and communications includes the production and distribution of information and cultural products, the provision of the means to transmit or distribute these products, data or communications, information technology activities, and the processing of data and other information service activities. Software development and services will grow exponentially in the 5G era.

Mexico City is among the most populated cities on the planet with almost 22 million people. It is also the economic center of the country and a cultural hub, creating opportunities for the retail market. There are several large chains, both local and multinational, that dominate the industry and an extended industry of small local shops. Retail is the main GDP contributor (apart from the rather broad other services category) and is one of the sectors that is expected to adopt 5G technology to create new experiences and differentiation to compete with the regional and international e-commerce marketplaces that already have presence in Mexico and are growing rapidly.

Since Mexico City is such a large urban area, construction and real estate are other opportunity areas for 5G. Every new building should be 5G ready, and people will be looking to buy apartments that will provide the home of the future. Constructing a building that has the ability to connect thousands of IoT devices at the same time, providing real-time information, highly secured, with lower energy consumption and easy maintenance, and which is capable of being a home office in such a heavy traffic city, will be a key differentiator.

So 5G is a key opportunity for large cities in terms of comprehensive smart city solutions. Furthermore, most cities in Mexico, and Mexico City in particular, experience serious traffic and transit infrastructure issues for which a smart city (or at least components of one) would be extremely useful. Using 5G to improve security will also be one of the main applications. Tourism, to Mexico City and to the country as a whole, is growing every year. The Riviera Maya is one of the world's top destinations. Providing 5G technology to the more than 40 million tourists who visit Mexico every year will completely transform tourism, because it will give the hospitality industry access to almost unlimited communications, data, and computation services in real time for both business and leisure travel. With 5G, travelers will enjoy new travel experiences, and tourism companies and hotels will have much better knowledge of their customers, their characteristics, and their tastes, preferences, interests, and customs, segmented by groups of interest and profiled in great detail (with total respect for privacy and anonymity). Any country left behind in this race will suffer a severe setback in its appeal as a destination.

Additionally, there are certain specific use cases that might also be 5G drivers, such as opportunities in the entertainment industry, which has a long history as a hub for Spanish speakers. Agribusiness is not highly developed in Mexico, so it is a greenfield in which to implement precision agriculture and the ability to manage a farm from anywhere using 5G.

Government could be a 5G catalyzer, taking the opportunity to implement 5G in different social areas such as health, education, public safety, and transportation. Selecting a few strategic

government projects with high social impact would create a foundation for 5G and speed adoption in the country. Establishing public-private partnerships, collaborating with government assets, offering tax incentives, and being a demand aggregator are some of the ways that governments could boost 5G adoption and catalyze economic growth.

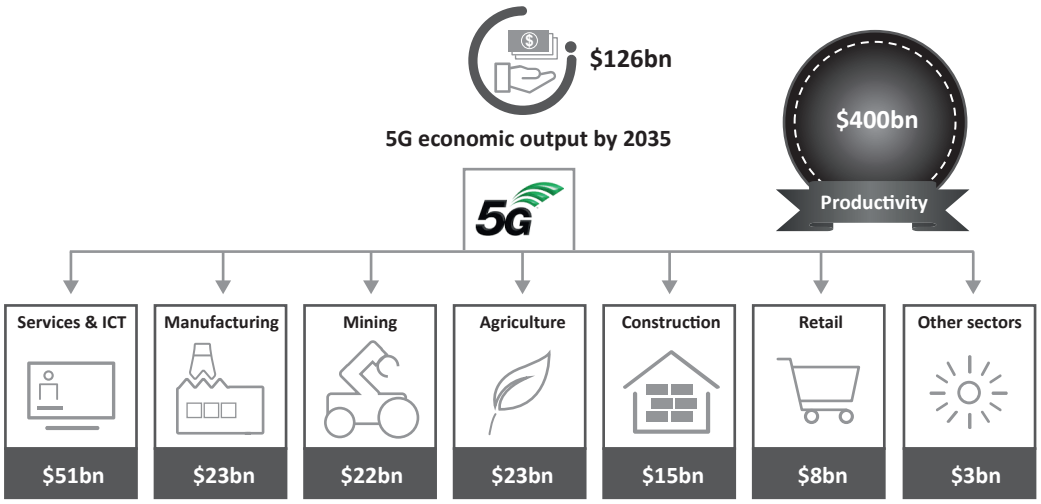
Mexico has a great potential for 5G, being the second-largest economy in the region and with the advantage of having a very competitive market, which could lead to a more rapid launch. América Móvil has already announced a 5G launch in 2020 as has AT&T, following its North America network coverage strategy.

Peru

In 2035, 5G will enable $126 billion of social and economic output in Peru. ICT, manufacturing, services, retail, real estate, and construction will be the industries most impacted by 5G.

Peru has been described as an economic miracle, growing much faster than the region as a whole and rapidly reducing poverty. That should help raise the opportunity level for enterprise 5G in the region. However, the International Monetary Fund, in its latest report, expressed concern that "Informal employment comprises nearly 70% of total employment in Peru, well above the already high Latin American average of 54%." Part of the blame is ascribed to onerous conditions and additional costs when a firm reaches 20 (formal) employees, creating a large number of very small companies and a small number of medium-sized ones.

Figure 5.25: Peru, 5G economic and social value impact

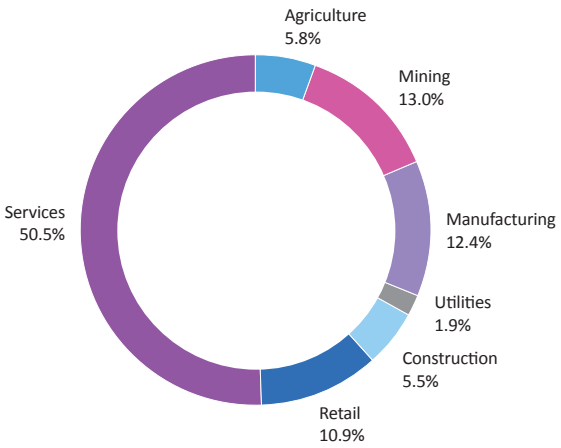


Source: Omdia, based on Omdia and Bell Lab economic models

This means that Omdia expects to see enterprise 5G only in those sectors naturally dominated by large companies.

Figure 5.26 shows the structure of Peru's economy by productive sector. Unfortunately, the national system of accounts available on the web does not break down the services category, so we are unable to provide the same level of detail as we have for other countries.

Figure 5.26: Peru, gross value added by economic sector



Source: Omdia

In the model it was not possible to separate ICT from other services as could be done for other countries.

Like its peers, Peru has about 50% of its GDP coming from the services sector. However, this is a very broad category, certainly when 5G opportunities are being thought of, so this lack of data limits our analysis. Less than 10% of the GDP produced by Peru's service sector is exported, meaning most of the sector's activity is for domestic consumption. While this does not necessarily imply a low level of sophistication, it does mean the sector does not compete for global business with major players.

Apart from services, mining is the largest and most emblematic sector of Peru's economic rise, and it features very large multinational companies. It ranked a close third in Omdia's model, and indeed, Peru has one of the few live examples of a private mobile network (in this case LTE) at the Las Bambas mine in the southeast region of the country, near the historical and tourist city of Cuzco. Telefónica and Nokia recently announced a five-year deal with the mine's management to install and manage an LTE network over the coming five years. In a Nokia press release, Miguel Canz, regional technology manager at Minera Las Bambas, said: "This is an important milestone for Minera Las Bambas as it will enable a series of new automation technology solutions increasing productivity in our mining operation as well as supporting more advanced automation to improve worker safety."

Omdia expects this network to migrate to 5G as the automation technology projects proceed and performance requirements become more stringent.

We also expect more mining companies to adopt this technology in Peru now that the ice has been broken with a first application. The Peruvian government, in its latest budget report, identified three new major mines to begin construction in 2019/20 and two major expansion projects. New and expanded operations are ideal opportunities to adopt advanced, automated mining technologies and private mobile broadband communications.

The next-largest sector is manufacturing, and it came number two in our model for 5G impact. About 25% of this category in Peru is primary transformation of raw materials, which is driven by mining, oil and gas, and fishing. The remaining 75% is spread over a very large number of products, many for domestic consumption, such as food processing and construction materials. The largest contribution to gross value added is from precious and nonferrous metal manufacturing, and that was only 9% of manufacturing in 2018.

As in most of Latin America apart from Argentina, Brazil, and Mexico, Peru's agricultural sector is dominated by a large number of small farms. The World Bank estimates that in 2012, 99% of farms were smaller than 100 hectares. These are unlikely to have the cash flow for investing in advanced agricultural applications except in the case of very high-value-added crops such as grapes for wine and pisco.

However, the 1% of large farms are very large (average size is about 1,300 hectares) and together represent 77% of Peru's farmland. Depending on the crop and the sophistication of the owner, precision agriculture could bring significant benefits. High-value exports such as asparagus and fruits are increasing rapidly, so the potential is there.

Fishing is another important and growing export sector, and the government has identified fish farming as a priority, recently slashing tax rates on the sector to encourage investment.

Although retail is not prioritized in our model, there is notable growth in what is called modern distribution (i.e., big-box stores and malls). One-third of Peruvians live in the Lima Metropolitan Area, and 78% of the country's population is urban. The major players in modern retail include both large local groups and the usual multinational and multi-Latina companies.

The presence of large and multinational players helps amortize the investment in advanced applications, making them come to fruition faster. Advanced retail 5G use cases will develop in stores with the rollout of consumer 5G, and logistical applications could come sooner with private networks in major warehouses / transportation centers.

6. Preparing for 5G

As we have seen, 5G is coming to Latin America. But this is a revolution not an evolution, and the industry must get ready for it. Service providers have to prepare their networks, and regulators have to prepare the regulatory and legal framework.

Service providers

4G coverage

With respect to 4G population coverage, Argentina, Brazil, and Chile are in good shape (over 90%); Mexico and Peru are at just under 90%; but Colombia needs work (63%).

As explained earlier, 4G is an essential platform for 5G NSA, the version of 5G available commercially. Figure 5.3 shows the 4G population coverage situation for the major markets in the region. Argentina, Brazil, and Chile are in good shape (over 90%); Mexico and Peru are at just under 90%; and Colombia needs work (63%).

However, some of this coverage may be early generations of LTE, and all operators will want to upgrade their networks: first, so that they are 5G ready, perhaps requiring only a software change to offer 5G, and second, so that the fallback to 4G is a decent customer experience.

Transport network

Given the potential bandwidth of 4G, service providers had a number of options for hauling the traffic to and from base stations.

Fiber was the preferred option, and Latin American operators have deployed much fiber, which was synergistic with their plans to deploy fiber to the home (FTTH). Base stations and FTTH distribution points could be co-located and share a high-capacity fiber connection back to the internet.

For remote 4G base stations without nearby high-capacity fiber, mobile operators could use high-capacity microwave.

But in other cases, where alternatives were not available or where the operator determined traffic would be light, DSL was used, preferably more advanced and higher-speed versions but copper-based DSL nonetheless.

The first important change for 5G is that it requires an all-IP network. Base stations connected with fiber will be ready for this, but this is not necessarily the case for microwave and DSL. Today there are microwave backhaul solutions for 5G, but the DSL connections will have to be replaced.

The final transport challenge has to do with small cells. Today small cells are used in 4G, but with higher frequencies planned including millimeter wave (mmWave), the need will become more acute. Even so-called mid-band 5G spectrum is at a much higher frequency (3.5GHz) than those used today, so cell ranges will be smaller, and we have yet to fully experience what indoor coverage will be like. It is a virtual certainty that many more small cells will be required than exist today, each of which will require more backhaul bandwidth than we have currently.

Release 16 promises IAB (integrated access backhaul), a kind of mesh solution where the small cells can be backhauled over the same 5G spectrum as that used for radio access. This will be an important step, but service providers should plan anyway for much deeper fiber access than they currently have for 4G.

Core network and edge computing

One of the important benefits of 5G NSA is that it runs over the same 4G core that supports networks today. However, many of the higher-performance 5G use cases will require 5G SA, and that will require a new core network.

From another perspective, use cases that require the 1ms latency promised by URLLC (Release 16 and 17) will require computing resources to be very close to the end device. The speed of light eventually becomes a constraint, and there is no technological solution to that problem, at least with physics as we understand it today. That means that many enterprise and perhaps even some consumer use cases (such as gaming) will require distributed computing resources, very much more distributed and closer to the end customer. The solution is known as MEC or multi-access edge computing, and it will require a reengineering of service providers' compute resources.

Both these technologies—5G SA and MEC—will require a new architecture and investment in additional high-performance computing. Service providers will have to take both into account in their medium- to long-term capital planning.

5G evolution

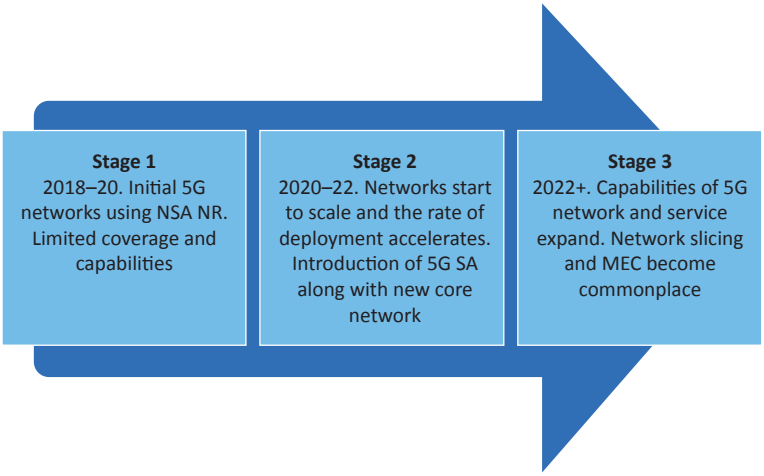
Another challenge is deciding what to focus on first when launching 5G. Operators have limited resources. To get a better understanding of how 5G will progress, Omdia has segmented the global market into three different stages:

Stage 1, 2019–21. This is where the market is today. The focus of this period will be to deploy the initial 5G networks, based on 5G non-standalone (NSA) New Radio (NR), which means they are anchored on existing LTE networks. The 5G coverage and network capabilities will be limited. Services will mainly be eMBB and FWA.

Stage 2, 2021–22. Operators start deploying 5G standalone (SA) NR along with the new network core. The standards become more mature, and vendors start producing gear in higher volumes. Network coverage scales and the rate of deployment accelerates. Networks supporting multiple spectrum bands are common. Operators start working on launching new 5G-based digital services that offer more than just data connectivity.

Stage 3, 2022 and beyond. In this stage, 5G becomes fully mature, because 5G networks now incorporate technologies from at least two 3GPP release cycles. MEC and network slicing are widely used. Network operators start offering new enterprise and consumer services utilizing the full capability stack of 5G, and 5G devices become mainstream. Network rollouts of new 5G NR exceed those of LTE during this stage. All of the 5G elements are brought together, and services and network performance excel to a new level.

Figure 6.1: Three stages of 5G network development

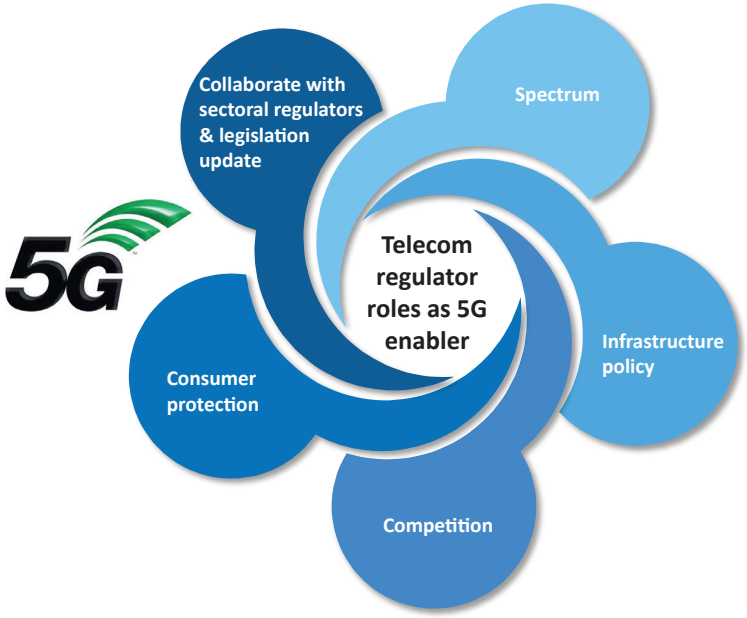


Source: Omdia

Public policy and regulation: Key enablers

Deploying a 5G network involves large sunk costs and long payback periods; therefore, prospective investors seek certainty and clarity about the legal and regulatory landscape. Latin American regulators must take a leading role to enable 5G in the region as a precondition to attract investments. The most obvious priority is spectrum policy, but infrastructure policy, competition regulation, consumer protection, and the collaboration with sectoral regulators and legislation are key to making 5G a reality in Latin America.

Figure 6.2: Telecoms regulator as an enabler for 5G



Source: Omdia

Spectrum

Spectrum is the key enabler of this technology and the changes that it will bring. Public policymakers should ensure that sufficient amounts of internationally harmonized spectrum are available and accessible for current and future needs, this having a direct impact on the competitiveness of countries in the new digital economy. A clear spectrum policy roadmap should be a priority and the starting point for 5G in the region. Globally and regionally harmonized spectrum would allow lower prices through global economies of scale, faster adoption, and a more cost-effective network deployment. In this massive planning effort, spectrum clearing and refarming are two of the activities that require the most effort and commitment. Spectrum-allocation mechanisms should put more weight on the speed and geographic extent of deployment than on financial compensation.

It is important to note that Latin American countries have not finished allocating the available 4G spectrum, so urgent action is required.

Spectrum for 5G includes a mix of low bands (600MHz and 700MHz bands), medium bands (C band, 3300–3800MHz), and high bands above 6GHz, including mmWave (the 26MHz band being the highest priority). Combinations of unlicensed spectrum and spectrum sharing will also be used as well as the current 4G spectrum.

Figure 6.3: Spectrum bands characteristics					
	Coverage range	Mobility	User throughput	Latency	Capacity
Low bands (<1GHz)	✔✔✔	✔✔✔	✔	✔	✔
Mid bands (1–6GHz)	✔✔	✔✔	✔✔	✔✔	✔✔
High bands (>6GHz)	✔	✔	✔✔✔	✔✔✔	✔✔✔
Source: Omdia					

Until 4G, only spectrum frequencies below 6GHz were considered suitable for mobile networks, mostly because of their coverage properties. While more spectrum below 6GHz is still needed for 5G to ensure coverage, innovative techniques are changing the way spectrum is being used, so there are a whole new set of mobile spectrum bands in the 6–100GHz range that require regulatory attention and innovative ways to allocate it and make new sharing models to unlock their potential in the coming years.

We are seeing the first announcements for auctioning 5G spectrum. Chile and Brazil are taking the lead in terms of total spectrum to be allocated, followed by Mexico and Peru. Interestingly, Mexico is taking leadership in 600MHz, bringing coverage benefits and synergies with the US deployment in this band.

Table 6.1: IMT spectrum, identified vs. assigned			
Country	IMT identified spectrum (MHz)	IMT assigned spectrum (MHz)	Announced or pre-announced for future auctions
Argentina	590	470	4G leftovers +90MHz: AWS ([10+10], 700 [10+10], 1900 [10+10MHz], 30 [AWS-E]) *
Brazil	1079+3200 (26GHz band)	650	+3610MHz: 700MHz (10+10), 2.3GHz (90MHz), 3.5 (300MHz) and 26GHz (3200MHz)
Chile	1490	490	1000MHz: 700MHz (10+10), AWS (15+15), 3.5GHz (150MHz) band and 28GHz (800)
Colombia	852	435	
Mexico	764	584	220MHz: 600 (70), 3.5GHz (150)
Peru	1254	424	Plans to auction 400MHz in 3.5Ghz
*Announced by the previous administration in 2019. No further announcement from the new authorities Source: Omdia			

Table 6.2: Latin American countries, identified or pre-identified 5G spectrum			
Country	Low (MHz)	Mid (GHz)	High (GHz)
Argentina	600	3.5	
Brazil	700	L band, 2.3, 3.3	26
Chile		3.5 & 2.3	28
Colombia		3.5	
Mexico	600	3.5	26
		L band, 2.3, 3.3	28, 38, 42, 48, 51
Peru		3.5	
		2.3	26, 28
Note: Purple text=auctions announced Source: Omdia			

Although progress has been made, concrete spectrum auctions are required under attractive investment conditions.

To support the evolution of private 5G networks for mines, ports, oilfields, factories, warehouses, buildings, farms, and other areas, a specific licensing model should be considered by regulators with specific spectrum provisions. Unlicensed spectrum might not be appropriate for these applications because of their reliability and security needs. A secondary licensing model or spectrum haring could be a viable alternative.

Figure 6.3: Latin American IMT spectrum status per key band

		MHz						GHz											
Country	MHz	450	600	700	800	850	900	AWS	AWS-3	L-band (1.4-1.5)	1.8	1.9	1.9-2.1	2.3GHz	2.5	3.3	3.5	26GHz	28GHz	High bands
Argentina*	478			+				+				+								
Brazil	630			+										+			+	+		
Chile	490			+				+?									+		+	
Colombia*	505																			40
Mexico	584		+					+		-		+				-	+			38, 42, 48, 51
Peru	424								+					+	+		+			

*Argentina: the new administration from December 2019 has not confirmed 5G plans nor spectrum auctions. Colombia studied suitability of several mmWave bands, but no decision taken by the time the report was released.
+Considering assigning more spectrum in this band (most countries have delayed spectrum auction due to economic crisis).
Precandidate band under analysis
Spectrum assigned/in use (lighter: less usage level/partial assignments)
In process to be assigned/awarded
Source: Omdia

Infrastructure policy

Infrastructure policy is the second key pillar of regulatory 5G enablers. Fiber connectivity becomes mandatory because copper and microwave links have performance limitations. Dense radio base stations installations are required, especially for higher-frequency spectrum. This requires a proactive approach for infrastructure policy to encourage and facilitate the private sector to invest in 5G networks, promoting a framework that simplifies and facilitates infrastructure deployment under a consistent national planning process; streamlined approval processes for network deployment and harmonizing and simplifying obtainment of local permits; defining reasonable requirements and efficient and transparent procedures; and establishing a maximum time for response and automatic approval in the case of no response from municipalities should all be promoted. A permanent alignment with municipal and local authorities should be an important focus to ensure no delays due to bureaucratic barriers. Facilitating the installation of small cells with minimum requirements is one of the drivers.

Policymakers should promote infrastructure sharing of all kinds of networks and infrastructure on commercially and technically agreed terms, which could result in substantial cost savings and make investment more attractive. Only in those cases where commercial agreements cannot be achieved on a timely basis should regulated pricing and conditions be a viable alternative in order not to delay the network deployment.

To ensure 5G network densification, we will see an increase in new models of network-sharing agreements. Considering the high investment requirements of 5G networks, regulators should facilitate this process while ensuring that these agreements do not have an anticompetitive impact on the market. The effective separation of networks that are housed within one physical infrastructure in a way that is equivalent to having separated physical infrastructures is made possible by 5G network slicing. In this way, each physical network will be able to host multiple logical service providers that provide specialist niche services over that network. Public policymakers should encourage coinvestment models, including public-private partnerships and joint ventures.

Competition

Competition has been one of the pillars of the mobile industry that has brought lower prices and options to consumers. Regulators have historically applied several remedies to ensure a competitive playing field such as engineering a minimum quantity of players in spectrum auctions (spectrum is a limited resource that restricts the number of possible RAN operators) and including infrastructure-sharing obligations, roaming, and MVNOs as part of regulation. Regulatory frameworks must restrict the ability of dominant players to behave in an anticompetitive way, thereby protecting economic opportunity for competitors that have previously invested or are in an investment process. There are no shortcuts to achieving competition. It is a long and continuous process, which requires constant monitoring, informed by an evidence-based approach. This must be considered in the 5G scenario, limiting ex ante regulation as much as possible to avoid having a negative impact on innovation. Because 5G will bring new business models and new players, regulators should monitor the market permanently and only regulate when strictly necessary.

Consumer protection

Consumer protection is a core concern in a service that would be essential for most economic activities. The majority of the necessary regulations are a continuity of the current framework, including privacy, emergency communications, end of contracts, complaints processing, and QoS. In some cases, this requires modernizing outdated regulation and simplifying the current requirements.

One of the main concerns of Latin American policymakers is how to ensure that all the population has broadband access and how to close the digital divide. Generating incentives and providing funding and regulatory flexibility for rural and high-cost areas should be key pillars. Consider creating incentives for coverage expansion, including tax exemptions, and granting subsidies to broadband investments in rural noncompetitive areas using transparent and competitive mechanisms with a technology-neutral approach.

The long debate about net neutrality already considers that specialized services may be offered where optimization is objectively necessary to meet the requirements of the services. Most of the new services that are going to be launched with 5G network-slicing capabilities fall under this category, so regulators should be monitoring to ensure that there is no anticompetitive conduct and the open internet principle is being maintained.

Some alarmists in the press have raised concerns about electromagnetic radiation (EMR) with 5G, especially in mmWave. The Australian health regulator has warned against “misinformation” being spread about 5G networks and states that “Contrary to some claims, there are no established health effects from the radio waves that the 5G network uses.” This has also been the consistent message from authorities in many countries including France, Germany, and the UK. International technical standards exist for the assessment of 5G networks. In current deployments, it has been proven that 5G EMR shows levels similar to 3G, 4G, and Wi-Fi, in many cases around 1,000 times below the safety limits.

Collaboration

Because 5G is not just a new RAN standard, it will generate new regulatory challenges. It provides new capabilities to support the digital economy in combination with other advanced technologies such as AI, cloud, VR, and edge computing. It brings new business models and disruptive ways of handling education, health, security, and so on. This requires a holistic approach, where ICT regulators should cooperate with other sectoral regulators, contributing to update laws in those cases where this is required. Sectoral regulators are less well placed to assess 5G network reliability than an ICT regulator, so a collaborative approach must be implemented. The ICT regulator has a key role as enabler of the ICT ecosystems.

There are several general regulations that are already under revision such as taxation, data privacy, new consumer protection and competition challenges, and copyright, but several sectoral regulators are already working in more advanced economies. Automotive regulation around autonomous cars and airspace regulation for drones are just a couple of examples.

A comprehensive national digital transformation strategy plan that includes timeline, objectives, and goals with 5G as an enabler of the digital economy should be a priority for Latin American policymakers.

Security

Security risks in 5G

The risks inherent in 5G networks start with the number of devices that will be connected. Today we speak of millions of devices per square kilometer and of the diversity of these devices, ranging from small sensors to controllers of large machines. Vastly more diverse use cases and sensitive, mission-critical services such as industrial automation, connected cars, and improved public safety will use 5G. This means that 5G networks will be more attractive targets and that any vulnerabilities could have a far greater and more wide-reaching impact than before, affecting all elements of society, the economy, and national security. Human safety and even human lives depend on the availability and integrity of the network service. In other words, much more is at stake.

Another factor is that to achieve latency of 1ms, part of the network's intelligence must be closer to the user (edge computing) with the control functions ranging from a few points on the network to hundreds if we consider countries of the size of Brazil or Mexico. Protecting the integrity of the network will become more challenging, because the network intelligence that routes calls and provides services will be scattered across numerous regional data centers and will depend on a high degree of system virtualization. At the same time, edge computing will bring the security blanket closer to at-risk devices.

The arrival of 5G will also introduce so-called *network slicing*, where distinct, end-to-end virtual slices of the network can be isolated and tailored to specific customers or applications. Each slice will be different—one might be used for a public safety solution, another for cloud gaming—so their security needs will vary. Security in 5G has to be flexible enough to deal with such differing requirements.

The relevance of security in 5G, and why it is different from 3G and 4G

The 2G, 3G, and 4G networks were essentially networks designed for services intended for consumers, where security-control mechanisms can be more easily applied, for example, in the certification of all devices. In 4G, with the introduction of support for IoT connectivity, we have a natural increase in vulnerability with the variety of connected devices. With 5G, the number of devices that can be used increases exponentially, ranging from small sensors to controlled drones.

Also, 5G has a much higher dependence on virtualization than previous generations with, for example, the same hardware running many instances of a network function. It is essential that the data in these virtualized instances cannot be mixed up and that one instance does not jeopardize the function of another by consuming too many resources. Companies operating 5G networks will also require robust tools to keep the fragmented infrastructure secure and up to date, because security patch cycles will be significantly shorter.

At the same time, 5G also brings substantial security improvements such as better protection of subscriber identities and the ability to create isolated, end-to-end virtual network slices to allow radically different use cases to coexist securely within the same 5G infrastructure. An operator can have one slice for consumer use, another slice for the industrial automation of a large manufacturing company and a third slice for law enforcement and emergency personnel. Such use cases have different security and QoS needs, and network slicing ensures the data will remain within the appropriate slice.

Why governments need to think about security, and the EU approach

As a result, security is an essential component of 5G. Networks for 5G are architected around and include technologies such as IoT, big data, AI, and machine learning. Among other things, 5G will potentially be a vast planetary sensor that can instantly spot anomalies and identify even multidimensional attack vectors. This kind of intelligence and analytics will be necessary for 5G networks to be able to accommodate the multiple use cases and performance parameters that they will have to meet. It also equips them with the intelligence and resources to be able to sense attacks and defend themselves when required.

Security for 5G includes a multilayer approach requiring

- Trusted infrastructure (devices, HW, SW, VMs)
- Automated security and orchestration (security policies)
- Network exposure and data federalization
- Secure data (access control, regulation, and privacy)
- Security intelligence (shared across all the parts of the network to help identify abnormal behavior and traffic and address it proactively)

Building integrated end-to-end security for 5G government and defense networks must include the full set of these layers and capabilities.

Additionally, since 5G networks are the future backbone of our increasingly digitized economies and societies, a national cybersecurity risk assessment is recommended. For this, the European Union issued a toolbox of mitigating measures to address 5G security risks.

The EU toolbox addresses all the risks identified during the EU-coordinated assessment, including risks related to nontechnical factors such as the risk of interference from non-EU states or state-backed actors through the 5G supply chain. This risk was highlighted as a major concern during the assessment stage, and the toolbox outlines two steps that member states should take to protect themselves. Rather than targeting a particular supplier or country, it recommends assessing the risk profile of suppliers, considering criteria set out in the EU-wide coordinated risk assessment, and then applying relevant restrictions for suppliers considered to be high risk, including exclusions for key assets defined as critical and sensitive. Other strategic and technical measures are outlined in the toolbox, covering areas such as regulatory powers, third-party suppliers, diversification of suppliers and sustainability, diversity of 5G supply and value chain, baseline network security measures, requirements related to suppliers' processes/equipment, 5G-specific network security measures, and resilience and continuity. This could be a good starting point for governments and Latin American policymakers.

7. Conclusions and recommendations

Omdia believes that the evidence in this report demonstrates that 5G will come to Latin America sooner rather than later, and that operators should prepare for it. The need for higher-speed broadband at home and new immersive experiences will drive adoption in the mass market. The region lags its peers in productivity and economic growth, both of which will be enhanced by digital transformation. This, in turn, requires significantly enhanced broadband communications, and that leads to 5G.

Three markets will create the push

- **Mass-market adoption** as data traffic continues to grow and consumers are attracted to 5G's superior performance in entertainment services, from video watching to gaming to AR. Operators that successfully bundle digital offers with high-speed connectivity services in a new 5G immersive experience should see lower churn and better ARPU results. Omdia predicts that 17% of Latin American mobile lines will be 5G by 2024.
- **Fixed wireless access** because 5G performance can compete with fiber but offers a more flexible deployment strategy, bringing ultra-broadband to new areas and economic strata. Today there are 300 million households in the region without broadband of any kind and 45 million that have fixed broadband but at speeds below 30Mbps. Both groups are addressable markets for 5G FWA.
- **Enterprise applications** especially those leveraging network slicing or dedicated equipment to create private 5G networks.

In the consumer market, both fixed and mobile opportunities will be driven by increasing demand for video traffic and for the immersive technologies that 5G provides (cloud gaming, VR, AR, and mixed reality). Gaming is probably for early adopters, but 5G will inspire new modes of experiencing video entertainment, education, shopping, communicating, and even traveling. We do not want to wait for the next video to start when scrolling through a social network, miss a split second of a football match, have a glitch in the middle of our favorite song, or have the screen lock up just as we are about to defeat the villain, but 5G is much more than speed. Virtual reality will immerse us in a completely digital world, to interact with other humans or with the real world for training using AR that overlays digital information on physical objects or environments. Immersive technologies, enabled by 5G, will take our digital experiences to the next level, and beyond.

Furthermore, we want richer experiences, higher-resolution displays, and more complex software, which developers will supply as our handheld devices become more and more capable, catching up with our laptops and game consoles.

The challenge for operators in 4G has been monetizing this growth as competitive pressures have led to lower prices (or higher data caps) and lower ARPUs. Bundling valued content with connectivity is a way to avoid direct price competition and sliding tariffs. Obviously, one challenge is doing this in markets that are predominantly prepaid, but postpaid in Latin America has nearly doubled in the past 10 years and is now an important and lucrative segment.

That said, recent Omdia research found a much greater proportion of emerging market respondents said they would pay for bundled OTT services or switch to another carrier for such bundles. This is driven by the far higher share in emerging markets of mobile-first/mobile-only digital media consumers and their greater reliance on carrier billing in the face of low credit/debit-card penetration.

For the enterprise market, Omdia believes that different verticals in different countries will bring together three key characteristics:

- Key economic sectors that generate cash flow to invest and that governments and service providers will be motivated to help
- Large sophisticated players able to invest in digital transformation, especially multinational companies that can amortize these investments over many countries/sites
- Established use cases that demonstrate the potential for 5G-enabled digital transformation

Every country has its unique characteristics, but based on our analysis, Omdia believes that retail will be the most important enterprise vertical that will be supported by the deployment of mass-market 5G but that ICT and manufacturing will lead for 5G impact, followed by government (smart cities). In Argentina and Brazil, agriculture will also play an important role.

Chile is the most advanced country in the region for adoption of ICT and so will likely lead in experimentation and digital transformation more generally. Furthermore, the country is a regional leader in retail, with many of Latin America's multinational players coming from Chile. However, it is a relatively small market, so the leaders in absolute 5G impact will come from the region's larger economies such as Brazil, Mexico, and Argentina.

At the other end of the range, Colombia's economy is only slightly smaller than Argentina's, but the country lags its peers in 4G population coverage, a necessary precursor for 5G (especially 5G NSA). Until very recently, lack of assigned spectrum has been a constraint. There are opportunities in the usual sectors, and some specific cases may arise on the same timeline as in other countries. Broad deployment will have to wait until operators develop their 4G assets more fully.

Recommendations

Recommendations for service providers

- **Upgrade 4G to be "5G ready."** Although 5G-ready base stations will help, 5G will not deploy instantaneously to all parts of the network. Where 5G is not available, the fallback has to be high-capacity 4.5G or even 4.9G so that the customer's experience is not so dramatically different.
- **Expand 4G coverage to support 5G plans.** Except in Colombia, 4G population coverage is good in the region, but if a target vertical (e.g., transportation or utilities) requires broad coverage (e.g., between urban centers), more investment may be required.
- **Push fiber deeper into your network.** For 5G, a high-capacity, all-IP transport network is required. There are point-to-point microwave solutions for remote locations, but fiber will always be the preferred choice.
- **Plan the network's future computing architecture** for MEC and to (eventually) accommodate a 5G SA core.

Recommendations for policymakers

- **Finish allocating 4G spectrum.** Great strides have been made in all countries in recent years, but 5G requires vast amounts of spectrum and not only in so-called 5G frequencies.
- **Develop a clear spectrum policy roadmap.** Globally and regionally harmonized spectrum would allow lower prices through global economies of scale, faster adoption, and a more cost-effective network deployment. Such a roadmap should take unlicensed spectrum into account and plan for the private networks that Omdia believes will be a key driver of enterprise 5G.
- **Proactively develop an infrastructure policy to encourage and facilitate the private sector to invest in 5G networks.** Promoting a framework that simplifies and facilitates infrastructure deployment under a consistent national planning process; streamlined approval processes for network deployment, harmonizing and simplifying obtainment of local permits; defining reasonable requirements and efficient and transparent procedures; and establishing a maximum time for response and automatic approval in the case of no response from municipalities should all be promoted.
- **Promote infrastructure sharing of all kinds of networks and infrastructure on commercially and technically agreed terms.** This could result in substantial cost savings and make investment more attractive: 5G will require significant densification (including small cells), and sharing may be the only way to overcome community resistance to more sites.
- **Develop a national digital transformation plan.** A comprehensive national digital transformation strategy plan that includes timeline, objectives, and goals with 5G as an enabler of the digital economy should be a priority for Latin American policymakers.

Appendix: 5G overview

The three key performance indicators for IMT-2020:

Up to 10Gbps peak data rates for eMBB

One million connections per square km for mMTC

One-millisecond latency for URLLC.

Historically, each wireless standard was developed with emphasis on one use case: 2G standards were focused on digitizing mobile voice services, 3G introduced mobile broadband, and 4G brought improved mobile broadband. Nonetheless, 5G is different: it has been specified to be flexible enough to accommodate a range of different use cases, grouped in three categories in ITU's IMT-2020 recommendation.

Timeline

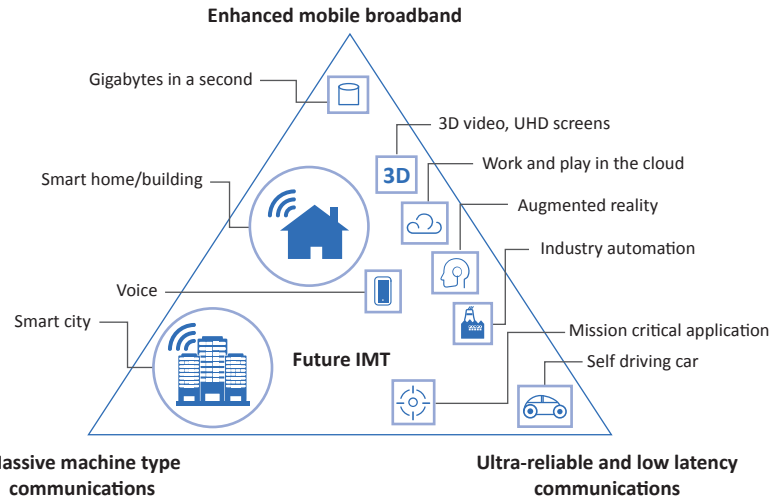
The International Telecommunication Union (ITU) defined its vision for 5G networks in IMT-2020, to be completed by 2020. Among the main requirements outlined by ITU are the following three key performance indicators for IMT-2020:

- Up to 10Gbps peak data rates for Enhanced Mobile Broadband (eMBB)
- One million connections per square kilometer for massive machine-type communications (mMTC)
- One-millisecond latency for ultra-reliable low-latency communications (URLLC)

Based on these IMT-2020 goals, 3GPP has been defining the set of technical specifications that form the 5G standard. Release 15 was finalized in June 2018 and detailed the 5G New Radio (NR) requirements. Release 16 had a freeze date target of March 2020, to be followed by three months of stabilization until its "Late Drop" in July 2020. Finally, Release 17 had an estimated conclusion date of July 2021, but the release schedule has been delayed because of the COVID-19 pandemic. Although 3GPP is focused on 5G, work on 4G has not stopped: each of the releases mentioned above includes 4G enhancements. Nonetheless, this chapter will focus on the 5G aspects of the 3GPP technical work.

Historically, each wireless standard was developed with emphasis on one use case: 2G standards were focused on digitizing mobile voice services, 3G introduced mobile broadband, and 4G brought improved mobile broadband. Nonetheless, 5G is different: it has been specified to be flexible enough to accommodate a range of different use cases, grouped in three categories in ITU's IMT-2020 recommendation, shown below:

Figure A.1: ITU's IMT-2020 broad use-case categories

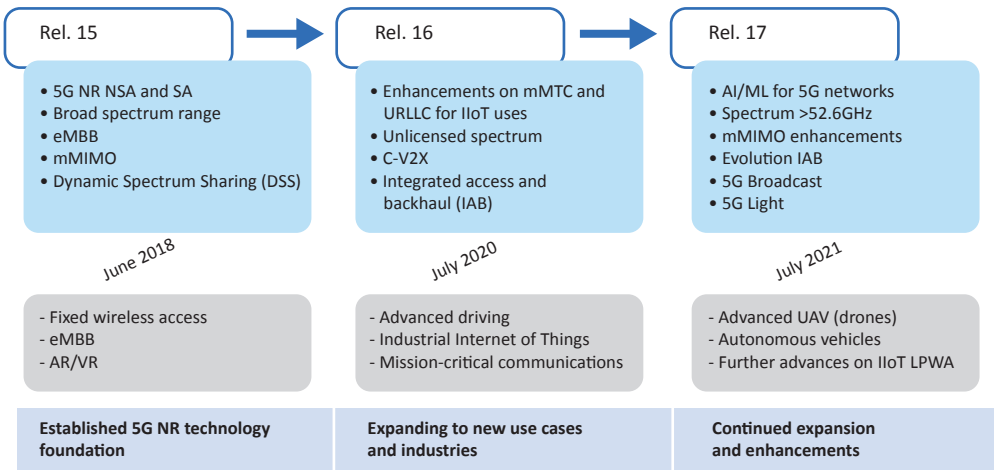


Source: ITU-R Recommendation M.2083

- Enhanced Mobile Broadband (eMBB), the early driver for 5G, encompassing the first use cases based on the standard, essentially, higher data rates than LTE, enough to enable new services such as AR/VR applications
- Massive machine-type communications (mMTC) use cases linked with the IoT (i.e., supporting a very large number of connections)
- Ultra-reliable and low-latency communications (URLLC) use cases that require strict latency and reliability specifications, including autonomous vehicles

The work of 3GPP on 5G specifications includes several specifications that have been studied in technical groups. Rather than detail each release, this chapter will discuss selected specifications in the analysis below.

Figure A.2: 3GPP timeline for 5G specification



Source: Omdia

Release 15

Release 15 kicked off 5G NR specification, paving the way for the commercial deployment of 5G and defining several technical characteristics that will be further enhanced in the following releases. Among the key aspects of Release 15 is the use of a broad range of spectrum, from below 1GHz up to 40GHz, opening unexplored swaths of spectrum to be used for cellular communications, including millimeter wave (mmWave). And 5G NR has also defined ultra-wide carrier bandwidth, up to 100MHz for spectrum below 6GHz and up to 1GHz in spectrum above 6GHz. Release 15 also specified massive multiple input, multiple output (mMIMO), enabling higher spectral efficiency and better user experience in a multi-user environment. Using beamforming techniques allows users to maximize the signal-to-noise ratio and hence throughput levels.

In order to provide a smooth transition from 4G to 5G, 3GPP put forward an early specification, and the strategy was to develop a non-standalone (NSA) and a standalone (SA) path for 5G NR. Both share the same air interface, but NSA uses existing 4G core, while SA will use a new 5G core once this is available. This dependency on a 4G core allows operators to deploy 5G services utilizing their existing infrastructure and not have to wait until a 5G core is fully standardized. Release 15 also set the stage for the next versions, outlining initial 5G capabilities that will be further enhanced in the next releases. This includes network slicing and another feature also aimed at smoothing the transition from 4G to 5G NR, dynamic spectrum sharing (DSS), which allows for the coexistence of both LTE and 5G NR users in the same frequency without the need to refarm spectrum.

All in all, the primary focus of Release 15 5G NR NSA was to set the standard for services such as eMBB and fixed wireless access (FWA), recognized as the initial uses for 5G, and indeed, these are the services offered at launch by the first operators to deploy 5G.

Release 16

Release 16 will be a major milestone, because together with Release 15, it will form 3GPP's submission to meet ITU's IMT-2020 specifications. Work on Release 16 is set to be ready in early 2020. The technical groups are working on several enhancements on the specifications included in Release 15 and introducing new ones. While Release 15 enabled the first 5G services based on eMBB, Release 16 will advance the standard in areas such as URLLC, which enables latency down to 1ms and improved reliability. These are requirements for mission-critical use cases such as vehicle to everything (V2X). Studies on V2X under Release 16 develop advanced use cases, including vehicle platooning, advanced (semi and fully automated) driving, extended sensors, and remote driving. Another set of features are classified as mMTC, and the target areas include uses for smart cities, transport and logistics, and energy, among others.

Release 16 will advance the standard in other aspects, including 5G in unlicensed spectrum. In the search for adding capacity, Release 16 covers the use of unlicensed spectrum in 5GHz and 6GHz bands, in coexistence with LTE-LAA and Wi-Fi. It will also include IAB, a way of reducing backhaul costs by introducing a mesh-type network topology in 5G. Another innovation will support satellite communications with 5G.

Release 16 has been designed to improve the specifications in Release 15 and further advance the case for 5G, supporting new features that will support the more innovative 5G cases. Most of these cases will be made possible once 5G NR SA is commercially available, in other words, when a 5G core (5GC) is available.

Release 17

Further evolution of 5G NR is guaranteed with the work conducted for Release 17. As is the case with Release 16, an important part of the work is focused on bringing enhancements to the specifications detailed previously and adding new, innovative features. The 5G core is intended to be built on a service-based architecture, and this flexibility will be required to support the various use cases planned for Release 16 and 17. Among the technologies to be covered in this release are

- mMIMO: better performance, improved spectral efficiency, and beam management for mmWave bands
- DSS: improvements to spectrum sharing between 5G NR and LTE introduced in previous releases
- NR-light: enhanced capacity for IoT including use cases such as high-end wearables and Industrial IoT applications
- Spectrum above 52.6GHz: previous releases support use of spectrum up to 52.6GHz; in Release 17 the support will be extended to spectrum up to 71GHz, especially the newly identified 60GHz identified by WRC-19

Devices

As expected, 5G phones were few in number and expensive in the first wave of commercial network deployments in the US and South Korea. However, 5G has been deployed in many more countries since then, and crucially, China brought forward its 5G debut to the second half of 2019. The scale of the Chinese market, and the high level of competition seen in its devices market, will positively affect 5G smartphone prices. Phone makers and operators are already announcing plans to launch more devices at lower price points, starting in 2020. Verizon, for instance, plans to have 20 5G devices in 2020, and Chinese vendors announced plans to offer 5G phones for less than $500, less than half of what the first 5G smartphones cost in early 2019.

Nonetheless, smartphones are not the only form factor to be developed for 5G. In fact, it is expected that 5G will be embedded in a number of different devices: indoor and outdoor customer premises equipment for FWA and tablets, for instance, are already in use, but are rapidly being joined by new 5G-enabled laptops, VR headsets, drones, and wearables among other things. This variety of devices is the materialization of the vision of 5G as the cellular network architecture that will connect people and things.

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