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The Impact of 5G on the United States Economy

This report outlines the influence of 5G, the world's next technological breakthrough, upon the United States economy. We will thoroughly examine the economic benefit driven by 5G, as well as illustrate how key industries will be affected through major industry use cases. Finally, we will identify opportunities to accelerate the economic benefits from 5G. 5G will be a force for growth and resiliency in a post-COVID-19 U.S. economy.

Accenture Strategy | February 2021

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The study was commissioned by Qualcomm Technologies, Inc. It was conducted by Accenture PLC, to assess the benefits of 5G and its impact on the US economy between 2021 and 2025.

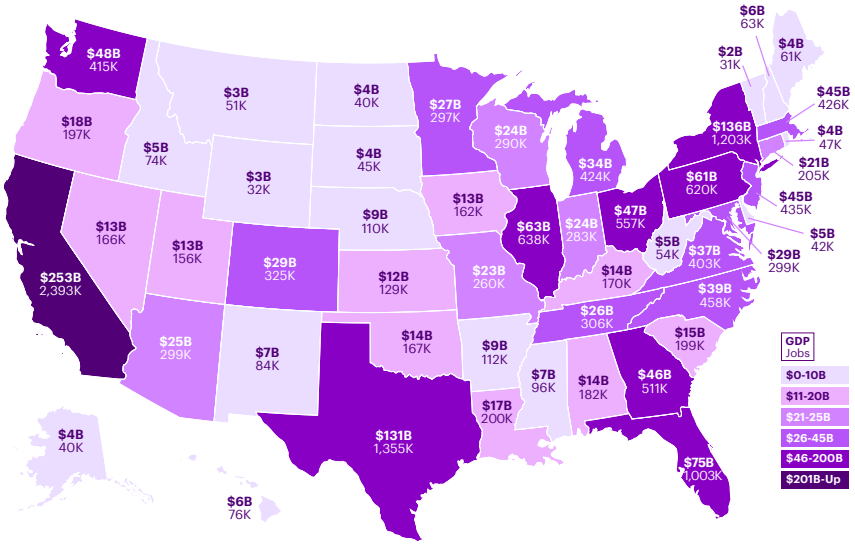
01 Executive Summary

New mobile technologies profoundly impact economies and societies. In 2010, a year after the U.S. 4G roll-out, "app" was voted word of the year. 2020 may forever be associated with COVID-19, but the deployment of a 5G network will have profound impacts on consumers and businesses by revolutionizing wireless communications and transform existing market sectors and industries. Beyond upgrading existing 4G-enabled capabilities such as faster video streaming, 5G will unlock new potential of technologies like artificial intelligence (AI), edge compute and the Internet of things (IoT). 5G will be instrumental to the success of these technologies by offering **rich bi-directional communications**,[a] **potential to support 1 million devices per squared kilometer**,[b] and **ultra-reliable sub-second response**.[c] The capabilities offered by 5G enable a variety of use cases, paving the way for the economy to realize the cross-industry benefits of magnified connectivity.

According to Accenture's latest economic modeling analysis completed for this paper, the impact of 5G on the U.S. economy will drive up to **$2.7 trillion in additional gross output** (sales) growth between 2021 and 2025.[d] Over the same period:

- 5G will add up to **$1.5 trillion to the U.S. GDP**.[e]
- 5G has the potential to create or transform up to **16 million jobs** across all sectors of the economy.[f]
- **Multiplier effects will be felt in every industry**. For example, every job created by 5G within the Information and Communications Technologies (ICT) sector will create an estimated 1.8 additional jobs throughout the economy.

The benefits of 5G will be felt across every corner of the United States, ranging from an additional $4 billion in GDP and up to 40 thousand jobs in North Dakota, to $253 billion in GDP and up to 2.4 million jobs in California, as can be seen below:



a eMBB: Enhanced Mobile Broadband
b mIoT: massive Internet of Things
c MCS: Mission Critical Services
d To arrive at these effects, we evaluated the increase in 5G on all economies based on historic growth from increased connectivity, and then adjusted industry-level relationships based on expected nuances in 5G use cases and impact.
e Gross Domestic Product is the value-add component of sales.
f Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Crucially, 5G technology will position the U.S. economy for accelerated recovery as Americans adjust to the turbulence caused by the COVID-19 pandemic. While businesses are grappling with unprecedented demand and supply chain disruptions today, 5G will fuel much-needed growth and facilitate long-term flexibility across value chains. Moreover, the 5G ecosystem will drive future economic resiliency by decoupling more workers from the physical workstation, sparking growth in new industries that are digital at their core and increasing efficiency and productivity across a variety of other industries. An accelerated application of 5G can ensure that the economy will emerge from this crisis even stronger than before.

5G in Action

5G is the foundational technology that enables other technologies to communicate and supports device development across the value chain, from chipset makers to infrastructure developers. Developing this technology requires companies to invest heavily and consistently in R&D to drive innovation over a long time horizon before the benefits materialize, prompting a balance between collaboration across the ecosystem and a robust IP protection strategy.

5G's outsized economic impact is predicated on its revolutionary technical capabilities, which include three major advances over previous generations of cellular connectivity:

Enhanced Mobile Broadband (eMBB)

5G can deliver high bandwidth and speed to enable rich bi-directional transfer of high-definition video and high-volume data. High speed mobile broadband is foundational for enabling applications like augmented reality (AR) and virtual reality (VR) that require rich data transfer in both directions and will unlock entirely new ways of engaging with people and information in the age of computer vision (CV) and machine learning (ML).

Massive Internet of Things (mIOT)

5G can provide simultaneous connectivity to potentially one million connections per square kilometer. This massively dense connectivity is essential to the effective implementation of advanced industrial Internet of things (IIoT) applications. One example of this is enabling large networks of sensors and machines to capture the rich data sets necessary to apply AI in smart power plants.

Mission-Critical Services (MCS)

For mission-critical applications such as automated vehicles or remote intensive care units (ICUs), the reliability and speed of the connection are crucial. 5G can carry network traffic with latencies as low as 1 ms, safely supporting use cases for which a fraction of an instant can make the difference between life and death.[1]

The benefits brought by 5G will redefine the way workers engage with their professions—new levels of connectivity will unlock higher productivity and untether employees from physical spaces in a way that has not been previously possible. For enterprises across all industries, 5G will help transform how business is conducted and everyday operations are run, presenting tangible productivity improvements through real-time flow of information. 5G will unlock the next wave of rapid data- and insight-driven decision making, allowing optimization of business functions and creation of new value for customers.

As a result of COVID-19, we are already seeing how tangible improvements in the connected worker experience can enable business shifts toward increased collaboration across geographies as well as support productivity gains and opportunities to upskill the workforce. 5G can provide connected workers with tools and data at their fingertips to drive more value for business and, therefore, the economy.

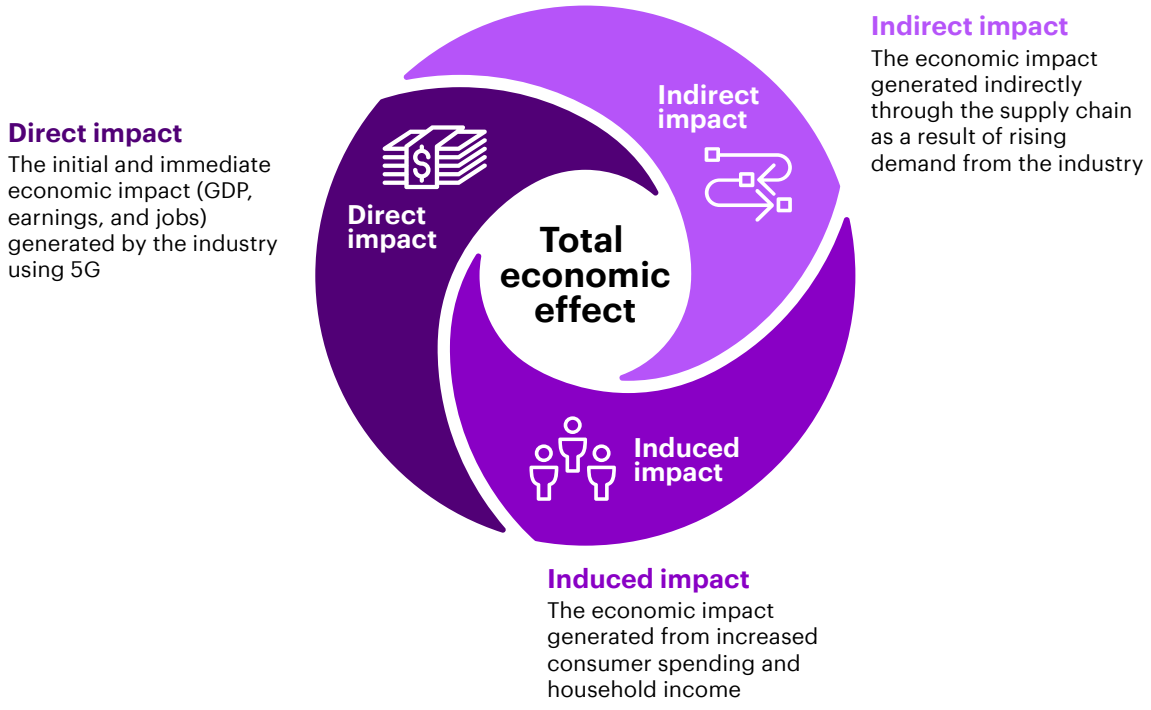
Economic Impact

The Impact of 5G on Total Sales

Between 2021 and 2025, 5G will drive up to $2.7 trillion in total new sales across all major industries in the United States. Over this time period, 5G will create or transform up to 16 million jobs and drive up to $1.5 trillion in GDP, a figure larger than the annual GDP of countries such as Brazil and Mexico.

5G's transformative impact on the U.S. economy will fuel an engine of economic growth across all industries in the United States, driven by the following:

- **Creation of new industries and sub-industries**: 5G will unlock new products, services and businesses based on high bandwidth, IoT and ultra-low-latency capabilities.
- **Cost optimization**: 5G will drive productivity improvements that will lead to increased economic output.
- **Product and service quality improvements**: 5G will generate increased customer value, driving up both willingness to pay and consumer surplus.



This paper examines specific use cases, illustrating how 5G will drive these shifts within industries. In addition to these examples (e.g. robotic process control in a manufacturing plant), many industries will experience economic growth because of their interconnections with other sectors. For example, manufacturing plants will play a key role in producing 5G devices both for consumers and to support transformation in other sectors like the automotive industry. Similarly, 5G's impact across industries will produce downstream ripple effects through their associated value chains.

The Multiplier Effect: 5G Value Chain Impact

The economic effect of 5G will propagate throughout the value chain of every sector, extending past the direct effect of increased growth within the primary industry. To understand the multiplier effect, consider the impact of 5G on Information and Communication Industry (ICT), the industry sector that lies at the core of 5G.

Information and Communications Direct[g]

The end-user benefits of 5G cannot exist without the network, hardware and software powering user devices. The direct economic effect of 5G activity on the ICT sector will account for $251.2 billion of the $1.5 trillion U.S. GDP impact, and $403.9 billion of the $2.7 trillion in additional sales.

Information and Communications Indirect (Supply Chain)

In addition to these direct benefits, 5G will create $85.7 billion in indirect GDP impact from suppliers and producers of intermediate goods and services. As ICT generates new sales and demand, their entire value chain will prosper. The companies that mine precious metals (e.g., gold) that are required to produce devices, for example, are part of the 5G indirect effect, as are professional service providers (e.g. accounting) that are employed within the industry.

Information and Communications Induced (Household Spending)

The labor income produced in the ICT value chain will produce $102.1 billion in additional GDP, generated by increased household spending from workers and newly created ICT sector jobs. This spending will, in turn, lead to additional job creation in sectors like arts and entertainment, food and beverage, retail and transportation.

Information and communications

*Multipliers are defined as the sum of direct, indirect, and induced jobs, divided by the direct job impact.

Source: Accenture Analysis

Because of the multiplier impact described above, for every job introduced by the direct effect of 5G in ICT, an additional 1.8 jobs will be created elsewhere throughout the economy, for a multiplier effect of 2.8 on the total number of jobs. This includes 1.2 million induced jobs and 1.0 million indirect jobs.[h] These multipliers exist in every industry and will be highlighted throughout this paper.

g Within this analysis, the ICT industry is defined to include communications providers, as well as the broader information technology sectors that develop software and hardware.

h To arrive at these effects, we evaluated the increase in 5G on all economies based on historic increases from increased connectivity, and then adjusted industry-level relationships based on expected nuances in 5G use cases and impact. Includes total headcounts.

Consumer Impact

In addition to these quantified benefits on GDP and jobs, 5G will further enhance **consumer value**, including by decreasing the number of road crashes, speeding medical diagnoses, reducing pollution and providing wider access to broadband connectivity.[i]

If addressed effectively within the United States, wider broadband connectivity can play a key role in solving the digital divide. Many lower-income Americans rely on mobile connectivity for online access versus fixed broadband. The trend is rising, with 26% of adults in these households being dependent on smartphones in 2019, as compared to only 12% in 2013.[2] This means that mobile connectivity can be a powerful tool for addressing the needs of these consumers in the future. 5G fixed wireless access, particularly in rural areas, could equip families who are currently constrained by limited broadband with the high-speed Internet they need to support initiatives like virtual schooling. The technology could reduce the disparity families today face at lower costs when compared to wired solutions. Economic literature suggests that 3G and 4G technologies' impact on consumer surplus was in the trillion-dollar range for the United States in 2017;[3] with 5G's new capabilities, the impact on consumer surplus has potential to grow even more.

Industry Impact

Each industry will be transformed in its own way. **5G will impact every industry by creating new products and revenue streams** (e.g. virtual care and personalized in-store experiences), **delivering cost and productivity benefits** (e.g. fewer crashes and more efficient traffic) **and supporting sustainability and resiliency** (e.g. smart factories and energy grids). To estimate the potential effects, our analysis subdivided the economy into 16 sectors, five of which are showcased based on potential for highly innovative use cases and benefits from 5G. Consider a snapshot of these findings:

Industry	Highlighted use cases	Potential benefits		
		New end services/ product	Efficiency/ productivity	Resiliency
Manufacturing 5G technology unlocks the ability to sense and respond for manufacturers in the United States, facilitating efficient communications between people and machinery.	Factory floor automation and robotic process control		●	●
	Intelligent asset management		●	
	Connected worker		●	●
	Quality assurance		●	●
Retail 5G technology will create superior customer experiences and operating efficiencies in retail through innovative new offerings and the removal of key points of sales friction.	Digital store consultations	●	●	
	Frictionless store checkout	●	●	●
	Intelligent clienteling	●	●	●
	Automated surveillance		●	●

i Economic analyses of digital services and cellular connectivity suggests that consumer surplus, the value consumers receive beyond prices paid for goods and services, is likely larger than sales and GDP impacts.

Healthcare 5G technology will allow more mobile/home care, better patient outcomes and more capacity and flexibility within the healthcare system.	Remote patient monitoring	●	●	●
	Virtual consultations and care	●	●	●
	Connected hospital	●	●	●
Auto & Transport 5G technology will enable smarter, safer, greener and more efficient transport from connected vehicles and transit infrastructure in the United States.	Enhance vehicle safety and automation	●	●	●
	Advanced fleet management and telematics services	●	●	●
	New intelligent transportation systems	●	●	●
Utilities 5G technology will enable reliability, safety and affordability throughout the utilities infrastructure and workforce in the United States.	Intelligent grid	●	●	●
	Next generation workforce		●	●
	Smart power plant		●	●

Source: Accenture Analysis

5G will not only provide improved performance compared to 4G, it will also profoundly expand the potential of what is possible with mobile data exchange. For example, there's a vast gulf between the user experience of **4G-enabled** telemedicine that lets a patient FaceTime with their doctor to get a prescription refill and a **5G-enabled** virtual visit that would equip a dermatologist to accurately diagnose skin cancer with real-time high-definition imaging. Other applications such as frictionless check out in retail stores have been limited to small scale trials with 4G but can become more reliable, effective and pervasive with 5G.

Select Findings

Manufacturing
5G-enabled factories can see up **to 20-30%**[63] in overall productivity gains, including improvements of **50%** in assembly time, **20%** in asset life, and **90%** in defect detection.[69]

Retail
5G can enable rich video streaming experiences in the store, enabling up to **50%** increase in sales growth when combined with human-focused processes and XR visualizations.[89]

Healthcare
5G will allow more post-acute care to transition to remote, home-based models, where cost savings are greater than **30%** and drive better patient outcomes.[109]

Auto & Transport
New connected vehicle technologies have the potential to reduce the severity of non-impaired crashes by **80%**[132], save **$3.6 billion** in collision costs[131], and reduce traffic by **25%**.[141]

Utilities
Transmission line monitoring using smart sensors and drones can reduce wildfire risk, potentially **saving billions of dollars**.[169]

Source: Accenture Analysis

Acceleration Opportunities

The potential benefits of 5G are immense but require a critical mass of network deployment, R&D and production of new devices across industries, along with significant investment from every major sector in the U.S. economy. There are, however, prominent opportunities to accelerate the realization of these benefits, which could secure America's role as a 5G leader and power further growth:

Opportunity #1: Intellectual Property (IP), Technology and the Ecosystem

In order to realize the benefits of 5G technology, use cases and their underlying foundational technology need to be built out and accessible. This requires continuous investment in R&D and innovation that make the 5G ecosystem possible. Furthermore, connected devices do not work in isolation, and there must be collaboration across the value chain in order to enable this communication technology for consumers. Facilitating a culture of innovation, including through IP protections, can ensure that the United States remains at the forefront of technology and protects its national goals.

Acceleration levers: Balance innovation stimulation with IP protections to ensure continuous investment. Encourage innovation via subsidies and government-funded R&D incentives, including in the startup ecosystem. Establish national strategy for 5G innovation, and industrial and ecosystem support. Ensure legal protections for IP and establish other policies that protect new technology and accelerate new development.

Opportunity #2: Resilient Wireless Technology Supply Chain

Benefits to the economy from 5G use cases depend on uninterrupted delivery of the entire value chain from R&D to manufacturing, as well as development of semiconductors, devices, network, and industrial solutions. Breakdown of any component will slow down or disrupt the economic benefits.

Acceleration levers: Develop policies to support reliable semiconductor, wireless device and network equipment innovation and design. Foster a robust global supply chain to power critical manufacturing, healthcare, automotive and other 5G use cases via trusted sources and reliable producers.

Opportunity #3: Network Deployment and Build Out

Building out the RAN presents multiple challenges.[j] The local permitting process can be slow and complex. A skilled workforce of tower climbers needs to be in place to install and maintain hardware. Finally, the cost of network deployment threatens to limit timely buildout, especially in rural areas.

Acceleration levers: Streamline local and municipal site approvals and processes. Provide education and training incentives to encourage the growth of the tower workforce. Further incentivize carriers to provide coverage in underserved areas. Support and fund the development of OpenRAN, which will allow interoperability and standardization of RAN functions to simplify integration across the RAN ecosystem and drive down cost.

j A RAN provides radio access and assistance to coordinate network resources across wireless devices like cellphones.

Opportunity #4: End User Return on Investment (ROI)

5G has massive potential to grow the U.S. economy at the macro level in terms of jobs and GDP. However, on a company-by-company basis, capital investment, complexity and legacy infrastructure can lead to a slower ROI. Enterprises need to see and be convinced of the effectiveness. Early adopters are most likely to derive a competitive advantage and improved ROI, while late joiners will see a reduction in relative competitiveness, as with most technology cycles.

Acceleration levers: Establish subsidies and tax incentives to encourage pilot projects or even full-scale testbeds that will demonstrate the benefits and possibilities of the technology. Provide investment support for use cases that have broad benefits throughout the economy and consider comprehensive frameworks such as Germany's Industrie 4.0. Supporting these test projects will lower investment risk and lead to improved ROI.

Opportunity #5: Spectrum Availability

5G use cases and benefits rely on available spectrum in key radio frequency (RF) bands, all of which are required to achieve the technology's potential. Mid band spectrum (1-6GHz) is imperative to enable a majority of 5G use cases and will be a driving influence in the rate of future adoption.

Acceleration levers: Continue to prioritize the release and allocation of critical mid-band spectrum, especially bands planned for global harmonization. Incentivize the development and deployment of millimeter-wave networks.

Opportunity #6: Balancing Regulations

Although industry regulations provide value to consumers and society, regulatory barriers, such as the 18- to 24-month timeline typical for FDA approval of medical-technology devices, can delay benefits and discourage investment in the development of 5G devices. The unintended result can be the slower implementation of key use cases that offer major potential benefits for the economy and consumers, alike.

Acceleration levers: Streamline industry-specific processes and policymaking, such as the FDA approval process for medical devices and healthcare use cases. Foster collaboration between the private sector and government, to balance public and economic benefit and accelerate timelines.

Conclusion

5G will have a transformative impact on both consumers and businesses that is only being accelerated for a post-COVID world. As the effect of 5G cascades throughout the U.S. economy, it will drive up to $2.7 trillion in sales, create or transform as many as 16 million jobs and contribute up to $1.5 trillion to U.S. GDP between 2021 and 2025. As with the original digital revolution sparked by the advent of the Internet, this advancement will lead to the creation of industries not yet imagined. There are tangible and realizable business opportunities to speed up the deployment process and maximize the benefits—driven by tremendous market opportunities. In this whitepaper, we will expand upon the themes highlighted above in detail.

02 Introduction

5G will transform industries and change the way consumers use mobile technologies, generating substantive benefits beyond previous generations of connectivity technology, driven by three defining differentiators: enhanced mobile broadband (eMBB), mission critical services (MCS) and massive Internet of Things (mIoT). In this paper, we present a study on how 5G will apply these benefits to transform industry landscapes, provide value to consumers and generate economic value throughout the economy in the form of new output, GDP and jobs.

Introduction to 5G

Benefits of 5G

Every decade, a new generation of wireless technology is introduced, representing a dramatic leap forward over the previous generation in terms of performance and capabilities. Compared to 4G, 5G can deliver up to 100 times higher bandwidth,[k] greatly improved reliability, ultra low latency, and connection to a much higher density of devices.

Gearing up for a 5G Connected World

Technology	3G	4G	5G
	Connecting humans	Connecting humans+devices	Connecting the world
Latency	**300ms**	**~55ms**	**<10ms**
High Bandwidth	**1hr** 3GB movie download	**18min** 3GB movie download	**55sec** 3GB movie download
Scale	**Millions** of devices	**Billions** of devices	**Trillions** of devices

Source: Accenture Analysis, OpenSignal

2G shifted the focus of wireless networking from analog voice to high-fidelity digital voice. 3G focused on data and 4G improved speeds so that video streaming, navigation and rich email over wireless networks became commonplace. 5G will not only surpass 4G performance in terms of bandwidth but will provide solution-centric connectivity, bringing together dimensions of speed, latency, reliability and high IoT connection density to support new use cases across all industries.

Developing the technology of each wireless generation requires extensive R&D investment (as covered in Opportunity #1: IP, Technology and the Ecosystem) as well as deep industry collaboration among various ecosystem players orchestrated by industry bodies such as 3GPP.

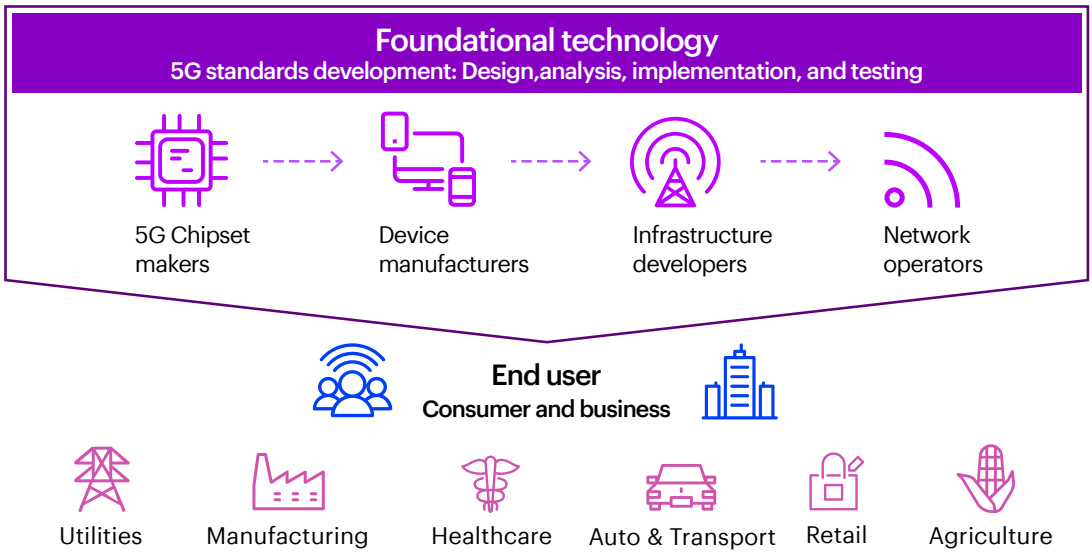
k Based on IMT-2020 requirements.

5G and all wireless communication technology starts with the efficiency of transmitting bits[I] over the air in a reliable and secure manner. Technologists from chipset companies, equipment providers and device vendors collaborate to design air interface standards. This involves innovation to improve modulation and error-protection schemes, encryption mechanisms, noise cancellations, antenna technologies, session setup and teardown flows.

Similarly, another team of technologists from the same companies work on developing the end-to-end network architecture that defines the various components, their functions, and standards-based interfaces allowing interoperability of equipment from different equipment vendors. This ensures end-to-end transmission and reception of data, interworking with other wireless or wireline networks, user identify management and the ability to manage the user experience, as well as track and bill for it.

Network equipment vendors and device OEMs work to ensure equipment and device are viable for commercial operations and in affordable economies.

Requirements from operators, industry players and governments play a crucial role in guiding this entire development process, as well as the subsequent trials and regulatory approvals that test the readiness of this technology.



Source: Accenture Analysis

This foundational technology development process is a multi-year endeavor and entails significant investments from chipset makers, network equipment vendors and device makers, as well as operators and other industry players. Therefore, in order to ensure fair return on this investment and keep this ecosystem growing, it is crucial that we have:

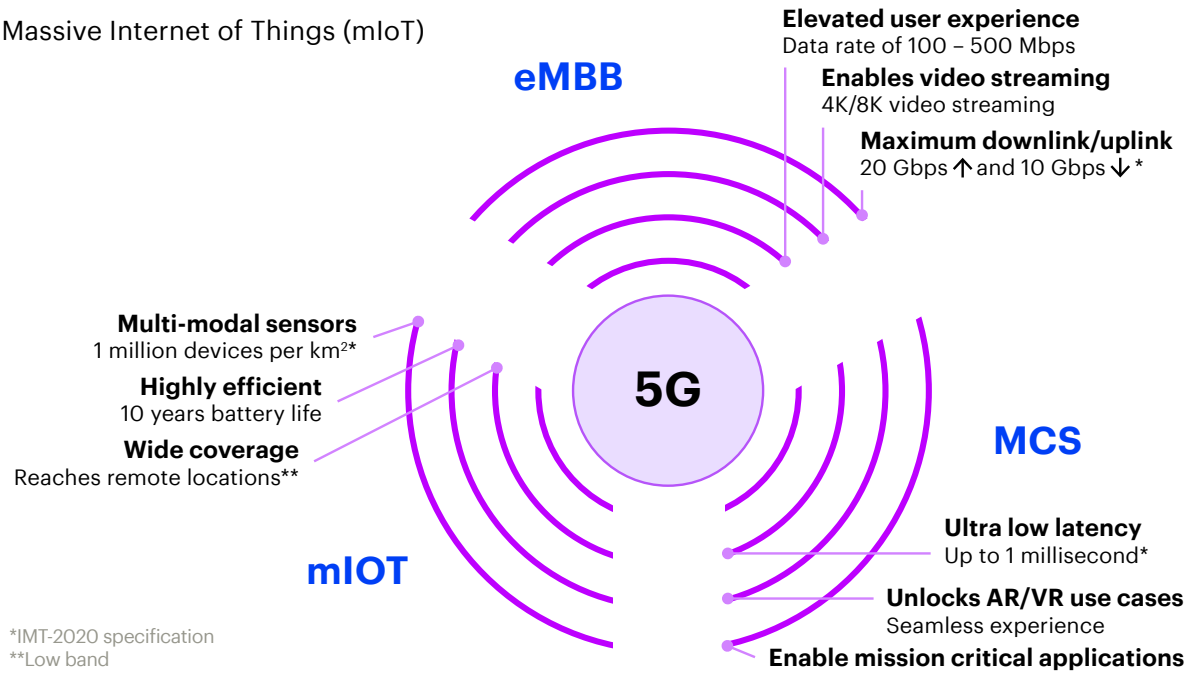
1. Proper IP protection to encourage ongoing investment in R&D
2. A friendly business environment to encourage growth and adoption of the technology
3. An objective regulatory framework to protect consumer interest while removing unnecessary cost and barriers to 5G network rollouts

I Unit of digital information, eight bits make up a 'Byte'.

In July 2020, the wireless standards body 3GPP finalized release 16 5G specification, which enhanced the foundational aspects of the 5G system, such as latency and capacity, and expanded into different verticals, such as industrial IoT and automotive applications.[4] Looking forward, Release 17 is expected to continue bringing improvements to capabilities and support that could significantly expand use cases such as extended reality.

These advancements unlock the opportunity beyond traditional mobile broadband through three key capabilities:

- Enhanced mobile broadband (eMBB)
- Mission-critical services (MCS)
- Massive Internet of Things (mIoT)



Source: Accenture Analysis

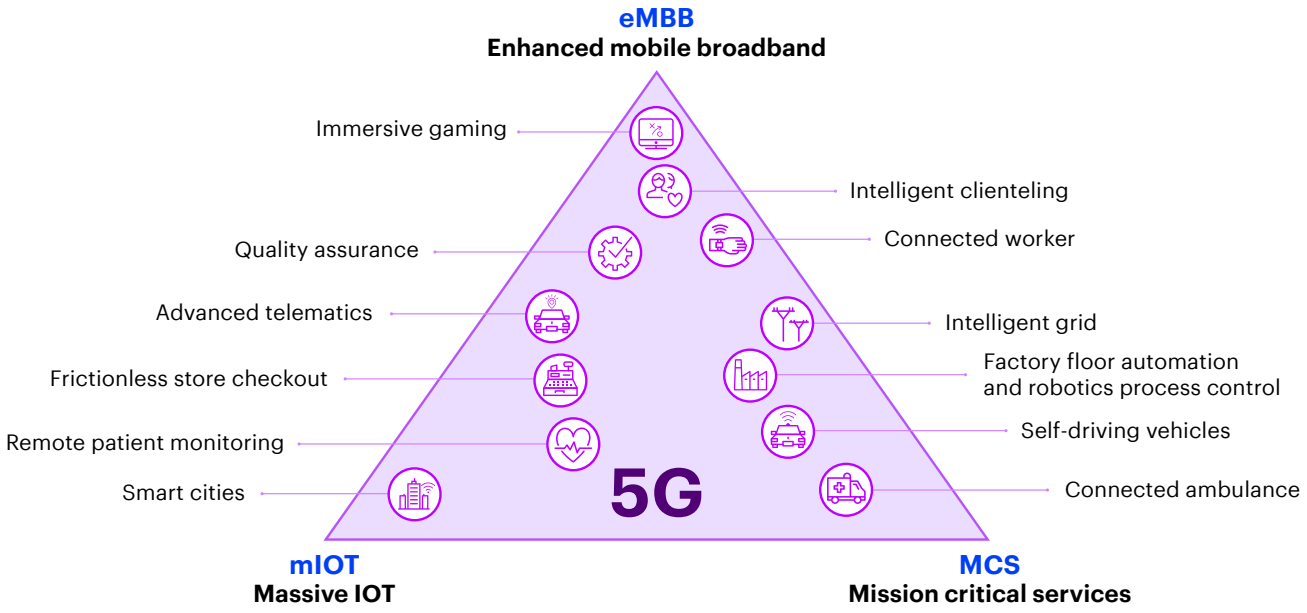
Enhanced Mobile Broadband (eMBB)

5G operates at speeds that can match the experience of using a wired connection, with an average data rate of 500 Mbps based on current implementations.[5] The technology is still evolving. Testing using millimeter wave (mmWave) is showing promising peak speeds of 5Gbps.[m] These advancements are crucial because they optimize the network for industrial and business applications such as live video monitoring and augmented reality (AR) and virtual reality (VR).[n]

In the automotive and transportation industry, for example, 5G will provide the capacity required to capture and analyze video data from various sensors within vehicles and on the roads near real-time—not to mention streaming entertainment options.

m Symmetrical uplink performance based on the underlying time-division duplexing (TDD) technology and uniform experience especially at the cellular network edge (cell edge) using massive multiple input multiple output (mMIMO) antenna technology.

n Previous technology was designed with downlink performance (download) in mind. Faster uplink (upload) speeds are necessary for modern applications like video monitoring (4K video requires at least 25 Mbps)[1] and AR/VR (at least 17 Mbps),[2] and the performance needs to be maintained across the network, including at the cell edge of the network. Traditionally, the further away a device is from the tower, the poorer the performance.



Source: Accenture Analysis

Mission-Critical Services (MCS)

5G provides a millisecond-level response time between the outbound network request and the return signal from the connected device (connection integrity is dependent on the distance to the nearest cell tower and the presence of obstacles like foliage or man-made structures). This performance enables 5G to support time-critical applications. The latency of 4G networks, at 45 to 55 ms on average,[6] is not good enough to support crucial safety and quality specifications for many use cases. To meet latency requirements, 5G networks can prioritize critical traffic, such as machine-to-machine (M2M) communications over delay-tolerant, non-critical data like streaming video entertainment.

In medicine, healthcare workers can rely on 5G connectivity to support critical patient applications. Home-based patient monitoring devices can send a continuous stream of data to providers to enable instant response if critical conditions change for the worse.

Massive Internet of Things (mIoT)

The enormous increase in connection density will enable 5G to support the skyrocketing number of devices that will be part of the Internet of everything. There are about 303 million phones in United States. In addition, M2M connections are at an estimated 974 million in 2020[7] and expected to grow to 14.7 billion by 2023.[8] The current infrastructure cannot support this growth. In addition, the 5G network is designed to support the diverse variety of IoT connections in terms of location, environmental conditions like weather and foliage, bandwidth and latency requirements and form factor.

5G's mIoT capabilities will bring a consumer's physical and digital life closer together, unlocked by the high density and deep coverage of 5G-enabled sensors. As Cisco ex-CEO John Chambers said, "[The technology shift to IoT will] have a five to ten times greater impact on our lives than the impact of the Internet."[9] With the development of smart cities and connected cars already underway, 5G-enabled road infrastructure in the United States will be able to tap into the power of the Internet, leveraging always-on, low-power 5G devices to maintain a consistent feedback loop among vehicles, infrastructure and mobile devices.

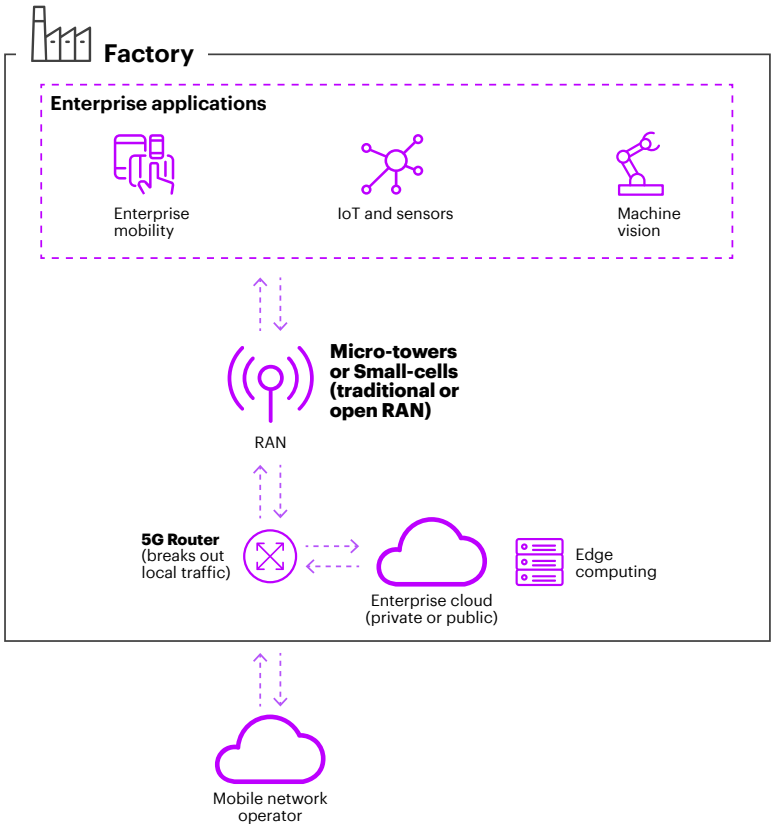
Comparing 5G to Other Technologies

	Wi-Fi 6	4G	5G
Latency	Several seconds	~55 milliseconds	<10 milliseconds
Mobility	Low	High	High
Coverage	10m (30 feet)	100m to km[1]*	100m to km[1]*
Bandwidth	High bandwidth[2]	Up to 20MHz band[3]	Up to 400 MHz[3]
Security	Reasonably secured[4]	Very secure[5]	Very secure[6]

[1]Depending on spectrum band; [2]Shared bandwidth (uplink), High bandwidth (downlink); [3]Guaranteed through scheduling/allocation; [4]WPA-3; [5]SIM-based security; [6]SIM-based security; hardware-based security at the chip/modem-level. *(traditional towers)

Source: Accenture Analysis

With 4G, consumers can already stream media with fast download rates, but 5G takes this a step further. 5G has faster bi-directional connectivity and ultra-low latency that will unlock many use cases across industries that 4G could not such as AR or VR. 5G also offers several important benefits compared to Wi-Fi 6. While WiFi-6 offers low cost and high speed, it lacks wireless mobility, reliability over wide-area coverage and the low latency benefits of 5G (see figure: **Comparing 5G to Other Technologies**).



Source: Accenture Analysis

Key Enablers

Realizing the full benefits of 5G requires an ecosystem of enabling technologies. Three of the most critical ones are: private network, edge computing and OpenRAN.

1. **Private Networks** take advantage of the highly modular architecture of the core network to enable enterprises to establish their own private 5G networks for their own communications needs such as broadband, HD video, sensor networks and voice calls. Enterprises can benefit by having more control over their networks (such as ensuring higher network reliability for mission-critical operations) as well as increased security offered by isolating their data from public networks.

The 5G private network is suited for industrial usage with requirements for predictable and reliable performance. It can fulfill the needs of demanding industrial applications and contribute to process automation across a range of sectors such as smart factories, energy, chemical processing, ports, oil and gas, etc.[10]

2. **Edge computing** moves processing of IoT data from the cloud to devices at the network edge, performing analytics and decision-making near the sensors and components generating and using the data. Consolidating this capability at the edge of the network with 5G-connected devices guarantees low latency and higher performance for applications that need real-time response. The approach lowers bandwidth consumption, reduces long-term costs and ensures processing scalability as IoT device density increases over time.

3. **OpenRAN** is the concept of a virtualized radio access network (RAN) and the defragmentation of radio network components. The RAN may account for approximately 70% of the total network cost.[11] In the past, the monolithic nature of RAN infrastructure implementations has severely limited the ability for upgrades and deployment flexibility. Conversely, through decoupling and virtualization, OpenRAN gives operators the flexibility to select best-in-class RAN components from any equipment vendor, as well as position the components based on deployment needs. As an example, during the deployment of small cells, this may enable 5G small cells to be installed on lamp posts with minimal electronics located onsite, reducing footprint and load factor on the lamppost. This market dynamic stimulates greater competition and encourages new entrants to develop innovative alternatives to individual network components.

   The interoperable multi-vendor approach ensures that operators can rapidly innovate by co-creating and optimizing reference designs that can be deployed at scale—an imperative for the country's growing wireless demand and evolving usage patterns. Moreover, early studies show that OpenRAN can reduce the total cost of ownership (TCO) by an estimated 30% to 49%.[12, 13]

   As wireless networks extend from macro site-based deployments serving smartphones to a wide variety of devices and various deployment models such as dense small cells and private networks, the flexibility and cost benefits of OpenRAN will also ensure the requisite ROI for enterprises investing in 5G by providing a flexible upgrade path. For more information on the benefits of this new vendor-neutral standard, the trials in progress and latest on the industry ecosystem coalescing around the OpenRAN project **click here**.

03 Market Context

Business and Technology Landscape

By 2023, a whopping 29.3 billion devices[14] will be connected to the Internet via IP networks—about three times the size of the global population. The world is becoming more and more connected as both consumers and businesses find innumerable ways to leverage connectivity that makes their lives easier. Wireless networking has typically been viewed in the context of personal smartphones but will be increasingly used for M2M communications.

There are three closely interlinked trends affecting businesses around the world that are driving the growth of these new wireless connections: **digitalization and IoT, personalization and AI and advanced robotics and automation capabilities**.

The growth of wireless devices in market sectors like manufacturing, healthcare, transportation, retail and utilities will dramatically transform the scale, traffic patterns, security needs and precision required from cellular networks. This is where 5G comes in. With higher speeds, lower latencies, denser connections and greater security, the technology promises to remake how we work, play and most of all, how we do business. It will propel new use cases, upgrade existing ones and enable entirely new industries. And along the way, it will turbocharge the economy.

Digitalization and IoT

Underpinning every major technological trend is digitalization and the number of new connected devices. From smart-home applications to the connected car and beyond, businesses are seeking ways to digitize everything and connect it all to the Internet. In addition to the growth of devices connected to the Internet, the global number of M2M connections specifically is expected to reach 14.7 billion devices by 2023—equating to 50% of all networked devices.[15] The underlying advantage of having connected products and digitized services is that they can be refined and redefined simply by updating the software code through the network.

The best digitized services today are constantly evolving, pushing through new features or improving the experience. Often, the ability to evolve efficiently requires a modular IT architecture that ensures that new features don't upend old, beloved ones. Leading companies have recognized that while modernizing their technology infrastructure and shifting toward a cloud-first architecture requires a non-trivial effort, it enables them to make the most of an increasingly digitalized world. Moreover, 93% of large enterprises in a 2020 survey stated that they have a multi-cloud strategy[16] in order to provide operational scalability, ensure ultra-reliable system availability and support rapid innovation without disruption to other services.

The combination of all these new connected devices and the always-changing, experience-driven microservices behind them will only achieve its potential with the right wireless networking foundation. 5G's substantially increased network capacity will ensure reliable connectivity for the surging number of simultaneously connected devices and their diverse usage patterns.

Personalization and AI

Another leading trend that affects both business-to-consumer (B2C) and business-to-business (B2B) companies alike involves AI and predictive personalization. With more data available through the digitalization of everything, competition between businesses is intensifying and business models are shifting to be more interactive with customers. This means that as customer preferences are captured, products and services can be customized for each individual customer's needs and wants.

An estimated 85% of executives agree that in order to compete in an era in which digitalized services and modernized technology infrastructure are table stakes, companies need to intelligently elevate their customer relationships.[17] Personalization will involve AI-driven feedback loops with cloud-stored rich datasets, such that devices become attuned to their current user. Moreover, some companies may use real-time data to design hyper-personalized experiences that are specific to the user, their environment and the moment. These more complex offerings require network infrastructures that can support these demanding needs end to end.

A large majority of business leaders believe that within two years, their industry will adopt connected solutions that can react to emergent situations within seconds.[18] Consider rich datasets like video and the advancements of AR and VR and the benefits they can garner. One innovative example is the startup Holoride, which is using navigational data and VR to transform commutes into hyper-immersive journeys.[19]

The connectivity capability required to support heavy data and provide real-time AI-driven adjustments to live experiences requires substantial bandwidth and reliability. This is where the concept of edge computing becomes vital to increasingly complex services that position computational power as close to devices as possible. IDC predicts that by 2022, edge computing will be a part of at least 40% of cloud deployments to support localized machine decisions.[20] AI-led products and services that can produce secure and individualized connected experiences will be the keys to success in the post-digital era. The efficiency and intelligence of these personalized mobile experiences will depend on a 5G network complemented by edge computing.

Robotics and Automation

As increasing connectivity gives devices access to more information and AI continuously makes devices smarter, these developments will be paralleled by a trend toward increasing machine sophistication. Robotics and automation are transitioning from systematic processes in closed, controlled environments to complex performances in open, uncontrolled environments. 61% of organizations plan to use robotics in uncontrolled environments within the next two years and 95% within the next five years.[21] This growth trend has IDC predicting a global robotics market of $241 billion by 2023, at a CAGR of nearly 20%.[22]

The market projection refers to automation beyond the traditional mainstay of manufacturing facilities and warehouses, and out into the open world. In agriculture, for example, the startup FarmWise is deploying automated robots that use various sensors and learning algorithms to handle seeding, weeding and harvesting optimized for each individual plant.[23] In delivery and logistics, companies like UPS are investing in unmanned drone delivery services.[24] And in retail, AT&T and Badger Technologies are experimenting with how robotics could identify stock levels and misplaced inventory using indoor wireless networks.[25]

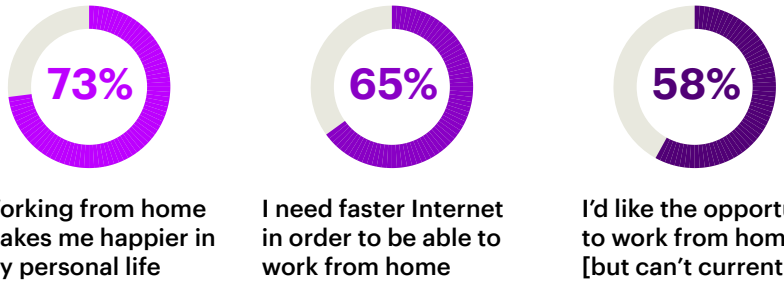
The common denominator in these three industry examples is that the robots must be able to communicate with one another and safely operate in an environment with additional uncontrolled entities (e.g., animals, people, vehicles, aircraft). This means that robots will need the ability to sense, communicate and react to irregularities in an instant. The future of automation will rely on 5G's ultra-low-latency wireless technology as well as low-power, always-on connections between robots and their surrounding environments. 5G will also create new revenue growth opportunities within these sectors by paving a path for industry employees to move away from manual tasks to upskill and focus on more value-additive activities, improving their work experience. Additionally, as robotics penetrate the commercial environment, the need for entirely new jobs such as drone operators will develop within these industries. This job creation will be one of the key benefits that 5G will drive.

Consumer Context

73% **of consumers consider high quality Internet a necessity.**

To the American consumer, connectivity is critical. With over 313 million active Internet users, the United States ranks third globally in the total number of the population that is online.[26] For U.S. consumers, the ability to stay connected is a fundamental expectation.[27] The COVID-19 pandemic made these views stronger. An overwhelming 73% of consumers consider high-quality Internet a necessity due to use cases like remote-access education, healthcare and business. 5G networks can enable providers to deliver on these expectations.

The COVID-19 pandemic set in motion a revolution in the demand for connectivity services. With a nearly overnight shift in circumstances amid stay-at-home orders and social distancing guidelines came a shift in consumer habits and needs. 42% of the U.S. labor force now works from home on a full-time basis, contributing to more than 60% of the U.S. GDP.[28] Consumer sentiment showed that the work-from-home (WFH) revolution is real and here to stay. A resounding 73% felt that this new WFH lifestyle allows them the freedom to choose where they would like to live and provides them greater happiness in their personal lives.[29] Of those consumers who did not have an opportunity to work from home, more than half said they would if they could.



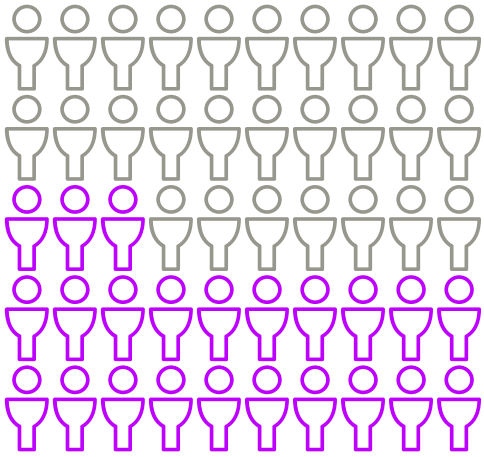
Source: Accenture Analysis

5G will be an important enabler of WFH. By providing high-speed connectivity that can be leveraged by employees in historically location-based occupations, 5G will enable a new set of jobs to be performed remotely. For example, field-service experts typically travel to customer locations to instruct technicians on how to solve a problem. By leveraging the ultra-low-latency capability of 5G, XR solutions like smart glasses can be used to provide direction to field workers without the expert technician leaving home.

One case study found that working from home can make employees up to 13% more productive and decrease the likelihood that they will quit their jobs.[30] WFH is creating a win-win for employees and employers.

The pandemic also intensified the demand for activities like virtual hangouts and video co-working, and showcased their usefulness. This ability to connect via video will only increase in value to users in the coming months. Consumers also asserted that secure online banking, streaming entertainment and virtual healthcare will grow in importance.[31]

Current technology does not deliver the performance levels consumers now expect. The average American spends 24 hours a week online.[32] In addition to this, a typical U.S. household has an average of 11 connected devices.[33] They require substantially higher bandwidth and a growing number of smart devices, not just for entertainment but to support educational and employment needs. In a recent survey, 45% of consumers felt that their Internet service quality diminished during high-demand periods[34] and the same amount categorized their ability to stream high-quality video outside the home as inconsistent. Offering faster speeds and greater connection density than 4G, 5G networks can provide faster streaming times and better video quality to consumers.[o]



45% of consumers **Agree** with the statement: "My ability to stream high-quality video while away from my home is inconsistent."

Source: Accenture Analysis

Consumers are aware that there is a digital divide within the United States.[p] Two in every three American consumers agree that access to the Internet is affected by the ability to pay.[35] Research also supports this sentiment. One study revealed that 44% of households with incomes below $30,000 a year do not have home broadband services,[36] a number that corresponds to about 29% of all American households.[37]

To address the issue, many lower-income Americans often rely on mobile connectivity for online access, versus fixed broadband. The trend is rising, with about 26% of adults in these households being dependent on smartphones in 2019, as compared to only 12% in 2013.[38] This means that mobile connectivity will be a powerful tool for addressing the digital divide in the future. 5G fixed wireless access, particularly in rural areas, could equip families who are currently constrained due to limited broadband with the high-speed Internet they need to support demands like virtual schooling. The technology could reduce the disparity families today face at lower costs when compared to existing solutions. (See section: **Acceleration Opportunity** for more details.)

Americans feel strongly that it is key for their government to influence and control the next generation of Internet connectivity (i.e. 5G). 62% of U.S. consumers consider leadership and influence in the next era of Internet a national imperative.[39] Consumers want state and federal governments to prepare this critical infrastructure for the future by working collaboratively with enterprises.[40]

o Based on IMT-2020 specifications.
p A digital divide is defined as any uneven distribution in the access to, use of, or impact of information and communication tools amongst different groups.

COVID-19 Context

COVID-19 has had an extremely disruptive effect on the world: the United States alone has seen millions of cases.[41] The pandemic has had the largest effect on the U.S. economy since the Great Depression, with GDP falling at a 32.9% annualized rate as of July 2020.[42] As of mid-September, the insured unemployment rate was 8.6%, with continuing claims greater than 10 million.[43]

Social distancing and shelter in place guidelines have increased reliance on connectivity and the demand for remote services. Voice and data traffic volumes have increased 70% since the crisis began and are expected to continue growing as consumers rely more on digital services to work from home, connect with family and friends or shop online.[44] For example, the video-conferencing company Zoom saw 94 million downloads of its iOS app from April 1 to June 30, breaking App Store records.[45] These short-term trends may drive longer-term demand for robust connectivity and connected living services. Many companies have extended WFH orders, while others, such as Twitter, REI, Nationwide Insurance and Mastercard, have offered some or all employees the option of working at home indefinitely.[46]

Overall, COVID-19 is expediting trends that were already in flight: the acceleration of digital enterprise transformation, the evolution of all businesses to connected businesses, the proliferation of zero-touch experiences and value chains and the reevaluation of geography-based strategies for businesses.

- **Acceleration of Digital Enterprise Transformation**: 94% of executives say their operating model puts their organization's growth and performance at risk, and 85% are not confident that their operating model can meet shifting strategic priorities.[47] Business leaders must think about how to ensure continuous operations through digital transformations such as use of the cloud. With the capacity and performance of 5G, the new network can help businesses benefit from cloud computing.
- **Evolution of All Businesses to Connected Businesses**: It is crucial to connect employees, business partners and consumers so that they can understand one another's evolving needs. Business must be able to adapt to rapidly changing customer and technology opportunities in order to emerge from the pandemic in a leadership position. 5G's added capacity will be beneficial for both consumers and businesses as data demand and consumption grow.
- **Proliferation of Zero-Touch Experiences and Value Chains**: Social distancing requirements have limited interactions with all parties along the value chain. Businesses and consumers are re-examining scenarios that require face-to-face interactions, leaning into the idea of limited touchpoints and automation. Not only does 5G have mission-critical properties for industrial applications, but it also provides extended range for widespread usage.
- **Reevaluation of Geography-based Strategies**:
  - **Supply Chains**: Globalization has been previously touted as a positive development, with global trade increasing from 40% of the world's GDP in 1980 to over 60% today.[48] The

disruption of COVID-19 has provided a graphic demonstration of the drawbacks of global supply chains, however. Going forward, businesses must consider vulnerabilities in their supply lines and establish strategies to navigate future crises. 5G can provide the visibility to support more informed decisions through track and trace capabilities.

- **Employment**: Between 1980 and 2020, the number of people living in cities has more than doubled to 4 billion.[49] Previously, in-person presence at work required employees to be physically close to their offices. However, COVID-19 has forced businesses to shift their staffing models, allowing some employees to work at home. Despite this, studies report that working remotely hasn't hurt productivity; in fact, 94% of employers said their company productivity was actually the same or higher.[50] Adoption of 5G will help enhance opportunities to work from home, as well as widen the pool of employees and talent available to employers.

Whether considered from a business standpoint, a consumer standpoint or the pandemic standpoint, the importance of connectivity for economic and social benefit is now clearer than ever. 5G is imperative to meet the needs of both businesses and consumers. The new generation of wireless networking will ultimately help drive connection quality, as well as address the increasing reliance on connectivity and the skyrocketing number of devices as use cases emerge and mature.

04 Economic Benefits of 5G

5G technology will have a transformative impact on the United States economy, fueling an engine of economic growth, driven by its ability to:

- Create new industries, products and business models. As 3G/4G unlocked the app economy, 5G will unlock new high bandwidth, IoT and mission critical products and businesses.
- Improve productivity and optimize costs, leading to increased economic output from the same inputs.[q]
- Improve service quality significantly and, therefore, consumer willingness to pay for goods and services.

$2.7 trillion sales

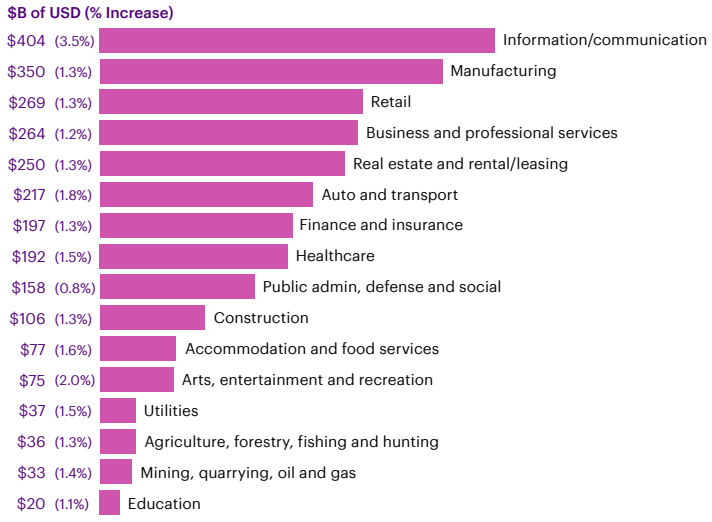
$1.5 trillion GDP

16 million jobs[r]

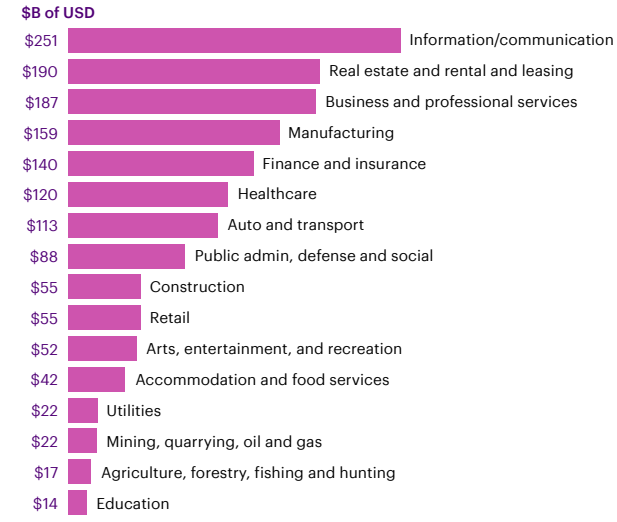
This increase is significant—our latest econometric model estimates that over the period between 2021 and 2025, 5G will drive up to $2.7 trillion in new economic gross output (sales), felt by every major industry. This translates up to $1.5 trillion in GDP over the same five-year period. In addition, 5G has the potential to create or transform up to 16 million full-time, part-time and temporary jobs to meet this increased demand, generating labor income that will circulate through the economy. This growth will play a key role in America's post-COVID-19 recovery and help build resiliency for the future.

Source: Accenture Analysis

5G Sales ($2.7 trillion)



5G GDP ($1.5 trillion)



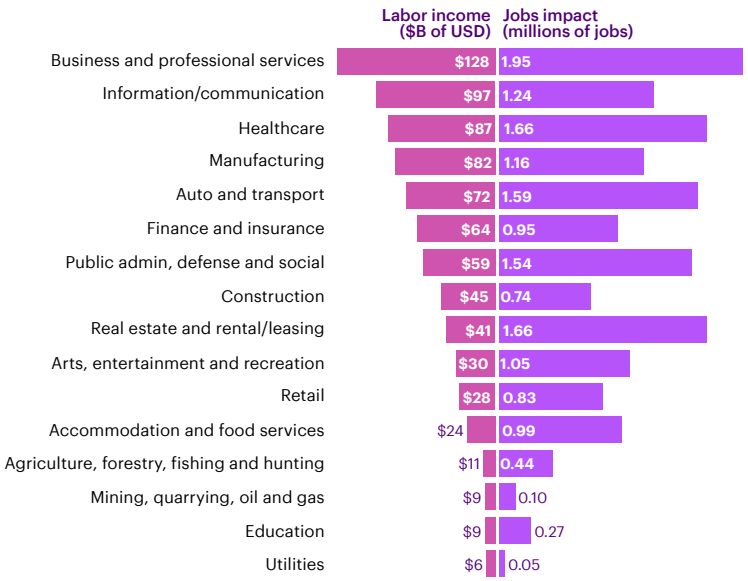
Source: Accenture Analysis

The benefits of 5G translate across industries, representing up to 3.5% additional sales in different sectors. The **Information Communication Technology (ICT) industry**, which includes **telecommunications** as well as **high-tech sectors**, is unsurprisingly at the core of this massive growth. Communications providers will play a key role, not only as the consumer-facing supplier of new 5G devices, but also through powering

q Based on our analysis this productivity is paired with new jobs and new types of jobs.
r Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

transformative 5G use cases within every other industry. As automotive manufacturers ramp up connected vehicles and telematics applications, for example, communications service providers (CSPs) will be providing the network, devices and services that unlock their potential. Even more than past generations of connectivity, the information technology sector will be central to 5G benefit, working in tandem with CSPs to drive the cloud services, software and new tech-driven sub-industries that will be enabled by enhanced connectivity capabilities.

Jobs and Labor Income



Source: Accenture Analysis[t]

5G has the potential to create or transform up to 16 million jobs across all sectors of the economy. While these are a mix of part-time, full-time and temporary jobs, in many sectors they represent high-quality employment at prevailing wages, and industries including ICT, manufacturing, utilities, mining and quarrying and healthcare will generate outsized labor income per job. The nature of these jobs will also change, including more data scientists, engineers and automation professionals. For example, within the agriculture industry, we will likely see a focus on digitalization and automation, driving new jobs for drone operators to work alongside traditional farmers.

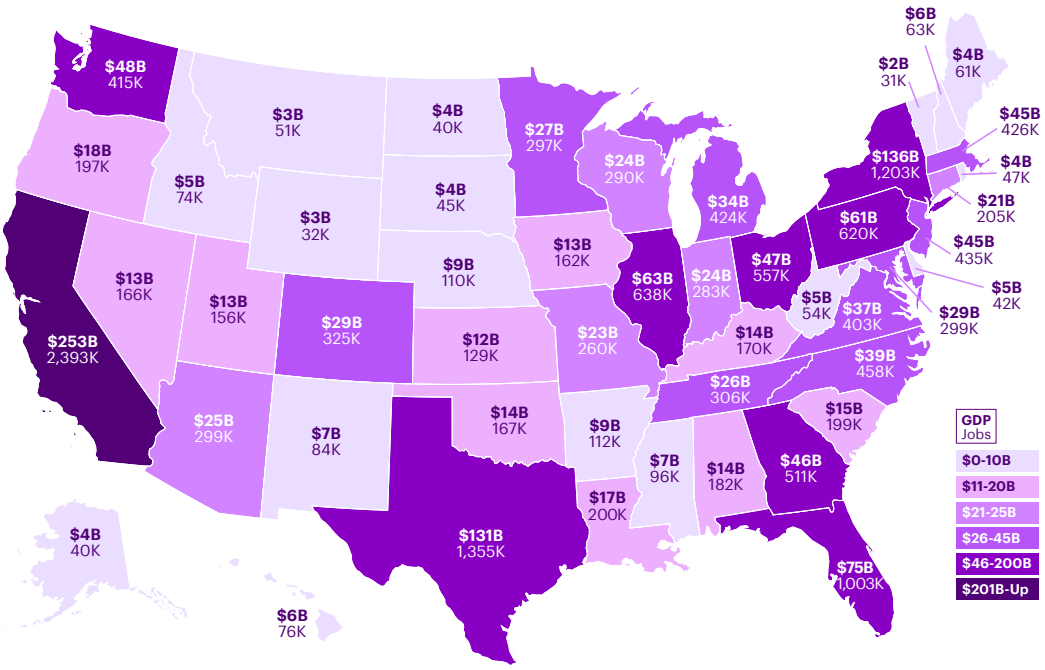
These job figures assume no supply constraints on labor;[s] in practice, we would expect an additional upward pressure on prevailing wages as employers struggle to fill the job needs described above. As we will see shortly, this labor income is not only great for workers, but is also an engine for driving consumer spending throughout the broader economy.

Geographic Impact (2021-2025)

5G's impact will affect every corner of the United States. Populous states unsurprisingly will reap a large portion of this benefit, partially due to a larger presence in the industries that are heavily impacted by 5G advancements. California, for example, can expect to create or transform up to 2.4 million jobs and $253 billion of GDP increase, and Texas can expect up to 1.4 million jobs and $131 billion in GDP increase. This effect is not limited to large states with high-tech hubs: in Nebraska, 5G will create or transform job growth equal to 6% of the state's 2019 population.[t]

s This is a constraint based on the partial equilibrium model used for our analysis, as we focused on GDP contribution and jobs generated, assuming homogenous production within an industry.

t Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.



Source: Accenture Analysis[u]

Value Chain Impact

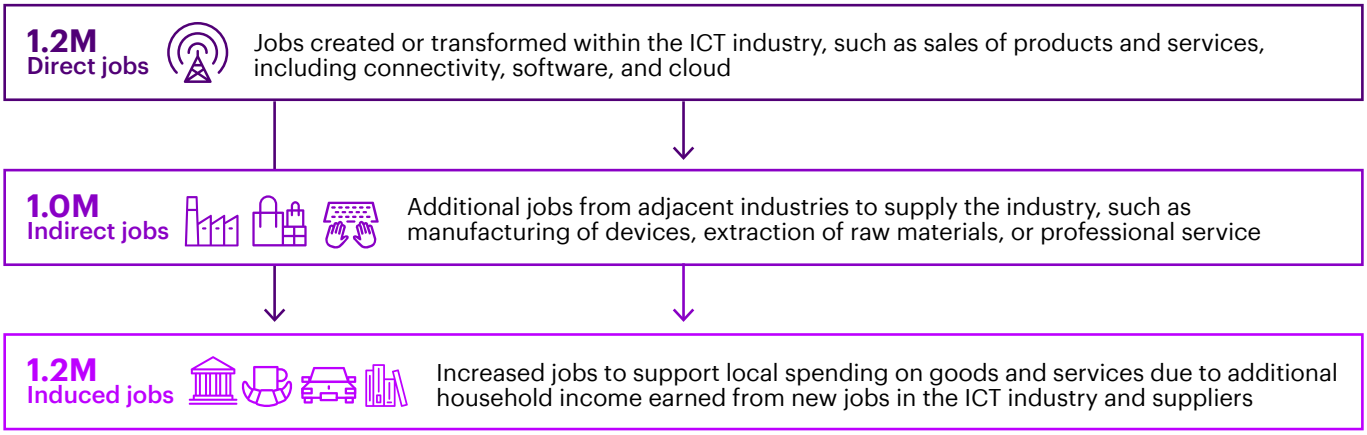
The growth generated by 5G represents the deep interdependencies between industry value chains within the United States. As an example, let's consider how the effect plays out in ICT.

We established earlier that ICT plays a central role in realizing 5G benefits, intrinsically intertwined with the investments and activity in other industries pursuing new connectivity and generating substantial revenue (and jobs, GDP) in the process. However, the impact within ICT does not capture the full contribution the industry generates throughout the broader economy because of 5G. We can break these effects into three groups:

- **Direct Effect**: Economic activity originating within the ICT industry and driven by industry sales, including elements of the ICT value chain that remain in ICT (e.g., tech spend on network services, software)
- **Indirect Effect**: Economic activity from the suppliers to the ICT industry and producers of intermediate goods and services (e.g., manufacturers, raw materials)
- **Induced Effect**: Economic activity from the household spending patterns arising from labor income generated in the ICT industry and its value chain (e.g., on retail, travel, real estate)

To illustrate, as we take the 1.2 million jobs driven by 5G within ICT, we can see through the graphic below how 2.8X total jobs are generated throughout the broader economy through the indirect and induced effects. These jobs are captured within other industries in our overall numbers. We list them here to show the interconnectedness across different sectors and the impact that demand in one industry drives in others.

u Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.



Source: Accenture Analysis

The full results for ICT are shown below:

Information and communications technology industry

$403.9B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	$251.2B	$439.0B	1.7x
Labor Income	$96.8B	$196.4B	2.0x

Jobs and Employment
1.2M jobs[v]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

Cross-Industry Impacts

The ICT results above are just one example. 5G will generate a multitude of benefits that are shared across enterprises and consumers in all industries. Key among these include the ability for businesses to leverage complementary technologies like cloud and edge computing more effectively through enhanced connectivity in office settings and remote locations. This enhanced connectivity also fuels analytics by effectively facilitating linkage within disparate data sets managed by various stakeholders. New business models will be made to address these tasks, thereby creating new data-focused jobs in all industries. The effective management of data connections can lead to better processes for all businesses, increasing return on major investments and decreasing operating expenses.

5G also impacts American consumers directly, beyond the GDP and job results shown in this paper. For instance, take the concept of consumer surplus, the value generated for consumers when there is a delta between their willingness to pay and the price charged for a product or service. Over time, consumer surplus has steadily increased as the quality-adjusted price for devices and connectivity continue to decrease.[51] Studies have also shown significant consumer value driven by new applications, enabled by stronger connectivity—one social-media application generated $241 billion in consumer surplus from launch to 2019.[52] 5G will continue these patterns and significantly increase the economic well-being of customers by improving their everyday lives well in excess of cost.

v Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

To further bring the overall impact of 5G to life, we explored five other industries in detail: manufacturing, retail, healthcare, automotive and transportation, and utilities. In each industry section, we illustrate how specific 5G use cases contribute to the economic impact, as well as detail the broader story about 5G benefits and the impact they will drive within the industry.

05 Industry Deep Dives

Manufacturing

5G technology unlocks the ability to sense and respond for manufacturers in the United States, facilitating efficient communications between people and machinery.

The next five years of 5G impacts in the manufacturing sector will drive:

$349.9 billion in additional industry revenues
$159.2 billion in added GDP contributions
1.2 million jobs created or transformed[w]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Factory floor automation and robotic process control		●	●
Intelligent asset management		●	
Connected worker		●	●
Quality assurance		●	●

Source: Accenture Analysis

Industry and Technology Context

After adopting and automating vital, streamlined processes, manufacturing is at the precipice of another great push toward digitalization, with 5G as a critical enabler that will help tackle key challenges. Today's consumers demand more new features, better performance and greater personalization, and they want it all right now.[53] To respond, manufacturers need to predict this demand and shift their processes to accommodate production. The current hard-wired state of most manufacturing floors inhibits fast changeovers, however.

Manufacturers are under pressure to keep pricing competitive, but operating expenditures can be crippling. The International Federation of Robots estimates that unplanned stoppages at a large automotive factory could cost $1 million per hour.[54] Assuming a scrap rate of 1.2%, $78 billion was

w Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

lost to scrap in 2019 alone.[55] As a result, 49% of manufacturers are hoping to lower scrap costs with new equipment, while 58% are looking to upgrade inspection technology in 2020.[56] A further 47% of manufacturers plan to buy new equipment to reduce cycle time and bottlenecks.[57]

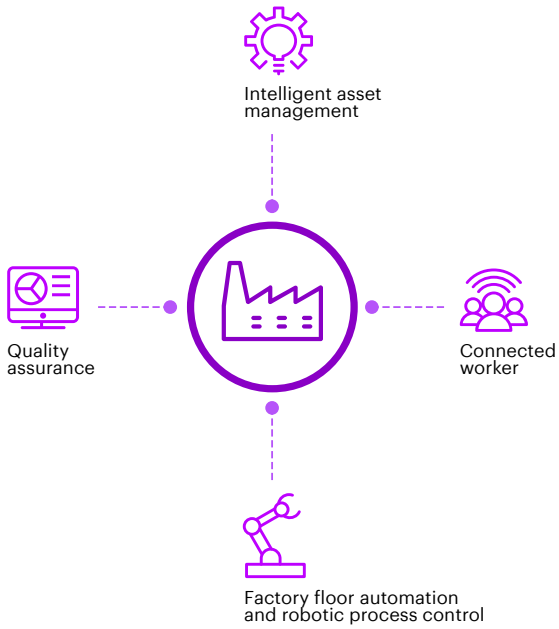
Worker safety and health compliance are always top of mind, with processes like the pre-startup safety review (PSSR) in place to catch any potential hazards. Despite this, the manufacturing industry had the highest injury incidence rate of all public and private industries (3.4%) in 2018. The risk of serious consequences pushes executives to perform detailed due diligence on new processes.

Furthermore, manufacturers must be conscious of the availability of qualified workers, especially as veteran operators and engineers leave the workforce. 10,000 baby boomers, a population heavily employed within the manufacturing industry, are retiring per day and taking their specialized knowledge with them.[58] The labor gap is exacerbated by evolving demographics: Millennials are less interested in manufacturing industry careers and only 37% of U.S. adults encourage their children to enter the sector.[59] Thus, manufacturers must find new ways to ensure they have the talent they need.

Data and data analytics can help manage some of these issues. Still, manufacturers have problems like connectivity interference and inadequate coverage. As a result, not enough data is being gathered and processed to yield actionable information. Indeed, 36% of manufacturers cite a lack of available data and insights as their biggest frustration.[60] Without enough data, manufacturers face an uphill battle in overcoming these hurdles.

COVID-19 Impact

The coronavirus pandemic has disrupted supply chains and shuttered businesses around the world, impeding production by restricting shifts and closing some factories. According to a survey by the National Association of Manufacturers (NAM), 53% of manufacturers anticipate a change in operations in the future.[61]



How 5G Can Help

At the highest level, 5G gives manufacturers the ability to sense and respond, facilitating efficient communications between people and machinery. 5G provides secure, pervasive connections throughout the shop floor and a level of automated movement, synchronization and control that wasn't possible before. Manufacturers can use 5G with other complementary technologies to draw insights and respond to improve precision, productivity and efficiency.

Economic Impact of 5G

Since manufacturing touches almost everything globally and significantly contributes to GDP, it is a key strategic area for 5G. 5G is expected to provide a direct productivity increase to the manufacturing industry in both sales uplift and cost savings. Based on Accenture analysis, manufacturing will see an incremental sales uplift up to $349.9 billion in the United States, or 1.3%.

Manufacturing industry

$349.9B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	$159.2B	$314.4B	2.0x
Labor Income	$81.6B	$161.4B	2.0x

Jobs and Employment
1.2M jobs[x]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

Manufacturers will not only be creating the components, devices and infrastructure that enable 5G, but also the products that will be used in other 5G applications. Each industry's manufacturing operations will require distinct equipment from each of their providers and will in turn provide different end products down the value chain. This increase in demand for 5G-enabled equipment and services will create or transform jobs, resulting in a direct GDP impact of up to $159.2 billion. This direct impact will cascade throughout the economy, including materials providers, logistics companies, Original Equipment Manufacturer (OEM), retail and other businesses.

5G Use Cases and Benefits

Manufacturers acknowledge the importance of digital transformations to drive productivity. Yet today, less than 30% of manufacturers globally report extensive adoption of digital technologies,[62] including 5G. Overall, activating multiple use cases in tandem using 5G and other enabling technologies such as edge computing and AI will yield 20% to 30% productivity gains.[63] Below, we will discuss four key use cases in manufacturing: factory floor automation and robotic process control, intelligent asset management, the connected worker and quality assurance.

Source: Accenture Analysis

Factory Floor Automation and Robotic Process Control

Factory floor automation and robotic process control encompasses applications like mission-critical remote control of machines, synchronized robots and smart logistics with automated guided vehicles (AGVs). Though complete factory automation represents a longer-term transformation, some synchronized robots and AGVs can be implemented in the short-term, ultimately contributing to about 10% of 5G-enabled GDP in manufacturing.[64]

x Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

20-30% improvement in productivity

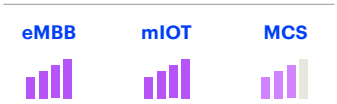
40% increase in usability

30% increase in efficiency

Source: Accenture Analysis

Ford,[65] which brought 5G private networks to one of its electric vehicle (EV) plants, believes that the factory of the future will need to be able to quickly reconfigure facilities to address rapidly changing needs. Wireless control of machinery allows manufacturers to optimize their floor layouts and improve reconfiguration times, ultimately leading to more efficient production. Low latency is essential for mission-critical remote control and human-machine interactions to promote coworking and safety.

Nokia recently used AGVs and 5G private networks to improve manufacturing logistics. Nokia's AGVs were initially connected to a dedicated Wi-Fi network, but coverage was insufficient, requiring manual reconnection.[66] 5G significantly improved material transportation without requiring separate network reconfigurations. The company saw a 40% increase in operational equipment effectiveness (OEE) and a 30% increase in efficiency. It also reported a 98% decrease in maintenance work, changing the cadence from daily to monthly and the time interval from hours to minutes.



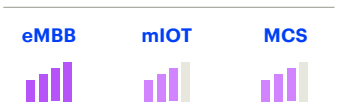
Source: Accenture Analysis

Intelligent Asset Management

Intelligent asset management enables better visibility, management and control of assets. This includes capabilities for real-time asset-health monitoring and predictive and prescriptive maintenance to reduce unplanned downtime, extend the useful life of assets and improve key metrics, such as mean time between failures (MTBF). Intelligent asset management will contribute about 15% to 5G-enabled GDP in manufacturing, driven by its large impact on unscheduled downtime and capital expenditures.

Non-invasive techniques such as attaching sensors and using UHD video analytics are immediately available solutions. With the vast data collected, AI can predict the remaining useful life of an asset and detect developing defects before they fail. This allows maintenance and operations to schedule targeted repairs at a time that minimizes cost and impact to production. Asset owners can get the most out of equipment instead of replacing good components unnecessarily.

Accenture and KPN, a Dutch telecommunications company, brought 5G to Shell's refinery to test industrial applications, including pipe maintenance.[67] UHD cameras scanned 99,000 miles of connected piping, then processed the data using machine learning to identify high-risk corrosion areas and determine the best corrective actions.[68] Predictive maintenance can reduce inspection costs by 10% to 20%, improve uptime and productivity by over 10% and increase asset life by more than 20%.[69] 5G equips manufacturers to "sweat their assets" by maintaining asset integrity and maximizing its useful life.



Source: Accenture Analysis

Connected Worker

Connected worker technology offers employees a safer and more seamless work experience, including use cases such as location monitoring and remote inspection, worker safety, and enterprise training using XR. By

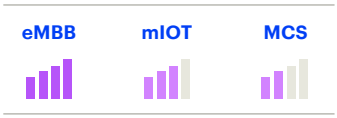
enhancing the work experience, manufacturers can upskill their workers while monitoring floor safety. These productivity improvements will contribute up to 5% to 5G-enabled GDP in manufacturing.

5G has the potential to improve the AR/VR experience by enhancing the quality of immersion through increased throughput, lower latency (worker safety, minimal buffering) and greater mobility (the ability to cope with quick movements, such as constant head movement). AR/VR can be used across the value chain. AR/VR in field service can improve first-time fix rates by 20% to 40% for technicians and reduce injuries by 5% to 15%.[70] On the floor, AR/VR can reduce downtime by 10% to 35%, lower scrap and rework by 15% to 25% and reduce assembly time by 20% to 50%.

Lockheed Martin has implemented AR-based how-to manuals for building spacecraft components.[71] The AR solution includes assembly animations, helping reduce the time required to interpret instructions by 95% and overall training time by 85%. It has also boosted productivity by more than 40%. In addition, the company's space unit used AR to realize savings of roughly $38 per fastener; for a company that buys more than two million fasteners per year, that's equivalent to $76 million in savings.[72]

Field Service
Technician productivity, safety and effectiveness: 20-40% improvement in first time fix rate, 5-15% reduction in injuries

Manufacturing and supply chain
Increased worker productivity, quality and safety: 10-35% reduction in downtime, 15-25% lower scrap and rework, 20-50% reduction in assembly time



Source: Accenture Analysis

Quality Assurance

Quality assurance monitors and reacts to quality breaches through in-line quality monitoring, digital quality inspection and precision monitoring. Improving quality monitoring processes via 5G will also naturally boost overall productivity, using cameras, sensors and AI to provide up to a 50% increase in quality testing throughput and a 90% improvement in defect detection.[73] Reducing scrap from defects and pseudo-defects will contribute up to 3% to 5G-enabled GDP in manufacturing.

50% increase in quality test productivity

90% improvement in defect detection

5G increases network capacity, providing easy access to UHD video streams and sensor data. With rapid access to high volumes of data, manufacturers can use analytics to help identify defects and dynamically test based on real-time conditions, improving on scrap rates and total cost of quality.[y] Furthermore, 5G's mission-critical service and low-latency properties can support rapid response to the program's results, providing immediate feedback to correct upstream processes and remove scrap.

y Total cost of quality is defined here as the aggregate cost of poor quality or product failures, as well as expenses incurred to prevent or resolve quality problems.

For example, Bosch implemented industrial AI to improve its quality processes. The operation used cross-value-stream analytics to optimize downstream processes, identify cross-component influences and reduce manual visual inspection efforts.[74] By automating optical inspection, the company achieved a 0% escape rate[z] and a false-alarm rate below 0.5%.[aa] In addition, Bosch was able to remove redundant tests and predict calibration settings, resulting in a reduction of 45% in test time and a savings of $1.3 million at a single plant.

5G Adoption Challenges and Mitigations

Although these use cases and their benefits are tangible, manufacturers struggle to adopt 5G technology, facing two main challenges: the large upfront investment and device and ecosystem readiness.

Investments and ROI

Capital expenditures are one of the largest outlays for manufacturers, who expect their legacy infrastructure to last 10 to 20 years. Manufacturers hesitate to invest before they have a clear idea of potential benefits because of the high impact on output. Because of this risk, they seek reassurance in a clearly defined ROI and will slowly retrofit new technology over longer time horizons. Although the investment may be prohibitive at the firm level, the benefits of adopting 5G will ripple throughout the broader economy, far beyond the ROI of an individual plant.

The government can facilitate adoption of 5G technologies by providing prescriptive policies and creating financial incentives. For example, the UK and German governments have set aside £40 million ($51 million) for 5G trials[75] and €400 million ($448 million) to develop Industrie 4.0, respectively.[76] These initiatives successfully kickstarted adoption; Vodafone and Ford received £65 million ($83 million) in public funds to create a 5G smart factory.[77] While this shows progress, these funds are still small relative to the size of their respective economies; a significant, coordinated public investment plan to drive 5G adoption will yield the most benefits.

Device and Ecosystem Readiness

Manufacturing infrastructure today is fragmented with a mix of legacy and new technology protocols. Equipment providers focus on proprietary protocols to ensure product stickiness. In a heterogeneous connectivity landscape populated by competing standards, manufacturers frequently do all they can just to make the current products work for them. Moreover, there are few commercially ready 5G-ready devices available in the ecosystem, partially due to the early stages of the technology adoption for manufacturing. Finally, manufacturers are wary about data privacy, noting security and access as key concerns.[78]

New devices must be developed in conjunction with progress on networks, with backward compatibility for retrofitting. Upgrading new devices will not only enable manufacturing's use cases, but also create additional value for equipment providers by increasing capability and compatibility. Leading groups such as the Open Platform Communications (OPC) Foundation are pushing for the inclusion of 5G into roadmaps to enforce interoperability; the government can also ready the industry for adoption through incentives and guided policy that promotes adoption of technologies and devices compatible with 5G. Policymakers can also facilitate R&D by fostering an environment that promotes innovation and competition while protecting IP.

z The escape rate is defined as the percentage of defective products that were not identified by quality assurance teams.
aa The false alarm rate is defined as the number of false defect detections per total number of detections.

Policy Example: South Korea

South Korea is pushing adoption of 5G and smart-factory technology, with a goal of 30,000 smart factories in the country by 2025.[79] The major telecommunications networks are offering 5G-enabled services that help enhance the efficiency of existing systems, including smart sensors to determine maintenance schedules. Creative plans to help onboard small and medium enterprises, including subscription-based smart-factory solutions and free trials have been established. With guided policy and cooperation across all ecosystem players, the country has been able to coordinate solution development while bringing manufacturers along.

COVID-19 Impact

One major concern is that manufacturers may be cash strapped, delaying capital expenditure, IT and operational technology budgets. However, firms that invested in and integrated new technologies recovered faster.[80] Though connected businesses are a well-known practice, COVID-19 has shown manufacturers that it is a critical time to explore automation technologies due to physical distancing requirements. This year, BMW saw an opportunity in stalled factories to install new technologies, including AI-powered quality-control checks.[81] Automation tools that formerly took years to fully roll out can now be installed in months, with the COVID-19 crisis acting as a catalyst for testing and adopting new technologies.

Conclusion

The manufacturing industry has much to gain from the adoption and implementation of 5G technologies. By activating use cases such as factory-floor automation, intelligent asset management, connected workers and quality assurance, manufacturers could see a direct sales increase of up to $349.9 billion in the United States. This growth would cascade through materials and equipment providers and throughout the value chain, resulting in a direct GDP impact of up to $159.2 billion and as many as 1.2 million jobs and an additional $155.2 billion and as many as 1.7 million jobs across the value chain. Companies must overcome several hurdles regarding investment and ecosystem readiness, but policymakers can facilitate adoption in the industry through efforts such as earmarked funds and guided policy.

Retail

5G technology will create superior customer experiences and operating efficiencies in retail through innovative new offerings and the removal of key points of sales friction.

The next five years of 5G impacts in the retail sector will drive:

$269.5 billion in additional industry revenues
$54.6 billion in added GDP contributions
800,000 jobs created or transformed[bb]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Digital store consultations	●	●	
Frictionless store checkout	●	●	●
Intelligent clienteling	●	●	●
Automated surveillance		●	●

Source: Accenture Analysis

Industry and Technology Context

The U.S. retail industry supports a quarter of national jobs, making it the largest private-sector employer in the economy.[cc] The industry directly and indirectly supports up to 42 million jobs and includes approximately 1.8 million businesses.[82] Retailers today face multiple pain points, many of which may be addressed through enhanced connectivity solutions. Top examples include:

- Driving revenue by delivering a superior customer experience
  - Decreasing friction to increase sales and customers' willingness to pay
  - Enhancing personalized in-store recommendations and marketing
- Improving operating margins through cost reduction
  - Decreasing shrinkage (e.g., theft, fraud, damage)
  - Executing channel and inventory rationalization

bb Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.
cc The paper refers to retail operations to be inclusive of all channels including in-store or brick-and-mortar, ecommerce and any additional channel operations.

5G connectivity provides a powerful tool for achieving these goals. Connectivity alone, however, is not enough. To unlock the value of connectivity, retailers need to embrace a new paradigm.

First, the purpose of brick-and-mortar locations is changing. Today, consumers expect differentiated experiences when they walk into a store and these locations can be utilized for far more than transactional procedures. Second, not all customers are created equal. Retailers can take action to satisfy the expectations of their most valuable customers: driving retention, growing basket size and generating a higher customer lifetime value. Last, growing operating costs must be curbed without impacting the customer experience. Put simply, retailers need to decide what new experience they want their stores to provide, determine which customers they want to drive to those stores, then find a way to deliver that enhanced experience without increasing costs. When used in conjunction with synergetic technologies, the enhanced connectivity of 5G can drive transformative improvements in each of these areas.

COVID-19 Impact

It is essential to acknowledge the near-disastrous impact that the COVID-19 pandemic has had on this industry. While the landscape was changing drastically and major industry players were already investing heavily in digitization, COVID-19 directly intensified this trend. Research estimates show that it could take the industry years to reach pre-pandemic levels of gross sales, with a total expected loss of $321 billion in 2020.[83]

The pandemic has highlighted the importance of the digital transformation.[84] Actions taken by incumbent retailers during this time, such as opening a curated selection of new stores and implementing buy online and pick up in store, also show that the retail store presence is not dead. Consumer behaviors once lockdowns were eased also confirmed that going into the store was still a part of their daily routines and not likely to change soon. In a 2020 survey administered by Adobe, 27% of consumers said they felt more comfortable shopping in physical stores in August compared with July.[85]

How 5G Can Help

5G-enabled technologies can equip retailers to lead the digital charge. Many retailers do not have the connectivity infrastructure required to support high-bandwidth applications within stores. As new solutions for human-centric technology experiences enter the marketplace, 5G will enable retailers to take advantage of them. With the improved connectivity infrastructure, retailers can unlock a myriad of use cases that leverage enhanced mobile broadband (eMBB) and mission-critical services (MCS) to offer personalized, convenient and safe services that build customer loyalty and trust. These same mechanisms can also be used to solve key retailer value pain points such as checkout and shrinkage, making the investment holistic.

Economic Impact of 5G

5G is expected to provide a direct increase to the retail industry in both sales uplift and cost savings. Based on Accenture analysis, retail will see an incremental sales uplift of $269.5 billion in the United

States. This growth will not only be driven by new retail use cases enabled by 5G, but also by the impact 5G will have on industries such as manufacturing. The additional demand for end-products will trickle down into production and sourcing. This increase in demand for 5G-enabled products and services will increase jobs and earnings throughout the value chain, resulting in a direct GDP impact of up to $54.6 billion and create or transform as many as 0.8 million jobs. This driver will create ripple effects through the value chain.

Retail industry

$269.5B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	$54.6B	$100.2B	1.8x
Labor Income	$28.2B	$51.3B	1.8x

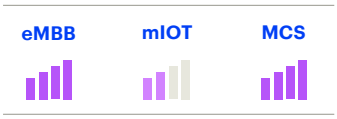
Jobs and Employment
0.8M jobs[dd]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

5G Use Cases and Benefits

The retail industry serves shoppers in multiple interactions daily. Consumers expect a seamless, well-designed experience, whether they are walking into the grocery store to buy milk or visiting a home-improvement center to make flooring selections. To move forward, retailers must synchronize business and technology models and reconcile them with evolving customer expectations to drive enterprise value. Retailers need to build a new path, developing digital experiences with a human focus.

The specific use cases presented here are estimated to contribute 25% of the total lift driven by 5G within the retail industry. Alongside these examples, there are many other retail use cases that contribute to the overall growth including back-of-the-store support functions like XR associate training and additional customer-facing experiences like digital signage.



Source: Accenture Analysis

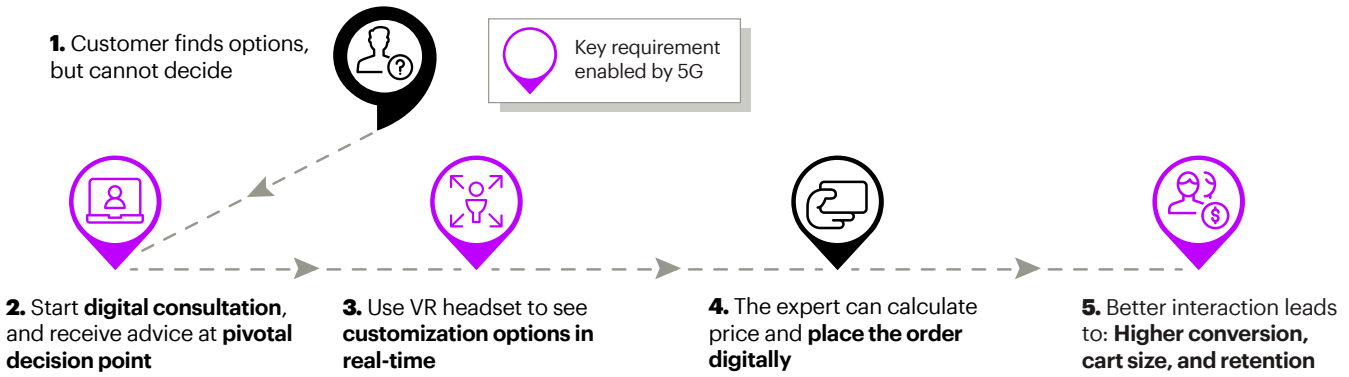
Digital Store Consultations

It is six times more expensive to gain a new customer than it is to retain an existing customer.[86] To retain important customers, retailers need to differentiate the value that they offer to make themselves more attractive. One of the most important forms of assistance a retailer can offer shoppers is by offering reliable product information and helping make purchase decisions, a study of 7,000 consumers showed.[87] Retailers can help customers in this decision making by offering expert advice in the store through digital store consultations.

Combining UHD video and virtual reality is an increasingly popular way to present customers with the choice to browse a curated set of products. The approach virtually presents experts like interior decorators to guide shopper decision making in store, where over 65% of purchase decisions are made.[88] Retailers that sell a variety of products, such as a home-improvement stores, can benefit from offering this type of

dd Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

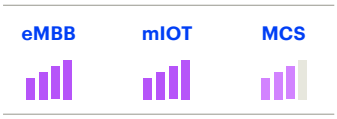
human-centric technological experience because it equips them to credibly explain pricing nuances and feature distinctions. Over 25% of American consumers are willing to pay a premium of 10% to 20% more than they initially budgeted for products that most effectively serve their needs, products that can be identified by a digital consultation. This use case can generate consumer and producer surplus.



Source: Accenture Analysis

This type of digital application must be executed without hindrances like digital lag. Unresponsive technology such as slow-to-refresh digital displays and high application load times will cause points of friction or customer frustration. In the worst case, it can cause the customer to walk away, resulting in a loss of share of wallet[ee] for the retailer. 5G connectivity can support a rich and reliable conversation without frustration, thereby creating a differentiating customer experience that will drive retail value.

In one case study, traditional sales at an Audi London showroom increased by 20% when customers were offered the ability to customize their cars. When the same options were visualized using VR technology, sales increased by 70%. Customers reported that they enjoyed the interaction of digital techniques alongside the human-centric sales process and were willing to pay a premium.[89]



Source: Accenture Analysis

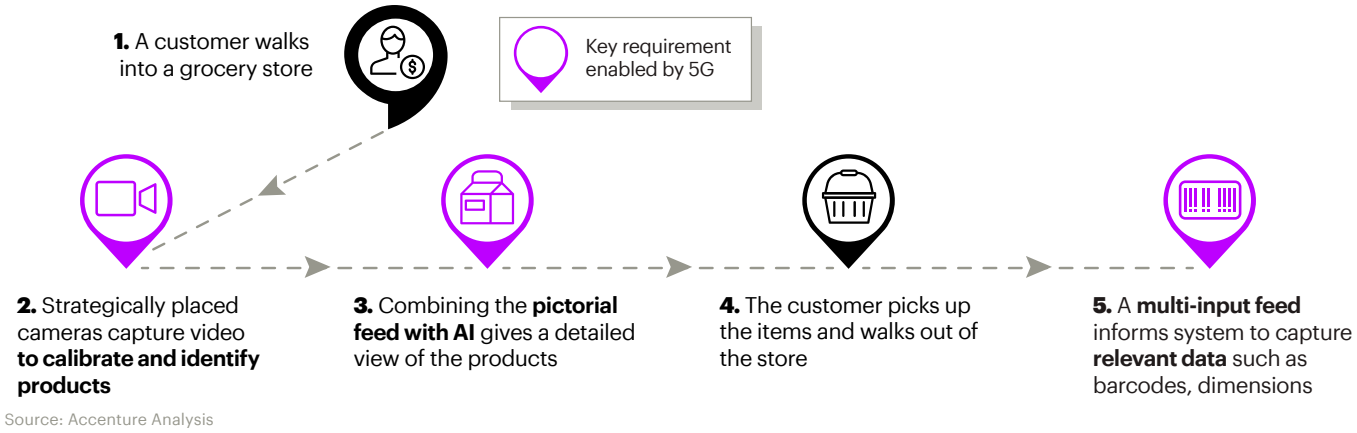
Frictionless Store Checkout

At some point in their shopping journeys, 86% of consumers have left a store due to long lines, resulting in an estimated $37.7 billion in missed sales annually in the United States.[90] Retailers are avidly looking for a solution to this pain point; 73% even agree that poor checkout experience is one of the biggest problems in retail.[91]

Frictionless store checkout solutions combine high-definition video with sensors and AI to recognize the products customers pick up for purchase. These systems can distinguish when the customer selects a product such as a chocolate bar and puts it back down, preventing erroneous charges. The data collected by the store cameras can be processed by AI that is trained to recognize the items in the retailer's inventory. Connectivity costs can be reduced by distributing the compute requirements associated with this type of experience.[92]

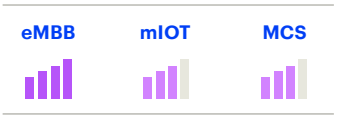
It's important to note that a small range of frictionless checkout implementations exist today with varying levels of sophistication. Select retailers like Amazon and Ahold Delhaize are currently experimenting with several frictionless store checkout formats but the footprint is light. For example, Lunchbox by Ahold Delhaize can only allow 12 shoppers in at once and is limited to small-square-footage stores selling

ee Share of wallet is how much a customer spends at one retailer versus a competitor.



Source: Accenture Analysis

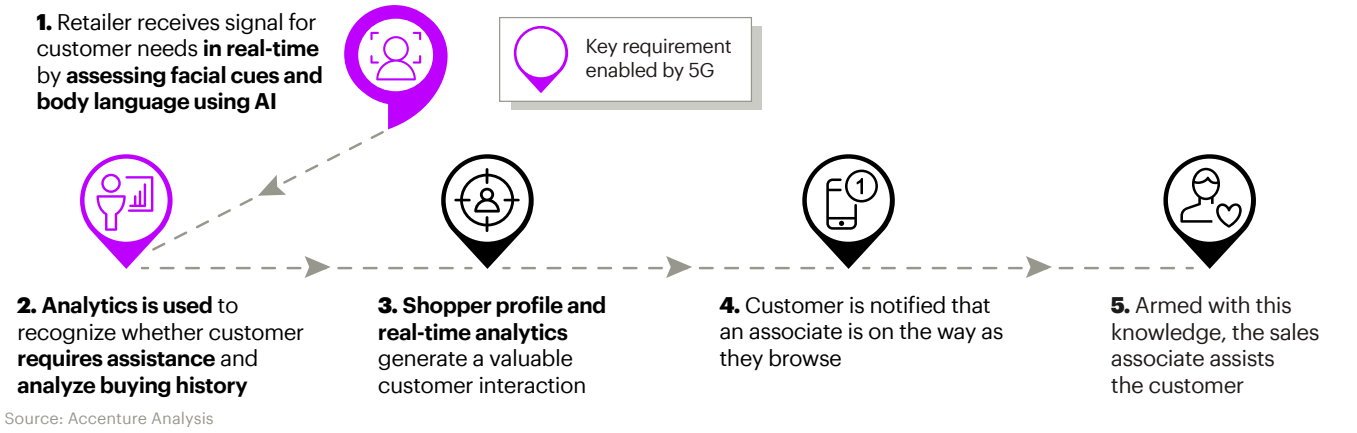
mostly packaged goods.[93] A key inhibitor for wider adoption is the need for greater data capacity. The enhanced mobile broadband provided by 5G can mitigate this. Applying 5G connectivity can enhance the implementation of frictionless store checkout as it exists today.[94]



Source: Accenture Analysis

Intelligent Clienteling

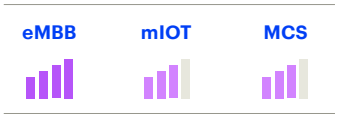
Clienteling[ff] allows businesses to focus on high-value repeat customers who generate more revenue and are less expensive to retain, an imperative when approximately 40% of customers drive 80% of a retailer's revenue.[95] Some technologies, such as in-store movement tracking, exist today and are already being used by digitally savvy retailers to better understand and identify shopper behaviors and patterns.[96] 5G connectivity equips users to take the technique to the next level. With 5G-enabled technology, the data collected from these types of actions can be analyzed in real time and made to benefit the customer immediately.



Source: Accenture Analysis

Intelligent clienteling pairs AI analytics with high-definition video footage to analyze customer behavior and body language. The result is real-time intelligence that can be used to inform the actions of store associates. Leveraging 5G connectivity to understand product preferences, shopping behaviors and real-time needs while alerting store associates to act is a game-changer. It can transform an unremarkable shopping trip into a personalized, memorable experience for the customer.[97]

ff Refers to the process or tools used to promote customer satisfaction throughout the shopping journey by personalizing the experience using client data like purchasing history to establish a long-term relationship and better cater to customer preferences.



Source: Accenture Analysis

Automated Surveillance

U.S. retailers lose approximately 1.5% of sales to shrinkage ($50 billion annually), even with more security guards being added. In 2019, retail loss was at an all-time high. Additionally, 20% of known shoplifters visit more than three locations of a single retailer.[98] If even 20% of the current problem can be mitigated, the industry stands to save close to $25 million in a single day.[99]

5G can boost loss prevention by transmitting detailed feeds of suspicious behavior. Research shows that the average person can engage in mundane tasks for about 20 minutes before their attention span decreases. Augmenting human-supported loss-prevention techniques with automatically generated alerts based on suspicious behavior, which can run on an AI engine and connect over a 5G network, can increase operational effectiveness efficiency. As with the intelligent clienteling solution, loss prevention requires the enhanced mobile broadband and ultra-low latency that 5G offers. The quality of the video stream and speed of results need to be reliable enough that the employees can be alerted before the shoplifter leaves the store.

5G Adoption Challenges and Mitigations

Consumer Data Privacy Concerns

There is an increasing consumer concern about data privacy. Consumers are wary that with greater connectivity, more and more devices will begin accessing personal data. Disruptive technology like facial recognition opens the door for enterprises to take a deeper and more influential position in the consumer's life. Failure to acknowledge this growing impact will push people to reject even the best of intentions as trust becomes currency in an era where digital is pervasive. A balance must be struck. Businesses and regulatory agencies need to work collaboratively to address consumer concerns without inhibiting growth.

Device Readiness and Installation Timeline

Another challenge with the implementation of 5G use cases is the lag in both industrial device readiness and infrastructure development. A 5G network buildout creates the opportunity for many XR use cases. For retailers to justify the substantial upfront infrastructure investment, they need to be certain that they can apply the technology to multiple use cases. Similarly, developers need to be certain that there will be a market for their products before they spend R&D budgets on designing new experiences. By fostering a culture that encourages innovation and IP protection for those enterprises that are investing in these 5G-enabled solutions as well as the infrastructure build-out, policymakers can ensure that these use cases reach the hands of the consumer.

Conclusion

These examples highlight ways 5G can improve the shopper and associate experience by addressing key points of retail friction. Inventing a better, human-centered future for shoppers requires a virtuous circle of trust, data and deeper experiences. 5G-enabled solutions equip retailers to apply technologies that exist today in test beds, to generate value for the customer when they walk into stores. This will drive GDP up to $100.2 billion in five years and create or transform up to 1.4 million jobs by 2025. The value 5G generates within the retail industry impacts the enterprise, employees and the end consumer.

Healthcare

5G technology will allow more mobile/home care, better patient outcomes and more capacity and flexibility within the healthcare system.

The next five years of 5G impacts in the healthcare sector will drive:

$192.3 billion in additional industry revenues
$120.1 billion in added GDP contributions
1.7 million jobs created or transformed[gg]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Remote patient monitoring	●	●	●
Virtual consultations and care	●	●	●
Connected hospital	●	●	●

Source: Accenture Analysis

Industry and Technology Context

The healthcare industry accounts for a substantial portion of U.S. economic activity, including 18% of GDP[100] and 14% of total jobs (growing by 15% leading into 2029).[101]

Healthcare is facing fundamental shifts—longer life expectancies and the aging baby boomer cohort are exponentially boosting demand for services, with increasingly complex medical cases and comorbidities. As of 2020, two thirds of system costs are driven by patients with complex conditions (more than three chronic diseases),[102] which will only grow with a graying population. These factors promise to drive total healthcare costs from $3.4 trillion to $6 trillion by 2027,[103] an amount corresponding to nearly 20% of U.S. GDP and that is larger than the economy of Japan.[hh]

This surge in demand is going to result in extreme labor shortages. Recent studies project physician shortfalls to reach as high as 139,000 by 2033,[104] alongside other role shortages including nurse practitioners, occupational therapists and physician assistants.[105] Technology and more scalable models of care will be critical to bridging this gap.

gg Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.
hh Annual GDP.

Growing cost and usage will also exacerbate existing issues with waste in the system. Driven by failure of care delivery, failure of care coordination and administrative complexity, waste is estimated to be as high as 30% of spending.[106] Unplanned hospital readmissions alone, for example, cost Medicare tens of billions of dollars annually.[107]

In parallel, healthcare is facing a new shift toward consumerization, with patients increasingly playing a more active role in health decisions and demanding more scrutiny in service choice. These challenges are compounded by both the high volume of health data being generated and new expectations for transparency and ownership.

COVID-19 Impact

During the pandemic lockdown, the virtual medicine trajectory in the United States made 10 years of progress in a matter of months. Still, the future outlook and lasting impacts are still uncertain; a hybrid model is likely in the United States as certain segments of consumers still value in-person physician relationships, and the structures for full virtual care as a replacement for in-person visits are not fully in place.

67% of executives predict their organizations will use telehealth at least five times more than pre-pandemic, but only one third believe they have all the needed telehealth capabilities.[108] Recent research has also shown that 83% of Americans remain concerned about the risk of viral exposure in medical facilities, and 36% won't return now. The decrease in elective procedures in healthcare systems has also created near-term revenue pressure, which may hinder available dollars for investment, but makes new revenue streams enabled by 5G even more critical.

How 5G Can Help

Broadly, 5G is a critical enabler for Internet of Medical Things applications by providing:

- Rapid transmission and processing of the high quality and quantity of medical data being collected by an increasing number of wearables, multi-modal sensors, etc.
- Richness of in-person physician interactions to remote/home settings (rich bi-directional communication, HD video and a wide array of biometric and other sensors)
- Reliability and extreme low latency in critical patient applications

Economic Impact of 5G

Healthcare industry

$192.3B in new 5G revenue

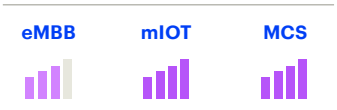
	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	$120.1B	$242.2B	2.0x
Labor Income	$87.4B	$149.1B	1.7x

Jobs and Employment
1.7M jobs[ii]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

5G's impact on healthcare will be significant, driving up to $192.3 billion in economic output, $120.1 billion in GDP and up to 1.7 million jobs. These results stem from not only healthcare use cases and new services, but also from the impact of other industries. As jobs are created across the economy, labor income and employer-provided insurance will lead to more health industry revenue. Healthcare will also produce benefits that will be felt across sectors—our analysis predicts that one 5G job in healthcare will result in 1.8X jobs throughout the economy, including in life sciences, medical device manufacturing, raw materials (extraction and agriculture) and more. Most critically, the improvements resulting from 5G will help workers and consumers live longer, healthier lives, driven by better patient outcomes and access, leading to a more productive workforce across the economy and more years of consumer spending.

5G Use Cases and Benefits



Source: Accenture Analysis

Remote Patient Monitoring

The cost, capacity and skilled labor constraints in healthcare are acutely felt within inpatient services, where beds, specialists and round-the-clock monitoring are in short supply. Remote patient monitoring has the potential to alleviate these constraints. Instruments can continually gather and analyze data on patients located off-site, sending alerts to initiate prompt intervention when needed.

Existing applications are limited by current connectivity technology consisting of periodic uni-directional, passive sensors. 5G allows for more continuous, reliable and secure monitoring, with integration of multiple sensors with high data volume, critical for driving better patient outcomes, including:

- Short-term monitoring for patients with **sensitive/critical conditions**, including opportunities to treat in outpatient settings
- Continuous loop of data and feedback to **manage chronic conditions, medication and preventative care**

In **acute and post-acute care**, 5G remote patient monitoring is at the center of the next generation of hospital-at-home applications. Patients who are treated in the ER and assessed for suitability can be

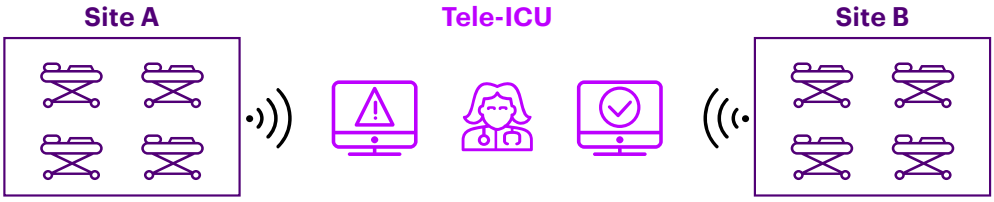
ii Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

outfitted with remote monitoring devices and go home to essentially have a connected hospital bed in their own dwelling. A remote care team can then monitor the patient's recovery and deploy in-person mobile staff only when needed. This results in shorter stays, reduced costs, higher patient satisfaction and better health outcomes.

Connected Hospital-at-Home models offer **30% cost savings** and better **patient outcomes**

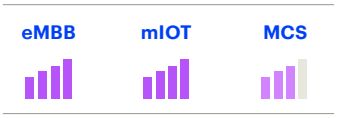
This model is already generating value. For example, Johns Hopkins Medicine Healthcare Solutions has demonstrated 30% cost savings, driven by reduced hospital overhead and more streamlined care.[109] Unfortunately, the eligible conditions and level of acuity remain limited today. 5G's potential to incorporate more sensors and real-time feedback will not only improve the quality of care and economics of this model (e.g. leveraging AI with multi-modal data to pre-emptively predict intervention needs), but also expand the breadth and criticality of medical conditions it can serve.

Intensive care is one of the most expensive elements of healthcare: A single day of treatment can cost more than $10,000[jj] and represents up to 60% of hospital cost despite accounting for only 10% of the volume.[110] In addition, the demand for these beds and need for capacity is rapidly rising. Expansion, at a cost of $2 million per bed,[111] is prohibitively expensive. Meanwhile, there is a severe shortage of qualified intensivists in the United States, despite their presence leading to improved patient outcomes. The tele-ICU model allows a team of intensivists (and other health professionals) to manage many remote ICU patients at once, using a "hub-and-spoke" model to expand capacity with much less investment from the health system. The approach also increases flexibility, allowing better management of supply and demand versus managing satellite sites in person.



For **chronic and preventative care**, 5G will allow better in-home monitoring and better use of the explosion in medical data being driven by wearables and smart medical devices. Beyond the short interventions in acute and intensive care, healthy individuals and those with chronic conditions will be able to get a much richer picture of their health. With high-speed, high-bandwidth and secure data transfer, 5G will allow timely treatment through AI-driven risk prediction beyond what is possible today (e.g. predictive warning of impending heart attack or stroke risk). Early diagnosis and intervention significantly improve patient outcomes.[112] 5G offers the potential to delay disease states or prevent them from developing entirely. Together, this family of applications will drive substantial economic benefit for healthcare, estimated at 30% of the total 5G economic benefit. More important, the benefits in terms of healthcare quality and patient outcomes will improve the quality of life for millions of Americans.

jj For patients requiring ventilators on their first day; $7000 otherwise.



Source: Accenture Analysis

Virtual Consultations and Care

Barriers to healthcare access exist throughout America. 63% of primary-care professional shortages are in rural areas. Meeting with specialists often requires travel to urban centers, where the ratio of medical specialists to the population is nine times higher.[113,114] For many Americans, reaching health providers that are "in-network" on their insurance plan can further limit care options. By removing the requirement of commuting and physically visiting a doctor's office, virtual consultations and care offer the promise of better health access from home and remove or lower many of these barriers, while improving patient outcomes and reducing cost.

5G can **improve virtual care,** which has **increased 3X to 5X** in volume

Telemedicine and telehealth are already a reality and have been accelerated by the pandemic—major U.S. healthcare providers have seen 3X to 5X increases in virtual care volume. While current communications technology is viable for voice and lower-definition video, 5G supports higher definition and more complex multi-modal data streams with bi-directional interaction. In addition, there's a critical relationship between virtual care and the remote patient-monitoring solutions described previously: The longitudinal, rich data captured on patients will provide context that simply does not exist today.

The bandwidth and speed limitations of current wireless networks remain major barriers to expanding the scope of services that can be provided remotely, as services such as dermatology, wound care and cardiac care require high definition and responsive image/video. As reimbursement levels are tied to relative service quality, the improvement in accuracy and precision driven by 5G will drive increased revenue for providers and greater adoption of virtual care; a lower-fidelity remote dermatology exam commands a lower fee than an office visit because the equipment and image quality have lower diagnostic precision.

The opportunity created by virtual care also extends beyond the home. With 5G, large health networks will be able to share specialists virtually across sites, balancing coverage among locations to increase system capacity and provide a better overall standard of care. By partnering with larger centers and conducting remote specialist consults, rural hospitals and primary care offices can offer access to services that aren't otherwise available in their community and at a fraction of the cost.

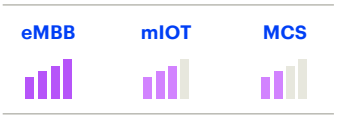
To reach full potential, virtual care requires 5G-level connectivity. Remote consults can involve the transfer of massive amounts of data such as for MRI images or CAT scans. High-speed, high-bandwidth connectivity is essential to ensure effective and accurate coordination of care among patient, provider and specialist. In the future, the millisecond latency and high reliability of 5G may enable remote surgical consults, with the specialist weighing in or even performing surgery robotically from an off-site location.

In a real-world example, United Hospitals Birmingham has used 5G virtual care to bring scale to its health system. A remote facility staffed by lower-cost health professionals was set up to enable physicians to access stethoscope data, ultrasound scans and ECGs, increasing overall capacity.[115]

In addition to increasing access and providing more timely, cost-effective care, virtual health provides a safer alternative. Hospital-acquired infections (HAI) are responsible for 1.7 million infections and nearly

100,000 deaths in America annually, some of which would be mitigated with a shift to more virtual care and post-care.

Overall, virtual care applications are expected to drive 20% of the overall 5G-enabled economic impact, as a result of volume increases from new healthcare access as well as productivity/cost optimization throughout the system.



Source: Accenture Analysis

Connected Hospital

Hospitals are heavily reliant on wired connections for everything from surgical equipment to heart monitors, with dedicated rooms for specific types of care. Wired connections prevent rapid scaling up or repurposing of healthcare capacity and space; rooms are limited by their wired connectivity. In addition, wired connections remain a major source of injury, causing trips and falls,[116] which represent 25% of healthcare workplace injuries.[117]

Previous generations of wireless connectivity have not had the reliability needed to truly untether hospitals. With 5G and private networks, adding or repurposing inpatient capacity is no longer reliant on physical wiring, adding flexibility to respond to disasters (e.g., future pandemics, floods) by rapidly scaling up capacity. In China, this was critical to their COVID-19 response and ability to stand up 1,600 new hospital beds within 10 days at the Leishenshan and Huoshenshan pop-up sites.[118]

In the United States, Chicago's Rush Hospital is building America's first 5G healthcare facility. In addition to taking full advantage of virtual consults, rapid data transfer and other services for physicians and staff, Rush is rethinking the entire patient experience, with app-based guidance of their entire visit. The transition alone, replacing legacy infrastructure with 5G and going fully wireless, is resulting in millions of dollars of savings for just a single site, even before accounting for the benefits of new services enabled by 5G.[119]

The benefits of connected hospitals are expected to drive 10% of the overall economic impact from 5G in healthcare, alongside the national security benefits of being able to rapidly respond to disasters and scale healthcare capacity.

5G Adoption Challenges and Mitigations

FDA Approval and Regulatory Barriers

5G healthcare use cases are closely linked with technologies subject to complex approval processes. For example, AI applications often struggle with FDA approval, while cloud and edge technologies receive extra scrutiny over HIPAA compliance, potentially hampering innovation and adoption. Supporting development of "white label" 5G use-case platforms with integrated quality-management systems (QMS), such as for remote patient monitoring, can speed approvals and spur innovation. In addition, any streamlining of approval processes for key technologies including cloud, edge and AI can help accelerate economic and social benefit.

Interoperability and Standardization

The U.S. healthcare system is highly complex with a heterogenous mix of standalone players. From a technology perspective, this makes developing and adding new capabilities more difficult, requiring

exponentially more custom integrations. Development and promotion of standards can play a key role here to allow broader ecosystem benefits to be realized.

Reimbursement Models

Reimbursement models remain a barrier to realizing 5G economic benefits, as many healthcare services continue to be tied to physical locations. Structures are not in place to transition to virtual visits in many care areas or those visits have substantially reduced fees and therefore limited incentive for adoption. Awareness and appropriate staffing remain barriers even with a reimbursement model in place: During the recent lockdowns, patients and providers only took advantage of 12% of reimbursable virtual services. As developers of 5G diagnostic technology and physicians prove the relative efficacy of remote/virtual solutions, policymakers should ensure that the right models are in place to encourage usage.

Network Deployment and the Digital Divide

In-home applications are dependent on network rollout; critically, the areas that can benefit the most from virtual health because of their existing health access limitations (rural communities) also tend to be the most disadvantaged in terms of connectivity, a trend that is likely to continue with 5G. A national 5G strategy and incentives/public investment in rural fixed wireless access could unlock dramatic economic benefit and patient outcomes in these areas.

Conclusion

The healthcare system in the United States is facing unprecedented challenges. 5G is positioned to play a critical role in meeting these demands by unlocking the Internet of Medical Things and providing better, more affordable services and treatment across the continuum of care. This will improve patient outcomes and the lives of American consumers, and give the healthcare system the resiliency it needs to face the challenges of our time.

Automotive and Transportation

5G technology will enable smarter, safer, greener and more efficient transport from connected vehicles and transit infrastructure in the United States.

The next five years of 5G impacts in the automotive and transportation sector will drive:

$217.1 billion in additional industry revenues
$113.2 billion in added GDP contributions
1.6 million jobs created or transformed[kk]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Enhance vehicle safety and automation	●	●	●
Advanced fleet management and telematics services	●	●	●
New intelligent transportation systems	●	●	●

Source: Accenture Analysis

Industry and Technology Context

The automotive and transportation sector is an integral component of the U.S. economy. In 2019, sales of vehicles and parts reached $1.25 trillion.[120] By the end of the year, there were nearly 280 million vehicles in operation across the United States,[121] translating into $780 billion in gross output for U.S. automakers (OEMs) and their supply chains.[122] That said, car sales in the United States, as in the rest of the world, have declined in recent years, falling from 17.4 million units sold in the United States in 2016 to 16.9 million units sold in 2019.[123]

Connected
Equipping vehicles with cellular connectivity will enable new services and vehicle capabilities through over-the-air updates.

Automated
The transition from cruise control to automated lane changing and eventually no driver at all is receiving a lot of industry attention.

Shared
Mobility-as-a-service (e.g. Uber, Lyft, Zipcar) is becoming an increasingly popular mode choice.

Electrified
Concern for sustainability and recent battery innovations have given the Electric Vehicle movement substantial momentum.

Source: Accenture Analysis

kk Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Decreasing sales numbers have intensified competition among OEMs and are contributing to the impetus for industry transformation. The major technology trends behind the evolution of both automotive and transportation business models are captured by the term C.A.S.E. (Connected, Automated, Shared, Electrified). An enabling factor in all four of these mega-trends is none other than 5G communication technology.

COVID-19 Impact

The shutdown of automotive production may have affected as many as 8 million jobs in the United States.[124] Carmakers, globally, are finding it harder to stay profitable, maintain automotive parts supplies and of course, combat the exacerbated dilemma of decreasing sales. And it may take a lot of time for the industry to return to some level of normalcy.

The pandemic is exposing complications within the industry's heavy supply chain, at the forefront of which is the reliance on often times single sourcing parts.[ll] Although these dedicated business relationships may have offered price and efficiency advantages, they also created a vulnerability that the pandemic could expose. The production interruptions or shutdowns taking place across globally connected supply chains have made it impossible for some OEMs to assemble a complete vehicle today. Going forward, manufacturers will need to focus on dual-sourcing strategies[mm] as a precaution against similar supply chain disruptions in the future. The visibility into the manufacturing process that 5G-enabled technology can create will help with this.

To keep customers engaged, the industry may increase and transform the use of online and mobile channels for a contactless sales process or a virtual trade fair. Whatever the approach, as pandemic conditions ease and customers return, the recovery process will be difficult and expensive. It will require OEMs to synchronize a disordered supply chain and idle workforce back into the highly coordinated process of just-in-time production.

How 5G Can Help

Over the course of the next decade, investments in 5G networks and enabling technologies such as multi-access edge computing will transform the automotive and transportation industry. Vehicles will become smarter, safer, greener and faster. Using 5G's increased device capacity, all connected consumer and enterprise vehicles and all 5G-enabled road infrastructure in the United States will be able to tap into the power of the Internet. New low-power networking equipment and cellular devices will maintain feedback loops between vehicles and the infrastructure without heavy energy use or EV battery consumption. The 5G network's enhanced bandwidth will provide the network speeds required to capture and analyze video data from various sensors within vehicles and on the road in real time—not to mention generate nearly boundless entertainment streaming options.

Mission critical to realizing the future of connected and automated vehicles (CAVs) and many other use cases are 5G's ultra-low latency capabilities, which ensure that information can reliably travel between devices nearly instantaneously to make life-saving decisions. And in crises, 5G networks are built to

ll Single sourcing means OEMs have established only one source for any automotive component due to the more cost-effective supplier terms that come from economies of scale.

mm Dual sourcing is a means of supply-chain risk diversification that involves leveraging two unrelated suppliers for the same component, such that any disruption to one does not impact the supply from the other.

prioritize emergency communications over delay-tolerant applications like movie streaming. Combining all of these features will result in more transportation efficiency, substantial reductions in crashes, countless lives saved, reduced idling and lower CO_2 emissions and a more productive economy overall.

Economic Impact of 5G

Automotive and transportation industry

$217.1B in new 5G revenue

		Total value chain impact	Multiplier effect
Gross Domestic Product	$113.2B	$230.1B	2.0x
Labor Income	$72.3B	$133.4B	1.8x

Jobs and Employment

1.6M jobs[nn]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

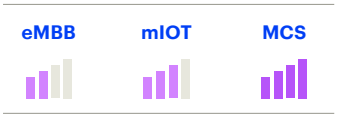
5G in the automotive and transportation sector will drive up to $230.1 billion in total GDP for the United States. Vehicles are essential to a vast number of public and private sectors, including delivery and logistics, agriculture, construction, emergency services, enterprise fleets, public transit and consumers. Over the next five years, the effects of 5G will boost U.S. automotive and transportation industry revenues by up to $217.1 billion and up to $113.2 billion in direct GDP impacts. These figures encompass sales of CAVs, connected-car services from automakers, mobility-as-a-service business models, improved logistics solutions and more.

The indirect economic impact of 5G on the automotive and transportation supply chains could generate up to $47.6 billion in additional GDP. These supply chains include everything from raw materials processing (e.g. metals and plastics for vehicles) to chipsets, sensors and cameras for CAVs. In addition, municipalities and private-property owners will be investing heavily in construction projects to create 5G-enabled road infrastructure or controlled environments for self-driving vehicles. The incremental labor to support this level of economic growth could lead to a total of 3.0 million additional jobs, generating approximately $133.4 billion in labor income. Software developers, device designers and equipment engineers will account for a large proportion of these positions, given the increasing digitization of road vehicles and road infrastructure as well as new over-the-air mobility applications.

5G Use Cases and Benefits

By 2030, an estimated 146 million connected vehicles will be in use across the United States, compared to 67 million as of 2020.[125] Leveraging various forms of M2M communications, connected vehicles will exchange data with road infrastructure (V2I), other vehicles (V2V), pedestrians or cyclists (V2P), power grids (V2G) and of course, wireless networks (V2N). Cellular vehicle-to-everything (C-V2X) connectivity began with LTE and expands in capability with 5G-V2X. This evolution underpins a variety of new use cases being advanced b y the major technology trends discussed above. Some of those use cases can be categorized as follows: (1) enhanced vehicle safety and automation, (2) fleet management and telematics-based services and (3) intelligent transportation systems (ITS) or smart traffic management.

nn Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.



Source: Accenture Analysis

Enhanced Vehicle Safety and Automation

The advanced capabilities of 5G promise to bring an ecosystem of automated vehicles and machines to reality. That being said, there are many incremental steps on the way to a fully-automated vehicle, designated as Level 5[oo] per the Society of Automotive Engineers (SAE) International taxonomy.[126] There are almost no examples of L3 or higher automation at the time of this writing, and U.S. regulations still prohibit use of L3 automation capabilities on public roads.

In conjunction with 4G LTE, 5G plays a key role in one of the most promising wireless standards for CAVs, cellular vehicle-to-everything (C-V2X). 5G-V2X has both short-range and long-range capabilities, allowing vehicles to communicate with devices in the immediate and distant surroundings. Effectively, 5G-V2X gives vehicles the ability to look through multiple cars ahead and almost instantaneously predict how hidden vehicles will react to events just up the road. mIOT offers simultaneous two-way communications for a large number of vehicles or devices using C-V2X and ultra-low latency helps ensure vehicle safety given the reaction times required in fast-moving CAVs.

Large scale C-V2X deployment began in 2020.[127] Initially, it will support early iterations of self-driving vehicles in supervised, enclosed areas (e.g. private campuses) with virtually defined perimeters (i.e. geofencing) as well as tele-operated driving and automated parking in these controlled environments. With 5G network coverage, these two use cases can be extended into less controlled environments such as public parking lots, and ultimately roads. 5G will also enable cooperative maneuvers and long-range sensor sharing, which require 10-ms service latency.[128] This would mean that existing highway traffic must be able to initiate a speed adjustment almost instantaneously after an incoming vehicle prepares to merge from the on-ramp.

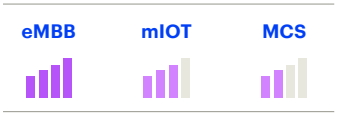
Similar safety applications like these are top of mind for Audi, Qualcomm and the Virginia Department of Transportation (DOT), which are teaming up to pilot C-V2X capabilities.[129] The group will be starting with C-V2X short-range applications such as work-zone warnings, which can notify drivers through their dashboard when they are nearing vulnerable road-side workers. Over time, with 5G deployment, the project calls for expansion into other alerts and other possibilities mentioned below.

Connected and Automated Vehicles could **save 4,000 lives** each year and **prevent 210,000 accidents**

These C-V2X applications offer a glimpse of the near-term possibilities of 5G, which are expected to have powerful impacts on the environment and public safety. German automotive supplier Bosch estimated that by 2025, CAVs could save 4,000 lives in the United States each year and prevent more than 210,000 crashes across the country.[130] This dramatic improvement in safety would translate to $3.6 billion in repair and collision cost savings for U.S. citizens and insurance companies.[131] The U.S. National Highway Traffic Safety Administration (NHTSA) estimates that that the combined impact of V2X technologies could mitigate the severity of up to 80% of non-impaired multi-vehicle crashes and 70% of crashes involving commercial trucks.[132]

oo Vehicle automation is classified as level 0 (no automation), level I (cruise control), level 2 (advanced driver assistance systems; e.g., acceleration, braking and steering), level 3 (conditional automation—vehicles self driving in many, but not all, situations), level 4 (automated vehicle but with driver override), and level 5 (self-driving in all situations).

Overall, C-V2X connected vehicle automation and sales over the next five years is estimated to make up to 40% of the economic impact of 5G in the US automotive and transportation sector by 2025.



Source: Accenture Analysis

Advanced Fleet Management and Telematics-based Services

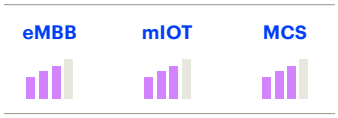
At a 30% global CAGR, it is estimated that the telematics applications of fleet management, in-vehicle entertainment systems, Internet hot spotting, emergency calling, vehicle diagnostics, navigation and more represent the fastest growing IoT category.[133] In each of these use cases there is important information for more parties than the driver; imagine the fleet managers, emergency services and insurance companies capturing valuable data about their insured drivers and vehicles. These stakeholders, much like automotive manufacturers, will start to consider how access to all of this usage data will inform future engineering designs and over-the-air updates.

While a select number of delay-tolerant telematics-based services are possible with today's 4G LTE networks, 5G will support new types of information that will be critical to managing future automated vehicle fleets. This includes new bandwidth-heavy computations and video-based telematics services. Additionally, MCS will ensure reliable connectivity for the growing number of vehicles, sensors and devices. Lastly, 5G-connected vehicles will have access to an almost limitless array of streaming entertainment options due to the high bandwidth of the new network.

5G video-based telematics solutions will broaden fleet management capabilities, for example supporting improved logistics security and goods-condition diagnostics. Fleet managers will use it to improve capacity utilization, reducing the estimated 20% of cargo space in U.S. trucks that currently rides empty.[134] Additionally, with new predictive maintenance services, fleet managers can address the 9% of their total fleet costs that go toward repairs.[135] Both enterprise and consumer drivers will be incentivized to drive more safely and reduce fuel consumption through pay-how-you-drive insurance policies that offer an average of 12% savings for good driving.[136]

The key to the success of these types of applications lies in the timely development of 5G telematics solutions. TuSimple, a foremost leader in self-driving technology for heavy trucks, plans to launch a fleet of automated vehicles in 2021.[137] To succeed, they will need a 5G telematics solution to handle the oversight and processing (both automated and human) of real-time information from their trucks. It is imperative that the industry develop new telematics services today with human drivers, so that mature, robust applications are ready for the world of tele-operated or self-driving vehicles in uncontrolled environments.

Altogether, 5G-enabled fleet management and telematics services are estimated to generate 10% of the total economic benefit from 5G in the automotive and transportation sector through a mixture of value-added aftermarket services and regulated solutions that are built into vehicle production.



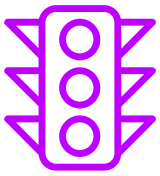
Source: Accenture Analysis

New Intelligent Transportation Systems

5G technology can completely transform traffic management systems and road infrastructure such as road signage, toll collection, road monitoring and traffic signals. In addition, 5G-enabled transportation infrastructure can facilitate new vehicle safety solutions, advanced weather analysis, enhanced public transit, smart parking management, etc.

Where V2V use cases need all nearby vehicles to be equipped with M2M communications technology, V2I use cases generate immediate value for both connected and non-connected vehicles. And as more vehicles come online, 5G networks have the quality of service (QoS) features to give preferential allocations of the network to safety-critical messages, such as emergency services.

There is an extensive list of V2I services that can be found through the U.S. DOT's National ITS Reference Architecture (ARC-IT),[138] many of which align with the applications deemed as "Day 1"[pp] services by the European Commission's C-ITS division.[139] One such possibility is Traffic Signal Pre-emption Requests, which allow emergency vehicles to be dynamically granted green lights and also signal nearby vehicles to yield right of way. In the city of Marietta, Georgia, an early version of this technology is being used today to get their firefighters "green to the scene" quickly and safely.[140]



Connected traffic management could lead to **25% reductions in traffic** and a **30% reductions in idling** at intersections

Connected traffic management solution providers in the United States have already realized a 25% reduction in traffic congestion and a 30% reduction in idling at intersections through adaptive traffic signals.[141] Alibaba City Brain, a smart highway project in China's Hangzhou province, is piloting a real-time video feed of road conditions that has resulted in 15% fewer crashes, 15% less traffic congestion and a 20% improvement in workload efficiencies for the road response teams.[142] 5G-enabled transportation infrastructure is a must-have, given the addressable $166 billion annual cost of traffic delays.[143]

Investments in intelligent transportation systems are foundational because they lay the groundwork infrastructure for improved vehicle automation and expanded telematics offerings. These systems are likely to drive 5% of the total economic benefit from 5G in the sector (primarily from improved smart parking utilization and connected toll-road demand and collections, among others).

5G Adoption Impediments and Mitigations

Commitments on Mid-Band Spectrum Allocations

In the United States, uncertainty exists around the intended availability of the high-quality mid-band spectrum traditionally reserved for transportation safety. In late 2019, the U.S. Federal Communications Commission (FCC) announced plans to open more than half of the 5.9 GHz spectrum band to unlicensed use, like Wi-Fi. It also halted the processing of new license applications, which would include requests submitted by organizations in the automotive and transportation sector.[144]

Losing access to this dedicated band presents a major issue for companies developing 5G automotive and transportation equipment for this globally harmonized spectrum band.

At a time when many countries are shifting toward the 5G future and also making a concerted effort around 5G-V2X technology, the U.S. automotive industry has experienced setbacks due to these interruptions. The 5GAA published a report on evolving spectrum needs for automotive V2X applications with one of the key findings suggesting that global harmonization is required on the 5.9 GHz band for basic and advanced C-V2X functions.

pp Day 1 and Day 1.5 services refer to a more basic set of vehicle-to-infrastructure services that have the technological readiness to be deployed today.

Although there will be some regional discrepancies and more scrutiny required, it is clear that the pace of innovation depends on national authorities and the timely allocation of required spectrum bands.

Modernization and Security of the Vehicle CAN Bus

A substantial challenge for the CAV ecosystem will be ensuring end-to-end cybersecurity from each vehicle and other connected devices, through the edge or cellular network and out to the cloud. The technology that enables the mechanical processes within a vehicle to be software controlled are the many electronic control units (ECUs) interconnected by a digital nervous system, known as the standard CAN bus.[145] The issue is that this 30-year-old standard was not designed with wireless IoT security in mind. It lacks basic security features such as message authentication and device attestation. In 2016 the Keen Security Lab of Tencent demonstrated these vulnerabilities by wirelessly hacking into a connected car.[146]

To address such concerns, the Automotive Information Sharing and Analysis Center (Auto-ISAC) was formed to share global intelligence related to vehicular cybersecurity risks and capabilities.

Beyond security risks related to hackers, there is a substantial amount of vehicle data (recall, some 100 million lines of code[147]) that legitimate businesses will seek to access. Little to no progress has been made on laws related to what data OEMs and service providers are allowed to sell.[148] As new connected vehicle services and telematics offerings continue to grow, the public will want to know how their driving data is being used and how it is being protected.

Accelerated Public Investment in Cellular and Connected Infrastructure

As mentioned above, there are immediate safety and efficiency advantages to the connected road infrastructure applications that are ready to deploy today. Many of these applications can use existing mobile devices and 4G networks and if deployed with C-V2X, they will be future-proofed for 5G network transformations. The 5GAA conducted a study on the cost of delivering ITS services through cellular networks to complement the dedicated road-side units (RSUs) used in short-range communications and discovered it is significantly less expensive to deliver ITS using cellular networks.[149]

By adopting connected ITS solutions, local and national authorities have an opportunity to accelerate the deployment of C-V2X-based ITS solutions. This connectivity standard will be harmonious with future 5G deployments and can co-exist with ad-hoc RSU deployments as needed. A concerted focus on C-V2X solutions would not only promote ecosystem alignment on ITS communications standards but may also accelerate V2V device standards and ultimately lead to more lives saved.

Conclusion

The future of automotive and transportation is to leverage 5G to create feature-rich, secure and reliable connected and automated vehicles that are seamlessly integrated with the surrounding public infrastructure in cities, suburbs and even rural areas. To achieve this goal, the industry will need to closely coordinate with telecommunications players as well as local and federal authorities. 5G has the potential to transform not just the automotive and transportation industry, but also people's lives. The United States can optimize its travel into the 5G future through investment in V2I-enabled public infrastructure, heightened vehicle cybersecurity investment and policy actions and efficient and appropriate allocations of safety-critical spectrum bands to automotive and transportation connectivity.

Utilities

5G technology will enable reliability, safety and affordability throughout the utilities infrastructure and workforce in the United States.

The next five years of 5G impacts in the utilities sector will drive:

$36.9 billion in additional industry revenues
$22.3 billion in added GDP contributions
48,000 jobs created or transformed[qq]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Intelligent grid	●	●	●
Next generation worker		●	●
Smart power plant		●	●

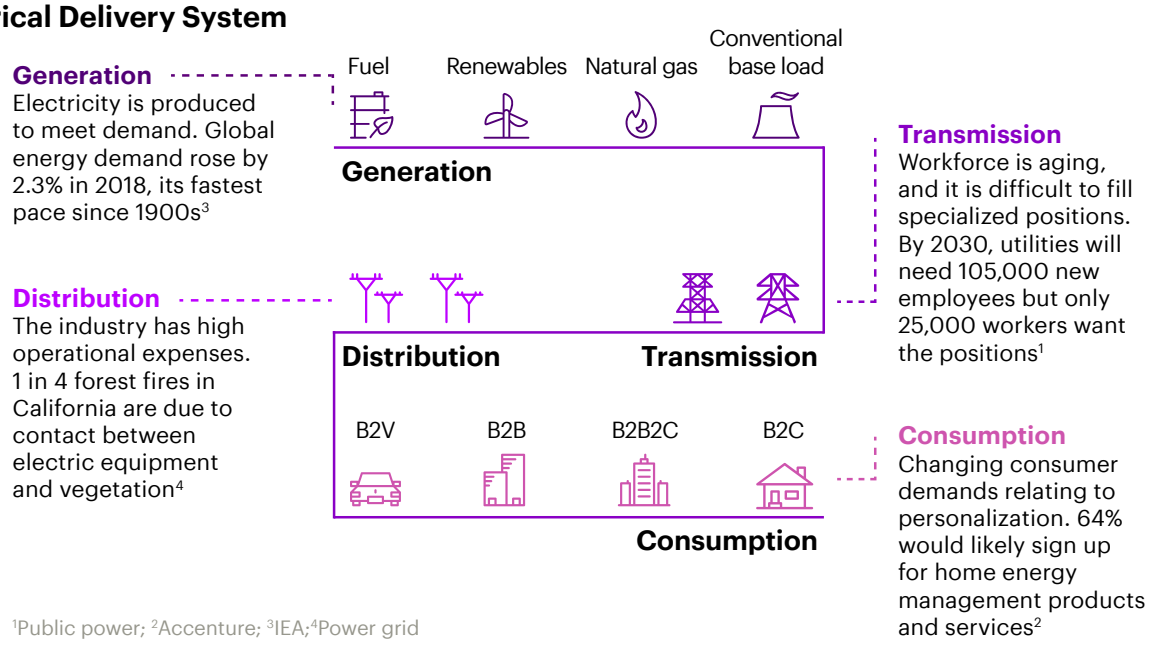
Source: Accenture Analysis

Industry and Technology Context

Approximately 330 million people in the United States depend on reliable utility services such as energy, gas and water. In this paper, we have focused on the energy sub-sector because of the transformation of jobs and infrastructure that can be realized across the four elements of the value chain: generation, transmission, distribution and consumption.

qq Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Electrical Delivery System



[1]Public power; [2]Accenture; [3]IEA;[4]Power grid

Source: Accenture Analysis

The energy utilities industry faces several major challenges, including vegetation and asset management, energy supply and resiliency and an aging workforce, all of which can be positively addressed by 5G.

Vegetation/Asset Management

Operating costs within the energy utilities industry are high,[rr] and vegetation management is the top operating expense at approximately $4 billion to $10 billion in annual spend.[150] It requires a regular crew to manually survey and identify vegetation that needs pruning, trimming and removal. The task is not only expensive but is critically important for public and environmental safety;[151] efficient vegetation management mitigates the risk of forest fires, which can lead to fatalities, property damage and environmental damage.

Similarly, with asset management, utilities have an aging infrastructure[152] that is spread across large geographical areas and requires labor-intensive preventative and corrective maintenance. When equipment fails, the resulting damages can be very expensive. From 2014 to 2017, the three largest utilities in California suffered over 2,000 fires caused by equipment failure.[153] Equipment health is a key aspect of preparing for extreme weather and natural disasters.[154] Utilities thus need a solution to manage the cost of vegetation management and equipment maintenance.

Energy Supply and Resiliency

Electricity demand is poised to increase 0.3% annually[155] until 2050, according to the U.S. Energy Information Administration (EIA). When the electrical supply cannot be balanced to match the demand, the entire system will experience disruptions such as power failures. This is not the only challenge. Electric transmission and distribution reliability is at further risk for disruption from calamities such as fires[156] and unpredictable weather patterns.[157] The industry is further cognizant of the additional demand that will come with the rise in EV adoption, given that the number of electric cars is expected to rise to 18 million by 2030.[158] As demand increases, energy supply resiliency needs to be enhanced through reliable connectivity and digitization.

rr Median Operating Ratio of 0.74 across the value chain.

Next-Generation Workforce

Within the next ten years, the utilities industry is projected to lose 50% of its current workforce, much of which consists of soon-to-be retiring baby boomers. The loss is exacerbated by the inability to attract and train new hires.[159] A utility worker is highly skilled, with training that combines education and extensive on-the-job experience. As a result, the process of becoming a senior line worker can take 10 to 12 years.[160] It is imperative for the industry to maintain productivity while continuing to build skills of the utilities workforce, which may include leveraging new techniques/tools and teaching them to operate and maintain new power-delivery equipment.

COVID-19 Impact

Utilities are essential to businesses and consumers, and the service must be dependable, reliable and consistent. As a result, governments are banning utility shutoffs[161] and are providing financial assistance due to COVID-19.[162] The energy-generation sector specifically relies heavily on an in-person workforce. Therefore, COVID-19 has generated safety concerns due to the risk of contracting the infection while on the job. 5G can provide workers with reliable and secure access to important information from home and the ability to do more traditionally in-field jobs remotely.

How 5G Can Help

Utilities companies sit at a precipice of change, eager to transform operations and provide new value to society. With a connected 5G network, they will have the infrastructure to do so, through:

- **Reliability**: 5G can be leveraged to ensure reliability for customers and support real-time communications for mission-critical situations and sensor-driven efficiency across the grid.
- **Safety**: 5G can drive major improvements in the workforce through safety training via AR/VR tools. Wireless-supported vegetation management improves environmental safety by protecting against forest fires.
- **Affordability**: 5G enables cost optimization by reducing operational costs via real-time monitoring of high-value assets in remote areas.

Economic Impact of 5G

Utilities industry

$36.9 in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	$22.3B	$35.1B	1.6x
Labor Income	$5.7B	$12.5B	2.2x

Jobs and Employment
48K jobs[ss]

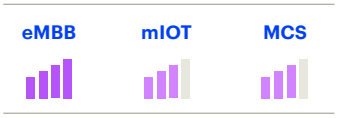
Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.
Source: Accenture Analysis

The utilities industry represents $296 billion in annual U.S. GDP.[163] This contributes to 1.4% of the overall GDP. Accenture estimates that within the utility industry, 5G-enabled technology will grow sales up to 1.5% or $36.9 billion of total sales in economic benefits. This is driven not only by utilities use cases and new services, but also by the impact from other industries.

With 5G emerging across multiple industries, utilities will play a key role in 5G network densification because of their existing assets and power poles throughout the country. This is a significant opportunity for utilities to be part of the CSP ecosystem and set up new business models in partnership with operators. As utility poles can host radios to enable next-generation communications and IoT capabilities, this will open the pathway to future employment offerings across industries, including smart city and automated vehicle use cases.

5G Use Cases and Benefits

The benefits of digitalization across utilities is driven by 5G-enabled solutions that can solve the previous pain points mentioned. To explore these benefits, representative use cases include the intelligent grid, the connected worker and smart power plants.



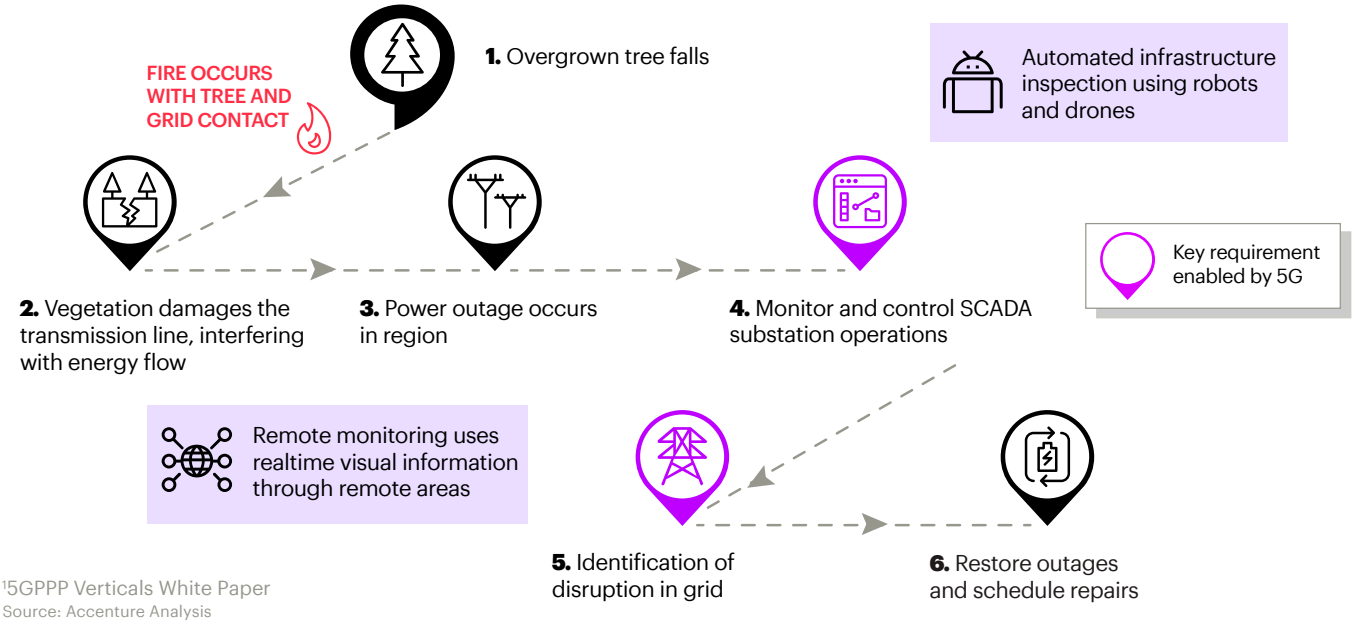
Source: Accenture Analysis

Intelligent Grid

The intelligent grid is the improvement of the power grid across transmission and distribution, which helps mitigate the number of energy disruptions and reduce excessive operational expenses. The intelligent grid consists of three main elements: automated infrastructure inspection, remote monitoring and distributed energy management. These use cases are estimated to contribute up to 28% to 5G-enabled GDP from utilities by supporting the transformation to a reliable, affordable and real-time intelligent grid.

ss Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Intelligent Grid 5G Use Case Journey



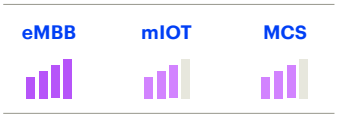
[1]5GPPP Verticals White Paper
Source: Accenture Analysis

Automated infrastructure inspection uses real-time enabled aerial surveying and ground imagery with image analytics and AI to supplement historically manual, time-intensive procedures, improving the safety and reliability of the grid. Lack of visibility of the grid and equipment contact with vegetation are the primary causes of fires. The intelligent grid uses 5G to enable accurate monitoring across the entire grid using sensors/IoT devices.[164] By 2026, utilities globally will spend an estimated $13 billion per year on drones and robotics to monitor the grid and identify problem situations.[165] 5G provides the bandwidth, connection density, speed and low latency required to support these efforts.

Automated infrastructure inspection makes use of multiple technologies. Utilizing LIDAR capabilities in large, remote areas supports automated intelligent analysis within infrastructure planning. Real-time aerial surveys and ground imagery can be used to identify hazardous vegetation, supporting precise forecasting, fault management and accurate monitoring of the grid using sensors and IoT devices.[166] The quality of the video stream, along with processing speed, need to be reliable for the visual intelligence of drones.[167] High operational expenses can be reduced through the improved data capture provided by comparing satellite-powered remote monitoring with drone and aerial imaging.

5G-enabled remote monitoring can help reduce the operational costs of faulty equipment across the entire grid by the use of alarm management and, at times, through the control of equipment (e.g. pylon stability). Smart monitoring is already in broad deployment across the industry, with only 17% of utilities not using the technology to track asset health.[168] Southern California Edison plans to spend $582 million to monitor power lines and install cameras to cover 90% of high-risk areas where assets may spark wildfires.[169] Cameras and sensors (heat, sound and force) can help utilities management make better informed business decisions through real-time response. Pylon stability sensors equip utility workers to predict and reduce the risk of instability and theft. Pylon stability with 5G offers the ability to monitor the grid system over vast, remote areas with a more effective and flexible communications system.[170]

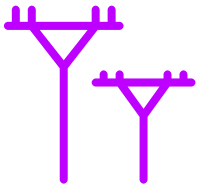
Furthermore, the value of distributed energy resource (DER) management allows for efficient energy control in generation and distribution across increasingly distributed sources of energy, including renewables. A 5G transformation provides the flexibility to detect and respond to fluctuating demand. Using real-time information and advanced analytics in the two-way grid, it supports better response to peak demand to mitigate potential blackouts.[171] This presents an opportunity for utilities to invest in 5G-technologies to create a smarter and more responsive power grid.



Source: Accenture Analysis

Next generation workforce

The next generation worker can perform activities with real-time data visibility and decision making, allowing for greater worker safety and reliability. Utilities are facing an aging workforce, and the number of qualified workers is diminishing. By leveraging digital tools, fleet telematics and safety monitoring, connected worker applications will drive up to 3% of the total 5G-enabled GDP benefit in utilities.

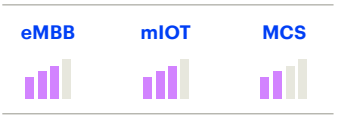


Efficiencies from AR-enabled field services can lead to **20% less equipment downtime** and outages

Digital tools improve worker productivity by presenting information electronically without the delay of historically manual methods. Utility work is essential to the energy industry, but it can be dangerous, making it imperative for workers to constantly be vigilant of their surroundings and to use proper safety protocols. Digital tools provide easy access to real-time insights and data and can provide further assistance for operations through AR/VR, thus creating a safer work environment. AR/VR helps deliver real-time problem solving and remote assistance. The use of AR/VR unlocks further training applications and helps prevent accidents through visual trainings. For example, Schneider Electric is using AR in field service for remote expertise, leading to 20% less equipment downtime and outages.[172]

Another important element of the connected worker model is fleet telematics and safety monitoring. Fleet telematics combines 5G connectivity and input from the IIoT to enable dynamic routing and optimal utilization of vehicles and equipment by collecting fleet data for analysis.

Utility fieldworkers operate in environments with high voltage and other types of hazards. In order to provide better workforce support, increased worker safety is needed. Building a highly skilled workforce and ensuring the safety of those workers are important, as 30% to 50% of workers are concerned about workplace hazards.[173] Safety monitoring with intelligent connected devices can help. For example, Honeywell is currently deploying cloud-based gas detection hardware to help workers safely monitor their environment for gas leaks.[174] With added 5G connectivity, workers can use equipment to deliver real-time awareness, improved productivity and faster response to emergencies when time is of the essence.



Source: Accenture Analysis

Smart Power Plant

The smart power plant[tt] consolidates the control of all sources of electricity generation in one place and helps mitigate the challenge of maintaining energy resiliency while reducing operational costs. 5G technology elevates

tt References energy generation, not including energy consumption and tracking at the consumer level (ie solar panels and batteries).

the smart power plant by enabling digital twin technology and remote monitoring. With benefits of overall increases in efficiency, convenience and improvements in power-plant security, the smart power plant is estimated to contribute up to 8.2% to 5G-enabled GDP in utilities.

A digital twin is a detailed model of a physical asset that is updated with a steady stream of real-world sensor input. Digital twin technology, supported by 5G, can unite both the physical geospatial landscape and operational electric grids in real time, enabling operators, maintenance and planners to visualize data and monitor systems. The result is a virtual clone of the power plant that can be used to check on an asset's current condition, efficiency and activation scenarios. This will result in availability of real-time asset information that can be used for immersive simulation of operating scenarios.

Proactive **5G-enabled real-time remote monitoring** could save utilities operators **10% or more in operating costs**

Real-time remote monitoring captures and communicates critical information essential to the power-generation infrastructure of a utility. Windmill turbines, for example, need regular preventive maintenance due to the harsh operating environment. By using 5G and near real-time monitoring, it is possible to keep the digital twin aligned with corresponding physical assets over large, remote areas. This supports the identification of issues and fixes proactively before dispatching a crew to the remote location that could save operating cost up to 10%.[175]

5G Adoption Challenges and Mitigations

Limited Network Availability and Need for Reliability

Utilities operate in rural and uninhabited areas and may have limited or no wireless connectivity due to poor return on investment for CSPs. In populated areas, their traffic may not be prioritized when the network is congested, especially during emergencies, which is when connectivity is most crucial to troubleshooting and restoring services. Due to these issues, the government should consider providing incentives and encourage collaboration, not only to provide connectivity in the rural and remote areas, but also to prioritize utility traffic during emergencies such as natural disasters.

Cost-Intensive Infrastructure and Devices

5G use cases will require the installation of new technology, sensors and even network connectivity (private networks), all of which are capital intensive. For example, the infrastructure cost for 5G is higher than for previous wireless generations due to the higher RAN density required to provide adequate coverage. Key collaboration with CSPs is important to mitigate this. In 2016, one in two customers already had a non-5G smart meter.[176] Many utility companies could benefit from new 5G-enabled smart meters; however, the investment to replace the millions of meters already deployed would not outweigh the benefits. Supported by government incentives, utilities could form an alliance to align on a common requirement and reference design to ensure interoperability and drive the cost of devices down.

Security of the Grid

Utilities in the United States deliver energy to customers across over 7 million miles of transmission and distribution lines.[177] As the power grid becomes more connected, security is paramount to protect against

cyber-attacks. Any wireless network is open to monitoring over the air, interception and/or tampering. Government incentives should be provided to encourage equipment developers and end users to design security systems with these vulnerabilities in mind, enabling the network to be better secured than legacy systems.[178]

Conclusion

80% of American consumers consider electricity service disruption to be a major pain point in their lives.[179] 5G-enabled use cases like the intelligent grid and the smart power plant will vastly improve power reliability and affordability. This will benefit society with more efficient control over energy management and provide utility companies with substantial operational savings. Future prosperity is attributable to transformation, leading to the reinvention of the worker experience through the connected worker and enabling better worker safety. In addition, the utility industry will be a cornerstone in providing the essential infrastructure and support for 5G connectivity.

Major utilities have provided consistent value for decades, sidestepping the ebbs and flows of technology trends, but for the industry to unlock the next level of benefit for consumers and help fuel 5G growth, they must double down on the 5G opportunity. This, in turn, will drive up to $36.9 billion sales in five years by 2025 and create or transform up to 48,000 jobs. Leading utilities are paving the way for next-generation communications and are enabling new sub-industries such as smart cities and automated vehicles. Utility players can leverage their current strengths and take hold of their future as the demands of the industry are evolving.

06 Acceleration Levers

As previously discussed, the benefits to be derived from 5G are significant and will be felt throughout the U.S. economy. The question is how quickly the effects will be manifested. Significant opportunities exist to maximize those benefits and realize them sooner.

Opportunity #1: IP, Technology and the Ecosystem

Even as network deployment proceeds, there is a distinct lack of mature, 5G-enabled devices available in the ecosystem. Without these devices, companies cannot adopt and reap the benefits of 5G. The scarcity of new devices and technology in the ecosystem can be largely attributed to two factors: (1) the ongoing standards development and (2) the nascent stage of device development across industries.

First, 5G networks and standards are still being rolled out and ratified. Although the pandemic caused some delays, 3GPP ratified 5G Release 16 in July 2020, which was a major step toward improving 5G performance and enabling V2X and IIoT deployments.[180] Concurrently, the 3GPP also warned that Release 17 is at "high risk" of being delayed. According to GSMA, commercial volumes for more standard, commercial releases of simple standardized wireless devices typically lags ratification by 12 to 18 months while development, testing, trials and pre-commercial activities take place.[181] As a result, even for IIoT and V2X applications, which have been highly touted as drivers of value in 5G, specialized and industrial devices will not be seen until mid-to-late 2021 at earliest.

To address this, stakeholders should continue pushing for timely standards ratification and releases, to prevent excessive delay in equipment availability. The ratification process of Release 16 can serve as a benchmark and provide ideas on best practices for Release 17. Stakeholders should also encourage collaboration between regulatory bodies and trade and research associations to give a voice to all groups and ensure full coverage of the advancements and capabilities of 5G. In addition, the establishment of standards should balance utilizing the full spectrum of international expertise with national security to ensure seamless connectivity globally.

Next, vendors have not made enough progress in R&D to put out industrial products that are fully ready for migration to 5G. As with any revolutionary technology, developing the wireless technology and the devices associated with 5G requires heavy upfront R&D investment. For example, the semiconductor industry has invested more in R&D since the 1990s than all other major industrial segments individually,[182] with major companies such as TSMC, Intel and Qualcomm leading the way for cutting edge, technological innovation.[183] Device makers must be able to continue pursuing R&D to expedite commercial viability of new device types and pave the way for a smooth transition to 5G. Yet, incentives for device makers should not come at the expenses of those that have already invested in the developed of the foundational technology. Companies that have developed the 5G standard have taken on substantial risk to enable an ecosystem that took years to come to fruition and must therefore be encouraged with a supportive regulatory framework. In other words, the need to encourage investments in 5G-enabled devices must be balanced with the need to protect inventors who have made 5G possible.

Ultimately, government and regulatory bodies should balance innovation stimulation with IP protections to ensure that the reinvestment cycle continues. There is an opportunity to lay the groundwork for and accelerate 5G adoption by promoting innovation and R&D through public investment. This can be implemented in a variety of ways, including a combination of more guided policy with financial incentives like subsidies, direct investments and tax credits. Furthermore, policymakers can maintain a level playing field through IP protection; this will encourage competition, leading to a proliferation of commercially viable devices within the ecosystem that can access and harness 5G's full array of benefits.

Opportunity #2: Resilient Wireless Technology Supply Chain

Benefits to the economy from 5G use cases depend on uninterrupted delivery of the entire value chain, from R&D to manufacturing, as well as development of semiconductors, devices and network and industrial solutions. Breakdown of any component will slow down or, worse, disrupt the economic benefits.

Disruption is most significant up the value chain: the development, manufacturing and delivery of chips, wireless devices and equipment. The chips are the 'brains' that provide the intelligence for modern electronics. The wireless devices and network equipment use them to transfer information for processing and necessary action—for example, a connected utility worker fixing a malfunctioned furnace in a plant requiring precise instructions. To de-risk the development and delivery of 5G technology, it is imperative to ensure the supply chain resiliency of chips, devices and equipment.

The development of policies to support reliable semiconductor, wireless device and network equipment innovation and design, and a reliable global supply chain will power critical manufacturing, healthcare, automotive and other use case solutions by trusted sources and reliable producers.

Opportunity #3: Network Deployment and Build Out

Compared to previous generations of wireless technology, 5G deployment is very complex. Especially in the higher-frequency spectrum bands, 5G networks may require 10 to 100 times as many antennas as 4G networks, due to the shorter propagation range of higher bands and also limited ability of these frequencies to penetrate structures. Previous Accenture analysis estimated the cost of this infrastructure to be a significant portion of overall capital spend, at $275 billion for U.S. carriers.[184]

In addition to the volume of small cells required, municipal approvals and permitting often add months to the network deployment timeline per location, delaying network availability while causing networks to develop disproportionately within specific regions, depending on the level of government involvement. Recent changes have set shorter 'shot clocks' for approval and limited fees, but the overall process remains a significant driver of deployment timelines.[185] Streamlining elements of the approval process at the state or federal level, rather than the municipal level, is an opportunity to accelerate 5G access and associated economic benefits.

Another element constraining timeline is skilled workforce availability. The tower industry is projected to need as many as 20,000 additional tower technicians over 10 years, nearly doubling the current workers.[186] Current funding, training and apprenticeship opportunities are limited and restrict the speed at which

the country can bridge this gap; expansion of existing grants and alleviating these barriers are significant opportunities.

The benefits of 5G will not be felt equally across the country. While studies have shown 5G fixed wireless can provide a cost-effective way to improve rural connectivity (up to 40% savings vs traditional FTTP deployment),[187] today, only 65% of rural Americans (30 million) have fixed broadband access, compared to 97% in the urban centers.[188] Past studies have shown a strong relationship between connectivity and economic growth: a 10% increase in broadband penetration is expected to drive a 0.9% to 1.5% incremental GDP increase. Applying a purely valuation-based perspective, operators are not always incentivized to bridge this gap in the areas most critically affected. Because of this, a national 5G strategy with funding and incentives could both help bridge this digital divide and pay dividends throughout the economy.

Opportunity #4: End User Return on Investment

Although 5G is expected to drive appreciable benefits throughout the economy, the required levels of investment remain prohibitive relative to the ROI for many industry use cases. For a number of industries, the changes to infrastructure, supply chain, workforce, user device migration and education are costly.

In order to realize the benefits of 5G, businesses require significant capital outlay, not only for network connectivity infrastructure, but also for the devices, software and new processes and operating models. In many industries, this issue is compounded because of long asset lifetimes, where replacement cycles are spread over a decade or two. These investment cliffs represent tangible barriers for 5G deployment and will stymy the level of economic impact throughout the economy. Cost barriers also represent clear opportunities to accelerate impact through new financing/incentive initiatives.

In manufacturing, for example, investments in key 5G use cases are being held up because of concerns around ROI relative to capital expenditure, compounded by long depreciation schedules of existing assets and cultural adoption barriers. Enabling a single use case requires new equipment, as well as integration with a complex network of legacy hardware and software to drive value for the enterprise, a costly endeavor.

Industries are going to lag in their own investment unless the returns from 5G use cases are above the hurdle rate and competitive investments for their industry. This, unfortunately, creates a disconnect relative to the positive externalities and economic impact driven by 5G and represents a clear lever for driving benefit throughout the broader economy, with the support of external incentives.

Opportunity #5: Spectrum Availability

Enabling a wide variety of new use cases will require a range of different spectrum bands and supporting network equipment as well as deployment types; while some industry applications will require localized high bandwidth. These requirements are achieved by using a combination of mid and high bands (i.e. mmWave).

The mid-band spectrum from 1 GHz to 6 GHz is highly desirable spectrum, as it provides a good balance between reliable coverage and enough data capacity. Therefore, we expect a significant number of 5G use cases will be leveraging this band. Around the world, national authorities are maximizing the availability of mid-band spectrum by ensuring that it is made available for the appropriate verticals. In some cases, this may require incentives for incumbent users to migrate away from mid-band use in order to make the spectrum available for 5G services.[189]

Given the high demand for mid-band spectrum, there is lot of focus over how regulators will manage the reallocation of the mid-band spectrum. US has made good recent progress on this front with the auction of CBRS (Citizens Broadband Radio Service, 3.5 GHz) and C-Band spectrum (3.7 to 3.98 GHz). The telecommunications industry continues to identify the need for additional mid-band spectrum.[190] It is important for the FCC to continue freeing up more mid-band so that the United States can continue to drive 5G innovation.

Opportunity #6: Balancing Regulation

About 70% of value generated through digitalization in the next ten years will be based on platform-enabled, ecosystem-based business models. 5G will play an essential role in this development. Governmental agencies should collaborate with stakeholders across industries, civil agencies and enterprises to ensure that 5G's full potential value is attained.[191] This collaboration is key for the successful realization of 5G economic and consumer benefits.

Inherently, 5G is a secure network. However, when the network is combined with a broader ecosystem of IT infrastructure and connected devices, security needs may change. Regulatory agencies and policy makers must examine new security measures holistically and partner with businesses to balance security best practices without hindering growth and deployment.

Major regulatory and policy concerns can be broken down into two key areas:

- Security and privacy (i.e. cyber security and consumer data privacy)
- Industry-specific regulations

The key will be to streamline 5G deployment effectively and transparently to ensure economic prosperity and consumer benefits. Keeping an eye toward the future, regulatory agencies must manage risk and understand the costs of additional regulations to ensure that they do not hinder deployment. To do so, policymakers need to aid in facilitating conversations that highlight the benefits of 5G-enabled technology while alleviating concerns about the risks.

Security Requirements

The 5G standard builds upon previous wireless generations to result in a more secure, flexible network built around best practices, including heightened encryption and end-to-end authentication. The risk that needs to be addressed is the increase in overall volume and types of connections, data and applications.[192] Safeguarding the new applications that will leverage a secure 5G network is key. Identifying

and addressing new vulnerabilities exposed by the connected 5G ecosystem without slowing down deployment due to security measures is an important balance to strike.

Device and equipment manufacturers are already building in higher reliability and security than current regulations require. It is fair to assume that new use cases will deploy security best practices at an early stage. Businesses are also aligned with adapting to new security standards as needed with 5G deployment. From an enterprise view, the technology framework is already in place for an ultra-secure build out.[193] Governments must work with them in a thoughtful manner to ensure that data security, collection and storage concerns are addressed to balance policy and messaging with business goals and consumer needs.

5G also strengthens specific security measures for consumers, such as offering improved subscriber identity protection, among other benefits.[194] But consumers are still worried about how their data will be leveraged. For consumers to trust and benefit from the value that 5G enables, they must be given agency over their data to decide how and when it is used. Businesses understand this. For example, Google is giving customers the option to manage data on a constant basis.[195] As businesses tread this fine line between delivering on consumer expectations and ensuring regulatory compliance, government officials must address and dispel these consumer fears and propel development.

Industry Regulations

Heavily regulated industries such as healthcare and automotive also face headwinds due to stricter policy and regulatory guidelines established to meet consumer safety needs. For example, FDA medical device approval can cost thousands of dollars, and U.S. regulations on device development add typically about 6 to 12 months for clinical studies and institutional review board approval at the clinical site.[196] Additional HIPAA security compliance for any transmission of health information in electronic form impacts all digital decisions a hospital makes.[197]
Government agencies and businesses must understand what a 5G ecosystem will enable from the beginning and address their plans for handling vulnerabilities. Strategic collaboration with key policymakers and stakeholders will be essential to ensure progress is not inhibited. Aligning early on with other governing bodies from certain industries regarding 5G expectations facilitates quicker deployment and adoption.

The regulatory challenges outlined above are an identified selection based on current understanding of 5G. As with any transformational digital technology, there will be the need for significant engagement among partners to realize the full value that can be unlocked.

07 Conclusion

5G offers tremendous potential and will undoubtedly transform industry landscapes and consumer life. This will drive a substantial impact throughout the U.S. economy, fueling up to $2.7 trillion in gross economic output (sales), creating or transforming up to 16 million jobs[uu] and adding up to $1.5 trillion to U.S. GDP between 2021 to 2025, with lasting benefits for years to come.

Critically, as the United States looks forward to a long period of recovery in the wake of COVID-19, 5G has the potential to power a new wave of growth, creating new industries and jobs and setting up American businesses, workers and consumers to thrive in the new normal. For enterprises, the IoT, AI and edge/cloud benefits we've anticipated for years can finally come to fruition. For workers and consumers, 5G will unlock the fullest potential of remote and digitally enabled work, add new scalability to the services we use every day and drive significant consumer value. This will touch every element of American life, from our relationship with cars and transportation, to healthcare quality and access. These benefits to the end consumer are substantial and represent an excess consumer surplus benefit on top of the macroeconomic figures we've described above.

Today, the United States is able to maximize this potential, if the right actions are taken. By making 5G a national priority and taking advantage of the levers available, America can capitalize on the tangible acceleration opportunities. This will allow the sizeable benefits of 5G to be realized faster and maximized, improving the lives of every American and injecting new life into the economy at this critical juncture.

uu Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

08 Appendix

Economic Model Methodology

In the fall of 2020, Accenture conducted a comprehensive study on 5G's expected impact on key macroeconomic outcomes for the United States. To arrive at our answer, we asked two key questions:

1. How did the increase in mobile penetrations affect economic outcomes for past connectivity technologies?
2. How is 5G's impact going to **differ** compared to past connectivity technologies?

To quantify the impact of 5G technology across the economy, we looked at the historical penetration of past connectivity technologies and their relationship with the increase in industry output over time. Data on mobile penetration of previous connectivity technologies such as 2G, 3G and 4G, along with projected 5G penetration was obtained from Global Systems for Mobile Communications (GSMA). Data on historical and projected gross output by industry for all 16 industries was obtained from Oxford Economics for all relevant geographies including US and all countries in European Union and United Kingdom. Additional endogenous determinants of output growth such as consumption, government expenditure and trade were also obtained from Oxford Economics. The projected metrics from Oxford Economics account for the baseline COVID-19 scenario.

We use the Arellano-Bover/Blundell-Bond dynamic panel data estimator to estimate the relationship between gross output/sales and increased mobile penetration. Using this estimated relationship, we project out the impact on sales from increased 5G penetration based on projected GSMA and Oxford Economics data on 5G penetration and gross output. This projection gives us a baseline increase in sales.
5G differentiates itself from past connectivity technologies and unlocks industry value that would not have been possible with past generations (including 4G). To account for this differentiated impact, we, in consultation with internal and external industry subject matter advisors, evaluated the potential outsized benefit of 5G compared to 4G for each industry on: creation of new industries, productivity gains, cost optimization, service improvements, time to impact. We then adjusted our baseline results to account for the differential impact of 5G. Based on the relationship in the national input-output tables, we then estimate the resulting GDP, jobs and earnings impact from the increase in sales for each industry, country, or state.

In order to arrive at value-chain impact, we leverage inter-industry relationships inherent in the national input-output tables to estimate the indirect and induced effects of mobile penetration for key industries.

In interpreting our value-chain results from the input-output analysis, we need to bear in mind some standard assumptions of this type of analysis:

1. **Fixed purchase patterns**: assumes that industries do not change the mix of inputs used in their production process.
2. **Industry homogeneity**: assumes that businesses within an industry use the same production process.
3. **No supply constraints**: assumes that there are enough inputs in the economy to meet the increase in demand by the industry and that supply shortages or price changes of inputs do not occur.

Industry Definitions

NAICS Codes	Industry
72	Accomodation and food services
11	Agriculture, forestry, fishing and hunting
71	Arts, entertainment and recreation
48, 49*	Auto and transport
55, 56	Business and professional services
23	Construction
61	Education
52	Finance and insurance
62	Healthcare
51	Information/communication
31, 32, 33*	Manufacturing
21	Mining, quarrying, oil and gas
92	Public admin, defense and social
53	Real estate and rental/leasing
42, 44, 45*	Retail
22	Utilities

* Automotive manufacturing and retail have been included as part of "Auto and transport"; all other manufacturing remains in "Manufacturing".

Consumer Survey Methodology

In September 2020, Accenture surveyed a nationally representative sample of 1,000 Americans between the ages of 18 and 64 via an online survey conducted by a leading global research firm.

Direct, Indirect, and Induced Economic Effects

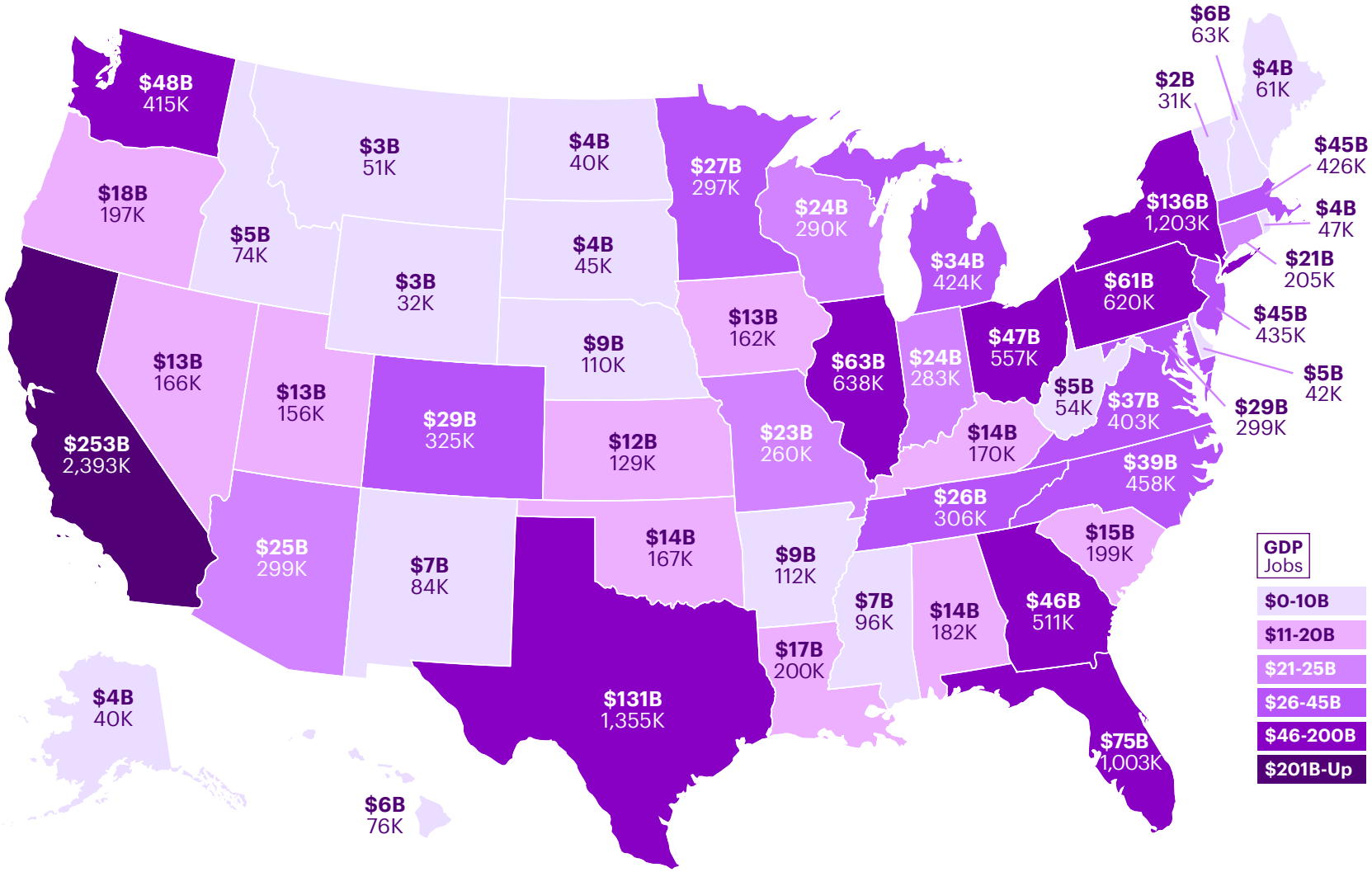
Effects on GDP

Figures in $B of USD	Direct Industry Impact on GDP	Indirect Impact on GDP	Induced Impact on GDP	Total Value Chain Impact on GDP
Accommodation and Food Services	$42.3	$21.2	$24.1	$87.7
Agriculture, Forestry, Fishing, and Hunting	$17.5	$8.7	$10.2	$36.4
Arts, Entertainment, and Recreation	$51.8	$15.0	$26.0	$92.8
Auto and Transportation	$113.2	$47.6	$69.3	$230.1
Business and Professional Services	$186.9	$46.2	$106.8	$339.9
Construction	$54.9	$27.2	$41.8	$124.0
Education	$14.1	$3.9	$7.5	$25.5
Finance and Insurance	$139.7	$27.6	$55.1	$222.4
Healthcare	$120.1	$45.0	$77.0	$242.2
Information / Communication	$251.2	$85.7	$102.1	$439.0
Manufacturing	$159.2	$71.4	$83.8	$314.4
Mining, Quarrying, and Oil and Gas	$21.6	$6.1	$9.5	$37.1
Public Admin, Defense and Social	$88.4	$40.1	$55.9	$184.4
Real Estate, Rental, and Leasing	$189.7	$40.1	$44.4	$274.2
Retail	$54.6	$18.8	$26.7	$100.2
Utilities	$22.3	$6.3	$6.5	$35.1

Effects on Labor Income

Figures in $B of USD	Direct Industry Impact on Income	Indirect Impact on Income	Induced Impact on Income	Total Value Chain Impact on Income
Accommodation and Food Services	$23.6	$10.7	$12.3	$46.6
Agriculture, Forestry, Fishing, and Hunting	$11.2	$4.0	$5.3	$20.5
Arts, Entertainment, and Recreation	$29.5	$7.3	$13.2	$50.0
Auto and Transportation	$72.3	$25.6	$35.5	$133.4
Business and Professional Services	$127.9	$22.9	$54.1	$204.9
Construction	$44.6	$14.1	$21.4	$80.1
Education	$9.1	$1.6	$3.8	$14.5
Finance and Insurance	$64.3	$14.6	$27.7	$106.7
Healthcare	$87.4	$22.6	$39.2	$149.1
Information / Communication	$96.8	$48.0	$51.6	$196.4
Manufacturing	$81.6	$36.7	$43.1	$161.4
Mining, Quarrying, and Oil and Gas	$8.8	$3.4	$4.9	$17.2
Public Admin, Defense and Social.	$59.4	$20.8	$28.4	$108.6
Real Estate, Rental, and Leasing	$40.7	$22.3	$22.6	$85.6
Retail	$28.2	$9.4	$13.7	$51.3
Utilities	$5.7	$3.5	$3.3	$12.5

5G Impact on GDP and Jobs by State[vv]



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