# Deloitte.
# Insights

# Technology, Media, and Telecommunications Predictions 2019

Middle East edition

# Contents

# Foreword

Dear reader,

Welcome to Deloitte Global's *Technology, Media, and Telecommunications Predictions* for 2019. The theme this year is one of continuity—as evolution rather than stasis.

*Predictions* has been published since 2001. Back in 2009 and 2010, we wrote about the launch of exciting new fourth-generation wireless networks called 4G (aka LTE). A decade later, we're now making predictions about 5G networks that will be launching this year. Not surprisingly, our forecast for the first year of 5G is that it will look a lot like the first year of 4G in terms of units, revenues, and rollout. But while the forecast may look familiar, the high data speeds and low latency 5G provides could spur the evolution of mobility, health care, manufacturing, and nearly every industry that relies on connectivity.

In previous reports, we also wrote about 3D printing (aka additive manufacturing). Our tone was positive but cautious, since 3D printing was growing but also a bit overhyped. But time has passed. Reality has caught up to—or in some ways even surpassed—the earlier enthusiasm, and we now have new and impressive forecasts for that industry. We also wrote about eSports, which has evolved from a cult phenomenon to simply "phenomenon," with big implications for media companies and advertisers.

In each of the last two *Predictions* reports, we discussed the truly exponential growth in machine learning, largely focusing on the chips that provided the processing foundation for that growth. We believe that machine learning will be the biggest and fastest-growing trend in technology again in 2019. We look at how machine learning is evolving rapidly from the domain of experts to a powerful technology any company can harness through the cloud. We also examine how China is growing its domestic chip industry, in part by leading with the artificial intelligence chip business.

We've had a prediction around TV, which is always worth writing about, every year for the last decade. In 2019, we focus on TV sports, young viewers, and TV sports watching's surprising (and hitherto largely undocumented) connection with sports betting. To prove that even old (media) dogs can learn new tricks, we also write about traditional radio and its resilience ... even as it celebrates its 99th birthday this year! The first-ever commercial radio broadcast was November 2, 1920.

Of course, our report features new themes that will surely evolve. Smart speakers have rocketed onto the scene as one of the fastest-adopted new devices in history; where will they go from here? Finally, we look at the world of quantum computers, a technology so new that it is still damp behind its superposed and entangled ears. When will quantum computing be big, and how big will it be? Read to the last page to find out!

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From a regional perspective, 2019 is set to be again a great year for the Technology, media and Tele-communications industry in the Middle East. We have seen renewed commitments across all regional telcos to be amongst the first to roll-out 5G commercially in some segments of the market. Regional companies (e.g. in Energy and Resources) have been amongst the first in the world to sign a pledge to Quantum Computing despite the very long development cycles. Governments across the GCC have included Artificial Intelligence as a cornerstone of their national transformation agenda. Finally after years of subdued growth we see some exciting movements in the media market with some of the global predictions themes around TV rights and esports resonating particularly well in the Middle East.

While there is continuity, the changes—often rapid changes—we track in this year's report are new, important, and usually counter-consensus. TMT companies should understand and account for them as *they* evolve. We think they will matter to our readers in other industries as well, and they are important in all markets globally.

**Paul Sallomi**
Global Technology,
Media & Telecommunications
industry leader

**Mark Casey**
Global Telecommunications,
Media & Entertainment
sector leader

**Craig Wigginton**
Global Telecommunications
leader

**Paul Lee**
Head of global
TMT research

**Jeff Loucks**
US TMT Center
executive director

**Duncan Stewart**
Canada TMT research director

**Emmanuel Durou**
Middle East Technology,
Media, Telecommunica-
tions industry leader

**Chris Arkenberg**
US TMT Center
research manager

# 5G

## The new network arrives

Duncan Stewart and Paul Lee

ELOITTE GLOBAL PREDICTS that 2019 will be the year in which fifth-generation (5G) wide-area wireless networks arrive in scale. There were 72 operators testing 5G in 2018,[1] and by the end of 2019 **we expect 25 operators to have launched 5G service** in at least part of their territory (usually cities) with **another 26 operators to launch in 2020**, more than doubling the total. Further, we expect about **20 handset vendors to launch 5G-ready handsets in 2019** (with the first available in Q2), and about **1 million 5G handsets** (out of a projected 1.5 billion smartphone handsets sold in 2019) to be shipped by year's end. **One million 5G modems (also known as**

**pucks or hotspots) will be sold**, and **around a million 5G fixed wireless access devices will be installed**.

At the end of 2020, we expect 5G handset sales (15–20 million units) to represent approximately 1 percent of all smartphone sales, with sales taking off in 2021, the first year in which retailers will sell more than 100 million 5G handsets. The most noticeable benefits of these first 5G networks for users will be faster speeds than today's 4G technology: peak speeds of gigabits per second (Gbps), and sustainable speeds estimated to be in the hundreds of megabits per second (Mbps).

## The three main uses of 5G—in the short term

In 2019 and 2020, 5G wireless technology will have three major applications. First, 5G will be used for truly mobile connectivity, mainly by devices such as smartphones. Second, 5G will be used to connect "less mobile" devices, mainly 5G modems or hotspots: dedicated wireless access devices, small enough to be mobile, that will connect to the 5G network and then connect to other devices over Wi-Fi technology. Finally, there will be 5G fixed-wireless access (FWA) devices, with antennas permanently mounted on buildings or in windows, providing a home or business with broadband in place of a wired connection.

All of these 5G devices will operate over traditional and new cellular radio frequency bands in the low- (sub-1 GHz, such as 700 MHz), mid- (1–6 GHz, such as around 3.5-3.8 GHz), and millimeter-wave (mmWave, such as 28 GHz) ranges. While smartphones, modems, and hotspots will mostly use low- and mid-range frequencies, 5G FWA devices will often operate using mmWave technology,[2] which offers the potential for higher bandwidth than sub-6 GHz frequencies. Because mmWave frequencies struggle to penetrate walls or pass through certain types of glass, many 5G FWA devices will require mounting antennas on windows or a building's exterior wall.

**5G smartphones.** Making a 5G-ready handset is more complicated than one might think due to differences in two critical components of a 5G versus a 4G phone: the radio modem and the antenna. The modem in a smartphone usually sits on the same chip as the processor. A bundled 4G chip for a high-end phone cost an estimated US$70 in 2018;[3] the 5G version will almost certainly cost more. A leading modem/processor manufacturer has announced that its 5G chipset will be ready in 2019,[4] although supply constraints suggest that wide availability will not occur until the second half of the year.[5]

The bigger challenge is designing an antenna for 5G. Since the new radio technology will launch both at frequencies around 28 GHz (which require narrow-beam, high-gain antenna systems made up of multiple combined radiators) and at frequencies below 6 GHz (for which single-element, low-gain, omnidirectional antennas can be used), the design of a 5G antenna is much more complicated than that for a 4G antenna.[6] The antennas and front end of a leading-edge 4G smartphone typically cost around US$20 in 2018, and 5G solutions, expected to be available in 2019, will almost certainly carry a higher price—possibly much higher.

Putting these factors together, a 5G-ready phone's component costs in 2019 will likely be US$40–50 higher than for a comparable 4G phone—for a phone with relatively few networks worldwide to connect to, and likely with only narrow coverage even where available. There's one good piece of news, however: Battery life will likely be a smaller issue than it was when 4G was launched. Chipmakers have said that they expect battery life for the first 5G phones to be more or less in line with that of current 4G handsets.[7]

**5G modems/hotspots.** The first 4G network was activated in December 2009. From 2010 through 2012, retailers sold tens of millions of 4G modems/hotspots, generating hundreds of millions of dollars of revenue for both the device makers and the operators charging wireless subscription fees.[8] These small devices, about the size of a hockey puck, sold for US$200–300 each at first but rapidly dropped to under US$100.[9] They were portable, and

people used them to connect phones, computers, tablets, and other devices to the internet. But their sales began to decline as more and more 4G handsets entered the market, particularly as users were able to use later-model smartphones as 4G hotspots to wirelessly tether other devices to their phones instead of needing standalone modems.

We expect the 5G equivalent of the 4G modem/hotspot to be approximately as successful, bridging the gap between when 5G networks are turned on and when 5G handsets become widely available and affordable for casual users. The two largest American carriers have already publicly discussed selling modems before mobile handsets,[10] and one major chip manufacturer's new 5G chipset is so large that it is unlikely to fit in a smartphone but can easily be used for modems.[11] Since modems consist of just a radio, antennas, and a battery, they cost much less than smartphones, with no need for a screen (usually a phone's most expensive component), camera, or sleek body. Thus, although handsets will rapidly overtake them in the first year or two following launch, modems will likely be an important part of the nascent 5G market. It should be noted that although the signal to the modem will be on 5G, the signal from the puck to the devices it connects (smartphone, PC, etc.) will be over Wi-Fi or other local-area wireless technology, which means that speeds could be degraded depending on the technology.

## Where fiber-to-the-home or other high-speed internet service is ubiquitous and affordable, FWA does not always deliver a particular advantage.

**5G FWA devices.** As discussed above, a small antenna about the size of a hardcover book can be placed on the inside or outside of a home or business window that has an unobstructed line of sight to a 5G mmWave transmitter not more than about 200–500 meters away. (That mmWave transmitter will usually be located on a commonplace utility pole, not an expensive special-purpose tower, and will likely use multiple bands, both mmWave and sub-6GHz.) If that transmitter is connected to a high-speed fiber network, the subscriber will enjoy speeds of hundreds of Mbps, with possible peaks of gigabits per second. The antenna will connect or be attached to a modem/router that distributes the high-speed signal inside the home or business over Wi-Fi, connecting smartphones that otherwise would not achieve 5G speeds, as well as computers, tablets, smart TVs, and other connected devices.

Some American carriers have already begun their 5G launch on a limited basis in a few cities using both mmWave and traditional frequencies.[12] There have also been many non-US trials of 5G FWA devices using mmWave; however, at this time, the only firm outside the United States that is definitely planning a 2019 launch is an Australian operator.[13]

Note that the markets for *both* 5G modems/hotspots and 5G FWA devices are about providing wireless connectivity as an alternative to traditional home broadband, rather than providing an alternative to 4G for mobility. In the long term, the 5G mobile market (for handsets, Internet of Things devices, and connected vehicles) will likely be measured in terms of billions of connections, but in 2019, most 5G customers will likely use 5G as an alternative to wireline, not as a replacement for 4G. Used in this way, the applicability of 5G FWA over mmWave varies considerably by country. In places where fiber-to-the-home or other high-speed internet service is ubiquitous and affordable, FWA does not always deliver a particular advantage (although there may be some situations in which 5G FWA offers higher speeds and/or capacities than some fiber solutions). It is in places where wireline is less widely available and/or more expensive, or where wireless capacity in the traditional cellular radio bands is already congested, that mmWave solutions will likely be more useful.

Indeed, many internet users worldwide already rely on cellular wireless data for 100 percent of their home data needs. According to a 2017 Deloitte survey, that percentage is very low in some countries (such as the United Kingdom, at 5 percent). But in other countries (such as the United States, Canada, and Turkey), nearly one-fifth or even more of the internet-using population relies on cellular radio waves instead of wires (figure 1).[14] It is worth noting that there can be a form of digital divide between wired and wireless-only users, with those resorting to the latter option sometimes experiencing lower speeds and/or capacity. The two user groups are also demographically different: Wireless-only consumers in each of the countries studied differ in age, income, education, and other factors.[15]

When it comes to reaching the broadest possible customer base in a country where both wireless and wired connections make sense in different geographies, 5G wireless (at both sub-6 GHz and mmWave frequencies) can be useful when combined with a wireline fiber strategy. In Canada, two of the country's three major operators have announced such a hybrid strategy, using FTTP for homes where fiber density is high enough, and 5G to cover the rest. One carrier plans to enable 9 million of its 12 million subscriptions with FTTP and sees an "immediate opportunity" to reach another 0.8–1 million using 5G wireless technology.[16]

## Wireless adoption through the generations: It always looks like this

To some, our predictions for 5G adoption might seem unusually conservative or pessimistic. But we see no reason to doubt that the first years of 5G will look almost exactly like the first years of 4G

FIGURE 1

## Some countries rely relatively heavily on wireless-only connections

Percentage of data mobile-only homes in 2017, selected countries



Canada 24% | United States 19% | Spain 15% | United Kingdom 5% | France 9% | Turkey 27% | Russia 16%
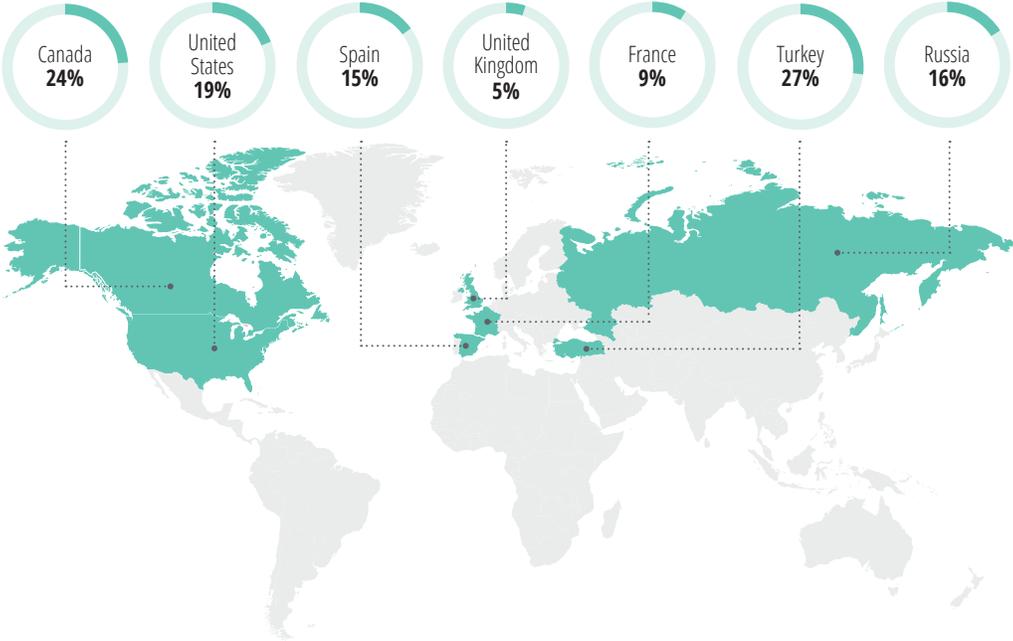
Source: Deloitte Global survey of adults in seven countries: 1,096 in the United States, 1,090 in Canada, 1,061 in Turkey, 1,118 in the United Kingdom, 1,097 in France, 1,082 in Spain, and 1,097 in Russia. Survey conducted August–October 2017.

(2009–10). At that, 5G usage will spread faster than 3G, which launched in 1998 and took time to gain widespread acceptance.[17]

4G launched in late 2009 and early 2010 with only a handful of operators offering services within a limited territory.[18] Although more and more 4G networks have deployed in the decade since then, it will take until 2019 for 4G to become the single-most used wireless technology worldwide, and according to the GSMA, 4G usage will not surpass 50 percent of all subscribers globally until 2023—14 years after launch.[19] This means that 5G will likely still be a relatively niche technology even in 2025, with its forecast 1.2 billion connections making up only 14 percent of the total number of mobile non-IoT connections worldwide (figure 2). Considerable variance will be seen across countries: 49 percent of all American subscribers are expected to be 5G in that year, 45 percent in Japan, 31 percent in Europe, and 25 percent in China, but only single-digit percentages in Latin America, Middle East, and Africa.[20] Ten years from now, providers will still be rolling out 5G.

## The need for speed: Ideal vs. real-world conditions

New wireless technologies always offer faster speeds, but *speed* can mean at least three different things: speeds achieved in the lab or in limited trials, peak speeds achieved in the real world under ideal conditions, and the speeds that real users in the real world achieve on average. Although 5G is still in its early days, there is some data indicating what each measure is likely to be.

The fastest-ever 5G lab transmission has been 1 terabit per second,[21] and the record for a field trial currently stands at 35 Gbps.[22] Neither is a good indicator of real-world speeds in the short term, although longer-term projections are that 20 Gbps may be an achievable real-world peak speed.

5G under real-world conditions will likely be slower than 35 Gbps but still markedly faster than 4G networks—and also faster than some fiber and cable solutions. In general, peak speeds of more than 1 Gbps are likely, although that would only be for someone ideally situated, very close to the

FIGURE 2

## Only one in seven mobile connections will be 5G by 2025

Global mobile adoption by technology, share of mobile connections, excluding cellular IoT
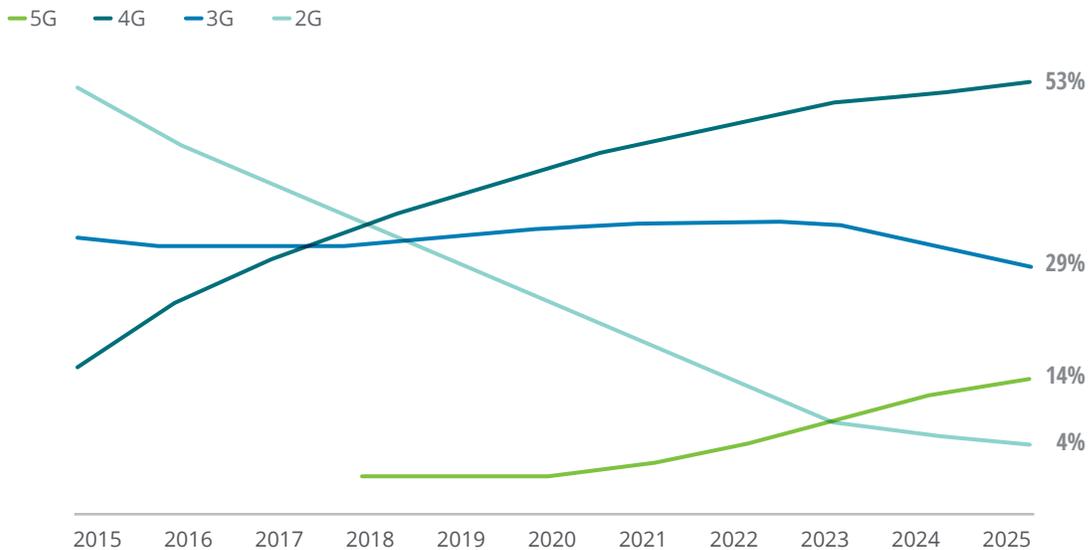


Source: GSMA, *The mobile economy*, 2018.

transmitter, and using the network when it was not busy. Nonetheless, according to simulations, median data speeds would surge with the upgrade to 5G, based on the cell-site locations and spectrum allocations of two current networks. One simulation based on a Frankfurt-based network estimated a ninefold increase in median speed, from 56 Mbps to 490 Mbps.[23] Another test based on a San Francisco network calculated a 20-fold increase, from 71 Mbps for a median 4G user to 1.4 Gbps for a median 5G user if using mmWave coverage.[24] As with real estate, achieved 5G speeds will come down to location, location, and location!

Speed is not the only benefit of 5G networks, of course. Another additional potential benefit is lower latency: the time it takes to send a message from a device to the network and get the answer back. 4G networks average latencies of around 60 milliseconds (ms),[25] although there can be considerable variation, and 4G latencies could theoretically be lower than that. But 5G networks will have, in time, a latency of less than 1 ms.[26] Even in 2019, 5G will have lower latency than that of the average 4G network—and although 5G's average latency may not be much lower than that of 4G, the worst-case

latency will likely be much better. In 5G field trials, real-world latency has been "as low as 9 ms,"[27] although it is unclear what the average latency will be on the commercial networks that expect to launch in 2019; 20–30 ms seems like a plausible figure.

## Additional potential benefit is lower latency: the time it takes to send a message from a device to the network and get the answer back.

For the average consumer or enterprise user, and for most current real-world applications, there is little practical difference between one-tenth of a second and one-fiftieth of a second (100 ms and 20 ms, respectively). Over time, however, ultralow latency may matter a great deal for IoT-enabled applications,[28] autonomous vehicles,[29] and performing remote surgery with haptic feedback,[30] even though these applications are more likely to materialize in 2021 and beyond rather than in the next two years, and will require both ultralow latency and ultrareliable networks with guaranteed reliability.

# BOTTOM LINE

So far, this chapter has largely focused on the aspects of 5G that are likely of most interest to 5G network users (whether enterprise or consumer). Here, we focus more on the concerns that are likely more relevant for network operators.

The predictions at the top of this chapter relate to only true 5G networks and devices, excluding those operators who will almost certainly market the very latest 4G LTE (long-term evolution) technology, often referred to as 4.5G, as 5G.[31] To users, the distinction may not matter at first: Both 4.5G and 5G networks offer very high speeds of hundreds of megabits per second, or even gigabits per second. However, there is an important difference for the operator—namely, cost. If operators can deliver 500 Mbps wireless service over 4.5G, why should they bother to spend tens of billions of dollars on capital expenditures (capex) for equipment and radio spectrum to enable 5G globally?

There actually is a nonflippant answer to this question, and it has to do with 5G's greater capacity. Through various technologies, 5G is expected to provide a hundredfold increase in traffic capacity and network efficiency over 4G.[32] This may not matter to all operators: A third- or fourth-rank player with a lot of spectrum but relatively few customers may well be able to offer 5G-like speeds on a less efficient 4G network. But for the leading operators in many countries—such as the United States, the Philippines, France, Ireland, Australia, and the United Kingdom, where networks are running at higher capacity than in some other countries[33]—the ability to offer higher speeds, more-uniform high speeds, and greater overall capacity per month can be achieved only by moving to 5G.

Speaking of capex, the picture for 5G looks better for operators than was first thought. One study predicted that, to enable 5G, operator capex spending would need to rise from 13 percent to 22 percent of revenue for only a limited rollout.[34] But as 2018's field trials progressed, many operators in North America, Europe, and Japan are reevaluating the cost, and releasing public guidance that capex intensity for 5G will be more or less flat with their 4G spending.[35] One major reason for this is that they have "pre-loaded" spending by aggressively investing in denser fiber networks (both in anticipation of 5G in the future and to support 4.5G technology today), as well as by purchasing 5G-ready radio hardware that can be upgraded to full 5G with software upgrades when the time for launch comes.[36]

All of the above, it should be noted, applies only to capex—one-time investments. It is unclear what impact 5G might have on annual operating expenses.

As far as spectrum goes, early signs are that operators' spectrum costs will be closer to the 4G experience than the 3G (see figure 3). For the launch of 3G, network operators spent heavily on spectrum: As measured in price per MHz per person (MHz pop), the United Kingdom's 3G spectrum auctions sold frequencies for an average of US$3.50 MHz pop. In spectrum auctions prior to 4G's rollout, however, operators spent much less, with 800 MHz spectrum going for US$0.60 MHz pop, and spectrum in the 2.6 GHz bands garnering only US$0.07 MHz pop. (It is important to note that the exact bands matter a lot to price: Lower frequencies travel further and better penetrate buildings, and are spectrum's equivalent of beachfront properties. Hence, the higher the frequency, the lower—usually—the MHz pop.) Based on some early auctions, the prices for 5G spectrum, depending on the frequency band, are consistent with those for 4G spectrum: All auctions in the six countries in figure 3 have been for less than US$0.20 MHz pop, and two were under a penny.[37]

FIGURE 3

## Early auctions suggest that spectrum prices will be similar to those for 4G

Price per MHz pop, US dollars
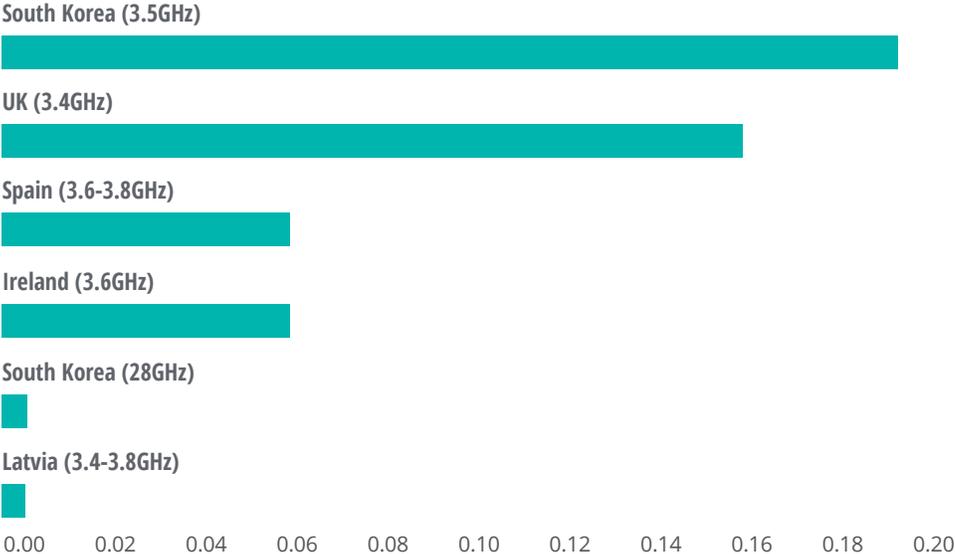


Source: Regulatory authorities, operators, Light Reading.

However, spectrum prices have not been so uniformly low in all geographies. The Italian spectrum auction that concluded in October 2018 saw higher prices, with 700 MHz spectrum commanding a robust US$0.65 MHz pop, and the mid-band 3.6–3.8 GHz frequencies priced at more than US$0.42 MHz pop— much higher than expected (more than double, in fact) for the Italian market. Going forward, if the Italian experience is more typical, operators may need to adjust their expectations upward, at least a little, for how much they will have to pay for non-mmWave spectrum. At this time, no one appears to be paying a premium for mmWave frequencies: Even the Italian auction is pricing them at less than 1 percent of the MHz pop of the mid-band spectrum.[38]

Make no mistake: 5G is the connectivity technology of the future. Although its adoption curve may be relatively shallow in the next 12 to 24 months, and it will likely take years for 5G to replicate 4G's marketplace dominance, many telecommunications operators have a strong incentive to jump on the 5G bandwagon for reasons of speed, latency, penetration, and (especially) capacity. When that happens, it should be a much faster world.

# 5G in the Middle East

The connectivity of the future reimagined

Emmanuel Durou and Hasan Iftikhar

DELOITTE MIDDLE EAST predicts that the GCC will be among the early global adopters of 5G and lead the deployment of the technology across the MENA region. We predict that the UAE and Qatar will lead the 5G charge, closely followed by Saudi Arabia, Kuwait and Bahrain. 5G will also accelerate the realization of smart city goals by enabling a host of use cases in the utilities, healthcare and transportation sectors. With the implementation of smart IoT initiatives in the next two years, we envisage operators in the Gulf to emerge as vital digital transformation partners providing connectivity, infrastructure, and analytics.

## Who will launch first?

Within the MENA region, some GCC countries have already launched the first commercially available 5G networks while others have already undergone trials and tests. The ambition and technological investment in the GCC will allow it to establish itself as one of the global leaders in the deployment and adoption of 5G. According to GSMA, the overall MENA region will witness an approximate 50 percent increase in smartphone and mobile broadband connections as a percentage of total connections by 2025 (from 2017 levels). The GCC's high mobile penetration rate, combined with its plans to commercialize as early as 2019, positions the group ahead of the other states in the region, which are planning launches in 2020 and beyond. GSMA expects that the GCC states will reach above global average 5G adoption rates of 16 percent of total connections by 2025, widely surpassing the regional average of 6 percent across the MENA.

Recent initiatives undertaken by operators within the GCC support that trend. In December 2017, Etisalat launched a pilot using an advanced 5G-based drone equipped with a 360-degree virtual reality (VR) camera with 4K streaming. Additionally, the operator will provide 5G access to the Dubai Expo 2020 event. STC launched its 5G network in May 2018 and recently set up 450 locations across the Kingdom of Saudi Arabia (KSA) as an initial phase to provide 5G access. As of July 2018, Ooredoo (Qatar) has deployed over 70 live 5G stations, while in August 2018 Vodafone Qatar connected the first enterprise customer, Gulf Bridge International (GBI), to its 5G network in the Qatar Science and Technology Park to provide broadband access at speeds that exceed 1Gbps with a real time and uninterrupted user experience.

## What will the initial launch look like? How will it progress?

The initial launch in the region will be across four main areas: "wireless fiber" through fixed wireless access (FWA), smart cities, mega events, and media consumption.

**1) "Wireless Fiber" powering national broadband plans**

In line with global and regional developments, we believe that 5G modems/hotspots and FWA services will likely lead the initial adoption of 5G. This is going to be a leading 5G use case, cutting down on the lead times and costs of traditional fixed access. Manufacturing of 5G chips for modems and hotspots has already started and operators around the world are committing to start offering 5G-compatible modems and

hotspots prior to smartphones. With respect to FWA, we believe there is a significant potential fit between the technology and the ambition of Middle Eastern countries to significantly enhance the ubiquity of high-speed broadband. Cases in point are KSA or Kuwait, with both ambitious national broadband plans and large masses of land to cover. Operators in the GCC are already deploying 5G FWA to complement their fiber footprint. In the first phase of Etisalat's 5G commercial launch, the operator will start providing FWA services in certain locations across the UAE and similar initiatives are being undertaken by Ooredoo in Qatar. Both operators will also start offering 5G-compatible home devices, confirming that modems will be part of the initial 5G uptake. Outside of the GCC, we see a number of countries as ripe candidates for 5G FWA as an alternative to costly fiber rollout. Countries including Lebanon, where broadband access remains below expectations, or Egypt, which is likely to see upcoming investments in infrastructure, are amongst potential contenders. In comparison and while the GCC has been historically an early adopter of the newest smartphone releases, we see the uptake of 5G-compatible smartphones to come at a later stage of the 5G lifecycle, in line with global trends.

## 2) 5G as a national transformation and smart city enabler

The increased throughput and lower latency brought by 5G will revolutionize entire industries and bring enormous improvements to today's use cases. In the GCC, digital transformation and smart city initiatives have been at the top of the agenda for the past five years. Leveraging 5G capabilities will enable governments to scale progress across use cases such as smart transport, driverless cars, smart utilities, remote healthcare and industry 4.0, seeing the earliest of these use cases implemented as early as 2019 and at the latest by 2021.

Transport and logistics is a significant industry in a number of GCC economies. The UAE, Qatar and KSA have articulated the importance of mobility in their future visions and have even deployed small-scale intelligent transportation

systems on 4G LTE networks. The increased bandwidth and low latency accompanying 5G will scale transport and logistics use cases including fleet tracking & management, smart parking, intelligent traffic management, smart journey planning and most importantly connected autonomous vehicles. Even in this pre-5G era, the UAE ranks in the top 10 countries globally by being at the forefront of the race towards autonomous vehicles in terms of government support, highway infrastructure, large-scale innovation, and consumer acceptance (autonomous vehicles readiness index). In the medium term, we expect driverless cars enabled by telco smart platforms to be operational in designated city spaces.

Smart city ambitions, however, are not only limited to the transportation industry for smart technology rollout will also cover security, environment (weather & atmospheric monitoring), energy and healthcare. In the healthcare industry, increased connectivity will enable remote patient monitoring, where medical professionals are able to monitor vital signs of patients through wearable devices or even smart pills equipped with monitoring technology that allows information to be relayed back to a mobile, in turn giving patients and medical professionals real-time access to vital signs.

While ultra-fast, low-latency communication is necessary for connected cars to exist (to ensure cooperative decision-making and avoid collision), other IoT-driven use cases such as the healthcare example do not require similar throughput and reaction times. Nonetheless, 5G will enable both in a cost-efficient manner through network slicing. With 5G, different network service types would be able to be delivered over the same common physical network on virtual network slices. This enables a host of use cases, each with unique network requirements, while optimizing both the utilization of the infrastructure and the allocation of resources.

While 5G will provide governments with the required technology to realize smart city aspirations, in the next generation of connectivity the role of operators will not be limited to infrastruc-

ture provision, as operators will play a pivotal role in educating customers, creating demand and catalyzing digital transformation through 5G. We expect that by 2020 at least five telecommunications companies in the GCC will have dedicated B2B 5G-enabled solutions as part of their enterprise business units, which will serve as supporting infrastructure that will enable a host of smart solutions. In addition to the connectivity element, solutions will also include sensors, devices, analytics, data-processing services as well as the user interface. Ooredoo has already launched the IoT Connect Manager platform, which supports successful connectivity and allows companies to manage and track their networked devices, offers track tools and products online, measures data bandwidth consumption and flags international roaming connections. Ooredoo in Qatar also offers three vertical machine-to-machine solutions with IoT features. One of these solutions enables smart fleet management. We also expect to see utility platforms (smart grids) integrating with an electricity supply network that uses narrowband IoT enabled by 5G to detect and react to local changes in usage.

### 3) Connecting mega events

The wide-scale rollout of 5G coincides with the host of major events scheduled across the GCC in the next five years. Event planners will be able to leverage 5G-enabled applications to create an optimal and unrivaled guest experience at these events. For these impending high-profile major events, an ultra-high speed low latency high quality of service-enhanced broadband could be made available for free to visitors for a limited period to showcase the technology. We also expect to see customized augmented and virtual reality guest experience apps. These applications will cover entertainment and navigation to enable an enhanced customer experience. We suspect that Expo 2020 will be a large-scale test bed for 5G, featuring connected devices, smart infrastructure and an improved mobile customer experience. By 2022, major events such as the FIFA World

Cup will leverage 5G to enable connected transport, 4k UHD streaming and AR/VR applications. Examples of such applications include 'augmented environments', where contextual real-time information such as descriptive text, interactive videos, targeted offers and event information is overlaid on top of mobile device digital screens; and 'augmented sports viewing', where the viewing experience is complemented through smart glasses, mobile phones and tablets to extend the field of vision during live events and overlay contextual information, such as player information and statistics.

### 4) Consumer use cases – Middle East patterns of media consumption

The Middle East currently boasts one of the fastest growing data-consuming populations in the world. Nine in ten people in Lebanon, Qatar, KSA and the UAE use Wi-Fi or mobile data services to connect to the internet. According to Ericsson, the Central & Eastern Europe and Middle East & Africa region will experience a twelvefold increase in mobile data traffic up to 2022. This growth is driven primarily by a young and growing population, double-digit smartphone subscriptions, and strong demand for data-intensive applications such as video and gaming. Millennials, who are amongst the leading consumers of video games in the world, comprise 30 to 50 percent of the population in Middle Eastern countries. There are more than 60 million gamers in the region – 21 percent of Saudi Arabia's population play video games on a weekly basis.

Given the region's demographics, 5G consumption on the consumer side will be exponential as data consumers in the Middle East are drawn to faster download speeds. This will provide an increasingly seamless user experience that eclipses the quality of service we currently enjoy from fixed and mobile broadband technologies, as well as new consumer applications such as 360° video streaming, immersive VR and AR applications and real 4K UHD video with a resolution of at least 3840 x 2160 and a frame rate of 50fps.

On the B2C front, the immediate play of telecommunications companies will be the continued enhancement of mobile broadband to match the growing data demand, which is increasingly being consumed via handsets. Increased speeds will enable better gaming experiences, allow for seamless viewing of higher quality video content and improve the user experience for AR and VR with a decrease in current lag time issues due to reduced latency. To match future consumer use cases, 5G will likely lead to customer data packages being unlimited and unbundled.

## Moving forward

There is significant financial benefit that can be generated from the deployment of 5G. According to research from Analysys Mason, over the span of 10 years, from 2020 to 2030, 5G will provide a total of USD 270bn in new revenue in the GCC region, with the share being split evenly between operators and other companies in the ICT sector. However, in order to take full advantage of the 5G technology, governments and regulators in the GCC should focus on specific initiatives and applications. On the one hand, governments should identify how 5G will assist in the development of sectors and verticals. While 5G roadmaps and strategies have been developed in some GCC countries, these plans do not specify how 5G will contribute to key sectors and verticals under national strategies. On the other hand, from a regulatory perspective, there are still a number of 5G-related regulatory issues that should be addressed, including concerns for the 5G use cases such as spectrum allocation, spectrum reframing from older technologies, and QoS management (e.g. regulated latency QoS metrics). As the technology matures, however, and is enabled by the right ecosystem, we expect to witness a full-scale rollout of autonomous cars and the rise of the connected factory, as well as more advanced healthcare use cases such as remote augmented surgery.

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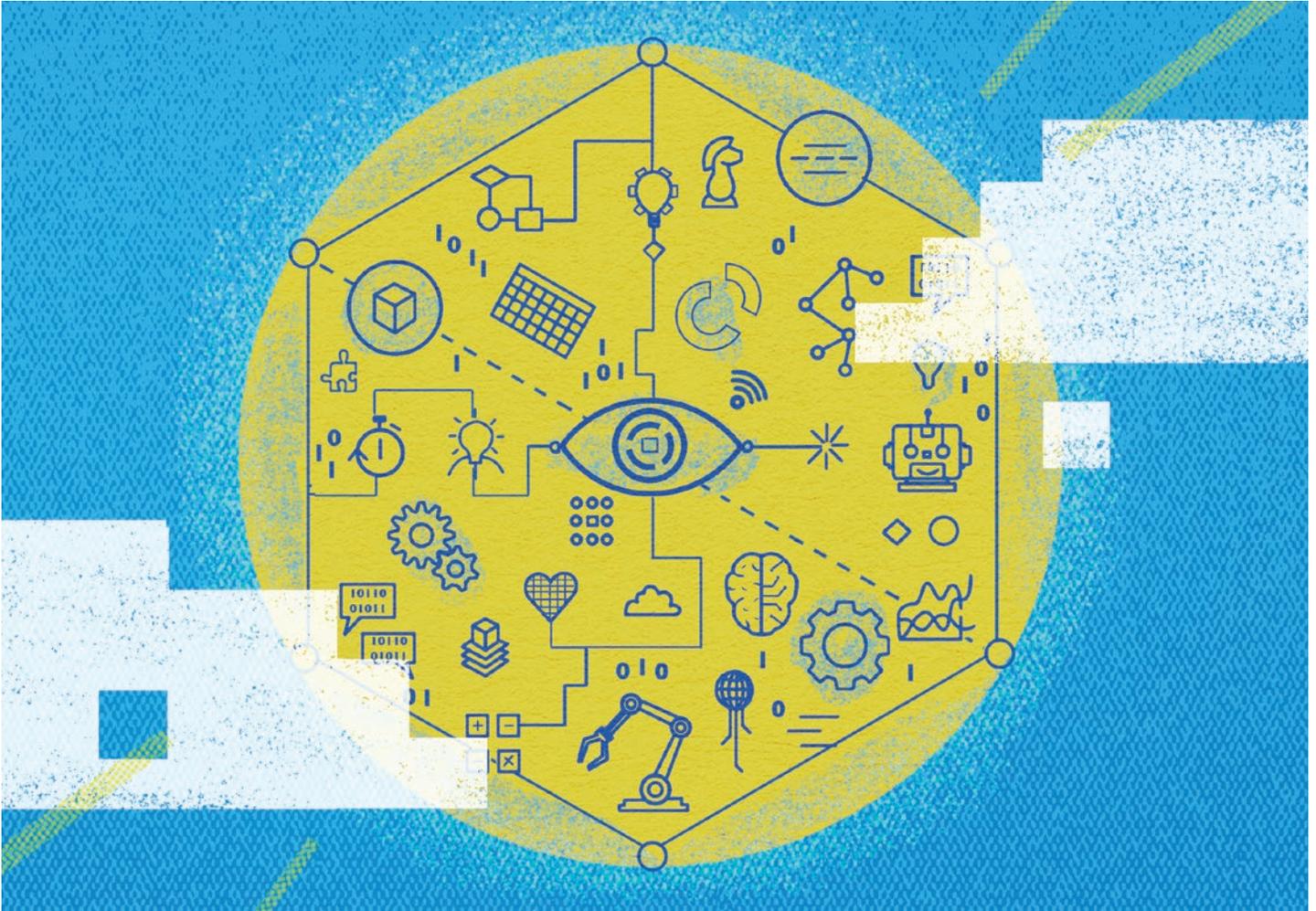
# Artificial intelligence

From expert-only to everywhere

Jeff Loucks

DELOITTE GLOBAL PREDICTS that in 2019, companies will accelerate their usage of cloud-based[1] artificial intelligence[2] (AI) software and services. Among companies that adopt AI technology, 70 percent will obtain AI capabilities through cloud-based enterprise software, and 65 percent will create AI applications using cloud-based development services.[3] Further, Deloitte Global predicts that by 2020, penetration rates of enterprise software with integrated AI and cloud-based AI platforms will reach an estimated 87 percent and 83 percent, respectively, among companies that use AI software. Cloud will drive more full-scale AI implementations, better return on

investment (ROI) from AI, and higher AI spending. Importantly, we'll see the democratization of AI capabilities—and benefits—that had heretofore been the preserve only of early adopters.

## AI has benefited the few thus far

AI consists of multiple technologies. At its foundation are machine learning and its more complex offspring, deep-learning neural networks. These technologies animate AI applications such as computer vision, natural language processing, and the ability to harness huge troves of data to make accurate predictions and to unearth hidden insights (see sidebar, "The parlance of AI technologies"). The recent excitement around AI stems from advances in machine learning and deep-learning neural networks—and the myriad ways these technologies can help companies improve their operations, develop new offerings, and provide better customer service at a lower cost.

The trouble with AI, however, is that to date, many companies have lacked the expertise and resources to take full advantage of it. Machine learning and deep learning typically require teams of AI experts, access to large data sets, and specialized infrastructure and processing power. Companies that can bring these assets to bear then need to find the right use cases for applying AI, create customized solutions, and scale them throughout the company. All of this requires a level of investment and sophistication that takes time to develop, and is out of reach for many.

For this reason, AI's initial benefits have accrued mainly to pioneers with the required technical expertise, strong IT infrastructure, and deep pockets to acquire scarce and costly data science skills—most notably the global "tech giants."[4] They have the resources to engage in bidding wars for increasingly expensive AI talent.[5] They have also invested billions in infrastructure, including massive data centers and specialized processors. For example:

- Google has designed its own AI-specific chips to accelerate machine learning in its data centers and on IoT devices.[6] The company has been exploring deep learning since the launch of Google Brain in 2011,[7] and uses it extensively for everything from performing video analytics to cooling data centers.[8]
- Amazon has used machine learning to drive recommendations for many years. The company is using deep learning to redesign business processes and to develop new product categories, such as its Alexa virtual assistant.[9]
- China's BATs—Baidu, Alibaba, and Tencent—are investing heavily in AI while expanding into areas previously dominated by US companies: chip design, virtual assistants, and autonomous vehicles.[10]

## The few are bringing AI to the many

These tech giants are using AI to create billion-dollar services and to transform their operations. To develop their AI services, they're following a familiar playbook: (1) find a solution to an internal challenge or opportunity; (2) perfect the solution at scale within the company; and (3) launch a service that quickly attracts mass adoption. Hence, we see Amazon, Google, Microsoft, and China's BATs launching AI development platforms and stand-alone applications to the wider market based on their own experience using them.

Joining them are big enterprise software companies that are integrating AI capabilities into cloud-based enterprise software and bringing them to the mass market. Salesforce, for instance, integrated its AI-enabled business intelligence tool, Einstein, into its CRM software in September 2016; the company claims to deliver 1 billion predictions per day to users.[11] SAP integrated AI into its cloud-based ERP system, S4/HANA, to support specific business processes such as sales, finance, procurement, and the supply chain. S4/HANA has around 8,000 enterprise users, and SAP is driving

## THE PARLANCE OF AI TECHNOLOGIES

Below are short definitions of several AI technologies.[12] While no definition can capture every nuance of these technologies, here are the basics:

- **Machine learning.** With machine learning technologies, computers can be taught to analyze data, identify hidden patterns, make classifications, and predict future outcomes. The "learning" comes from these systems' ability to improve their accuracy over time without explicitly programmed instructions. Machine learning typically requires technical experts who can prepare data sets, select the right algorithms, and interpret the output. Most AI technologies, including advanced and specialized applications such as natural language processing and computer vision, are based on machine learning and its more complex progeny, deep learning.

- **Deep learning.** Deep learning is a subset of machine learning based on a conceptual model of the human brain called neural networks. It's called "deep" learning because the neural networks have multiple layers that interconnect: an input layer that receives data, hidden layers that compute the data, and an output layer that delivers the analysis. The greater the number of hidden layers (each of which processes progressively more complex information), the "deeper" the system. Deep learning is especially useful for analyzing complex, rich, and multidimensional data, such as speech, images, and video. It works best when used to analyze large data sets. New technologies are making it easier for companies to launch deep learning projects, and adoption is increasing.

- **Natural language processing (NLP).** NLP is the ability to extract or generate meaning and intent from text in a readable, stylistically natural, and grammatically correct form. NLP powers the voice-based interface for virtual assistants and chatbots. The technology is increasingly being used to query data sets as well.[13]

- **Computer vision.** Computer vision is the ability to extract meaning and intent from visual elements, whether characters (in the case of document digitization) or images such as faces, objects, scenes, and activities. Computer vision is the technology behind facial recognition, which is now part of consumers' everyday lives. For example, iPhone X owners log in to their devices simply by looking at them,[14] and computer vision technology "drives" driverless cars and animates cashier-less Amazon Go stores.[15]

its adoption by announcing that the company will not support legacy SAP ERP systems past 2025.[16]

A host of startups is also sprinting into this market with cloud-based development tools and applications. These startups include at least six AI "unicorns," two of which are based in China. Some of these companies target a specific industry or use case. For example, Crowdstrike, a US-based AI unicorn, focuses on cybersecurity, while Benevolent. ai uses AI to improve drug discovery.

The upshot is that these innovators are making it easier for more companies to benefit from AI technology even if they lack top technical talent, access to huge data sets, and their own massive computing power. Through the cloud, they can access services that address these shortfalls—without having to make big upfront investments. In short, the cloud is democratizing access to AI by giving companies the ability to use it now.

## Cloud-based AI helps companies surmount barriers to adoption

Deloitte recently surveyed 1,900 "cognitive-aware" executives whose companies have begun to use AI for pilots and implementations. All of these companies—representing 10 industries and

seven countries—can be considered "early adopters" compared with average organizations, though they are not in the same league as AI pioneers such as Amazon, Google, and the BATs. The survey found that data issues, such as accessing quality data, cleaning data, and training AI systems, were one of the two top obstacles to AI adoption, ranked as a top-three challenge by 38 percent of the surveyed companies. Integrating AI into existing processes and workflows also ranked as a top-three challenge for 38 percent of the respondents, while difficulties implementing AI—a serious problem when companies try to scale proofs of concept to full production—followed close behind at 37 percent.

Separately, we asked these early adopters about whether a "skills gap" inhibited their AI initiatives. Forty-one percent said they had a "moderate" skills gap, with an additional 27 percent calling their skills gap "major" or "extreme." The skills gap was most acute for technical roles such as AI researchers, data scientists, and software developers.

Cloud-based software and platforms help companies benefit from AI, even if they lack the expertise to build and train systems, or to manage data on their own. And according to our survey, AI early adopters are taking advantage. Many compa-nies that aren't using these technologies today plan to do so in the future.

## The easy path: Enterprise software with an AI infusion

Our survey of AI early adopters showed that the most popular path to acquiring AI capabilities is also the easiest: enterprise software with integrated AI. Overwhelmingly, this software is cloud-based, either through public or private cloud deployments. Fifty-eight percent of our survey respondents globally are currently using this approach. Deloitte Global estimates that by 2020, about 87 percent of AI users will get some of their AI capabilities from enterprise software with integrated AI (figure 1).[17]

This method of adopting AI can have big advantages:

- **Companies do not need to develop their own AI applications.** AI simply runs in the background, making the software more valuable to the end user.
- **End users do not need any specialized knowledge** to use AI embedded in enterprise applications.

FIGURE 1

## Early adopters have their heads in the cloud

### Cloud enterprise software + AI

| 2018 | | 2019 | 2020 | |
|---|---|---|---|---|
| 58% Usage | | +12 Growth estimate | +17 Growth estimate | |

### Cloud AI development services

| 2018 | | 2019 | 2020 | |
|---|---|---|---|---|
| 50% Usage | | +15 Growth estimate | +18 Growth estimate | |

Note: N = 1,900 global respondents.
Source: Deloitte's "State of AI in the enterprise" survey 2018, global data.

- **Companies do not need to develop intuitive, new user interfaces.** This can be a challenge for AI applications developed from scratch, especially since 21 percent of respondents with skills gaps cited a shortfall of user experience designers. In fact, software firms are using AI technologies such as natural language processing to make their solutions easier to use. Salesforce, for example, recently released a voice assistant for Einstein.[18]

claims are worth resubmitting.[22] Such applications, though modest in scope, can help companies address thorny—and costly—problems.

## Companies hoping to add AI capabilities can tap into an array of single-purpose applications, such as chatbots, that can be deployed quickly and serve as the foundation for a digital business.

The addition of new features such as voice assistance underscores another benefit of all cloud-based AI services: continual upgrades. Competition among AI providers is fierce; they are rapidly improving their services, and cloud-based delivery allows customers to take immediate advantage.

Companies will have an expanding range of enterprise AI services from which to choose in 2019. New cloud AI service providers are entering the market. For example, Google recently announced three AI services aimed at specific business functions such as HR and marketing, and plans to launch more. Soon, we expect that nearly all enterprise software products will incorporate at least some elements of AI.[19]

Companies hoping to add AI capabilities can also tap into an array of single-purpose applications, such as chatbots, that can be deployed quickly and serve as the foundation for a digital business. Lemonade, a disruptor in the insurance industry, uses chatbots to sell its policies as well as to settle claims faster and more efficiently than humans.[20]

Industry-specific AI apps are also emerging—often from startups. Reflektion uses deep learning to help e-commerce sites increase sales by presenting products that match individual customers' preferences.[21] Ayasdi develops cloud-based AI software that helps hospitals determine why insurers reject claims, suggest fixes, and identify which denied

However, perhaps the biggest advantage of this "easy" path is also its biggest limitation: The use cases are strictly defined by the software. On the one hand, companies don't need to worry about whether a use case exists; the AI they buy has been developed specifically to address specific—often critical—business functions. On the other hand, these solutions offer limited customization, and the same capabilities are available to any company that uses the software. Companies that hope to gain a competitive advantage from AI will need to develop their own solutions.

## AI development services: A faster track to customized solutions

That's where cloud-based AI development services come in.[23] These include services for creating new AI applications, selecting the right models, and for getting a head start on higher-order AI technologies such as natural language processing and computer vision.

Unlike enterprise software that has AI "baked in," AI development services require companies to have in-house technical talent, such as AI programmers and data scientists. These services can help companies get the most out of their technical talent by providing access to tried-and-true models and

by accelerating key processes. In other words, they allow companies with some technical AI expertise—but not enough to develop their own AI services, or to develop them fast enough—to create a higher volume of AI services, and at scale.

For instance, it takes multiple steps to build a solution using machine learning and deep learning: building models, training the models using large data sets, evaluating the models' performance, and "tuning" the models for optimal results. Each of these steps can be labor-intensive and require data scientists to make multiple decisions. AI development services reduce the time needed to build and test models, and to "wrangle" with data. Automated machine learning can select the most robust model out of a given set and "auto-tune" it 100 times faster than a human data scientist, allowing data science teams to produce more models with fewer steps.[24] This helps companies "test and learn" rapidly, even with only a small staff of specialists.

## Some AI development services are getting so intuitive that developers don't even need much specialized knowledge.

Some AI development services are getting so intuitive that developers don't even need much specialized knowledge. For example, Baidu recently released an AI training platform called EZDL that requires no coding experience and works even with small data training sets.[25]

Even for companies with significant resources, AI development platforms can help deliver industry-changing innovation. For example, Samsung Heavy Industries is using AWS to develop autonomous cargo vessels and the services needed to manage them.[26]

Of course, as with enterprise software, there's no need to reinvent the wheel. Cloud providers have developed pre-built machine-learning APIs for

technologies such as natural language processing that customers can access instead of building their own.

## The many are starting to benefit

Our survey of AI early adopters suggests that the democratization of AI is increasing AI usage. While our respondents are taking varied paths to AI,[27] enterprise software with integrated AI and cloud-based development platforms represent two major avenues for companies to access AI technology.

Among the US-based respondents to our AI survey, AI early adopters' use of deep learning increased from 34 percent in 2017 to 50 percent in 2018. Cloud-based AI services, many of which specialize in making deep learning more accessible, contributed to this growth. In a separate survey on cloud services, Deloitte found that companies are 2.6 times more likely to prefer obtaining advanced innovation capabilities, such as AI and advanced analytics, as a service versus traditional IT.[28]

As cloud technologies become more pervasive, and early adopters gain experience with them, they're producing results:

- From 2017 to 2018, US-based survey respondents, on average, increased their number of full-scale AI implementations from 6 to 9—a 50 percent jump that validated Deloitte Global's prediction in 2018.[29]
- Across all countries, AI early adopters are seeing positive financial returns, reporting an average ROI of 16 percent. This is a promising start for companies that are gaining experience with a rapidly evolving set of technologies.
- ROI is helping build momentum for AI, but that's only part of why companies are adopting it. Our respondents also believe AI will have major ramifications for their competitiveness in the next two years (figure 2).

FIGURE 2

## AI is becoming mission-critical

Executives report AI will become more strategically important to their companies' business success

■ Now　■ In two years
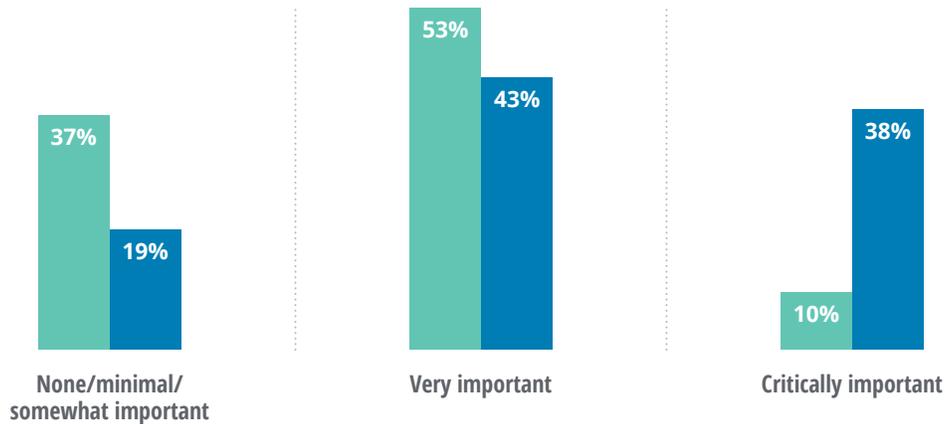


Note: N = 1,900 global respondents.
Source: Deloitte's "State of AI in the enterprise" survey 2018, global data.

- Encouraged by their successes, and betting that AI will play a critical role in enhancing their competitiveness, companies are increasing their AI investments. The companies responding to our survey spent an average of US$3.9 million on AI in 2017, a level projected to increase to US$4.8 million in 2019.

**AI adoption will accelerate as more services come into the market—from prepackaged enterprise AI solutions to development tools.**

Judging by our survey results, the use of cloud-based enterprise software with AI will accelerate. Interestingly, this "easy path" is not just for beginners. The most successful AI early adopters in our study—the ones with the most internal resources—are also the biggest users of enterprise software with AI.

However, we also see that as companies mature in their AI usage, they tend to rely more heavily on AI development platforms to leverage their AI talent. AI development platform providers are seeing growth, too: According to Amazon, the number of developers using AWS for machine learning increased by 250 percent over the last year.[30]

What's clear is that AI adoption will accelerate as more services come into the market—from prepackaged enterprise AI solutions to development tools that can transform ordinary programmers into AI model builders.

# BOTTOM LINE

What can companies do to emulate the success of AI early adopters?

**Follow AI trends closely.** The market is changing rapidly, and new capabilities are emerging. Even the most advanced techniques are becoming accessible to organizations with modest in-house AI skills. Just as the competition for market share is driving advances among tech giants and startups alike, AI early adopters are experimenting with these capabilities to leapfrog their rivals.

**Get what you can "off the shelf."** AI applications focus on specific business processes, whether home-grown or available from a vendor. Where software firms have created an "off-the-shelf" solution, companies should see if it suits their needs. Don't "reinvent the chatbot" unless it's necessary.

**Make sure to hire at least *some* AI experts.** While enterprise software and cloud-based development platforms can provide an effective gateway to AI, they are not a substitute for having at least some technical AI talent in-house. They will not provide the competitive advantage that customized solutions can, especially as AI becomes ubiquitous in enterprise software. Companies need their own AI experts to develop and customize algorithms using AI development platforms. These experts also can help ensure that companies invest in AI applications and services that will address business needs. "Reality checks" from technical experts can become increasingly important as vendors try to pass off ordinary analytics as the latest deep learning capabilities. Internal AI experts can also help companies be realistic about what AI technologies can do for them given their current levels of talent, data access, and strategies.

**Focus on the business need.** The answers companies get from AI are only as good as the questions they ask. Companies should understand which challenges AI can help them solve and how it can help solve them. This requires not only technical talent, but also executives who understand business needs and can "speak data science" to technical experts. These translators can help companies ensure they're not just building models more efficiently, but also efficiently building effective models.

# Artificial intelligence in the Middle East

## From experiential to serial adoption

Emmanuel Durou and Gaurav Govil

N LINE WITH global trends, we envision a growing appetite for artificial intelligence (AI) investment in 2019 across the Middle East[31]. In fact, some sources estimate that spending on cognitive and artificial intelligence systems in the region will triple from 2017 to 2021, to reach over US$100 million in 2021[32].

Although far from full maturity in this area, GCC member nations such as Saudi Arabia and the UAE are already paving the way.

- A recent study forecasts the contribution of AI to the UAE economy will reach about 14 percent by 2030[33]. Leveraging the recently launched UAE Artificial Intelligence Strategy 2031, the myriad use cases seem to attest to the potential value add of AI-based technologies to the country's economic output. In the financial services industry, the UAE Exchange resolves about 30 percent of its customer queries with Zoey, a chat-based solution with more than 80,000 users and 85,000 interactions across 12 geographies[34]. Healthcare is also expected to reap the benefits from AI-related technologies. According to recent proofs of concept carried out by the Dubai Health Authority, Dubai Diabetes Centers can treat 144 times more patients with diabetic retinopathy (DR) and related eye diseases by using deep learning systems (DLS)[35]. The resulting impact in optometric care is a predicted 87 percent increase in accuracy for identifying individuals who require an eye care specialist. Within the UAE, Dubai leads in the adoption of AI through programs such as the Dubai Future Accelerator that has outlined ambitious targets to boost AI across the Emirate. This will eventually translate into the transformation of 25 percent of public transport into driverless transit modes by 2030,

or the reduction of the city's crime rate by 25 percent over the next three years via Dubai Police's AI system[36].

- Although the UAE is expected to witness the largest relative contribution of AI to GDP by 2030, Saudi Arabia is predicted to amass the biggest monetary gains by 2030 amounting to a contribution of USD 135.2 billion, equivalent to 12.4 percent of GDP[37]. To capitalize on the AI opportunity, Saudi Arabia has placed technology at the heart of the Kingdom's national development plan Saudi Vision 2030. The clearest sign of this commitment is NEOM, a planned USD 500 billion ultra-high-tech "megacity" devoted to AI-powered innovation that is expected to fund itself and contribute as much as USD 100 billion a year to the Saudi economy[38]. An additional data point further emphasizing Saudi Arabia's ambition in leading the space of technology and AI is Sophia. The Kingdom granted citizenship to a humanoid robot created by Hong Kong company Hanson Robotics called Sophia - the first country in the world to create a robot citizen.

From an industry perspective, adoption of AI is highly uneven. Industries with long histories of digital investment in the development of digital tools, both for their core product offerings and for optimizing their operations, are leading the way in the adoption of AI. The financial services industry fits this pattern of adoption. The industry's access to more and better-structured data, compared to other industries in the region, as well as banks' willingness to enhance productivity, will allow financial services to take the lead. Deloitte Middle East predicts that machine learning-based applications will increasingly help financial service providers to detect fraud,

assign risk more accurately, and provide more curated offers. Healthcare, manufacturing and retail, on the other hand, will reap the benefits of automation due to their labor-intensive nature. We may witness, for example, early diagnosis capabilities and smart electronic health records for healthcare, and predictive sales, automated customer engagement, and an optimized supply-chain for retail.

In contrast to mature AI markets, where more than half of TMT companies have already implemented machine learning and natural language processing technologies[39], uptake amongst local players appears to be low so far. Our analysis demonstrates that AI usage has been mostly restricted to initiatives aimed to augment the customer experience, including location-based offerings and the extension of customer care channels to social media, remote control of IoT devices, and increased AI use cases in adjacent industries through facilitation of technology capabilities, such as Etisalat's "Dubai Future Accelerators". With the progressive cloudification of business networks and core business systems, telecom operators must take advantage of AI technologies as a way to survive and differentiate, not simply for incremental improvement. Deloitte Middle East predicts that by 2020 telecom operators such as Etisalat, Du and STC will have adapted quickly to the new reality of a software-based, open-source network by mastering AI-driven network operations features such as predictive maintenance to increase and optimize the efficiency of its infrastructure.

The governments of the Middle East have responded with a number of interconnected strategies to take full benefit of AI. However, any transformation program comes with an even greater challenge in mapping the actual initiatives to the desired outcomes. In line with the challenges pointed to by early adopters at a global level, the lack of skilled human capital and the absence of quality data sets constitute major barriers to the effective deployment and operation of AI solutions by Middle Eastern organizations. Our analysis strongly suggests limited cross-vendor operability as a top-three challenge to AI adoption in the region.

Middle Eastern countries have shown great agility in being able to overcome these challenges by localizing the success formulas applied globally. By realizing the potential of mass-scale adoption of cloud as a key enabler to benefit from AI in low-skilled ecosystems, local governments have mandated their regulatory bodies to extend their frameworks to cloud computing. With this in mind, the region has now witnessed the emergence of regulatory initiatives as prime illustrations of these interventions. In 2017, Bahrain adopted the 'Cloud First' policy in the public sector, becoming the first Arab country and one of the first worldwide to mandatorily evaluate cloud-based services when undertaking ICT procurements. Last year, Saudi Arabia's telecommunications regulator issued a cloud computing regulatory framework aimed to prevent abuses, ensure content security, and enable people to remain in control of their data and of how it's being collected, stored and treated. While the UAE does not yet have a Cloud First policy strategy, the Telecommunications Regulatory Authority (TRA) has recently commissioned a public consultation around a Cloud First policy and guidelines. Considering the increasing number of regional jurisdictions with cloud-specific regulation, Deloitte Middle East predicts the cloud services market will continue to experience double-digit revenue growth during the next five years, and, by causality, induce an exponential growth in cloud-based AI adoption.

In 2019, Deloitte Middle East predicts that key Gulf economies will continue to embrace new AI use cases leveraged by cloud technology adoption. Furthermore, regional governments are expected to reinforce regulatory instruments of AI-enabling technologies in order to accelerate the transition from promising standalone proofs-of-concepts to serial adoption. Industries with high automation potential and upside growth driven by service innovation are expected to drive the usage of AI. Structural constraints will remain long-term challenges: growing the local talent pipeline using AI, creating data management programs, and enforcing interoperability standards to regulate AI solution providers in the market.

# Endnotes

1. This chapter uses the term "cloud" as a synonym for other service-based technology models such as everything-as-a-service (XaaS) and flexible consumption models (FCM).

2. This chapter uses the term AI as a synonym for "cognitive computing."

3. Cloud-based AI development services include "building blocks" such as application programming interfaces (APIs) and AI development platforms. This chapter uses the terms "cloud-based AI development services," "AI development services," and "AI development platforms" interchangeably.

4. The global tech giants include Alphabet (Google), Alibaba, Amazon, Baidu, Facebook, Microsoft, Netflix, and Tencent. These are not the only companies to benefit from AI, but simply the ones that have had the most success to date in using AI to improve operations and increase revenue.

5. Cade Metz, "AI researchers are making more than $1 million, even at a nonprofit," *New York Times*, April 19, 2018.

6. For example, in 2016, Google unveiled the Tensor Processing Units that operate in the company's data centers to accelerate AI processing. Google recently developed an edge AI processor for use in Internet of Things (IoT) devices. See James Vincent, "Google unveils tiny new AI chips for on-device machine learning," Verge, July 26, 2018. For more on the development of AI chips, see the chapter "Hitting the accelerator: The next generation of machine learning chips" in Paul Lee, Duncan Stewart, and Cornelia Calugar-Pop, *Technology, Media and Telecommunications Predictions 2018*, Deloitte, December 2017. Alibaba is among the Chinese tech giants that are developing their own chips.

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18. Michael Machado, "Introducing new Einstein Voice," Salesforce, September 20, 2018.

19. Tony Baer, "AI is becoming ubiquitous across enterprise software," ZDNet, March 19, 2018.

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24.  MIT News, "Auto-tuning data science: New research streamlines machine learning," December 19, 2017. These technologies are now widely available through cloud providers.

25.  Kyle Wiggers, "Baidu launches EZDL, an AI model training platform that requires no coding experience," VentureBeat, September 1, 2018.

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28.  Thirty-nine percent prefer advanced technologies such as AI-as-a-service, 15 percent prefer traditional IT, and another 30 percent say it depends on the situation. See Gillian Crossan, Susanne Hupfer, Jeff Loucks, and Gopal Srinivasan, *Accelerating agility with everything-as-a-service*, Deloitte Insights, September 17, 2018.

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35.  Deloitte Analysis, Arabhealthonline.com, "Dubai to Deploy Cutting-Edge AI devices in Healthcare", 2018

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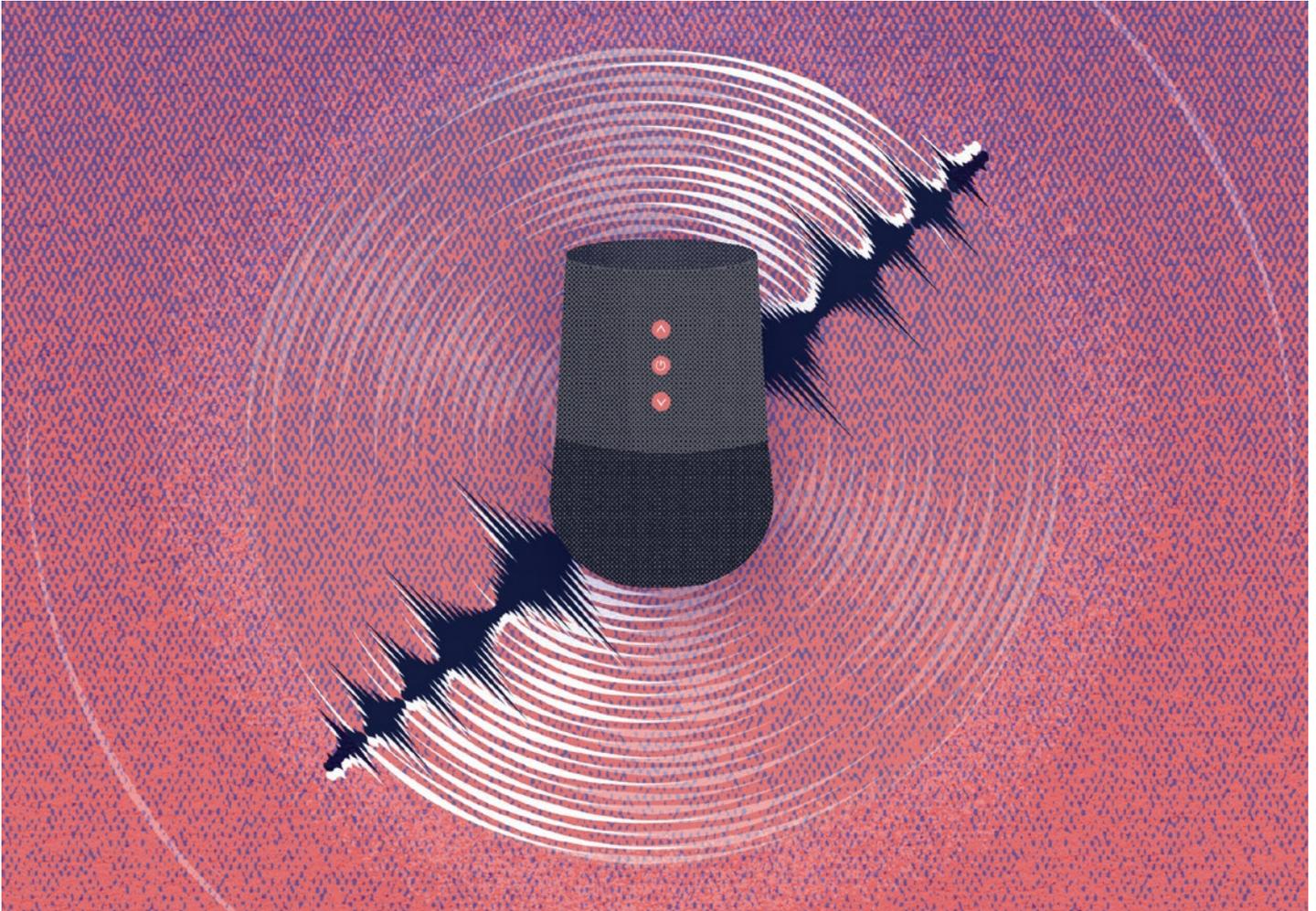
# Smart speakers
## Growth at a discount

Paul Lee

DELOITTE GLOBAL PREDICTS that **the industry for smart speakers—internet-connected speakers with integrated digital voice assistants—will be worth US$7 billion in 2019,** selling 164 million units at an average selling price of US$43.[1] We expect 2018 sales of 98 million units at an average of US$44 each, for a total industry revenue of US$4.3 billion. This 63 percent growth rate would make smart speakers the fastest-growing connected device category worldwide in 2019, and lead to an installed base of more than 250 million units by year-end.[2] Robust sales performance in 2019, although high, will represent a deceleration from the prior year: In

Q2 of 2018, smart speaker sales were up 187 percent year over year.[3]

## The opportunities: What will drive smart speaker growth?

Smart speakers have, literally, a world of opportunity for growth. Much of that opportunity comes from expansion into non-English-speaking countries. At the end of 2017, smart speaker sales were largely confined to English-speaking markets, with more than 95 percent of sales in the United States and the United Kingdom.[4] By the beginning of 2019, however, these speakers will be spreading their linguistic wings, and sales should take off in countries in which the majority of the population speaks Chinese (Mandarin or Cantonese), French, Spanish, Italian, or Japanese, as well as English. In most of these geographies, the smart speaker category is

likely to enjoy the fastest growth in ownership and shipments relative to other smart devices.

Sales in non-English-speaking countries will likely further expand a rapidly growing user base. Already, the worldwide installed user base exceeds 100 million units as of the start of 2019.[5] According to Deloitte research, the smart speaker was the device with the highest year-over-year increase in ownership through mid-2018 in six of the seven markets in which they were available from multiple major brands (urban China, the United States, Japan, the United Kingdom, Canada, and Australia, with only Germany lagging).[6] As of mid-2018, penetration of smart speakers was highest in urban China, with 22 percent of adults having access to a smart speaker, followed by the United States, with 19 percent of adults having access to one (figure 1). In these markets, the smart speaker was also the fastest-growing of all emerging connected devices.

FIGURE 1

## Urban China and the United States lead in smart speaker ownership
Smart speaker adoption by country
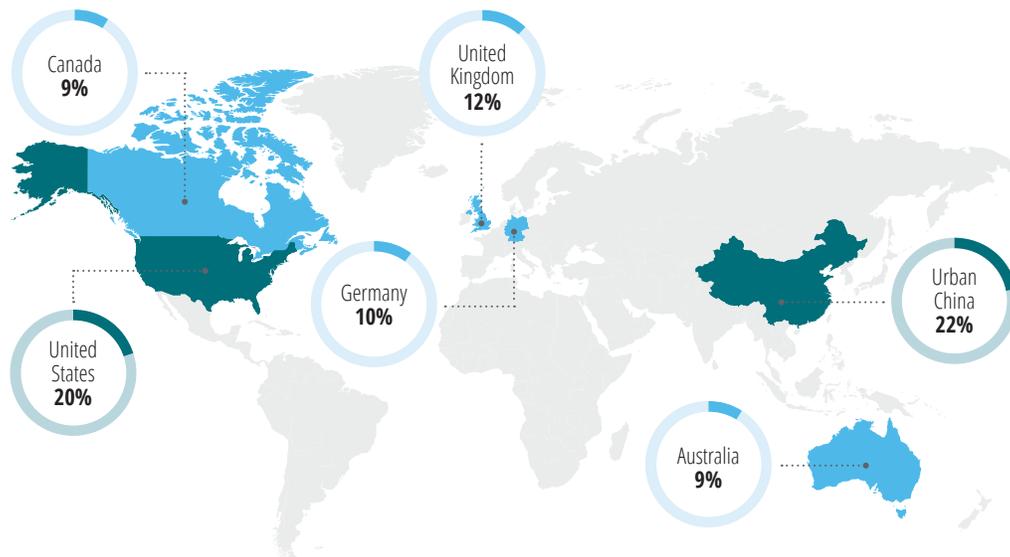


Base: All respondents aged 18–75 residing in Australia (2,000), Canada (2,000), Germany (2,001), the United Kingdom (4,000), the United States (2,003); all respondents aged 18–50 residing in urban China (2,000).
Source: Australia/Canada/China/Germany/United Kingdom/United States edition, Deloitte Global Mobile Consumer Survey, June 2018.

Localization may place some constraints on smart speakers' global expansion. Creating support for new languages is likely to be capital- and time-intensive due to the complexity of spoken languages.[7] In China, there are 130 spoken dialects.[8] In India, while most people speak Hindi, there are roughly 10 different variations of that language, and the amount of Hindi content available for machine learning is limited. According to one analysis, 90 percent of all digital voice assistants in India support only English.[9] But these issues are not insurmountable, and the size of these markets provides ample incentive for smart speaker manufacturers and voice recognition capability creators to spend the time and money to address them.

# Smart speakers are improving in speech recognition accuracy, an enhancement that can be applied and amortized across a widening range of devices.

In addition to wider language support, smart speakers are improving in speech recognition accuracy, an enhancement that can be applied and amortized across a widening range of devices. Google's word error rate for English speech recognition, for instance, has steadily declined from 8.5 percent in July 2016 to 4.9 percent in May 2017.[10] Further, machine learning is now allowing smart speakers to narrow the accent gap: In their early years, smart speakers understood standard English well, but could be befuddled by strong regional or national variations, or English spoken by nonnative speakers, with accuracy up to 30 percent lower.[11]

Smart speakers' complexity and build cost are also declining, partly due to a reduction in the number of microphones required per device. By using neural beamforming, Google was able to ship its Home smart speaker using just two microphones, rather than eight as originally planned, with no resultant decline in accuracy.[12] The micro-

phones themselves are also improving due to the emergence of piezoelectric microelectromechanical systems (MEMS) technology, which consumes less power than earlier technologies. While most current smart speakers need to be plugged in (as opposed to being battery-powered), as they are constantly powered up and listening for a spoken trigger,[13] MEMS microphones use almost no power until activated by the wake word. This new microphone technology enables digital voice assistants to be more readily incorporated into battery-powered speakers.

So 2019 will likely be a strong year for smart speakers with robust growth in unit sales. But what are their longer-term prospects?

Potential demand for smart speakers could be in the many billions of units, possibly even higher than for smartphones. A speaker could be installed in every room in a house or a hotel, every office in a building, every classroom in a school, or every bed in a hospital.

Several hotel chains have undertaken mass deployments of smart speakers, whose applications include serving as in-room concierges. The Marriott International Group plans to deploy Amazon's and Alibaba's smart speakers in some of its hotels;[14] 100,000 units will be deployed in China alone.[15] The Wynn Las Vegas has installed smart speakers in all 4,748 of its rooms.[16] If this trend continues, many of the world's estimated 187,500 hotels and 17.5 million guest rooms[17] could feature smart speakers or voice control within the next decade.

Drive-through restaurants could use voice automation to take orders. This would free up workers from having to manually process orders. In the United States alone, there are more than 12 billion drive-through orders per year.[18]

One hospital in Sydney, Australia has piloted the use of smart speakers as an upgrade to a bedside call button.[19] Unlike a call button, smart speakers allow patients to specify requests. The smart speaker can handle simple tasks, such as turning on the televi-

sion, lowering the blinds, or turning down the lights, via voice commands from the patient, saving time and labor. If a patient just needs an additional pillow, a junior staff member could get it, leaving nurses and doctors to focus on tasks that require their specialized skills. If a nurse or doctor were needed, the patient could describe their symptoms, which would enable the staff to prioritize requests. The appropriate medical staff member would be notified, and the patient would be reassured (via the speaker) that someone was on the way.[20]

In some contexts, voice can be the most natural and productive way to communicate with a computer. When one's hands are occupied operating machinery, typing with both hands, holding an infant, or cooking, voice may be the most convenient option. While driving, voice may be the safest option as well.[21]

Indeed, in many workplaces, including theaters, factories, chemical labs, and restaurant kitchens, smart speakers may make operations safer and more precise than they are today. Deloitte Global believes that in the long term, the number of smart speakers in the workplace might exceed the number in homes, and the value of the tasks they do may be orders of magnitude greater than playing music, hearing the weather forecast, or asking what zero divided by zero is.

Further, for the visually impaired, smart speakers can be an additional, more convenient way to access computing power. For many of these people, speaking a search query to a machine that can always be on, and that has an array of microphones listening for commands, may be easier than using a smartphone or touch-typing on a computer keyboard. The potential market is large: More than 250 million people in the world are vision-impaired, of whom 36 million are fully blind.[22] The vast majority of the visually impaired are age 50 or older, and as such, they may be less comfortable using a computer or smartphone than they would simply speaking to a machine. That said, while the visually impaired may be more likely to have multiple

speakers per home (one in each room) than sighted people, they may also be more price-sensitive, with one-half being underemployed or unemployed and earning less than US$20,000 per year.[23]

# For the visually impaired, smart speakers can be an additional, more convenient way to access computing power.

Smart speakers may also be the way in which illiterate people are able to access the Web. About 14 percent of the world's adults—about 700 million people[24]—cannot read.

## The caveats: What could slow smart speaker growth?

While there is plenty for smart speaker makers to be optimistic about, there are also grounds for caution. While 2019 will likely be a good year for the product, the market's growth will likely be only one-half what it was in 2018, and a further decline in subsequent years is possible.

The initial demand for smart speakers has been driven heavily by price promotion. In the United States, entry-level devices, which likely represent the majority of units, have been priced as low as US$25 per device during promotional periods.[25] In China, promotional prices of US$15 have been available.[26] For example, Alibaba's Tmall discounted the price of its Genius X1 by 80 percent to RMB99 (US$14) from RMB499 (US$70); it sold one million units at this price.[27]

It is possible that these discounted prices may not be sustainable in the long term, constraining demand. Already, smart speakers are something of a luxury item; ownership or access to smart speakers in the United Kingdom was twice as high among individuals earning more than £50,000 (US$65,250) than those below that threshold.[28] It may be that for those on lower incomes, a smart speaker would

need to be very useful indeed to become a must-have product, especially if sold at full price. Some analysts have concluded that most smart speakers today may be being sold at cost or at a loss, based just on the cost of their components.[29] This suggests that there may be little further scope for the price of smart speakers to fall much further.

## It may be that for those on lower incomes, a smart speaker would need to be very useful indeed to become a must-have product, especially if sold at full price.

The demand curve for smart speakers may also be being somewhat artificially shaped by the integration, by default, of voice assistants into all wireless speakers. For instance, Sonos, one of the wireless speaker market's pioneers, now incorporates support for Amazon's Alexa across many of its products.[30] Buyers may be purchasing more expensive smart speakers primarily for their audio quality, with their voice assistant capability being

of relatively little value to them. Yet revenues for these higher-end devices would be categorized as smart speaker revenues, potentially flattering the revenue line.

The provision of free over-the-air upgrades may also dampen demand for upgraded smart speakers among existing owners. For example, additional language support can be installed through a software upgrade, making the device more useful, at no incremental cost to the user.[31]

Demand for smart speakers will likely be driven by utility. It is worth noting in this regard that, even though digital voice assistants, which are core to smart speakers, have been available on a range of devices for several years—and are installed on tens of billions of consumer devices today—the majority appear to be little used. According to Deloitte's research, most voice assistants on smartphones, tablets, and computers have *never* been used (figure 2). In fact, the only product type for which the majority of owners have used a voice assistant is the smart speaker, since they cannot be controlled without using the voice feature.

FIGURE 2

### Most smartphone, tablet, and laptop/desktop PC owners don't use these devices' digital voice assistants

Proportion of smartphone, tablet, and PC owners that have never used their device's/devices' digital voice assistant, 2018



Smartphone — 57%
Tablet — 71%
Laptop or personal computer — 81%

Base: All respondents age 18–75 residing in Australia (2,000), Canada (2,000), Germany (2,001), the United Kingdom (4,000), the United States (2,003); all respondents age 18–50 residing in urban China (2,000).
Source: Australia/Canada/China (urban)/Germany/UK/USA edition, Deloitte Global Mobile Consumer Survey, June 2018.

FIGURE 3

## Many people don't even know their smartphones have voice recognition

Daily device usage, 2018

■ Awareness (2018)  ■ Usage (2018)                    Year-on-year increase in usage

**Australia**
17%
3%                                                    1%

**Canada**
15%
4%                                                    2%

**Urban China**
39%
16%                                                   3%

**Germany**
24%
5%                                                    1%

**UK**
15%
3%                                                    1%

**US**
18%
6%                                                    -2%

**Overall (average)**
21%
6%                                                    1%
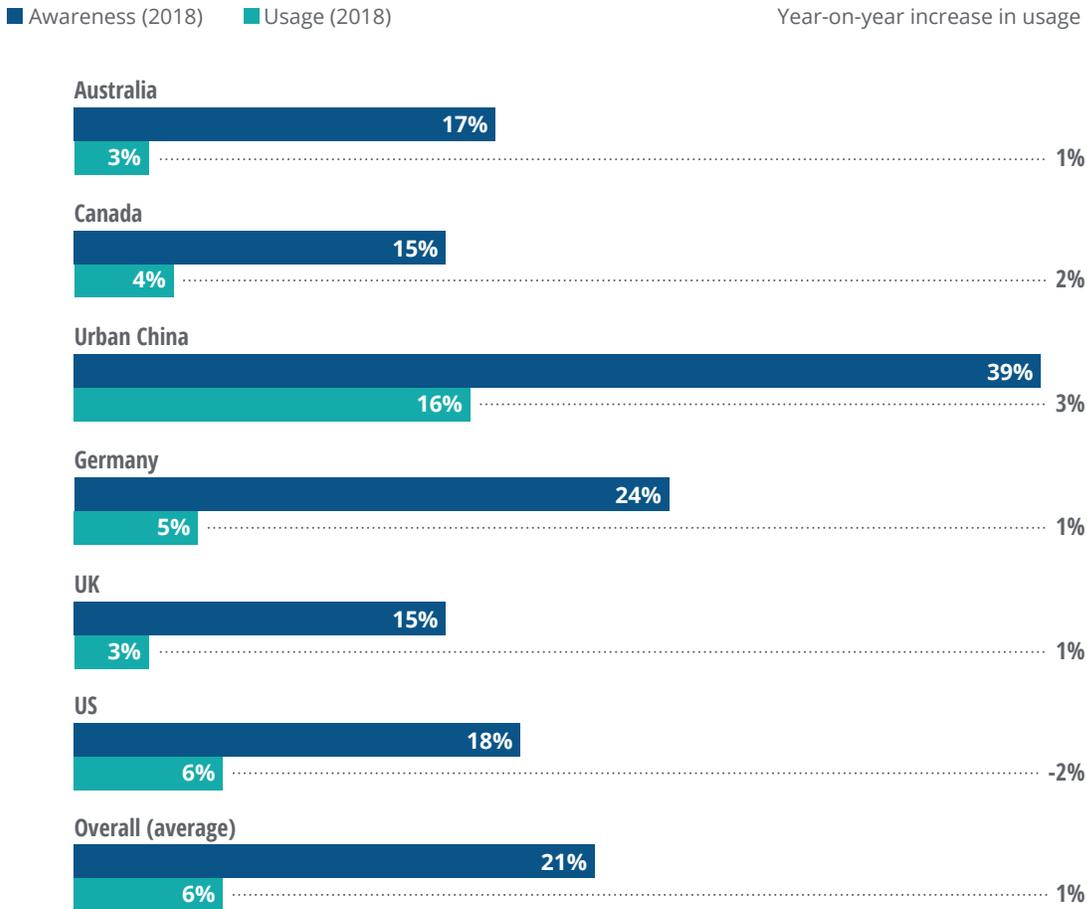
Base (2017/2018): Respondents aged 18–75 years residing in Australia (2,002/2,000), Canada (2,000/2,002), Germany (2,000/2,001), the United Kingdom (4,002/4,000), the United States (2,000/2,003); respondents aged 18–50 residing in urban China (2,001/2,000).

Source: Australia/Canada/China/Germany/UK/USA edition, Deloitte Global Mobile Consumer Survey, May–June 2017, June 2018.

The challenge is not just getting people to try out voice assistants, but their general (historic) disinterest in voice recognition per se. Figure 3 shows the extent of usage of voice recognition in a number of major markets. For all countries represented in the figure, smartphone penetration exceeds 75 percent. Yet awareness of the smartphone's voice recognition capability is low (averaging 21 percent), and usage is even lower (averaging 6 percent). And although usage is growing, it is only growing by 1 percentage point per year on average, and that is from a very low base.

One measure of utility is the frequency of usage. Here, smart speakers perform better, but only marginally better. In the six countries represented in figure 3, most smart speakers are used daily, but it is a slender majority. Indeed, based on a sample of countries with relatively mature smart speaker markets, these devices are only the seventh-most used device on a daily basis (figure 4).

FIGURE 4

## Smart speakers are the seventh-most-used device on a daily basis

Daily device usage, 2018
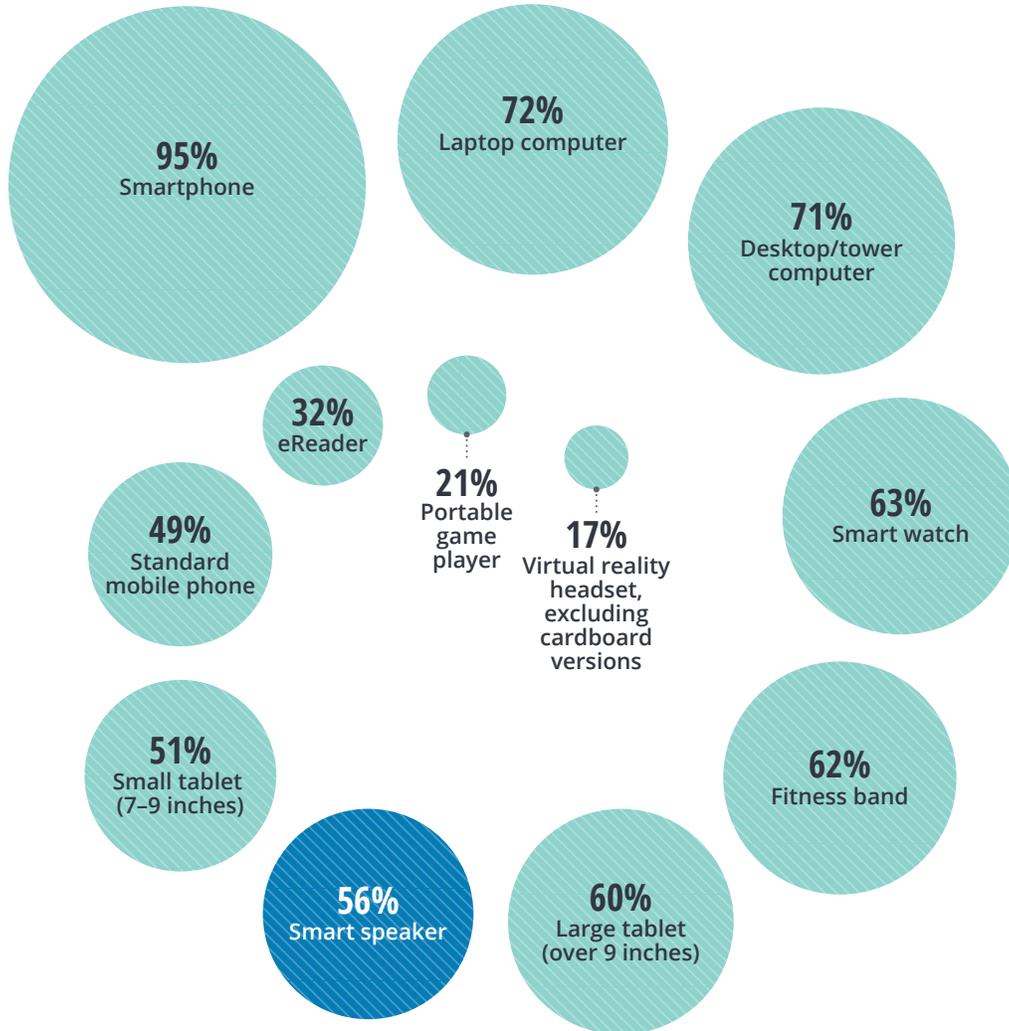


Base: All respondents aged 18-75 years. Standard mobile phone: 1,867. Smartphone: 12,221. Small tablet, 7–9 inches: 4,217. Large tablet, over 9 inches: 5,177. Laptop computer: 10,869. Desktop/tower computer: 7,565. eReader: 3,063. Smart watch: 1,528. Fitness band: 2,861, Portable game player: 2,275. VR headset: 854. Smart speaker: 1,855.
Source: Australia/Canada/China/Germany/United Kingdom/United States edition, Deloitte Global Mobile Consumer Survey, June 2018.

The smart speaker's usefulness also partly depends on the range of applications for which it can be used—or, often, how people *actually* use them. In most markets so far, they have most commonly been used to play music, which arguably is not that disruptive: Devices that emit sound have been around since the 19th century. In fact, De-

loitte research from mid-2018 showed that smart speakers' No. 1 application across five countries was to play music (figure 5)—except in Canada, where checking the weather was the top usage; in most other markets, weather was the No. 2 application. Possibly, checking the weather via a spoken command is an improvement over requesting the

FIGURE 5

**Smart speakers are most often used to listen to music—just like dumb speakers**

Top five applications of smart speakers, selected markets, 2018



| 60% | 52% | 39% | 39% | 38% |
| --- | --- | --- | --- | --- |
| To play music | For weather updates | To set alarms | To search for general information | For amusement |
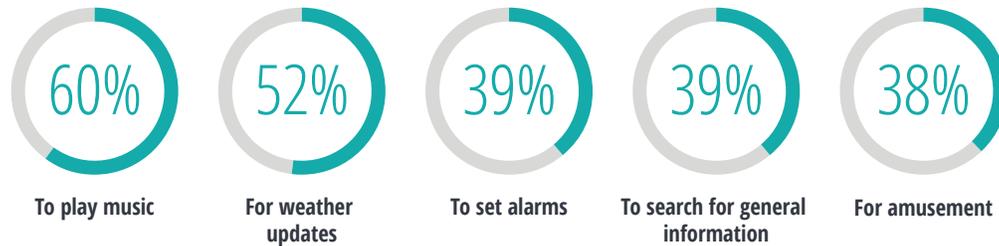
Base: Respondents aged 18–75 years who use a voice assistant on their voice-assisted speaker (661).
Source: Australia/Canada/China/Germany/United Kingdom/United States edition, Deloitte Global Mobile Consumer Survey, June 2018.

weather on a smartphone app, but is it enough of an improvement to drive smart speaker sales?

Some people may even prefer selecting music with an app to dictating the name of a track in a playlist. Given that smart speakers' third-most common use in several markets is setting up timers or alarms, the combination of music, weather, and alarm-setting makes smart speakers look much more like an updated bedside or kitchen radio than a fundamentally disruptive device.

**In most markets so far, smart speakers have most commonly been used to play music, which arguably is not that disruptive.**

# BOTTOM LINE

Smart speaker sales to both new and existing users should grow strongly in 2019, and also likely in 2020. For the market to continue growing beyond then, however, the device should have multiple applications beyond just playing music or speaking a weather forecast. It needs to become more useful, more often. More applications and better accuracy will likely be key to market growth.

Smart speakers are more than just another product category, however. They are also likely to serve as an important introduction to voice assistants. Indeed, in the medium term, one of the key roles that smart speakers may play is to increase people's familiarity with voice assistants, as well as to help improve voice recognition capabilities.

Smart speakers may provide the first experience many consumers—especially younger family members—have of voice recognition. Some people may be reluctant to use voice recognition technology on a smartphone, but may be willing to try out voice interfaces on a smart speaker in the seclusion of their homes. Once comfortable with the technology, these people may subsequently become more frequent users of voice recognition across a range of environments, from cars to connected homes to call centers. All major smart speaker vendors have their own digital assistants, and this core technology can be deployed in multiple types of devices.

Nor is this the smart speaker's only potential broader benefit. The more that smart speakers and other voice recognition devices are used, the better voice recognition will likely become. Seeding the smart speaker market with devices priced near cost may be the fastest way to generate billions of samples of dialogue that can be used to support ever better voice recognition capabilities across a wide spectrum of devices.

Smart speakers—and, more widely, voice assistants—will almost certainly find myriad applications in the enterprise space. The ideal situation for them is in a not-too-noisy room where someone has their hands busy. This does happen at home (while cooking or changing a baby, for instance), but not on the scale that it happens in operating rooms or on factory floors. Voice recognition will likely be an ideal way of mechanizing repetitive processes such as taking orders in a drive-in restaurant or reserving spaces in a shared office.

Considering all this, it is probable that, over time, people will end up talking to speakers (and other machines) much more than they do today. Voice may never become the dominant user interface with technology, but it is very likely to become a core one, particularly for those who are vision-impaired and/or may struggle with keyboards or small buttons. And while voice recognition does not work well in all contexts and environments, the same could be said of keyboards and mice, which cannot readily be used on the move and need two hands to operate, or touchscreens on smartphones and tablets which need at least one free hand to use.

While voice recognition can be challenging, the long-term benefits are significant. Whether on a speaker or any other device, voice recognition and voice assistants open up the benefits of computing to everyone. For the Web to be truly worldwide, there are two options: to make the whole world literate, or to offer voice-enabled computing to everyone. The latter approach may be easier.

# Endnotes

1. The sources for our forecast include Canalys, "Smart speaker installed base to hit 100 million by end of 2018," July 7, 2018, and David Watkins, "Smart speaker price tiers by units, ASP & value forecast by region 2014–2023," Strategy Analytics, July 5, 2018.

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4. Futuresource Consulting, "Wireless speakers command 75% of home audio shipments, smart speakers driving growth," January 9, 2018.

5. Canalys, "Smart speakers are the fastest-growing consumer tech; shipments to surpass 50 million in 2018," January 4, 2018.

6. In Germany, the smart speaker was the second-fastest growing device category after smart TVs. Deloitte, Australia/Canada/China/Germany/UK/USA edition, Deloitte Global Mobile Consumer Survey, June 2018. Base: All respondents aged 18–75 residing in Australia (2,000), Canada (2,000), Germany (2,001), the United Kingdom (4,000), the United States (2,003); all respondents aged 18–50 residing in urban China (2,000).

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16. Chris Welch, "The Wynn Las Vegas is putting an Amazon Echo in every hotel room," The Verge, December 14, 2016.

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20. Deloitte, "Deloitte Australia takes out AMY Grand Prix for Prince of Wales Hospital: DeloitteASSIST wins best digital idea," press release, accessed October 21, 2018.

21. Aftermarket dashboard-mounted smart speakers, such as Amazon's Echo Auto, are available. See Sasha Lekach, "Amazon brings Alexa into the car with Echo Auto," Mashable, September 21, 2018.

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25. For example, see Rick Broida, "Labor Day deal: Get 3 Amazon Echo Dots for $75," CNet, August 30, 2018; Natt Garun, "The best Google deals of Black Friday 2017: Google Home Mini, Chromecast, Google Wifi," November 22, 2017; and Brian Heater, "Echo Auto brings Alexa to cars," TechCrunch, accessed October 21, 2018.

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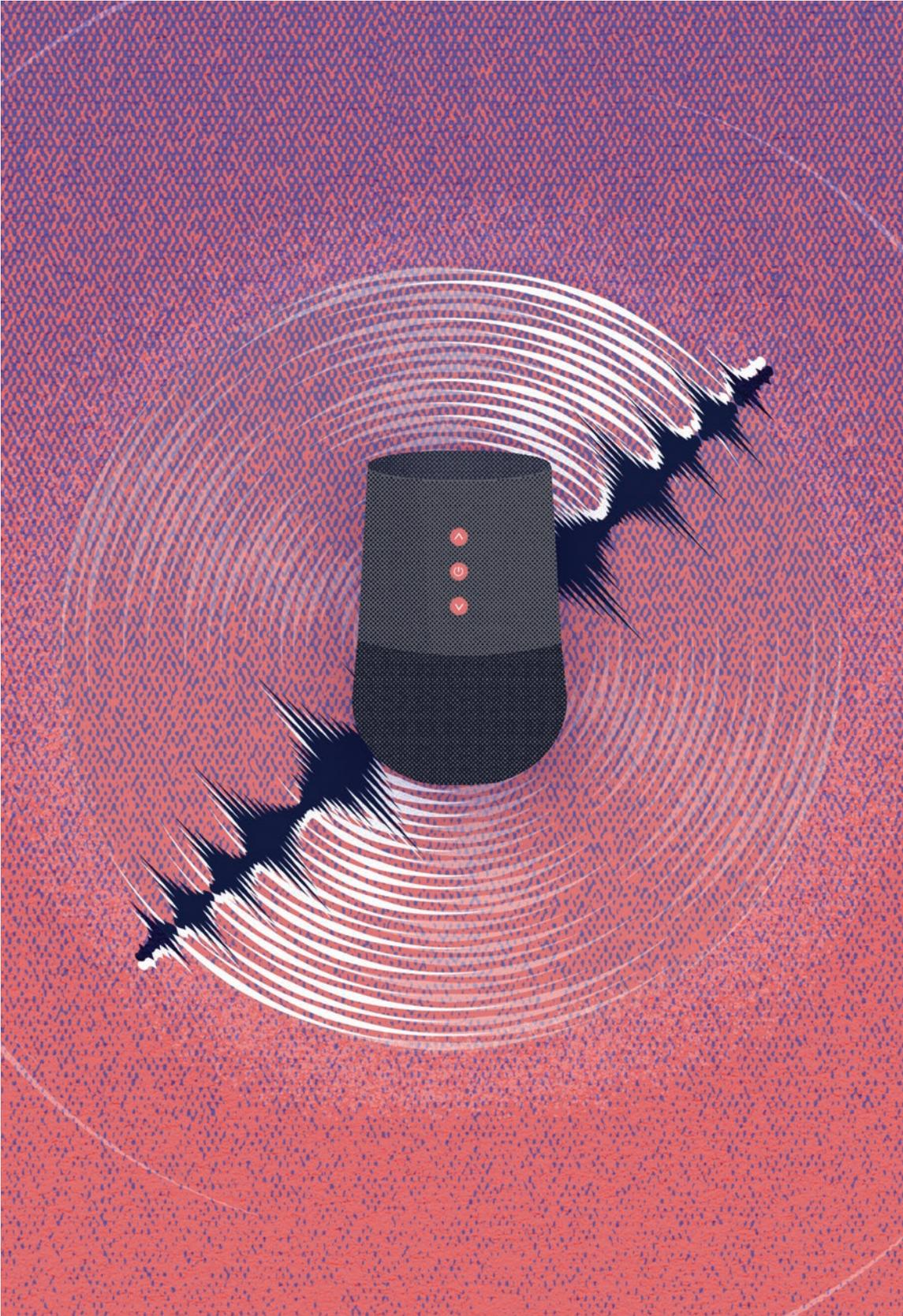
# Does TV sports have a future?

Bet on it

Duncan Stewart

DELOITTE GLOBAL PREDICTS that in 2019, **60 percent of North American men aged 18–34 who watch sports on TV will also bet on sports—and the more often they bet, the more TV sports they'll watch.**

Why should that matter to the broadcasting industry? Read on to find out.

Much of the up-front discussion in this chapter focuses exclusively on the United States, and sometimes Canada, because those are the countries for which we have recent data from a large Deloitte survey. But we look at the global implications and angles in the chapter's "Bottom line" section.

## TV sports: An island of strength in an industry under pressure

Young people around the world are watching less traditional TV (live or time-shifted TV, on any device) these days, but the sports category is an island of relative strength. One of the reasons for this is that young people, especially young men, are betting on sports matches, and watching on TV those contests where they have "skin in the game." In the United States, in fact, we predict that about 40 percent of all TV watching by men 25–34 years old will be driven by this factor.[1]

As an example of the relative resilience of TV sports, consider that, although 16–34-year-old men in the United Kingdom watched 42 percent fewer minutes of traditional TV per day in 2018 than in 2010—almost exactly the same percentage decline as among 18–34-year-olds of both genders in the US—traditional TV sports watching went down only 24 percent for the same demographic.[2] We expect roughly the same pattern to continue in many countries in addition to the United States and the United Kingdom, with variations in years that have the Olympic Games and the FIFA World Cup.

**MORE OF WHAT WE THINK WILL HAPPEN: 15 FURTHER PREDICTIONS ABOUT TV, TV SPORTS, AND SPORTS BETTING**

The scope of our research related to TV watching, TV sports watching, and sports betting makes it hard to resist formulating more opinions about what is likely to happen around these activities in the year ahead. For simplicity, we have categorized these 15 further predictions into those about TV watching in general, TV sports watching, sports betting, and the relationship between sports betting and TV sports watching.

### TV watching in general

1. Deloitte Global predicts that **more than 80 percent of US 18–34-year-olds will watch at least some TV in 2019** (that is, TV will have a "reach" of 80 percent among this demographic). Within this age group, men will be more likely to watch TV (more than 85 percent) than women (less than 80 percent).

2. Deloitte Global predicts, based on the multi-year downward trend for US 18–34-year-olds, that **this demographic will watch fewer minutes of traditional TV per day (live and time-shifted) in 2019** than in 2018—but they will still watch an average of around 120 minutes, or two hours, per day. The number of people who watch traditional TV will be about the same as in 2018 … they will just watch about 10 minutes less of it per day, on average.

3. Deloitte Global predicts that **not only will more 18–34-year-old US men than women watch TV in 2019, but they also will watch more hours of TV than women of the same age**. The median 18–34-year-old US male will watch about four hours more TV per week in 2019 than similarly aged US women—or approximately 16 hours for men and 12 hours for women.

4. Deloitte Global predicts that, although the average 18–34-year-old US man will watch about 16 hours of TV per week in 2019, **roughly one in four 18–24-year-old men will watch more than 30 hours per week, as will about one in three men age 25–34**.

*TV sports watching*

5. Deloitte Global predicts that **TV sports watching by 18–34-year-old US men will decline in 2019 compared to 2018—but only by about 5–7.5 percent**.

6. Deloitte Global predicts that **more than 60 percent of adult US men who watch TV will regularly watch sports on TV in 2019; around 40 percent of the US women who watch TV will do the same**. We further predict that these proportions will be lower among younger individuals, both men and women. "Only" half of 18–24-year-old US men who watch TV will regularly watch sports—and only a quarter of women that age who watch TV will regularly watch sports. However, proportionately as many 25–34-year-old TV watchers of both genders will watch about as much TV sports, on average, as all adults.

7. Deloitte Global predicts that, **of those who watch TV sports, the average 18–24-year-old US man will watch more than 11 hours of sports TV per week in 2019, while his 25–34-year-old male counterpart will watch about 16 hours of TV sports weekly**. Based on total TV watching rates, this suggests that TV sports will represent about two-thirds of all TV watching among 18–24-year-old men, and more than three-quarters of all TV watching for men age 25–34 who watch TV sports.

8. Deloitte Global predicts that a**bout 30 percent of US TV sports viewers aged 25–34 will be "superfans" in 2019, watching more than 21 hours of sports per week, and nearly 20 percent will be "super-superfans," watching more than 35 hours of TV sports per week** (five hours daily).

*Sports betting*

9. Deloitte Global predicts that **40 percent of US adult sports TV watchers will bet on sports at least occasionally in 2019**, with men of all ages more likely than women to bet. Further, Deloitte Global predicts that this gender disparity will be greater in the 25–34-year-old demographic: Less than 40 percent of female US TV sports viewers that age will bet on sports in 2019, but nearly three in four male US TV sports viewers that age will do so.

10. Deloitte Global predicts that **more than 40 percent of 18–34-year-old US men who watch TV sports will bet on sports weekly or more often in 2019**. In contrast, less than 15 percent of women that age will bet that often. Also, of all TV sports watchers who are 55–75 years old, less than 5 percent will bet weekly. In fact, half of all weekly sports bettors in the United States will be men age 25–34 who watch TV sports.

*The relationship between sports betting and TV sports watching*

11. Deloitte Global predicts that, in 2019, **more than half of all US and Canadian male sports viewers who bet on sports will be much more likely to watch games they have bet on**. This tendency will be even more pronounced among men aged 18–34 in both countries; more than two-thirds of these will be much more likely to watch a game they have bet on. Conversely, this effect will be less strong among US women, with less than half of women who both bet and watch sports being much more likely to watch games they have bet on.

12. Deloitte Global predicts that, in 2019, **those who bet on sports most frequently will be the most likely to watch the games they have bet on**, with three-quarters of individuals in the United States who bet on sports at least once per week watching the games they have bet on.

13. Deloitte Global predicts that **US sports watchers who bet weekly or more in 2019 will watch the most sports per week on TV (around 20 hours)**, and that they will watch sports twice as much as those who do not bet on sports.

14. Deloitte Global predicts that **betting and being a superfan or super-superfan will be closely linked**. More than a third of those who bet on sports at least weekly in the United States will be superfans, compared to only 10 percent of those who never bet; about a quarter of those who bet weekly will be super-superfans, watching TV sports more than five hours per day, compared to only 2 percent of those who don't bet.

15. Putting it all together, Deloitte Global predicts that **40 percent of all TV watching by US men aged 25–34 in 2019 will be of TV sports**, and their watching behavior will be heavily influenced by betting activity.

The stereotype is that men watch more TV sports than women, and our research confirmed that perception to be true. Forty-nine percent of 18–24-year-old men who watch TV in the United States watched at least one sports broadcast (including live sports, sports talk shows, and highlights shows) in 2018, compared to 26 percent of US women of the same age. Similarly, 64 percent of 25–34-year-old US men watched TV sports, while only 37 percent of US women the same age did (figure 1).

If we focus on male US TV sports-watchers between the ages of 18 and 34, we see that not only do they watch *some* TV sports, they watch a *lot* of TV sports. In the typical week, the median 18–24-year-old US man said he watched 1.66 hours of sports on the average weekday, 1.67 hours on the average Saturday, and 1.87 hours on the average Sunday (likely showing the impact of National Football

FIGURE 1

## As one might think, substantially more men than women watch sports on TV

Percentage of US TV watchers who watch sports, by age group and gender, 2018
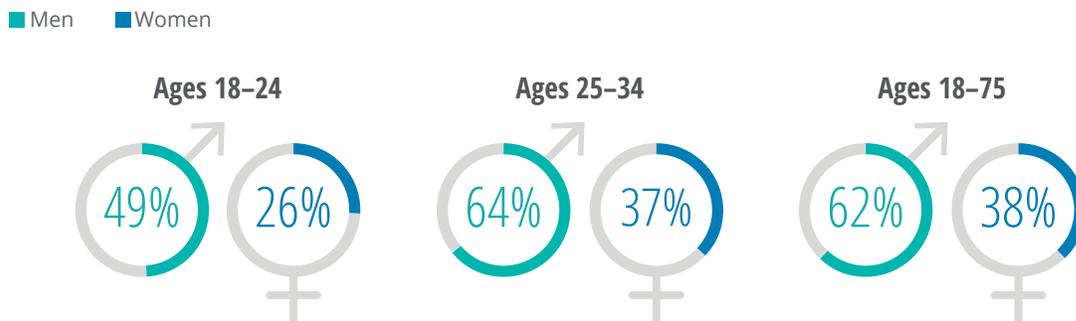


■ Men   ■ Women

| Ages 18–24 | Ages 25–34 | Ages 18–75 |
| --- | --- | --- |
| 49% 26% | 64% 37% | 62% 38% |

Note: 156 respondents were men aged 18–24, 143 were women aged 18–24, 223 were men aged 25–34, 301 were women aged 25–34, 659 were men aged 18–75 (this includes men aged 18–24 and men aged 25–34), and 403 were women aged 18–75 (this includes women aged 18–24 and women aged 25–34).
Source: Deloitte global survey, US data, August 2018.

League (NFL) football), a total of 11.8 hours per week. The median 25–34-year-old US male spent even more time watching TV sports: 2.33 hours on weekdays, 2.52 hours on Saturdays, and 2.66 hours on Sundays, for a total of 16.8 hours per week.

In fact, TV sports represents 64 percent and 74 percent of *all* TV watched by US men in the 18–24- and 25–35-year-old age groups, respectively. This is a straightforward calculation based on our finding that 18–24-year-old TV-watching US men spent a median of 18.5 hours a week watching TV (of any genre), and that 25–35-year-old US men spent a median of 22.7 hours a week watching TV.

Not surprisingly, there is also a hard core of fans who watch much more TV sports than average (figure 2). Twenty-two percent of the US men aged 18–24 who watch sports on TV, and 27 percent of the US men aged 25–34 who watch sports on TV, watch more than three hours of TV sports on a typical weekday; 20 percent and 30 percent, respectively, said they watched more than three hours of TV sports on Saturdays, and 23 percent of the younger group and 36 percent of the older group said they watched TV sports for more than three hours on Sundays. This suggests that about 22 percent of 18–24-year-old US male TV sports watchers, and about 31 percent of 25–34-year-old US male TV sports watchers, are consuming more than 21 hours of TV sports every week. We call this group "superfans"—individuals who watch more than three hours of TV sports on a typical day.

Nor is this the upper limit. Eighteen percent of male US TV sports watchers aged 25–34 qualify as "super-superfans": They typically watch more than *five* hours of sports TV every day, whether weekday, Saturday, or Sunday. Roughly one in five men in this age group watches more than 35 hours of TV sports per week. That translates to about 10 percent of the total 25–34-year-old US male population watching that much.

Some might be incredulous that anyone actually watches five hours of TV sports every day, and go on to wonder if such people are even attractive to TV advertisers. Interestingly, however, while about 6 percent of employed Americans who watched TV sports watched it for more than five hours on weekdays, only 3 percent of those without jobs did likewise. Affordability is a likely factor for this: It is easy to watch more than five hours of nonsports TV per day for free or a minimal cable bill … but watching five hours of TV sports often requires a premium cable package and more money.

FIGURE 2

## A nontrivial percentage of US men age 18–34 watch more than 21 hours of TV sports per week

Percentage of US male TV sports watchers who watch more than 21 or 35 hours of TV sports per week, by age group, 2018

■ Men age 18–24    ■ Men age 25–34

**More than 21 hours per week**

22%
31%

**More than 35 hours per week**

7%
18%
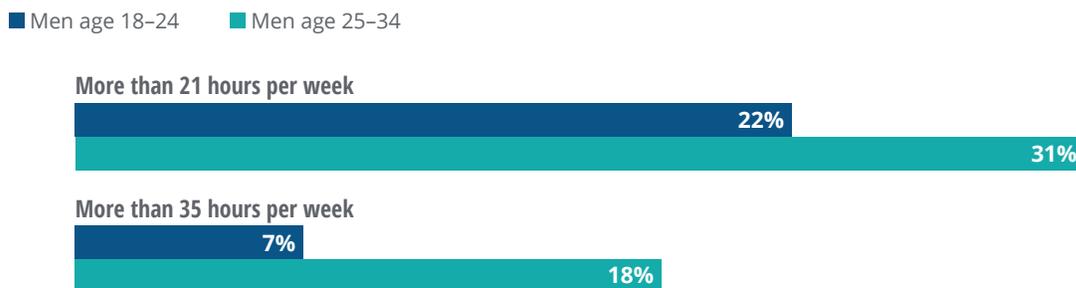
Note: The "more than 21 hours per week" category includes those individuals in the "more than 35 hours per week" category. Seventy-five respondents were men aged 18–24, and 139 were men aged 25–34.
Source: Deloitte global survey, US data, August 2018.

## Now, let's talk about gambling

Globally, gambling is a roughly half-trillion-dollar (USD) industry. Betting on sports tends to make up about 40 percent of the total market, or around US$200 billion per year. One report estimates that sports betting will grow at nearly 9 percent per year between 2018 and 2022.[3] In the United Kingdom in 2017, sports betting had £14 billion in turnover.[4] In the four Nordic countries, legal gambling of all kinds was an approximate €6 billion industry in 2015.[5] It is estimated (since measuring unregulated/illegal gambling precisely is difficult) that the "handle" (total amount wagered) for unregulated sports betting in the United States was US$169 billion in 2018.[6] Of that amount, one estimate posits that Americans bet US$93 billion per year (mostly illegally) on professional and college football.[7] For purposes of comparison, the US NFL made about US$14 billion in revenue from all sources in 2017[8] … which suggests that the wagering market for American football is possibly four to five times larger than all gate admissions and TV rights combined.

So, gambling on sports is a big deal. But what does this have to do with TV watching?

As can be inferred from the size of the US betting industry, gambling on sports is a widespread behavior. More than 25 percent of American men who watch sports on TV, regardless of their age, bet on sports at least once a year, and between 17 percent and 33 percent of American women do the same. About 40 percent of all Americans aged 25–34 (whether sports fans or not) bet on sports; among US men of that age who watch TV sports, that proportion rises to three-quarters. But although many American TV sports viewers are betting, they do not all do so with the same frequency (figure 3).

FIGURE 3

### Many US TV sports viewers also bet on sports

Percentage of US TV sports viewers who ever bet on sports, by age and gender, 2018
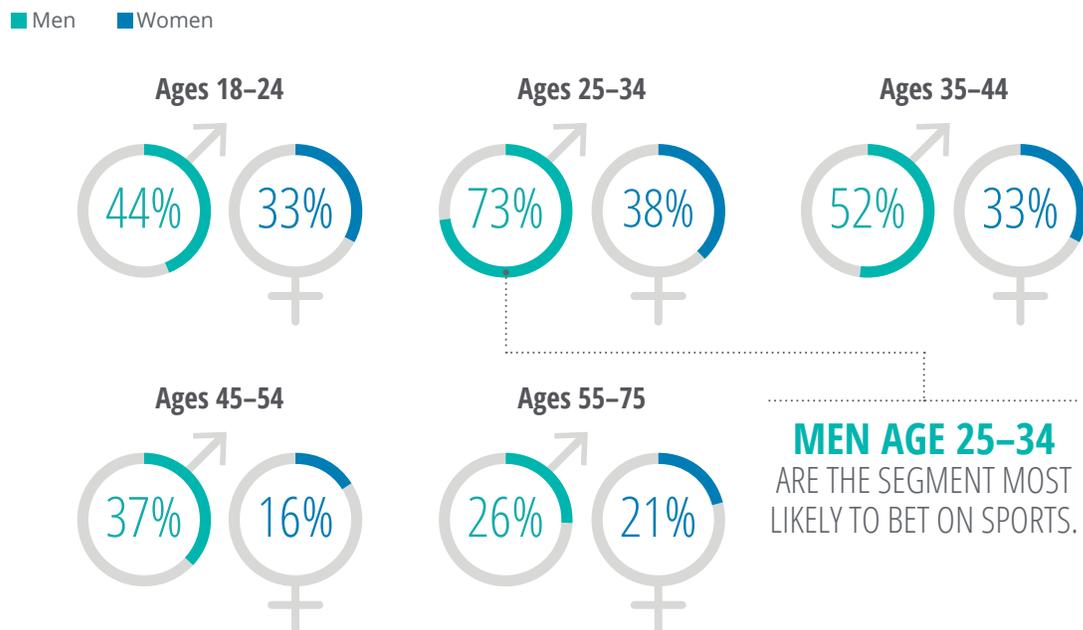
■ Men ■ Women



**Ages 18–24**  44% 33%
**Ages 25–34**  73% 38%
**Ages 35–44**  52% 33%
**Ages 45–54**  37% 16%
**Ages 55–75**  26% 21%

**MEN AGE 25–34** ARE THE SEGMENT MOST LIKELY TO BET ON SPORTS.

Note: 156 respondents were men aged 18–24, 143 were women aged 18–24, 223 were men aged 25–34, 301 were women aged 25–34, 659 were men aged 18–75 (this includes 18–24- and 25–34-year-old men), and 403 were women aged 18–75 (this includes 18–24- and 25–34-year-old women).
Source: Deloitte global survey, US data, August 2018.

FIGURE 4

## Regular betting on sports is concentrated among men age 25–34

Percentage of US TV sports viewers who bet on sports at least weekly, by age and gender, 2018

■ Men  ■ Women



**Ages 18–24**

14%  2%

**Ages 25–34**

43%  14%

**Ages 35–44**

20%  9%

**Ages 45–54**

8%  1%

**Ages 55–75**

4%  1%

**MEN AGE 25–34**
ARE THE SEGMENT MOST
LIKELY TO REGULARLY BET
ON SPORTS.
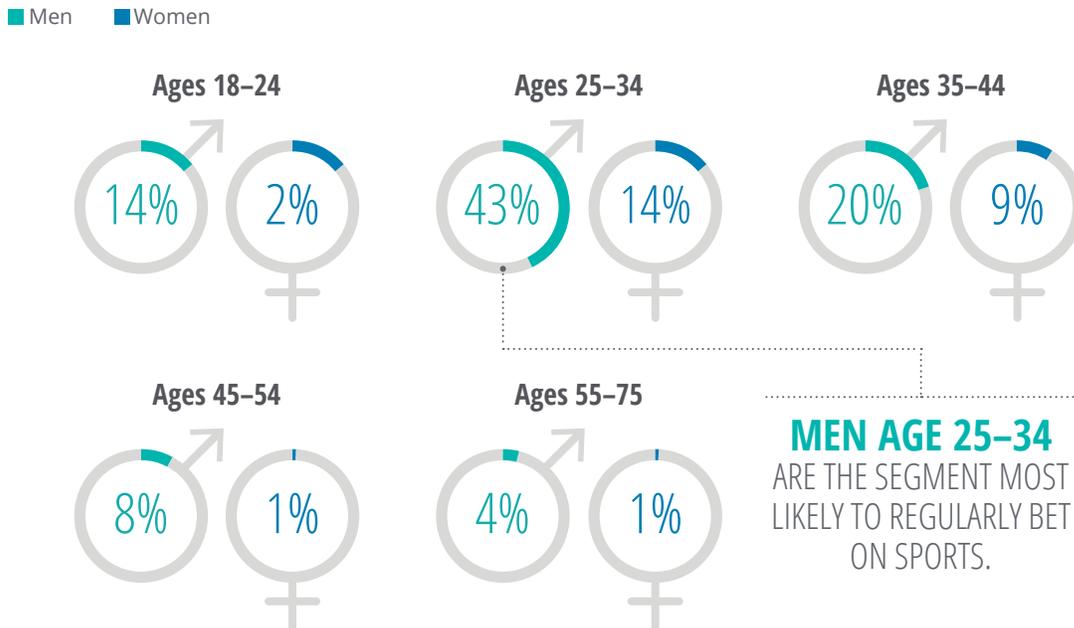
Note: 76 respondents were men aged 18–24, 36 were women aged 18–24, 140 were men aged 25–34, 111 were women aged 25–34, 96 were men aged 35–44, 69 were women aged 35–44, 126 were men aged 45–54, 79 were women aged 45–54, 186 were men aged 55–75, and 107 were women aged 55–75.
Source: Deloitte global survey, US data, August 2018.

As figure 4 shows, there is a remarkable pattern around TV sports watching and betting on sports. Although most Americans of all ages and both genders watch TV sports, and many of these bet on sports at least occasionally, regular betting on sports (once a week or more) is highly concentrated among men age 25–34. In fact, of all those who reported betting on sports at least weekly, 44 percent were men aged 25–34. Even more noteworthy, not only do 43 percent of men in this age group bet on sports

at least weekly, but 21 percent of those in that group who watch TV sports bet *daily*. In our sample, of all the people who say they bet on sports daily, more than half were men age 25–34, and 85 percent were men of any age. Only 15 percent of these heaviest bettors were women.

One might suppose that someone who has bet on a game would be more likely to watch that game than if he or she had not bet on it, and we find this to be the case (figure 5). As can be seen in Figure 5, more than half of all TV sports watchers in the US who bet on sports say that they are much more likely to watch a game they have bet on, and another 18 percent say they are a little more likely to watch a game they have bet on. When we drill down to 18–34-year-old men, more than two-thirds are much

## Although most Americans of all ages and both genders watch TV sports, regular betting on sports is highly concentrated among men age 25–34.

FIGURE 5

## Betting on a game prompts many people to watch it on TV

Influence of betting on a sports event on the likelihood of watching that sports event on TV, US respondents who both watch TV sports and bet on sports, 2018

■ Much more likely  ■ A little more likely

**Male sports watchers 18–24**
66%  24%

**Male sports watchers 25–34**
68%  17%

**All male sports watchers**
60%  18%

**All female sports watchers**
46%  18%
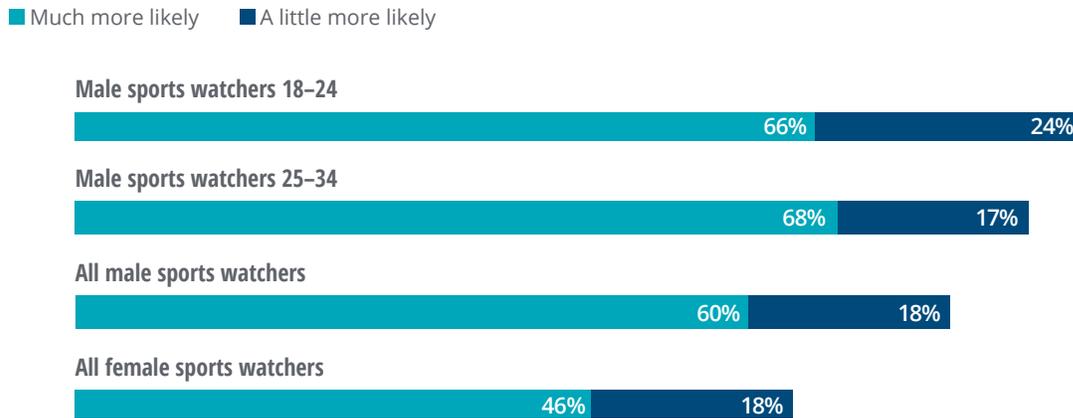
Note: 32 respondents were men aged 18–24, 100 were men aged 25–34, 274 were men aged 18–75 (this includes men aged 18–34), and 112 were women aged 18–75.
Source: Deloitte global survey, US data, August 2018.

more likely to watch games they have bet on, and 85 to 90 percent are at least somewhat more likely to watch such games. Here again, there is a gender divide, with a smaller percentage of female than male sports viewers saying they are more likely to watch a game because they have bet on it.

Although one might think that the likelihood of watching a game that one has bet on would have nothing to do with how often one bets on games, that does not seem to be true. Instead, there is a

fairly linear relationship between the likelihood of watching a game one has bet on and the frequency of betting on games overall (figure 6): As the frequency of betting increases, so too does the probability or propensity that the bettor will watch the game on TV. To be clear, more than half of all sports bettors, regardless of how often they bet, say they are much more likely to watch the games they have wagered on—but that proportion rises to nearly three in four for the most frequent bettors as opposed to "only"

FIGURE 6

## The more often people bet on sports, the more likely they are to watch a game they have bet on

"Much more likely" to watch a TV sports event that has been bet on, those who both watch TV sports and bet on sports, all ages and both genders, United States and Canada, 2018

■ United States  ■ Canada

73% 59%
**Bet at least weekly**

70% 55%
**Bet at least monthly**

62% 49%
**Bet at least biannually**

60% 49%
**Bet at least annually**

56% 45%
**Bet ever**

Note: Among the US respondents, there were 129 weekly, 185 monthly, 263 biannual, 323 annual, and 386 "ever" bettors. Among the Canadian respondents, there were 102 weekly, 166 monthly, 235 biannual, 257 annual, and 306 "ever" bettors.
Source: Deloitte global survey, US and Canada data, August 2018.

56 percent for infrequent wagerers. This phenomenon holds for all ages and both genders. As can be seen in the same figure, the same relationship is evident in Canada, although it is a little more muted than in the United States.

The propensity to watch the games one has bet on based on frequency of betting seems to translate directly into more hours per week of watching sports on TV (figure 7). Considering all of the sports viewers in the United States (including bettors and nonbettors) as a single group, we know that they watch about 12 hours of sports per week—but those who never bet on sports average just over 10 hours while those who bet weekly or more average more than 20 hours, or almost exactly twice as much as those who don't bet at all. Again, the relationship seems highly linear: As gambling frequency goes up, so does weekly viewing time. Also notable is that the "gambling effect" is much more noticeable for weekday TV sports watching. On weekends, the most-frequent bettors watch about 6.4 hours of TV sports over the two days, or 60 percent more than the approximately four hours spent watching sports TV by nongamblers. But on weekdays, nongamblers watch TV sports for an average of only 1.25 hours daily, while the heaviest gamblers watch 2.8 hours, or 160 percent more. To put it simply, it appears that weekend TV sports has broader appeal, while weekday TV sports appeals more to the hard-core

FIGURE 7

## In the United States and Canada, betting on sports drives more hours spent watching sports on TV

Mean weekly hours spent watching TV sports, by betting frequency and day of week, all TV sports watchers in the United States and Canada, 2018
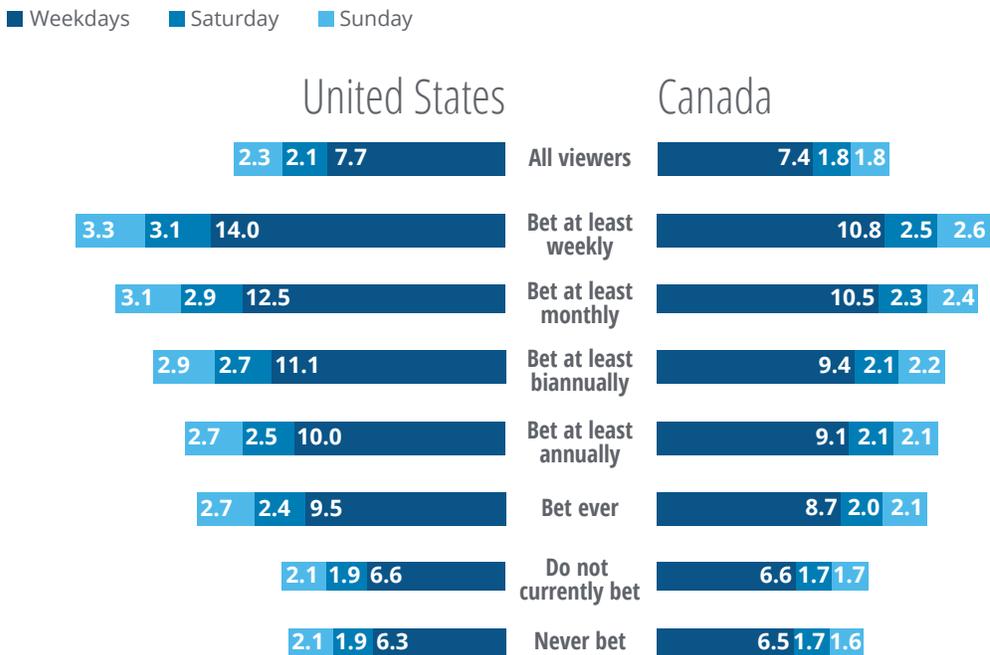
■ Weekdays ■ Saturday ■ Sunday

| | United States | | Canada |
|---|---|---|---|
| All viewers | 2.3 / 2.1 / 7.7 | | 7.4 / 1.8 / 1.8 |
| Bet at least weekly | 3.3 / 3.1 / 14.0 | | 10.8 / 2.5 / 2.6 |
| Bet at least monthly | 3.1 / 2.9 / 12.5 | | 10.5 / 2.3 / 2.4 |
| Bet at least biannually | 2.9 / 2.7 / 11.1 | | 9.4 / 2.1 / 2.2 |
| Bet at least annually | 2.7 / 2.5 / 10.0 | | 9.1 / 2.1 / 2.1 |
| Bet ever | 2.7 / 2.4 / 9.5 | | 8.7 / 2.0 / 2.1 |
| Do not currently bet | 2.1 / 1.9 / 6.6 | | 6.6 / 1.7 / 1.7 |
| Never bet | 2.1 / 1.9 / 6.3 | | 6.5 / 1.7 / 1.6 |

Note: Of 1,062 US TV sports watchers surveyed, 129 bet at least weekly, 186 at least monthly, 266 at least biannually, 362 at least annually, 486 had "ever" bet, 653 did not currently bet, 563 never bet, and 13 did not know (not shown). Of 964 Canadian TV sports watchers surveyed, 111 bet at least weekly, 178 at least monthly, 257 at least biannually, 280 at least annually, 418 had "ever" bet, 621 did not currently bet, 534 never bet, and 12 did not know (not shown).
Source: Deloitte global survey, US and Canada data, August 2018.

watchers—and gambling or not gambling on the games makes a bigger difference.

Not only does the average time spent watching TV sports rise as betting frequency rises, but we also see a direct and linear relationship between betting frequency and being what we call a TV sports superfan (figure 8). Only 10 percent of those who never bet on sports are weekday superfans, watching more than three hours of TV sports on weekdays. Among those who bet most frequently, that proportion rises to 35 percent—3.5 times more than those who don't bet at all. (We are focusing on weekday watching behavior in this paragraph, on the assumption that many Americans and Canadians—bettors and nonbettors—watch TV sports on the weekends when they have more free time, but

that those who watch three or more hours of TV sports on weekdays are particularly interesting to broadcasters and sports leagues.) Again, the results from Canada parallel the US results almost perfectly, adjusting for the slightly lower tendency to watch TV sports in Canada.

The betting effect is even stronger when it comes to weekday super-superfans (figure 9). Those who watch more than five hours of TV sports per weekday are split sharply along the gambling line: Only 5 percent of all US sports TV watchers watch it for five-plus hours on the typical weekday; only 2 percent of nonbettors do so, but a whopping 23 percent of those who bet on sports weekly or more often—10 times more than the non-gamblers—qualify as weekday super-superfans.

FIGURE 8

## Weekday superfans: Betting on sports is associated with watching sports on TV for more than three hours on a typical weekday

Percentage of TV sports watchers who watch more than three hours of TV sports on a typical weekday, by betting frequency, United States and Canada, 2018
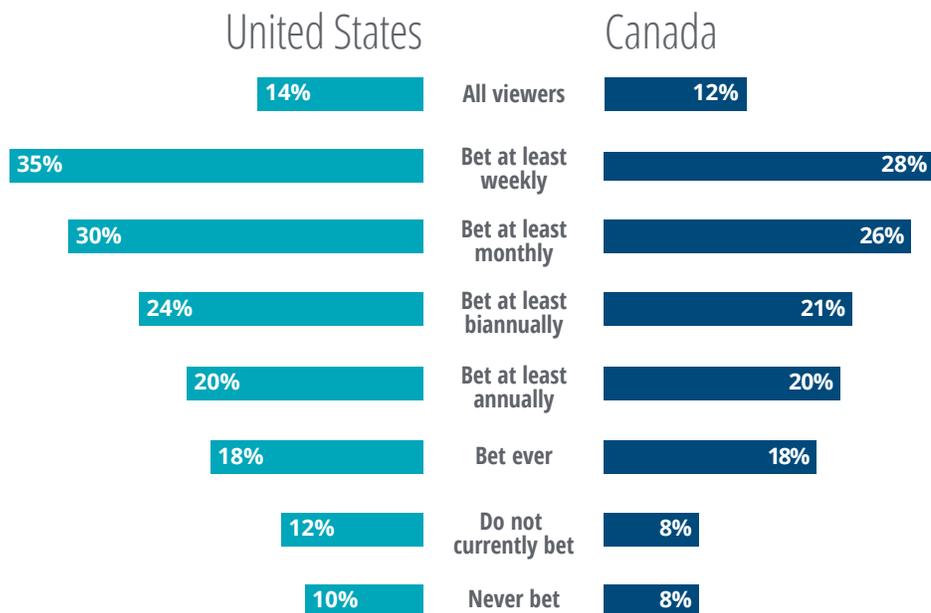
| | United States | | Canada |
|---|---|---|---|
| All viewers | 14% | | 12% |
| Bet at least weekly | 35% | | 28% |
| Bet at least monthly | 30% | | 26% |
| Bet at least biannually | 24% | | 21% |
| Bet at least annually | 20% | | 20% |
| Bet ever | 18% | | 18% |
| Do not currently bet | 12% | | 8% |
| Never bet | 10% | | 8% |

Note: Of 1,062 US TV sports watchers surveyed, 129 bet at least weekly, 186 at least monthly, 266 at least biannually, 362 at least annually, 486 had "ever" bet, 653 did not currently bet, 563 never bet, and 13 did not know (not shown). Of 964 Canadian TV sports watchers surveyed, 111 bet at least weekly, 178 at least monthly, 257 at least biannually, 280 at least annually, 418 had "ever" bet, 621 did not currently bet, 534 never bet, and 12 did not know (not shown).
Source: Deloitte global survey, US and Canada data, August 2018.

FIGURE 9

## Weekday super-superfans: Betting on sports is associated with watching sports on TV for more than five hours on a typical weekday

Percentage of TV sports watchers who watch more than five hours of TV sports on a typical weekday, by betting frequency, United States, 2018
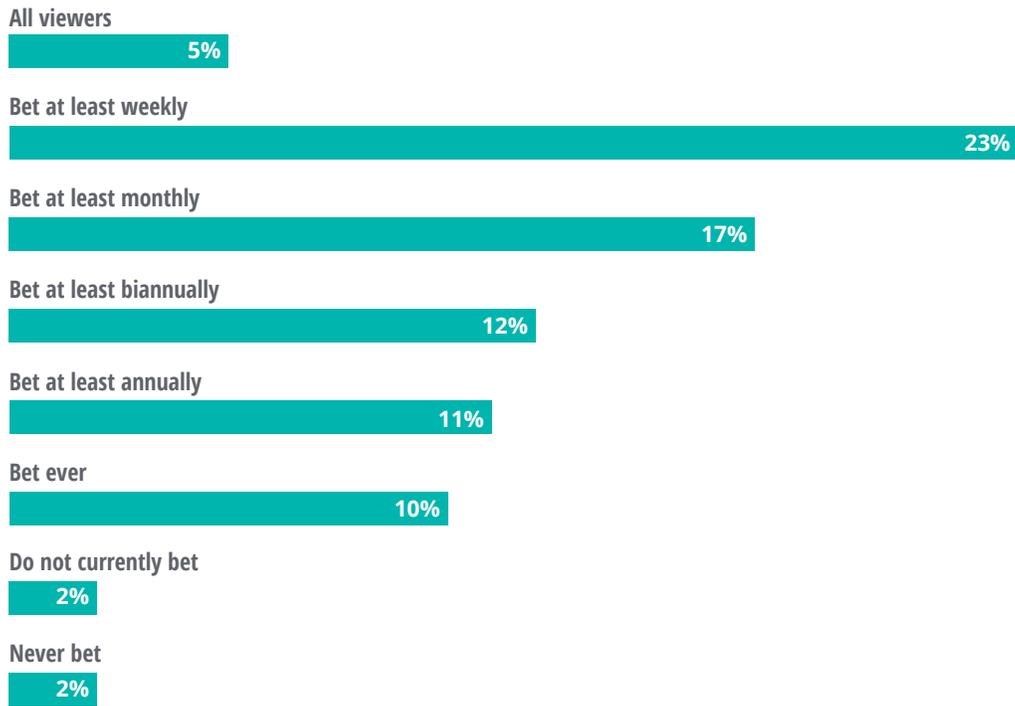
**All viewers**
5%

**Bet at least weekly**
23%

**Bet at least monthly**
17%

**Bet at least biannually**
12%

**Bet at least annually**
11%

**Bet ever**
10%

**Do not currently bet**
2%

**Never bet**
2%

Note: Of 1,062 US TV sports watchers surveyed, 129 bet at least weekly, 186 at least monthly, 266 at least biannually, 362 at least annually, 486 had "ever" bet, 653 did not currently bet, 563 never bet, and 13 did not know (not shown).
Source: Deloitte global survey, US data, August 2018.

# BOTTOM LINE

It will be little surprise to most that young men watch a lot of sports on TV, that they watch more sports than women do, or that they gamble. What is new is how important TV sports watching is for men aged 18–34, how frequently some of them gamble, and how close the relationship is between gambling frequency and watching more TV sports. Broadcasters, distributors, and advertisers could do well to undertake further research to examine this relatively unexplored correlation.

It seems probable that this driver of TV watching may make TV watching more resilient than some critics expect. Live TV sports watching motivated by gambling may boost overall TV-watching statistics among younger demographics, either slowing the decline somewhat, or perhaps even providing a floor.

That said, the "gambling effect" on TV sports watching may show significant variation by country. Even between the United States and Canada, two markets that tend to be very similar, the relationship between TV sports watching and gambling showed small but important differences. Based on focus group studies done by Deloitte France and Deloitte Nordics, we would expect the relationship between gambling and TV sports watching among men aged 18–34 to be much higher in North America than in France,[10] but possibly similar to that in North America in the Nordic countries—especially in Norway and Finland, where more than 60 percent of the young men in our focus groups engaged in gambling. Interestingly, in the Nordics, women aged 18–34 were much less likely to gamble (on anything, not just sports) than women of that age in North America. In countries with less of a gambling culture, it seems likely that TV sports, and TV watching itself, may be less resilient.

Indeed, it is interesting to speculate in which countries the "gambling effect" on TV sports watching might be stronger than in others. Examining gambling behavior in different countries may hold a clue. A 2016 study looked at per-capita gambling losses, which correlate well with total gambling activity, in selected countries.[11] The study showed that, while the United States and Canada reported per-capita gambling losses of US$400–500, Australia, Singapore, Ireland, Finland, and New Zealand's per-capita gambling losses were at or above US or Canadian levels, nearing US$1,000 per capita in Australia. Based on these findings, it would seem reasonable to infer that sports betting could be a large factor in driving TV sports watching in these countries.

Although all markets matter, the US TV market, at around US$250 billion per year (for TV broadcasters and distributors),[12] is the largest, and TV sports is a big part of that market. Even though most of the sports gambling that occurs is illegal and unregulated in the United States, it still has a large impact on TV-watching behavior. Also, the US Congress is currently reviewing gambling laws,[13] and any measures that allow Americans to gamble more easily or more often could have an effect—likely a positive effect— on TV sports watching. Consider that a 2015 study by the American Gaming Association concluded that millions more US football fans would bet on NFL games if gambling were legalized—and that, if sports betting were legal, sports bettors would represent 56 percent of all minutes watched of regular-season NFL games.[14]

It's hard to escape the conclusion that companies that make and distribute TV sports should talk more to, partner with, or even acquire those companies that are involved with sports betting. Or vice versa. It is clear from our research that the two industries, at least as far as American men 18–34 years old are concerned, are not sitting in splendid isolation.

For those worried about problem gambling, it is worth noting that we do not believe that the size of the bet matters much. Although our survey asked about betting frequency rather than wager size, in the focus groups where we developed the survey, we heard from participants that the *amount* they bet on a game was more or less irrelevant to their increased propensity to watch it. Bettors were equally more likely to watch a game that they had bet (say) US$10 on as a game they had bet US$50 on. This means that, although the gambling industry makes most of its money from "whales" (those who bet heavily), sports broadcasters and distributors need only think about driving sports viewing by tapping into increased betting frequency. They don't need to encourage *large* bets to do that.

Where will all this lead? As a thought experiment, one can imagine a 30-year-old American man in the year 2025 (yes, it could be a woman too, but our survey results show that it is *much* more likely to be a man) watching a football game on the TV set, smartphone in hand. He can bet on the match at any point, modify his wager, buy back a losing wager, bet on the outcome of individual plays or individual stats such as the number of passing yards by the quarterback—all in real time, and all tailored to him. Ads could be served that are customized for him, informed by his betting and attention, and watching would have to be 100 percent live. The broadcaster or betting site could not only charge more for ads seen by such an involved viewer, but even have a share in (or own outright) the profits from the betting/video stream ... at margins much higher than the usual for TV broadcasting. To an American, this sounds like science fiction, but in the United Kingdom, these solutions (or variations of them) are available today.

Will this come to America? Will young men use it? Will it drive increased watching of live TV sports matches?

We would bet on it.

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# On your marks, get set, game!
## eSports and the shape of media in 2019

Chris Arkenberg

ELOITTE GLOBAL PREDICTS that **in 2019, the North American market for eSports will expand by 35 percent, driven by advertising, broadcast licensing, and franchise sales**. The global eSports market will grow a bit more slowly due to the maturity of Asian leagues and uncertainty in China's growing regulatory response. In 2018, overall eSports revenue saw a considerable boost from the introduction of the first North American franchise leagues. Investors paid up to US$20 million to launch a league team.[1] In 2019, existing leagues will expand,

and new leagues could launch under other top game titles, all generating significant revenue for leading game companies.[2]

Indeed, Deloitte Global predicts that **in 2019, the new North American franchise leagues for Overwatch, NBA2K, and League of Legends will expand into major US cities**, following the model for professional sports. This will help draw more fans and players, making them even more attractive to broadcasters. Overall, analysts expect reported revenues from the global eSports market to reach US$1 billion in 2019, driven by advertising, broadcast rights, and league expansion.[3] But how much more can it grow?

Granted, eSports have momentum, especially with young demographics, perhaps most visibly in the Epic Games battle-royale phenomenon Fortnite, with the largest payer base and the biggest audience.[4] In the month of August 2018, Epic Games hosted 78.3 million Fortnite players.[5] In the first week of that same month, viewers on the social streaming platform Twitch watched an aggregate 28.5 million hours of Fortnite play.[6] But as more broadcasters spend to fit eSports into their programming, they may learn that eSports—and the video game platforms on which the industry is built—are more complex than they appear.

## The appeal of eSports

eSports are competitive online video games with a professional league structure. The global eSports industry includes numerous game titles, leagues, and players competing on PCs, gaming consoles, and mobile devices. While the eSports industry itself is still young, it represents a confluence of contemporary digital services and user behaviors.

People are consuming more media than ever, but how they engage with entertainment continues to evolve.[7] Consumption has become more fragmented across devices, platforms, and content

services, particularly among the 18–34-year-old demographic.[8] More content is being viewed through the web, smartphone apps, and social networks.[9] Americans still consume a lot of TV, but the number of overall subscribers is declining.[10] Likewise, the number of 18–34-year-olds who watch any TV in an average week has declined 10 percent since 2016, to 77 percent.[11] Media analytics company *Nielsen* also found that 18–24-year-olds are less likely to watch professional sports on TV than older generations.[12] For broadcasters, the salient point is that while linear TV viewership remains large, the changing behaviors can be worrisome, especially among young digital natives.

## Consumption has become more fragmented across devices, platforms, and content services, particularly among the 18–34-year-old demographic.

Could eSports help traditional TV broadcasters recapture young audiences? In 2018, Disney, ESPN, and ABC bought a multiyear license from Blizzard Entertainment to broadcast games and content for the eSports hit Overwatch.[13] The game, a frenetic first-person shooter pitting two teams of six players against each other, is one of the world's most popular eSports, with an estimated 40 million-plus people playing the game.[14] During the three nights ESPN broadcast the Overwatch League finals, the network saw a peak viewership of 358,800 Nielsen TV households, a little lower than for its popular show SportsCenter, which aired just prior to the closing Overwatch final.[15]

ESPN may bank on the size of its audience to draw high eSports numbers, but it is still unclear how many viewers were merely curious, how many were existing eSports fans, and how many would watch again. Twitch counted 350,000 individual viewers for the same Overwatch finals but it's not a simple comparison.[16] The Twitch channel Over-

watch League commands over a million viewing hours each week, with approximately 1,300 other Twitch channels broadcasting Overwatch play at any given time.[17] This is fundamentally different from linear TV, and it creates an uncertainty for broadcasters: Can traditional TV capture the full eSports experience?

## Sports, video games, and eSports

Back in 2014, 40,000 South Koreans filled a stadium in Seoul to watch the League of Legends World Championship.[18] Millions there were regularly watching eSports leagues and professional teams on TV. Internet cafes—called PC-bangs—became focused on supporting online video games with affordances catering to the young customers.[19] Big Korean brands became regular sponsors.[20] And the PC-bangs are still filled with gamers. China has followed suit, growing to become the second-largest eSports market in revenues behind North America.[21]

This trend is not lost on the business of professional sports. Teams, players, and executives have all been investing in eSports.[22] These traditional sports stakeholders see an opportunity in eSports to not only expand professional sports as a domain but to also play a role in what has become a new competitive spectacle. In fact, professional sports franchises may be uniquely positioned to expand the reach of eSports, especially in the less-mature European and North American markets. Leagues have helped coordinate strong ecosystems of stakeholders in media, merchandising, ticketing, and venues, all committed to sustaining year-round engagement with their sport. They have built durable franchises with regional anchors sustained by competition, human interest, and the drama that swirls around the road to championship. And they offer support to developing athletes and install protections to safeguard their

wellness—something that will likely become more important as more careers are tied to eSports.

These same elements—from media and merchandising to competition, human interest, and championships—are also native to eSports. It's just that they have not yet been orchestrated into high-performing ecosystems, at least in North America and the European Union. The National Basketball Association's NBA2K franchise league in the United States is an early effort to do so, and 2019 will almost certainly see more activity from professional sports working to expand their audiences and the definition of *sport* itself.

An eSports league and its road to the championship would seem like a simple fit for broadcast TV. And broadcasters would do well to continue their efforts to bring eSports into their programming. But linear broadcasters may find it difficult to grow their audience given the many millions of people watching eSports through social streaming services like Twitch and YouTube Gaming. Original programming—dramatic documentaries about top teams, for instance—may bring more TV viewers into the world of eSports but may not draw existing fans accustomed to engaging directly with top players through social media and streaming platforms. This can introduce the risk of cannibalization. Traditional TV viewers who become interested in eSports may themselves switch to social streaming platforms for a more direct experience. Younger eSports fans also tend to show more sensitivity to advertising, and brands have faced challenges trying to reach them effectively.[23] These considerations all point to larger changes in the way people engage with entertainment.

**Linear broadcasters may find it difficult to grow their audience given the many millions of people watching eSports through social streaming services.**

As we will see, eSports are situated within an ecosystem of digital services and platforms that support immersive, interactive, and highly social entertainment. The top video game platforms are moving quickly to adapt to this new digital landscape and deliver entertainment, engagement, and monetization that meet the demands of a hyperconnected world.

## THE VIDEO GAME PLATFORMS THAT DRIVE ESPORTS

To better understand these changes, it's worth looking past the headline stories surrounding eSports to examine more closely the video game platforms that power the industry. While the global eSports market has not yet reached the billion-dollar mark, in 2017, revenues for the US video game industry were an estimated US$36 billion, growing 18 percent over the previous year.[24] In January 2018, the Epic Games phenomenon Fortnite: Battle Royale attracted over 2 million concurrent players; a month later, it recorded 3.4 million.[25] Fortnite's growth was at the expense of its direct competitor, Player Unknown Battlegrounds, which saw its dominance decline by 44.7 percent between January 2018, when it averaged 1.5 million players, and May of the same year, when the number of players dropped to 876,000.[26] Due to increasing competition, Valve Corp.'s battle arena game Defense of the Ancients 2 fell from a high of 1.2 million concurrent players in March 2016 to around 700,000 in July 2018.[27] Even back in 2014, Riot Games reported 27 million daily players for League of Legends.[28] These are the same titles grabbing the professional eSports headlines but most of their players are just doing it for fun.

These numbers and their trendlines are certainly notable, indicating the online video game market's large size as well as how fragmented that market is across top titles. Of course, an hour playing and socializing in an online video game is an hour not spent watching TV. And competitive video games seem to be grabbing more of those hours.

## eSports are different from TV: Inside an immersive experience

Top gaming companies have capitalized on digital transformation to deliver powerful platforms of engagement for very large user bases. In some ways, the biggest multiplayer videogames have evolved social networks into virtual worlds, complete with communications services, point-of-sale solutions, open-ended extensibility, social streaming ecosystems, and the ability to evaluate and modify play to maximize engagement.

**Videogames have evolved social networks into virtual worlds, complete with communications services, point-of-sale solutions, open-ended extensibility, and social streaming ecosystems.**

Unlike with traditional pro sports, game developers can continuously alter and update game play. They can add new weapons and modify the behavior of existing gear to fine-tune the balance of play.[29] They regularly introduce new game modes and character classes.[30] With centralized ownership and dominion over their digital platforms, game companies can innovate and experiment until they find approaches that advance engagement for both players and viewers—and if changes don't work, developers can easily roll them back.[31] This agility is made possible, in part, by upfront investments in robust and extensible platforms that enable developers to quickly and easily try new things. For players and audiences, the experience is regularly refreshed with novelty.

PLATFORM PLAYS

Some games are evolving to become full platforms with point-of-sale interfaces that further monetize engagement and extend game life. Many game titles now offer DLCs—downloadable content—that can be purchased to enhance gameplay. These can be anything from gear packs and accessories to new storylines and new game modes and capabilities. The revenue opportunity can be significant. Fortnite, for example, is free to play but nevertheless generated US$318 million in revenue in May 2018 alone—more than any free game before it.[32] Fortnite players can buy credits called V-Bucks and trade them for skill multipliers, wearable virtual costumes, and physical "emotes"[33] such as dances.[34] This lets players personalize the avatar they use when they play the game with others, underscoring the social nature of eSports titles. For US$10, players can purchase Fortnite's BattlePass, which gives them new challenges that are unlocked each week.[35]

## Broadcasters and many streaming video-on-demand players have resisted the calls to integrate messaging and social affordances around their content.

For the 2018 Overwatch League, Twitch partnered with Activision Blizzard to promote its Overwatch All-Access Pass, styled as a VIP experience for superfans. The pass included a changing VIP badge that players could wear in-game and in their Twitch chats, as well as multiple special skins and emotes.[36] Perhaps more interestingly, the pass gave users access to the Overwatch League Command Center, a second screen with alternative in-game camera views, backstage cameras, cameras with the player's PoV, and additional stats, all focused around the game-day livestream.[37]

This arrangement is notable for the level of control and collaboration required between partners. Each worked to tie the two platforms together to offer fans a high-value experience. Not only could fans show their status across the platforms—they could purchase greater control over how much of the game they could see, paying a fee for more cameras and deeper analytics. In 2019, the market will see just how much this approach has lifted revenues. If it works, such partnerships around fan engagement might become more common.

## The audience is on stage

For viewers, television has always been a passive experience. With eSports and online video games, by contrast, entertainment is highly social, immersive, and active. Many who watch eSports are also players. And many who play use social streaming platforms such as Twitch to broadcast their games to others. Top teams and players typically stream from their own accounts, engaging directly with their fans through chat. Engagement with online video game platforms is fundamentally a social experience.

In most cases, broadcasters and many streaming video-on-demand players have resisted the calls to integrate messaging and social affordances around their content. This relative lack of social enablement in the traditional TV experience may put it at a disadvantage in pursuing the eSports market. In popular online video games, players meet up and coordinate through the game. Communications platforms such as Discord and TeamSpeak make it easy for players to find each other and for teams to collaborate. Discord alone counts 145 million users in 2018, up from 45 million the year before, citing video games with strong team dynamics as a driver.[38] One of the largest makers of gaming headsets, Turtle Beach, claimed a 185 percent increase in net revenue

year-over-year in Q1 2018.[39] The company cites the growth of Fortnite and Player Unknown Battlegrounds as contributing factors, as well as the value of collaboration and the advantage of a greater ability to hear in-game audio cues.

These elements point to another key difference between eSports and traditional sports. Unlike the audiences for top TV events, the audiences for online video games are highly fragmented and distributed across numerous game titles and viewing channels. And yet one of the most valuable components of top-tier gaming platforms may be their ability to better understand the customer. TV audi-

## Digital analytics can help drive engagement

In eSports, audience engagement is all about optimizing both the viewing experience and the play—and because digital platforms can generate detailed analytics about usage, these analytics can deliver priceless insights on how to make that optimization happen. In 2018, SAP partnered with one of the world's most successful eSports teams, Team Liquid, to bring competition analytics into the team's gaming.[43] SAP has brought similar analytics capabilities to professional sports, and the company sees a new opportunity in the all-digital world of eSports. The company's approach to eSports analytics takes sabermetrics, the 20th-century method of evaluating baseball players' statistics and amplifies it into digital precision. Using its HANA platform, SAP will evaluate Defense of the Ancients 2 replay data to quickly show patterns and pitfalls in play.[44] These

**Unlike the audiences for top TV events, the audiences for online video games are highly fragmented and distributed across numerous game titles and viewing channels.**

ence counts are often approximations, but social streaming channels have total visibility into viewership.[40] They publish usage statistics instantaneously and publicly, enabling much greater transparency.[41] Game platforms likewise can instrument their interfaces to track purchasing and playing activity; this helps them to better understand engagement and set valuable advertising rates. Capabilities such as these become much more attainable when the value chain is mostly digital. Recognizing this, *Nielsen Media* recently partnered with *Activision* to obtain analytics from the game developer's eSports titles, and they also purchased the eSports market research firm *SuperData*.[42]

kinds of supporting services may further drive expansion of the eSports market.

This type of analysis is growing in value, and it is increasingly being used to gain insights into engagement, balance, and retention.[45] And analytical insights do more than benefit eSports teams. They can also drive learning for average players, helping them perform better and stay more engaged—all of which advances the value of online video gaming. Fundamentally, the similarities between eSports and professional sports will potentially make it easier to expand the broadcast viewing audience into new-but-familiar territory. The differences, however, will likely be either limitations or opportunities, depending on how broadcasters evolve and transform their services.

# BOTTOM LINE

The eSports phenomenon is large and growing. It offers traditional broadcasters an opportunity to access a young demographic of digital natives who are less engaged with TV and professional sports than previous generations. By adding key eSports events to their programming, broadcasters can get a better sense of how much of their existing audience will engage with this form of entertainment. eSports programing could also potentially offer additional advertising revenues, although broadcast executives might not see the upside they associate with professional sports content. Conversely, linear broadcasters could develop closer relationships with game platforms to bring some of their top media franchises into the games. Some popular eSports such as Fortnite may be particularly well suited to such high-profile marketing crossovers.

When making forays into eSports, broadcast companies should consider how they can minimize production costs to enable more lightweight experimentation and reduce risk exposure. By trying more things more quickly, they can better learn what works and what doesn't. This approach can be reinforced with better modeling, stronger market prediction, and a more global outlook on niche programming.

For savvy broadcast companies that are breaking out of the box and launching their own digital streaming services, understanding online video games offers a potential road map for developing stronger digital platforms that engage audiences around all of their content. Broadcasters that are rolling out digital streaming services should view this venture as an opportunity to better digitize customer engagement and sell to viewers more directly. Shifting from linear TV's mainly passive mindset to a more active and involved digital mindset can be the first step to getting closer to customers and keeping them engaged.

While linear solutions do remain viable with existing audiences, broadcasters should look to build more diverse portfolios that better align with macro shifts in consumer behavior. A contemporary broadcaster might have a linear service, a multichannel subscription video-on-demand solution, and a social streaming platform, all tied together with messaging and point-of-sale capabilities. With robust identity management across these touchpoints and a strong data analytics model underneath, broadcasters could transition more effectively and durably into the new landscape of entertainment.

The rise of social networks and, now, social streaming speaks to a deep human need. People often want to engage with entertainment together, whether physically or virtually. And this is one driver of the migration away from subscription TV, especially for young digital natives.[46] Broadcast and cable TV could better reach younger generations by becoming more social. Efforts to build network streaming services can help traditional players maintain their ground—but likely only if they incorporate ways for the audience to connect with others and share their content.

For better or for worse, media entertainment is becoming a participatory social experience, less something one *consumes* and more that something one *does*. It appears to be time for traditional media companies to get on board with getting online.

# Yallah play in the Middle East

Emmanuel Durou and Gaurav Govil

DELOITTE MIDDLE EAST predicts that the Middle Eastern[47] eSports market will experience double-digit revenue growth in 2019, driven primarily by the rise of local competition, sponsorship and broadcast licensing. As the region adapts to the future of entertainment, the Middle East will likely witness the emergence of eSports as a genre of widespread interest. The eSports industry, which is predicted to be worth approximately USD 1 billion globally[48] in 2019, currently generates more than 90 percent of its revenue in North America, Asia, and Europe.[49] In contrast, the Middle East region currently only captures a marginal share of the global market. However, the eSports industry is forecasted to grow globally at a compounded annual growth rate of approximately 20 percent between 2019 and 2021[50], with a high probability that the Middle East will contribute significantly to this growth. Due to the recent emergence of the eSports trend in the Middle East, the region has reached a significant turning point in the development of the eSports ecosystem. The local market is rapidly gaining momentum from both a demand and supply perspective, which will result in a surge in eSports popularity in the Middle East in the next few years.

The Middle East's notably large millennial population is a significant driver influencing the substantial growth in demand for eSports throughout the region. Millennials, who are amongst the leading consumers of video games in the world, comprise 30 to 50 percent of the population in Middle Eastern countries.[51] There are more than 60 million gamers[52] in the region; for example, 21 percent of Saudi Arabia's population play video games on a weekly basis[53] and their preferred games are FIFA, PlayerUnknown's Battlegrounds, League of Legends, Overwatch, Counter Strike and Fortnite. However, to date, very few players in the region have made a career out of eSports due to reasons such as the inability to monetize participation.

Regional gamers usually prefer to play in small-scale local competitions, which are increasing in frequency and scale across the Middle East. Despite this tendency to participate only in local competitions, some Middle Eastern eSports players such as Abdulaziz Alshehri of Saudi Arabia and Amer Al-Barkawi of Jordan have won substantial international prizes and have attracted sponsorships, in turn altering expectations and outlooks of competitive eSports participants in the region. In August 2018, Saudi Arabian gamer Mosaad Aldossary received USD 250,000 in prize money for winning the FIFA eWorld Cup grand finale, after having previously won the prize in 2015[54], proving that Middle Eastern eSports players have the potential to build international careers.

Middle Eastern governments are leaning towards economic diversification with a specific drive to develop the sports and entertainment sector in the region. This strong impetus to develop eSports can be explained by the growth of the regional gaming industry, which generated more than USD 3.2 billion in revenue in 2018 and is witnessing double-digit year-on-year growth. Last year, the Kingdom's General Sports Authority (GSA) launched the Kingdom's Sports Economy Strategy, which focuses on the development of a private sector-led sports economy, community engagement, and sports infrastructure development. Furthermore, the Saudi Arabian Federation for Electronic & Intellectual Sports (SAFEIS), founded in 2017, is driving the Kingdom's effort to increase the number of eSports events.

Since its inception, the Federation organized multiple events such as the GSA eSports Cup and the FIFA 18 eSports tournament. SAFEIS is also

taking the lead in establishing a regional ecosystem through the creation of the Arab Electronic Sports Federation. In parallel, the United Arab Emirates is aiming to become a regional hub for eSports competition, having recently announced the construction of the Middle East's first purpose-built eSports arena "X Stadium."

From a global perspective, international publishers are driving the creation of leagues and franchises to increase audiences and participation. Locally, publishers are also interested in capitalizing on this growing market but prefer to collaborate with local entertainment authorities to organize and sponsor locally-based competitions. With this in mind, the region has yet to witness the emergence of local franchises, despite attempts by SAFEIS to move the market in this direction with the creation of the eSport Saudi Football Professional League.

Telecom operators are also eager to capture a share of this market, both from a broadcasting standpoint and through hosting competitions using local servers. Up until now, servers used during regional competitions have been located outside the region, which has impacted latency and has affected the gaming experience.

The surge in the demand for eSports within the Middle East is driving the interest of local broadcasters. More than 75 percent of eSports' global audience is under the age of 35, and this audience is rapidly transitioning from linear broadcasters to the video-on-demand platform. With a majority of the regional eSports audience watching global eSports competitions using online streaming platforms (YouTube, Twitch etc.), these entities benefit from a preferential bias. Nevertheless, local broadcasters are considering tapping into this market to rejuvenate their audience, which in turn will increase the competition to distribute regional eSports content.

In 2017, OSN launched Ginx eSports TV, the Middle's East first eSports channel, broadcasting 24-hour competitive video gaming. Intigral, the video/content distributor owned by STC, recently launched Middle East Gaming, which organizes eSports events series in Saudi Arabia and aims to engage and encourage online participation between events through its digital platform. This year, the region will be introduced to Rawa.tv, the first eSports online streaming platform dedicated to the Middle East. Rawa.tv, a regional version of Twitch, will aim to broadcast localized content and organize competitions to support the development of a grassroots ecosystem.

Despite this range of activity in the region, monetization will remain a challenge for broadcasters, given the limited number of large-scale events across the Middle East, since only 2 percent of eSports events organized globally took place in the Middle East in 2018.[55] Additionally, local broadcasters struggle to attract advertisers. More than 60 percent of eSports revenue generated globally comes from advertising and sponsorship; therefore, it will be critical to appeal to these players to ensure the long-term sustainability of the regional eSports market.[56] At this stage, broadcasters should support the development of local events/leagues as a "proof of value." As the number of events in the region increases and broadcasters are able to demonstrate compelling metrics (e.g. audience figures, time spent watching competitions, etc.), this will de facto drive the interest of local advertisers and sponsors, ultimately reinforcing the development of the regional ecosystem.

Growth in the Middle Eastern eSports market is imminent. This growth is being driven by young demographics, local-based events, regional gaming talent, and broadcasters/sponsors entering into the market. Moreover, regional governments are playing a key role in setting up the foundation to support the development of eSports. Despite this positive momentum, large-scale monetization for broadcasters will remain a key challenge at this stage. To ensure long-term value creation, broadcasters will need to act as market catalysts by expanding their positioning across the value chain (e.g. event management, team sponsoring, etc.) and adapting to the rapidly evolving demands of its millennial audience.

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49. Middle East Gaming

50. New Zoo

51. World Bank, 2016 – Blended MENA (47%), KSA (44%), UAE (30%), Qatar (31%), Kuwait (36%), Bahrain (37%), Oman (36%).

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52. Lai

53. H&P Sports National Survey 2018

54. Arabian Business

55. New Zoo

56. New Zoo

# Radio
## Revenue, reach, and resilience

Duncan Stewart

ELOITTE GLOBAL PREDICTS that **global radio revenue[1] will reach US$40 billion in 2019**, a 1 percent increase over 2018. Further, Deloitte Global predicts that **radio's weekly reach will remain nearly ubiquitous**, with over 85 percent of the adult population lis-

tening to radio at least weekly in the developed world (the same proportion as in 2018), and reach will vary in the developing world. Combined, nearly 3 billion people worldwide will listen to radio weekly.[2] Deloitte Global predicts that **adults globally will listen to an average of 90 minutes**

FIGURE 1

## TV watching among young Americans is declining three times faster than radio listening

Daily minutes of viewing/listening, United States, TV and radio, 2014–2018
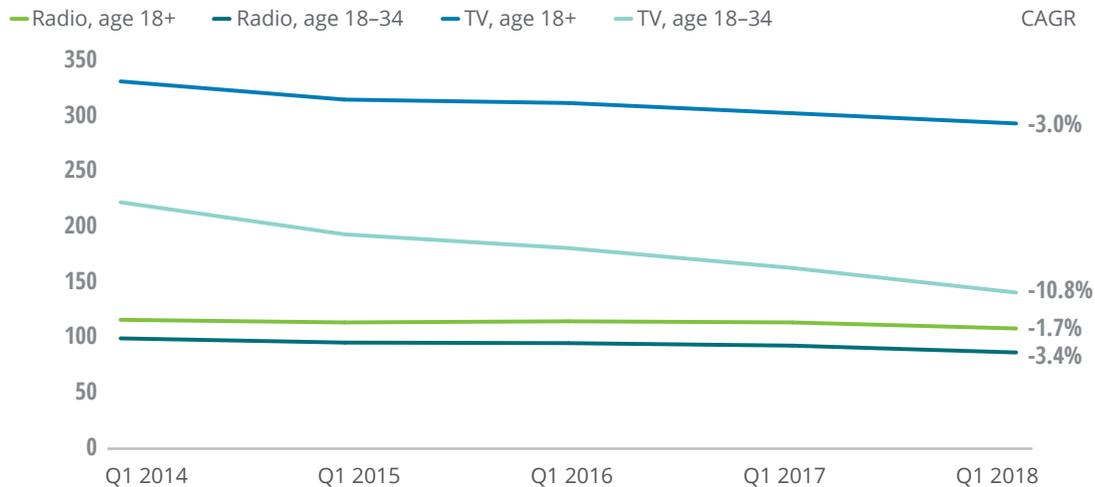


Source: Nielsen.

**of radio a day**, about the same amount as in the prior year. Finally, Deloitte Global predicts that, unlike some other forms of traditional media, **radio will continue to perform relatively well with younger demographics**. In the United States, for example, we expect that more than 90 percent of 18–34-year-olds will listen to radio at least weekly in 2019, and they will listen to radio for an average of more than 80 minutes a day. In contrast, TV viewing among 18–34-year-olds in the United States is falling at three times the rate of radio listening (figure 1). At current rates of decline, in fact, American 18–34-year-olds will likely spend more time listening to radio than watching traditional TV by 2025!

Many readers may scoff at these robust predictions for radio. "That can't be right … nobody listens to radio anymore." But radio has commonly been underestimated. Radio is the voice whispering in our ear, in the background of dinner, in an office, or while driving the car. It is not pushy or prominent … but it is there.

## At the current rates of decline, American 18–34-year-olds will likely spend more time listening to radio than watching traditional TV by 2025!

How do we know this? Radio listening measurement technology varies by country, but in many markets, the data is collected using passive technology devices worn by consumers that pick up radio programs via an undetectable (to humans) embedded audio signal. When asked to self-report their radio listening habits, humans tend to underestimate it, believing we listen to less than we actually do (see sidebar, "Radio is underreported, but resilient").[3] But the measured reality is that radio is still alive and well.

**RADIO IS UNDERREPORTED, BUT RESILIENT**

In the United States, AM/FM radio listening activity is measured by Nielsen. In 48 major markets, the measurement is done passively through a wearable device called a Personal People Meter (PPM). In smaller markets, a diary system is used. Each year, about 400,000 Americans participate in the measurement program.

The PPM device picks up an inaudible audio signal embedded in AM/FM radio programs. This form of measurement is the gold standard, and it is used as the currency for radio ads and ratings. While not perfect, it is considered highly accurate. According to Nielsen data, more than 95 percent of adult Americans heard an AM/FM radio program at least once in June 2017.

However, human beings are less accurate at measuring and recalling their radio habits. In the back seat of a car pool, in a restaurant, or even in our own homes, radio is unobtrusive but often present, and we consistently report listening to radio less—much less—than passive technological measurement systems say we do (figure 2).

To highlight the tendency to underreport radio listening, consider an August 2018 Deloitte survey that asked people of various ages if they ever listened to radio (any AM/FM radio broadcast, online versions of broadcasts, or satellite radio). When compared to Nielsen data for roughly the same time period, people in every age group underreported radio reach by between 25 and 43 percentage points, with younger listeners underreporting more than older listeners.

There are likely various reasons why radio listening is so consistently underreported in surveys. It is less obtrusive than TV and less novel than watching video on a smartphone. It is often perceived as "merely" background to a lunch or a commuter's drive. But the radio is on, the sound is coming out of the speakers, and our ears are hearing the radio (and the commercials) even if we are not consciously reminding ourselves, "Hey, we're listening to the radio."

FIGURE 2

## People consistently underestimate how much they listen to radio
Measured versus self-reported radio reach, United States, August 2018

■ Nielsen monthly reach for AM/FM radio ■ Deloitte survey, listen to radio ever



**Age 18–24**
95%
52%

**Age 25–34**
98%
60%

**Age 35–49**
98%
70%

**Age 50–64**
99%
74%
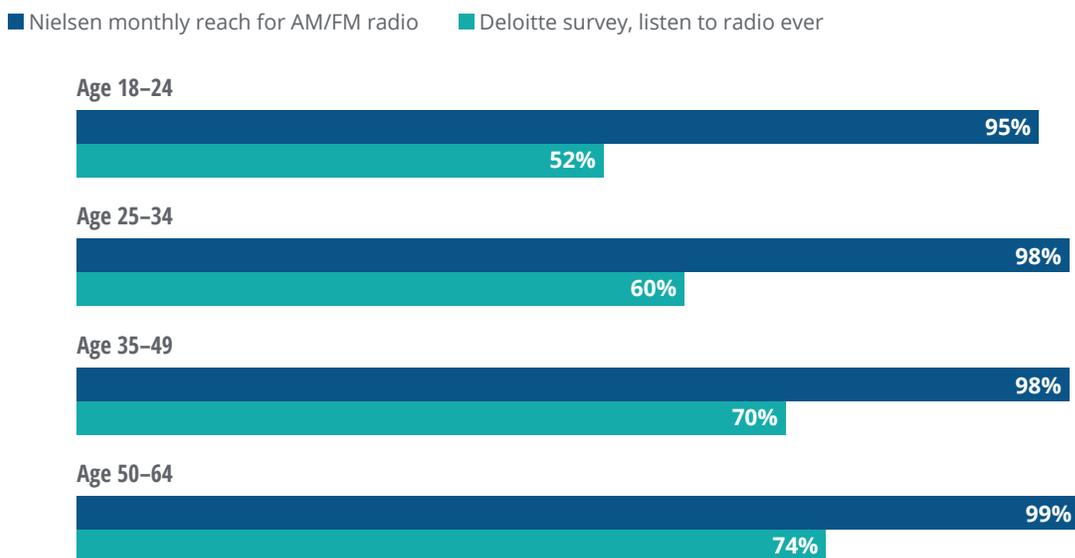
Sources: Nielsen; Deloitte global survey, US data.

Radio's weekly reach—the percentage of people who listen to radio at least once—has been remarkably stable in the United States. Not only has reach hovered around 94 percent for the last few years, but that number is essentially unchanged from the 94.9 percent figure in spring 2001 (when Apple introduced the iPod).[4] Canadian radio reach is only a little lower, at 86 percent.[5] Further, an August 2018 Deloitte Global survey found that, of those who report listening to live radio, over 70 percent say they listen either every day or on most days. This finding was consistent for both the United States and Canada, and across all age groups: A majority of radio listeners are tuning in as part of their daily lives.

## Not only has reach hovered around 94 percent for the last few years, but that number is essentially unchanged from the 94.9 percent figure in spring 2001.

It is true that Canadian radio revenue (among both private and public broadcasters, including satellite radio) has been declining, but only very gradually. From 2012 to 2016, total Canadian radio revenue declined 1 percent to C$2.2 billion (US$1.1 billion).[6] However, if we exclude public sector radio (whose revenue has been cut back), the decline in private radio revenue only averaged 1.1 percent per year,[7] while satellite radio has actually been growing at about 6 percent per year.[8]

Neither is the resilience of radio purely a North American phenomenon. In Q1 2018, for example, not only was radio ad spending in the United Kingdom up 12.5 percent year over year (after a lengthy period of decline), but radio advertising was the fastest-growing type of advertising, outpacing even internet advertising.[9]

A major reason that advertisers still like radio is its demographics. One might think, since radio in North America is popularly perceived to be largely free and ad-supported, that it would appeal mainly to demographics that are of less interest to those who buy advertising. The exact opposite is true: The August 2018 Deloitte Global survey found that the percentage of Americans who report listening to live radio is *higher* for those who are working, those with more education, and those with higher incomes (figure 3). Keep in mind, too, that, because radio listening in this survey was self-reported, the real numbers are likely 25 percentage points higher for older demographics and 40 percentage points higher for younger age groups.

When considering radio's attractiveness to advertisers, it is important to note that radio's popularity varies significantly from country to country in both reach and revenue generated per capita, with the United States and Canada at the extreme high end for the latter.[10] Likely due to these countries' commuter car culture and the dominance of radio being listened to in cars (figure 4), radio listeners in the United States are "worth" US$67 per year in radio

## One might think, since radio in North America is popularly perceived to be largely free and ad-supported, that it would appeal mainly to demographics that are of less interest to those who buy advertising. The exact opposite is true.

FIGURE 3

## Radio listening increases with higher employment status, education, and income

Employment, education, and income demographics of live radio listeners, United States, August 2018

**Not working**
61%

**Working**
71%

**No college**
56%

**Some college**
62%

**Bachelor's degree or higher**
74%

**Less than $25K**
50%

**$25K–$44.9K**
61%

**$45K–$74.9K**
68%
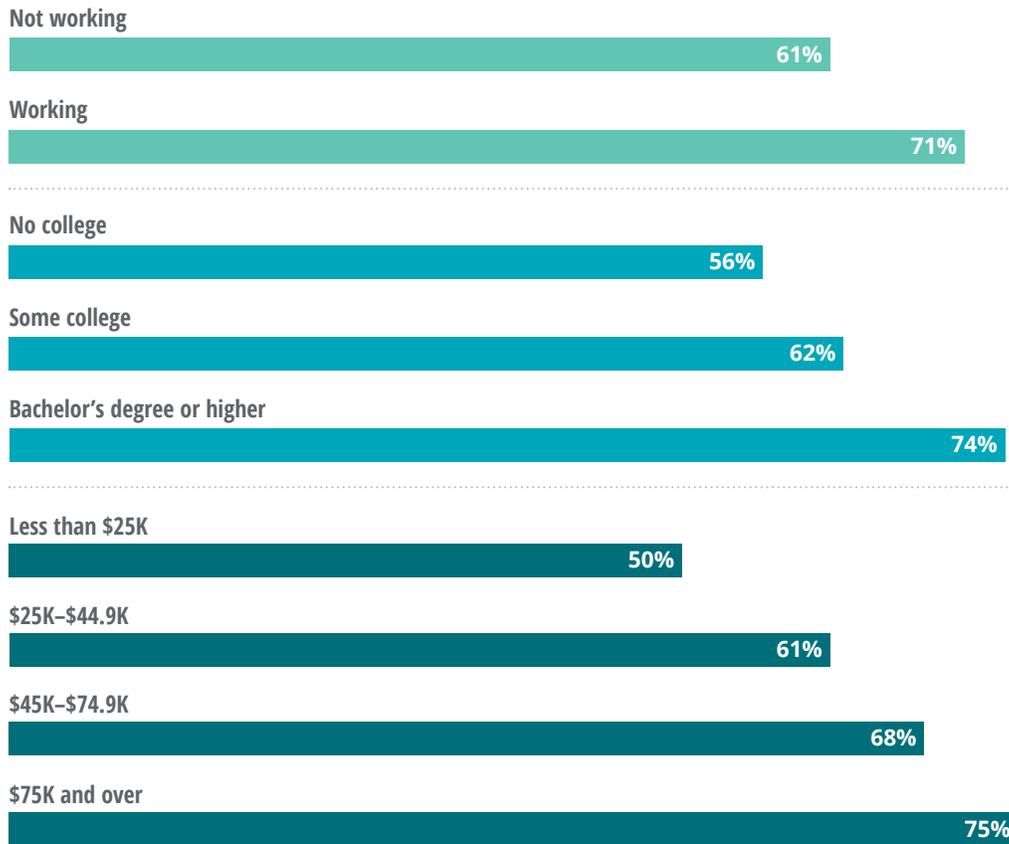
**$75K and over**
75%

Note: 404 respondents were not working and 671 were working; 313 reported "no college," 313 "some college," and 563 "bachelor's or higher"; 119 reported income less than $25K, 181 income between $25–44.9K, 268 income between $45–74.9K, and 468 income $75K and over. Income figures are given in US dollars.
Source: Deloitte global survey, US data, August 2018.

revenue per capita for the industry as a whole. In contrast, the radio industry in Canada and Germany makes about US$20 less per listener per year. In Sweden and Australia, the radio industry makes just under US$40 per capita per year; in the United Kingdom and France, around US$25 per capita per year, and in most other countries for which data exists, less than US$10 per capita per year (figure 5). Interestingly, there seems to be no clear correlation between radio reach in each country and industry revenues.

## Interestingly, there seems to be no clear correlation between radio reach in each county and industry revenues.

FIGURE 4

## US and Canadian radio listeners use radio most while driving

Where radio listeners listen to radio, all live radio listeners in the United States and Canada combined, August 2018

■ Age 18–24   ■ Age 25–34   ■ Age 35–44   ■ Age 45–54   ■ Age 55–75

**In the car**

| | |
|---|---|
| 89% | |
| 87% | |
| 87% | |
| 89% | |
| 93% | |

**At home**

| | |
|---|---|
| 42% | |
| 51% | |
| 50% | |
| 51% | |
| 53% | |

**At work**

| | |
|---|---|
| 30% | |
| 28% | |
| 23% | |
| 18% | |
| 16% | |
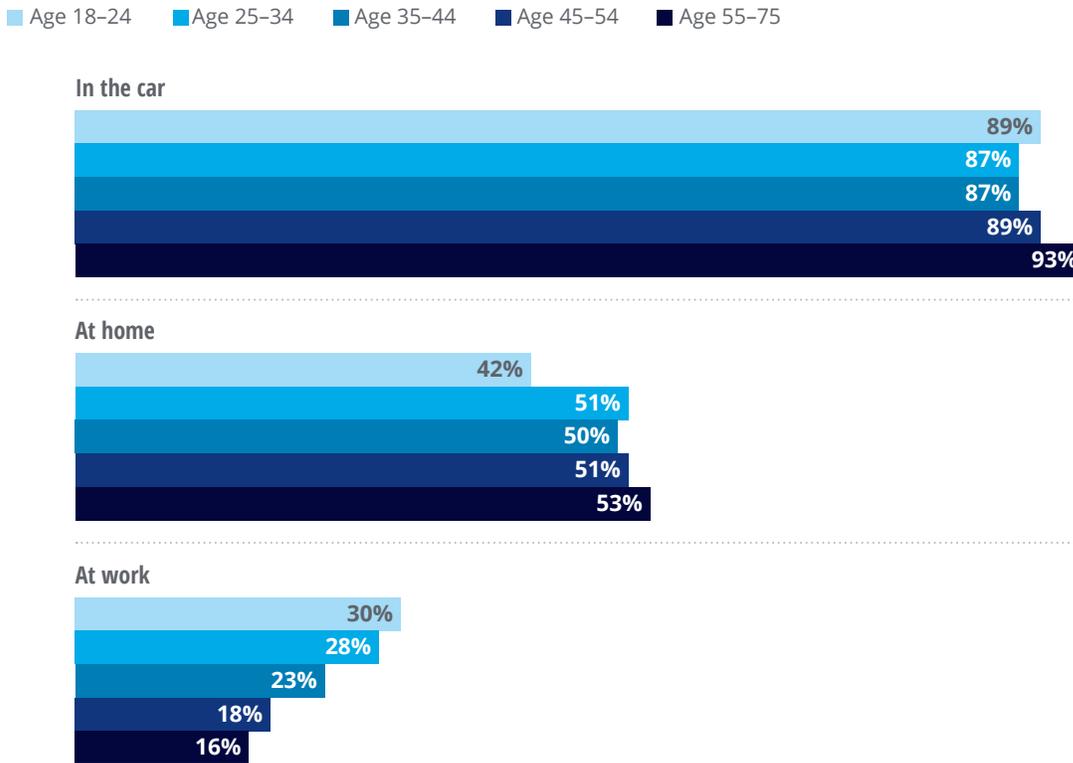
Source: Deloitte global survey, US and Canada data, August 2018. 134 respondents were aged 18–24, 243 aged 25–34, 250 aged 35–44, 311 aged 45–54, and 492 aged 55–75.

When one talks about the "global radio industry," the size of the US market—driven by its large population, radio's high reach into this population, and the very high value per capita of US radio listeners—makes it represent over half of all global radio revenues in 2017 (figure 6). From the same figure, even excluding the United States, radio's global market is worth nearly US$20 billion per year, and so remains important. It is also critical for both the radio and advertising industries to understand just how country-specific the radio market is. What is true in North America may not be true in Europe, Africa, or Asia—and what holds in one country may not hold in the next. Radio per capita revenue in Germany, for instance, is three times higher than next door in the Netherlands to the west, and 13 times higher than in Poland to the east.[11]

**Even excluding the United States, radio's global market is worth nearly US$20 billion per year, and so remains important.**

FIGURE 5

## Radio listeners in different countries are "worth" varying amounts to the radio industry

Annual radio revenue per capita by country, US dollars, weekly radio reach by country, 2017

■ Annual radio revenue per capita  ■ Weekly radio reach

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 86% | 93% | 90% | 82% | 88% | 94% | 68% | 94% | 63% |
| Canada | US | UK | France | Netherlands | Sweden | Germany | Poland | Russia |
| $48 | $67 | $25 | $23 | $14 | $39 | $46 | $4 | $1.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 84% | 71% | 85% | 20% | NA | 98% | NA | 38% | 65% |
| Brazil | Spain | Italy | Nigeria | India | China | South Korea | Japan | Australia |
| $1.6 | $11 | $9 | $0.4 | $0.3 | $2 | $5 | $9 | $37 |
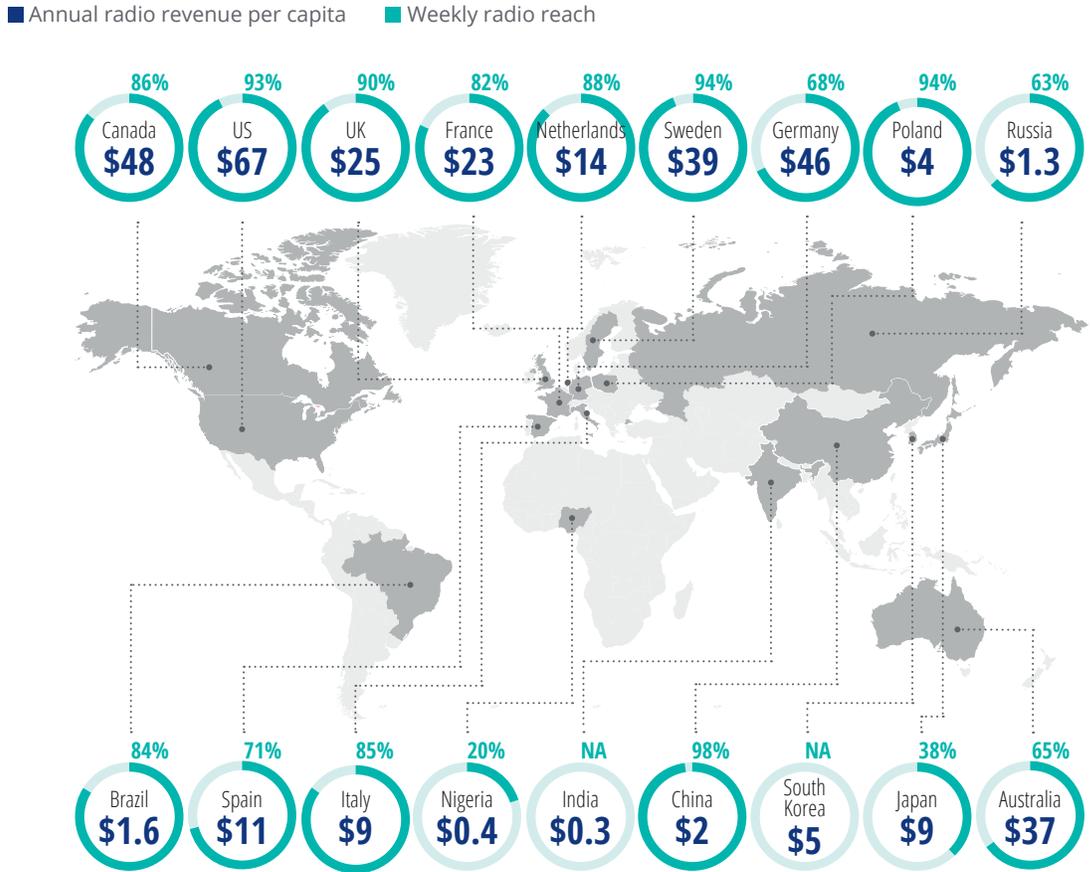
Sources: For per-capita revenue numbers, *The International Communications Market 2017*, Ofcom, December 18, 2017; Canadian Radio and Telecommunications Commission data; Statista. For radio reach, *The International Communications Market 2017*, Ofcom, December 18, 2017; Nielsen for the United States; Numeris for Canada.

FIGURE 6

**The United States represents more than half of all annual global radio revenue**

Top 10 global radio markets in US$ billion, by country, 2017



$21.81
United States

$3.88
Germany

$2.27
China

$1.74
Canada

$1.61
United Kingdom

$1.47
France

$1.20
Japan

$0.94
Australia

$0.54
Spain

$0.54
Italy
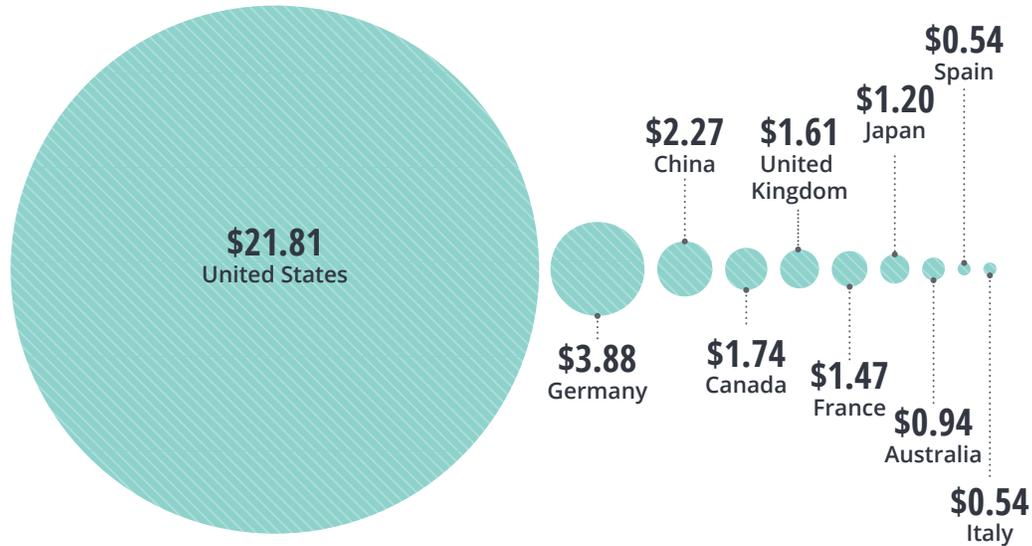
Sources: *The International Communications Market 2017*, Ofcom, December 18, 2017; Canadian Radio and Telecommunications Commission data; Statista.

# BOTTOM LINE

The obvious implication of all of the aforementioned aspects is that radio is not going away, and it should be a big part of the ad mix for those buying advertising. However, the importance of radio in advertising may not be well known: A 2018 UK study found that, even though radio had the second-best ROI for brand building, advertisers and agencies ranked it sixth out of seven.[12] If these results reflect typical attitudes, radio appears to be the most undervalued ad medium for brand-building. But if advertisers come to appreciate radio's value, the share of ad dollars that radio receives is likely to be stable at worst, and may even rise—as it did in the United Kingdom in Q1 2018.

At least some of what will be required to help radio attract more advertising revenue is better dissemination of the reality behind radio's resilience. Most people in the media industry hold negative assumptions about radio's effectiveness, largely due to entrenched myths that denigrate radio's reach and daily listening minutes, its popularity with young audiences, and its demographics with regard to income and education.The industry itself is partially to blame for these misunderstandings, and an aggressive campaign of mythbusting—always backed up by hard evidence—will likely need to be a key strategy for broadcasters and their industry associations worldwide.

One widespread belief about radio is both truth and myth at the same time. It is widely assumed that the most common venue where North Americans dial in is in their cars. This is true: Around 90 percent of radio listeners in the United States and Canada, across all age groups, do listen while in the car (figure 4).

But the flip side of that belief—that North Americans listen to radio only in their cars—needs some mythbusting. While not as prevalent, people in North America definitely are listening to radio in places other than cars. As we saw in figure 4 earlier, about half of North Americans aged 25–75 listen to radio while at home (although only 42 percent of 18–24-year-olds do so). A nontrivial proportion are also listening at work, with the percentage being highest for 18–24-year-olds at 30 percent, declining to half that for those aged 55–75 years.

Perhaps our most challenging finding is that there is no single, powerful, universal reason that people who listen to radio decide to listen (figure 7). Should a radio broadcaster spend a lot of money on attracting top DJs or hosts for the morning drive?[13] That will certainly attract or retain some listeners, but only about 25 percent across the various demographics. Playing new music so that listeners can discover new acts works well for the 18–34-year-old audience, with 36 percent saying that this is one of the reasons they listen to radio at all—but only half that proportion of 55–75-year-olds listen to radio for discovery. For some demographics, the facts that radio is live, free, and easy to listen to in the car were the only reasons that more than half of radio listeners gave for listening.

Our last takeaway is almost paradoxical. In the realm of traditional media, print newspapers are locked in an ongoing struggle for profits—and, in some cases, even their very existence. And although TV ad revenues continue to grow, at least a little, the decline in TV watching by young people—in multiple countries, TV watching by the youngest demographic has gone down by about 50 percent in the last six to seven years—suggests that TV almost certainly faces challenges ahead.[14] Radio has no such existential crisis or looming demographic cliff. In 2017, radio attracted about 6 percent of global ad spending (about 9 percent in North America), and in 2019, it will likely be around 6 percent again.[15] These advertisers know that advertising on radio works, and it needs to be part of any ad campaign.

FIGURE 7

## The reasons people listen to radio vary widely

Top 10 reasons radio listeners listen to radio, all live radio listeners in the United States and Canada combined, Q3 2018

|  | Age 18–34 | Age 35–54 | Age 55–75 |
|---|---|---|---|
| I like the DJs or hosts | 24% | 25% | 24% |
| It is good for discovering new music | 36% | 25% | 19% |
| I don't need to download anything | 28% | 30% | 41% |
| I like to have news bulletins | 22% | 33% | 38% |
| I don't need a mobile data connection | 37% | 28% | 36% |
| It has a good mix of content | 30% | 33% | 38% |
| It is more convenient | 37% | 45% | 45% |
| I like listening to the radio live | 34% | 47% | 55% |
| It is easier to listen to in my car | 50% | 51% | 62% |
| It is free | 57% | 61% | 66% |

Note: 134 respondents were aged 18–24, 243 aged 25–34, 250 aged 35–44, 311 aged 45–54, and 492 aged 55–75.
Source: Deloitte Global Survey, August 2018.

Many things have changed since the year 1962, in which the hit movie *American Graffiti* was set. But driving around in a car and listening to music, news, and a loudmouth DJ is still very much part of the US cultural fabric in 2019. In a world where digital changes everything, radio may be the exception.

# Endnotes

1.  Radio is defined as AM/FM broadcast, both digital and analog, satellite radio, and internet streams of AM/FM radio. Revenue includes advertising revenues, subscription fees, and public license fees where those exist.

2.  With over a billion people in the developed world, radio's reach will be about 900 million. Its 98 percent reach in China adds another billion. The rest of the developing world of 4 billion will have at least another billion listeners, although we do not have exact reach data for all of them.

3.  *Economist*, "The lazy medium: How people really watch television," April 29, 2010.

4.  Nielsen, "Radio reaches more than 90 percent of all consumers over the age of 12 each week," press release, September 23, 2009. *TMT Predictions* is an independent publication and has not been authorized, sponsored, or otherwise approved by Apple Inc. iPod® is a trademark of Apple Inc., registered in the United States and other countries.

5.  Numeris, "How Canada listens: Fall 2017," accessed October 18, 2018.

6.  Canadian Radio and Telecommunications Commission, "Communications monitoring report 2017: Broadcasting sector overview," accessed October 18, 2018.

7.  Ibid.

8.  Statista, "Sirius XM Canada's revenue in fiscal years 2011 to 2016 (in million Canadian dollars)," accessed October 18, 2018.

9.  Radiocentre, "Radio is the fastest growing medium, latest figures reveal," August 2, 2018.

10. The data for all countries except Canada was published in an Ofcom report released on December 18, 2017 and all amounts were denominated in GBP. We have converted them all into USD using the exchange rate of that day, which was 1GBP=1.3381USD. The Canadian figures are for 2016, not 2017, and were converted to USD using the December 18, 2017 exchange rate of 1USD=1.2861CAD. Ofcom, *The international communications market 2017*, December 18, 2017.

11. Ofcom, *The international communications market 2017*.

12. Ebiquity, "Re-evaluating Media study shows TV and radio are strongest advertising media for brand-building in UK," March 7, 2018.

13. *Economist*, "Ambitious commercial radio stations are poaching the BBC's stars," September 6, 2018.

14. Deloitte, "The kids are alright: No tipping point in TV viewing trends for 18-24 year-olds," 2017.

15. Zenith Media, *Global Intelligence: Data and insights for the new age of communication*, Q2 2017.
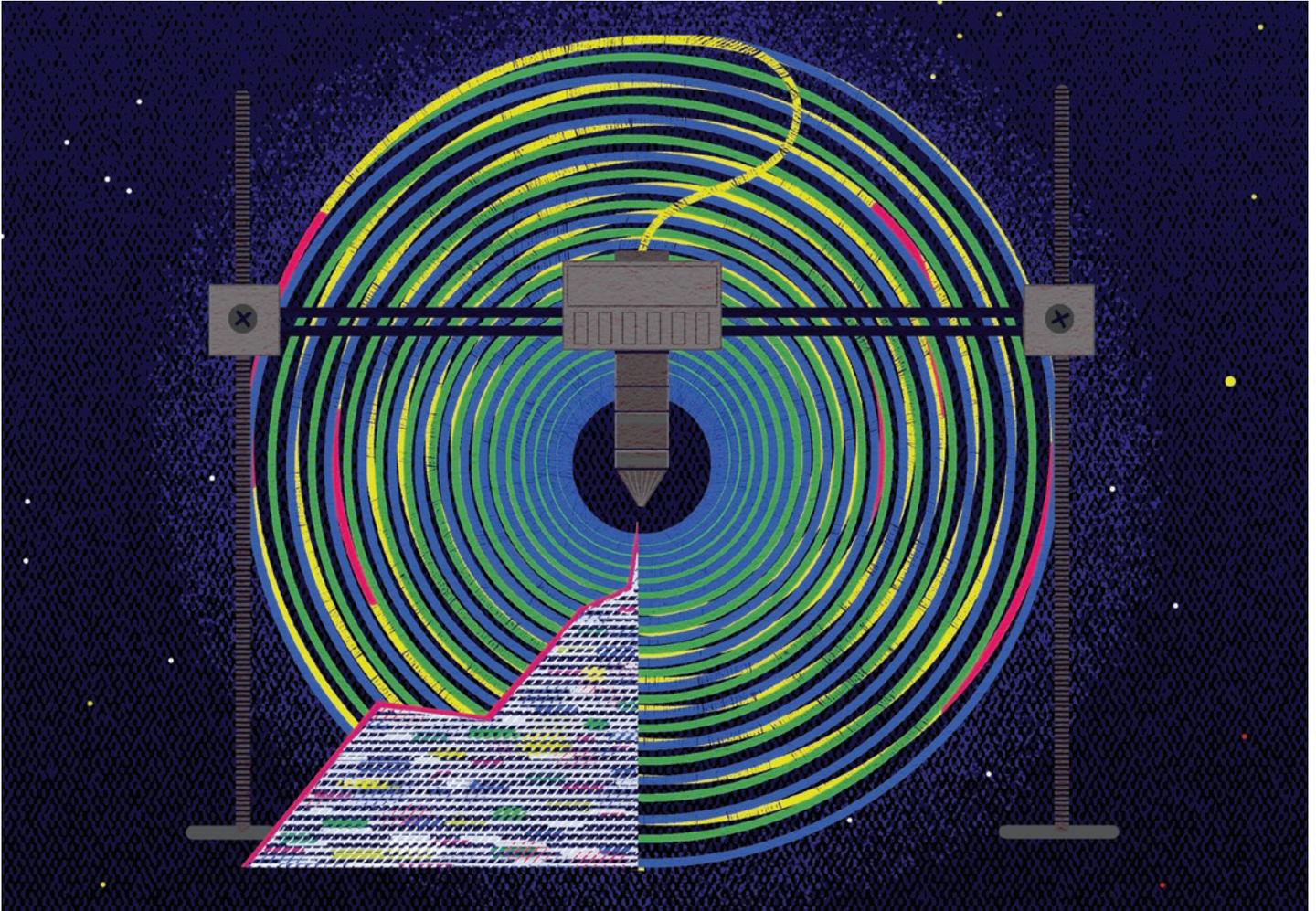
# 3D printing growth accelerates again

Duncan Stewart

D ELOITTE GLOBAL PREDICTS that **sales related to 3D printing (also known as additive manufacturing) by large public companies—including enterprise 3D printers, materials, and services—will surpass US$2.7 billion in 2019 and top US$3 billion in 2020**. (For context, the global manufacturing sector's revenue as a whole totals roughly US$12 trillion annually.[1]) This part of the 3D printing industry will grow at about 12.5 percent in each of those years, more than double its growth rate just a few years ago (figure 1).

## Growth in the 3D printing market has more than doubled

Global 3D printing revenues among large public companies, US$ billion, 2014–2020

| % increase | | 4.6% | 5.1% | 12.5% | 12.6% | 12.6% | 12.5% |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | $1.8B | $1.8B | $1.9B | $2.2B | $2.4B | $2.7B | $3.1B |
| | 2014 | 2015 | 2016 | 2017 | 2018E | 2019E | 2020E |
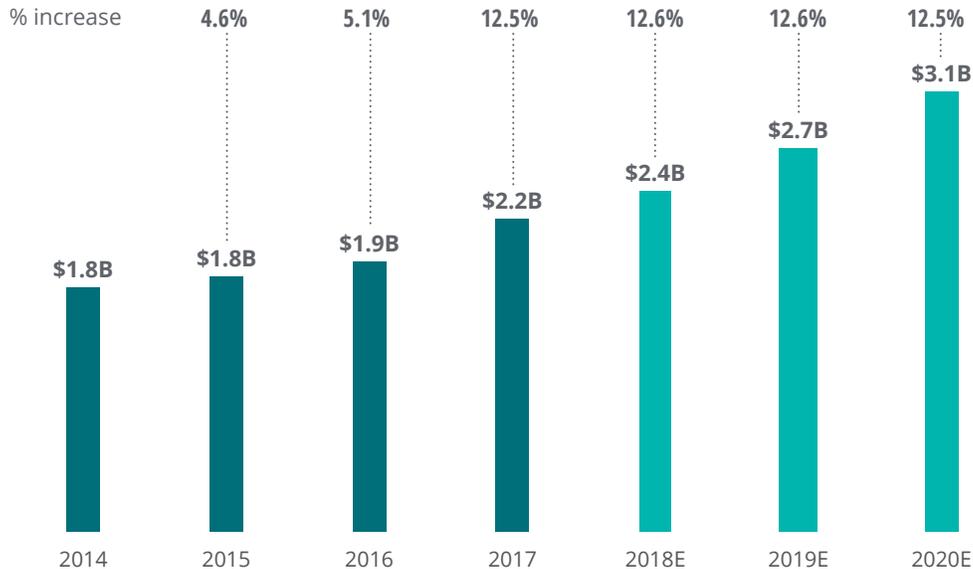
Source: Deloitte analysis of public company filings and analyst estimates.

3D printing is experiencing this inflection point likely because companies across multiple industries are increasingly using it for more than just rapid prototyping. 3D printers today are capable of printing a greater variety of materials (which mainly means more metal printing and less plastic printing, although plastic will likely still predominate); they print objects faster than they used to, and they can print larger objects (build volume). A steady stream of new entrants is expanding the market. 3D printing is considered "an essential ingredient" in Industry 4.0,[2] the marriage of advanced production and operations techniques with smart digital technologies that is being heralded as the "Fourth Industrial Revolution."

Before we examine why the 3D-printing industry is accelerating, it's worth explaining the methodology behind our market-size estimates.

There are other reports that give historical, current, and forecast market sizes for the industry. However, they are based on proprietary research and are hence neither reproducible nor falsifiable. In contrast, due to our focus on large public companies, our historical and current data is culled from publicly available sources with audited financials and updated quarterly. Our forward-looking estimates again draw on publicly available information and are based on consensus analyst estimates where they exist; for some of these companies, more than a dozen analysts provide forward-looking estimates.

**3D printers today are capable of printing a greater variety of materials; they print objects faster than they used to, and they can print larger objects.**

## The rise, fall, and rise of 3D printing

Like many new technologies, 3D printing was overhyped to an extent in its early days. By 2014, the industry (including but not limited to large public companies) posted revenues of more than US$2 billion, up from less than US$1 billion in 2009 (the year when certain fundamental patents expired, and the first consumer home 3D printer—the RepRap[3]—was introduced as a result). News articles talked excitedly about "the factory in every home," and there were predictions that traditional parts manufacturers, warehouses, and logistics companies would all be significantly disrupted in the short term. In reality, at that time, 3D printers were largely being used to make plastic prototypes, and although home 3D printers could be fun and educational, the things that they made were almost never of functional value.

## Today, we predict that annual industry growth will be well above 10 percent for the next few years at least.

Overhyped, the industry slowed, though it did not collapse. As can be seen in Figure 1, the large public companies in the industry experienced mid-single-digit percentage growth in 2015 and 2016 (although some companies did see year-over-year revenue declines), entering a trough of lowered expectations after the excessive hopes of the previous years. However, it was a shallow trough, and by 2017, growth had accelerated again. Today, we predict that annual industry growth will be well above 10 percent for the next few years at least.

Why the rebound in growth prospects? More 3D-printable materials, for one thing. In 2014, the list of materials that could be used in 3D printing was already long, but still far short of the complete list of materials that are commonly used in parts manu-

facturing. Plus, many parts need to be made of more than one material, a task to which the 3D printers of the time were not well suited. Fast-forward to the beginning of 2019, and the list of possible 3D-printable materials has expanded to more than double what it was five years earlier, and mixed-material printers are becoming more common.

The biggest shift in this regard has often been away from plastic and toward metal printing. Plastic is fine for prototypes and certain final parts, but the trillion-dollar metal-parts fabrication market is the more important market for 3D printers to address. Between 2017 and 2018, a 3D-printing industry survey showed that, although plastic was still the most common material, its share in 3D printing fell from 88 percent to 65 percent in that single year alone, while the share of metal printing rose from 28 percent to 36 percent.[4] At that rate, it seems probable that metal will overtake plastics and represent more than half of all 3D printing as soon as 2020 or 2021.

Another factor is speed. Building a part (out of any material) one ultrathin layer at a time is an inherently slow process. But things have changed since 2014. While print time can vary by the complexity of the shape being made, the quality of the print job, and/or the materials being used, the 3D printers on the market in 2019 are twice as fast, broadly speaking, as those that were available in 2014, all else being equal.

One particularly interesting innovation is in the metal-printing arena. In the last few years, many metal parts have been printed using selective laser sintering (SLS). This process is relatively slow and expensive, and it requires a near-vacuum environment. A more recent technology called binder jet metal printing, which could halve the time required to produce each part, is poised to become widely available in 2019.[5] (That said, although binder jet technology makes the actual 3D-printing part of the process much faster than SLS, the parts so printed are not yet finished, and require postprocessing by

sintering—baking them in an oven until the metal powder fuses. However, while sintering takes time, it can be done *en masse*, so the average time per part for larger numbers of parts is still faster than SLS.)

Not only are 3D printers getting faster, but their build volume—the printable objects' size—is growing. A few years ago, a typical high-end metal printer could only build an object that was smaller than 10 x 10 x 10 centimeters, or a cubic liter. In 2019, multiple printers are available with a 30 x 30 x 30-centimeter volume, or nine cubic liters. This allows for larger objects to be made without needing to print smaller objects and then assemble them. Further, progress is being made on very large build volumes, with the x, y, and z axes measured in meters rather than centimeters, at labs such as Oak Ridge National Laboratory with its Big Area Additive Manufacturing (BAAM) technology.[6]

Finally, some large companies are entering the 3D-printing market, validating the space and pushing the overall industry to innovate even faster. These large companies bring research investment, credibility, large customer bases, and marketing muscle—and fortunately for the industry's growth, they are generally expanding the overall pie rather than taking sales away from existing players. The revenue these *Fortune* 500 companies realize from 3D printing is immaterial for them—for a US\$50–100 billion company, even US\$250 million in 3D-printing-related revenue would represent less than 0.5 percent of its sales—but it is highly material for the 3D-printing industry and will likely represent about 15 percent of the 3D-printing industry's total revenue by 2020. Also, the entry into 3D printing by these larger companies is highly strategic for them in a product sense: They are using 3D printing to manage the long tail and improve part

performance in interesting ways, such as printing lighter-weight parts, gaining more flexibility in manufacturing, simplifying components, and so on.

## Will 3D printing become 100 percent of the manufacturing market?

With all the improvements of recent years, it might be asked why 3D printing is growing at "only" 12 percent or so per year. If 3D printers are now that useful in making final parts, why wouldn't growth be higher still? And will 3D printing ever become the only way things are made?

In short, no. But to understand why, it's worth exploring how parts are manufactured in a little more detail.

There are essentially three ways to make a part:

1. Take the amount of material needed, and shape it as desired
2. Take a block of too much of the material, and remove what is not needed (subtractive manufacturing)
3. Build the part up bit by bit over time using the material until the desired part is finished (additive manufacturing or 3D printing)

The first approach can involve multiple techniques and materials; forging, casting, stamping, and molding (injection molding for plastics) are among the most common. These techniques have been used for decades or even centuries; they are well understood, relatively inexpensive on a per-part basis in volume, and produce each part, on average, in a few seconds (not including finishing—in almost all kinds of parts manufacturing, further processing for finishing is required, which can take from seconds to hours). As of 2018, the machines that work this way are worth US\$300 billion per year,[7] producing parts worth over a trillion dollars annually. As a mature industry, this mode of

**Large companies are entering the 3D-printing market, validating the space and pushing the overall industry to innovate even faster.**

manufacturing is growing at about 2–3 percent per year, on average, worldwide.

The second technique—subtractive manufacturing—may involve the use of lathes and many other large factory tools, but importantly, it can also be carried out by computer numerical control (CNC) machines, which are becoming near-ubiquitous. Making objects with CNC machines costs more per part than the techniques described above, and it takes minutes per part instead of seconds (excluding finishing time). However, CNC-machine-based manufacturing is very useful in many markets, especially where volumes are lower than would justify making a mold (for example) or where the final part cannot be made using the older techniques. The global CNC-machine market is growing at about 7 percent per year, about twice as fast as traditional manufacturing; it is expected to reach US$100 billion by 2025, up from about US$60 billion in 2018.[8]

Additive manufacturing—3D printing—is still more expensive per part than using a CNC machine (making it much more expensive than traditional manufacturing), and it takes hours per part instead of minutes (again excluding finishing and postprocessing of various kinds). However, there are parts that can *only* be made with 3D printing, as well as situations in which part volumes are so low that neither traditional nor subtractive manufacturing is optimal. These are the markets that are driving some of the growth that we predict for 3D printing. An additional growth driver is that 3D printing is often quite useful for making the molds, casts, tools, dies, and jigs that might be used in the first two techniques.

3D printers are not always the right tool for the job, and for the foreseeable future, most parts will still likely be created by casting, forging, stamping, molding, and the like; a small proportion will be made with CNC machines, and an even smaller proportion will be made with 3D printing. But even 1 percent of a multitrillion-dollar global parts

industry—the annual metal parts industry alone is worth a trillion dollars[9]—is still a large opportunity.

Further, the proportions of parts made using each of the three techniques refer to the unit volume of parts. But objects made with CNC machines and 3D printers tend to be of much higher value than those made traditionally, so the dollar value of the parts made by more advanced techniques will be higher than the unit percentages indicate. In other words, parts such as nuts and bolts will be made the traditional way. But those parts are commodities and cost pennies, while 3D-printed parts can be worth hundreds or even thousands of dollars.

**There are parts that can only be made with 3D printing, as well as situations in which part volumes are so low that neither traditional nor subtractive manufacturing is optimal.**

The fact that 3D printers will not likely replace traditional manufacturing techniques is important. If manufacturers had to throw out all of their old machines and switch to a completely 3D-printed world, it would be a massive undertaking, but at the end of the process, it would have a certain simplicity. All goods would be made with 3D printers, and although companies would need large stocks of the feed materials, they would no longer need parts warehouses, depots, and distribution centers. The supply chain and logistics problems would be different from those of today, and simpler in some ways.

That likely isn't going to happen. Instead, companies and industries will always have to deal with a mixed manufacturing world, which is much more complex and difficult to manage. Parts will be made using all three approaches, often more than one of them at a time (which is actually a fairly important technique, expanding the market considerably).[10] All of this makes the solutions described below even more important than if 3D printing simply took over.

# BOTTOM LINE

In today's increasingly complex production and sustainment environments, more and more organizations are responding to constraints in their supply chain and manufacturing operations by looking to 3D printing.

How can, or should, a company get started with 3D printing? Of course, there is no single answer. Rather, there are multiple paths to integrating 3D printing into an organization's strategy (figure 2).[11]

FIGURE 2

## Framework for understanding additive manufacturing (AM) paths and value

**High product change**

**Path III: Product evolution**
- **Strategic imperative:** Balance of growth, innovation, and performance
- **Value driver:** Balance of profit, risk, and time
- **Key enabling AM capabilities:**
  - Customization to customer requirements
  - Increased product functionality
  - Market responsiveness
  - Zero cost of increased complexity

**Path IV: Business model evolution**
- **Strategic imperative:** Growth and innovation
- **Value driver:** Profit with revenue focus, and risk
- **Key enabling AM capabilities:**
  - Mass customization
  - Manufacturing at point of use
  - Supply chain disintermediation
  - Customer empowerment

**No supply chain change** / **High supply chain change**

**Path I: Stasis**
- **Strategic imperative:** Performance
- **Value driver:** Profit with a cost focus
- **Key enabling AM capabilities:**
  - Design and rapid prototyping
  - Production and custom tooling
  - Supplementary or "insurance" capability
  - Low-rate production/no changeover

**Path II: Supply chain evolution**
- **Strategic imperative:** Performance
- **Value driver:** Profit with a cost focus, and time
- **Key enabling AM capabilities:**
  - Manufacturing closer to point of use
  - Responsiveness and flexibility
  - Management of demand uncertainty
  - Reduction in required inventory

**No product change**

Source: Mark Cotteleer and Jim Joyce, "3D opportunity: Additive manufacturing paths to performance, innovation, and growth," *Deloitte Review* 14, January 17, 2014.

At a high level, organizations should examine their business models. Leaders should understand what opportunities and/or threats 3D printing represents for their business and how it could be used to disrupt their industry. Next, they should examine the business case for 3D printing. Traditional piece-price comparisons do not always fully uncover 3D printing's full benefits, so to properly evaluate the business case, companies should develop lifecycle cost comparisons that capture 3D printing's benefits (if any) across product development, production, and service/aftermarket. Essential to this evaluation is understanding where the company is applying 3D printing today, where 3D printing *could* be applied (aspiration), and finally where it *should* be applied (ambition based on reality). After that, companies should determine *whether* to proceed with the ambition—that is, whether the business case for 3D printing makes sense—and, if so, *where* (such as in the supply chain, product development, or other areas). After testing for viability, feasibility, and desirability, leaders should then assess the current state of their processes and assets, and after that, develop the roadmap to scale over time.

To use 3D printing at industrial scale, organizations need to manage a series of complicated, connected, and data-driven events. The "digital thread," a single seamless strand of data that stretches from the initial design to the finished part, is key to optimizing 3D printing's production capability.[12] Deloitte calls this the "digital thread for additive manufacturing," or DTAM.

Our five key recommendations around both the DTAM and 3D printing in general are:

**Assess the current state of tools and technologies.** Taking an inventory of the current state of one's manufacturing resources can enable companies to identify any pain points and understand where they may have to focus their energies.

**Determine where the company should focus: product development, supply chain optimization, or both.** Once manufacturers have taken stock of their current capabilities and where they would like to sit within the 3D-printing framework depicted in figure 2, they can begin to develop a roadmap for building and implementing a DTAM or an approach to 3D printing in general. Critically, this should tie to the business case: The emphasis should be on driving business outcomes, not merely building capabilities.

**Consider current approaches to data storage and use and how they might map to a DTAM.** 3D printing should be integrated into the general manufacturing process. To achieve this, organizations need a digital thread that incorporates 3D printing as well as any forming and subtractive technologies they may also use. Companies can examine how they collect, store, and use data in their current manufacturing practices, and then consider if they are storing and using the information coming from the factory floor as effectively as they could. In this way, they can architect a more efficient DTAM. It is easy to imagine scenarios in which all three manufacturing techniques would be used, but these activities would likely need to be supported by a digital backbone (thread) that cuts across the entire manufacturing process.

**Understand that there is no one-stop, end-to-end solution for creating a DTAM—yet**. Companies should examine how implementing a DTAM and scaling 3D printing will affect their business, and the start building requirements tailored to their specific needs.

**Think about the people.** 3D printing and the DTAM both will require acceptance and adoption among engineers and others within the organization, so recruitment, training, and retention are important considerations, as is change management.

After decades of development, 3D printing has finally reached a period of sustained growth greater than most other manufacturing technologies. As with so many other new technologies, it is important to "think big, start small, and scale fast." The next few years are likely to see 3D printing become much more widely used in all sorts of manufacturing, from robots to rocket ships. The ripple effects on industries even beyond manufacturing may be profound. Can your company benefit—and if so, how?

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# China by design

World-leading connectivity nurtures
new digital business models

Paul Lee

DELOITTE GLOBAL PREDICTS that **China will have world-leading telecommunications networks in 2019** and most likely in the medium term. Its communications infrastructure will provide a foundation for the ges-

tation and maturation of at least three significant new industries, each of which could generate tens of billions of dollars in revenue annually by 2023.

In China, 600 million people will use their phones to make mobile payments as of the start of

2019, about 550 million people will regularly use their smartphones to shop online, and about 200 million people will use bikesharing services.[1]

Deloitte Global further predicts that, **in 2019, China will have the world's largest fiber-to-the premise (FTTP) deployment** by a significant margin. At the start of 2019, China is likely to have over 330 million full-fiber connections, representing about 70 percent of the world's total.[2] FTTP enables gigabit-speed links to premises today, and typically operators offer a range of packages at multiple speeds; in the medium term, by 2024, multi-gigabit speeds should be possible.[3]

China's strengths in connectivity will likely be a key factor in enabling it to diversify from manufacturing technology to developing—and executing—new digital business models.

For starters, China is likely to soon have the world's largest 4G network, measured by both base stations and subscribers. At the start of 2019, it will have almost 5 million 3G/4G base stations and 1.2 billion 4G subscribers, representing at least a third of the world's total. Only India could rival China's billion-plus subscribers; as of the end of 2017, India had about 238 million 4G subscribers.[5]

Over the coming years, China is also poised to become one of 5G's leading markets, enabled in large part by the volume and density of the 4G network that the country has already built out. China had almost 2 million cell sites in early 2018; this compares with about 200,000 in the United States.[6] China has 5.3 sites for every 10 square miles; the United States has only 0.4.[7] The existing density of the 4G network in China should reduce the incremental cost of rolling out 5G. In fact, China is expected to launch 5G on a wide-scale basis by 2020 and to be the leading 5G market, with 430 million subscribers, by 2025.[8]

As 2019 begins, China's 4G network is likely to have limited areas with gigabit-speed service, with only the largest cities having these speeds.[9] (For context, as of the start of 2019, few markets around the world will have such speeds, so China is not unusual in this respect). However, the rollout of 5G, as well as the extension of ultra-high-speed 4G, over the coming years should allow such speeds to become more widely available.

China's world-leading fixed and mobile telecommunications networks should enable it to become the leading location for developing and deploying applications requiring hyperfast speeds of 500 megabits per second (Mbps) or more. In the near term, these applications may be predominantly delivered over fixed-fiber networks. Within two to three years, however, hyperfast speeds over mobile networks should become widely available in cities, thanks to 5G's rollout.

The upshot of all this connectivity will likely be business model innovation, as step changes in connectivity enable new business models. At the end of the 1990s, for instance, broadband enabled e-commerce to flourish in multiple markets. Fiber-based broadband, including fiber-to-the-cabinet (FTTC), has been the prerequisite for the mainstream adoption of video on demand around the world over the past decade. The introduction of 4G helped the growth of live streaming from smartphones via services such as Periscope and Facebook Live, which launched in 2015, and services such as TikTok and Douyu in China. And faster connectivity has been transformational at the enterprise level: All cloud-computing-based services rely on high-quality connections.

> **China's strengths in connectivity will likely be a key factor in enabling it to diversify from manufacturing technology to developing—and executing—new digital business models.**

Of course, connectivity alone isn't enough to support new business models; a base of users—potential customers—must also exist. But the recent upgrades to China's telecommunications networks have already provided a foundation for massive digital user bases, which are by far the largest in the world. These include:

- The world's largest base of fixed and mobile internet users, with more than 825 million people projected to be online at the start of 2019. China had 772 million people online at the end of 2017, and 802 million by June 2018.[10] With a population of 1.4 billion, China still has scope to connect hundreds of millions of more users.
- The world's largest base of mobile internet users—more than 800 million—with almost all of these using the mobile Web. In fact, almost all (97.5 percent) of China's online citizens were using the mobile internet at the end of 2017.[11]

Combined with China's advances in connectivity, the country's enormous online user bases have, in recent years, catalyzed the emergence of three new mass-market industries—mobile payments, mobile commerce, and bikesharing—each of which is likely to have hundreds of millions of users at the start of 2019. Mobile payments, mobile commerce, and bikesharing have all relied on fast connections to spur broad adoption.[12] While these services could all exist without 4G or high-speed broadband, they would likely be less useful, due to slower download speeds and higher latency; be more expensive to use, due to a higher cost per gigabyte; have smaller user bases; and generate less income.

We predict that 600 million people in China will use their phones to make mobile payments as of the start of 2019. This compares with 531 million mobile payments users at the end of 2017 and 474 million at the end of 2016.[13] The largest platform, AliPay (owned by Alibaba), alone had 520 million

users in February 2018.[14] The value of mobile payment transactions in China reached 81 trillion yuan (US$12.8 trillion) in the first 10 months of 2017.[15] This compares with an estimated US$49.3 billion worth of mobile transactions in the United States during the same period. In 2013, 3.8 billion transactions in China took place via nonbanking apps; in 2016, the volume was nearing 100 billion.[16]

We further predict that about 550 million people in China will regularly use their smartphones to shop online in 2019. In 2017, 506 million Chinese did so, a 15 percent increase over 2016. This positions China as having the largest base of mobile commerce users in the world.

# We predict that 600 million people in China will use their phones to make mobile payments as of the start of 2019.

Finally, we predict that China will have about 200 million people using bikesharing services in 2019.[19] In 2017, bikesharing users in China pedaled for a combined total of about 30 billion miles.[20] All major cities around the world face the challenge of offering integrated transport solutions that allow users to coordinate their usage of different modes of transport (car, bus, subway, and train), with bicycles and scooters being used for the last mile. China is a leader in this regard.

## What new applications could connectivity drive in China?

Looking ahead, China's communications network is likely to be the foundation of several key new bandwidth-hungry applications that are likely to become mainstream (with hundreds of millions of users) and generate significant revenue (tens of billions of dollars annually) by 2024. These applications are likely to include machine vision, social credit, and new retail concepts.

## MACHINE VISION

Machine vision, an application of artificial intelligence (AI), is being deployed for various applications. In most case, high-speed connectivity is likely to be a prerequisite.

Machine vision is likely to play an increasing role in authentication. In the long term, one's face may be the identifier used to authorize payment for everyday goods, or to verify access to public transport systems. Facial recognition compares the face presented with a stored image. The verification image may be stored in a passport or a phone, or it could reside in the cloud. Over time, the quality of the verification image is likely to become increasingly detailed.

Today, government bodies are using machine vision to identify people suspected of criminal activity. Scanning closed-circuit TV images is a task common to all police forces; machine vision can automate this often tedious but time-critical activity. High-speed connectivity can even enable footage to be scrutinized in the cloud. The application of machine vision to identifying criminals is being tested in many cities around the world, including Washington, DC,[21] Dubai,[22] and London.[23] In addition, airports in the United States, Canada, Australia, and the United Kingdom are piloting the use of automated facial recognition to detect illegal aliens using a false identity.[24]

# Machine vision is likely to play an increasing role in authentication.

In China, facial recognition has been used on a trial basis to regulate access to train stations[25] and airplanes,[26] pay for fast food,[27] verify the identity of taxi drivers,[28] track the attendance of university students,[29] and check into dormitories.[30] One of the largest Chinese companies in this space, SenseTime, has stated that its software is used in Guangzhou, a city of about 25 million, to match surveillance images from crime scenes to photos in a criminal database. The system deployed in Guangzhou has identified more than 2,000 suspects so far.[31] SenseTime is also reported to be working on a service that can parse data from thousands of live camera feeds.[32] FTTP and 5G connections can enable these feeds to be uploaded in real time. The higher the resolution of each feed, the easier it becomes to identify individual faces or items of clothing.

## SOCIAL CREDIT

Social credit is a variation on traditional credit scores. An individual's social credit is based on a person's:[33]

- Credit history, which includes the person's bill payment record
- Fulfillment capacity—that is, the person's ability to fulfill contractual obligations
- Personal characteristics
- Behavior and preferences, which are tracked or inferred from buying habits (for instance, purchasing diapers is equated to responsible behavior)[34] and even the number of hours a person spends playing video games
- Interpersonal relationships

AI, which relies on large data sets, can be used to iterate the algorithms used to determine each user's rating.

Social credit can be an alternative to traditional credit rating systems that rely on credit card history, mortgage payments, or time employed. In China and many other emerging countries, where such records may not exist for a large proportion of the population, social credit systems can fill the gap.[35] (As of 2015, the People's Bank of China maintained credit histories for only about 380 million citizens.)[36]

Consumers participating in social credit can realize multiple benefits, often financial, from having strong social credit, ranging from bike or car rentals with no deposit to loans at lower rates. Those

with a high credit score can also use fast check-in facilities at hotels or even apply for travel outside of China with less supporting documentation.[37]

Trials of social credit have been developed by private companies in the United States and United Kingdom,[38] but in China, social credit is expected to be deployed on a national scale. One social credit system has already been set up in China with the launch of Sesame Credit by Ant Financial, part of Alibaba, in 2015. Local governments have also set up social credit systems. The city of Rongcheng deducts a citizen's score for traffic violations but adds to it for volunteering or making charitable donations.[39]

## In China, Alibaba and Tencent, both of which were formerly online-only businesses, are buying into physical retail and looking to use their digital knowledge to create better shopping experiences.

The more information that is shared, the more accurately a social credit score may predict behavior.

Hence, again, fast connectivity may be a core factor in the success of social credit.

## NEW RETAIL CONCEPTS

The retail store is undergoing a digital reinvention around the world, often with tech companies leading the charge. In China, Alibaba and Tencent, both of which were formerly online-only businesses, are buying into physical retail and looking to use their digital knowledge to create better shopping experiences. Alibaba, for instance, has purchased stakes in Sun Art Retail Group, Beijing Easyhome Furnishing Chain Store, Intime Retail Group, and Suning Commerce Group.[40]

Tech companies, for their part, are looking to AI to improve supply chain efficiency and to optimize inventory and product recommendations. They are also experimenting with deploying cameras and developing autonomous stores. JD.com has invested US$4.5 billion in an AI-enabled retail center, whose aims include seamlessly integrating online and offline platforms as well as creating virtual fitting services and unmanned stores.[41]

# BOTTOM LINE

China is well-known for being the world's technology manufacturer; it is now becoming a leading designer of digital products, services, and business models as well.[42] Its world-class communications infrastructure is likely to be a key enabler of this shift.

Its strong position in fiber connections and 5G should position China well to become the premier nation for the development of applications that rely on hyperfast connections. The ubiquity of fiber and high-speed mobile in China also provides a vast base of beta testers and users. Indeed, the sheer size of China's market, as well as users' receptiveness to trying out new ideas, may make it the venue of choice for trying out new digital concepts. For example, Wheelys, a startup based in Sweden, located its first autonomous concept store on the campus of Hefei University, about 450 kilometers (280 miles) west of Shanghai.[43] A principal reason for locating the store in China was because of its citizens' unrivaled familiarity with paying by phone.[44]

China's strengths in connectivity should also catalyze the development of AI-based applications. AI depends on access to data sets—the larger, typically, the better. Thanks to the country's 1.2 billion 4G subscriptions, 825 million internet users, 600 million mobile payments users, and 200 million bikesharers, Deloitte's view is that some of China's data sets are unparalleled in size. If these data sets deliver better algorithms, competitive advantage may follow. Perhaps in recognition of this, Chinese AI companies have been receiving significant funding: In 2017, Chinese startups received 48 percent of the total US$12.5 billion that went to AI startups.[45]

And AI isn't the only technology attracting attention in China. The past few years have seen growth in overseas funding of Chinese tech startups in general, as well as rising valuations of a number of private and public Chinese tech companies. In fact, as of the middle of 2018, nine of the 20 largest tech companies in the world by market valuation were headquartered in China, with the other 11 based in the United States.[46] Over the next five years, these rankings are likely to be keenly contested. Companies that are able to scale their ideas fastest are likely to end up stronger.

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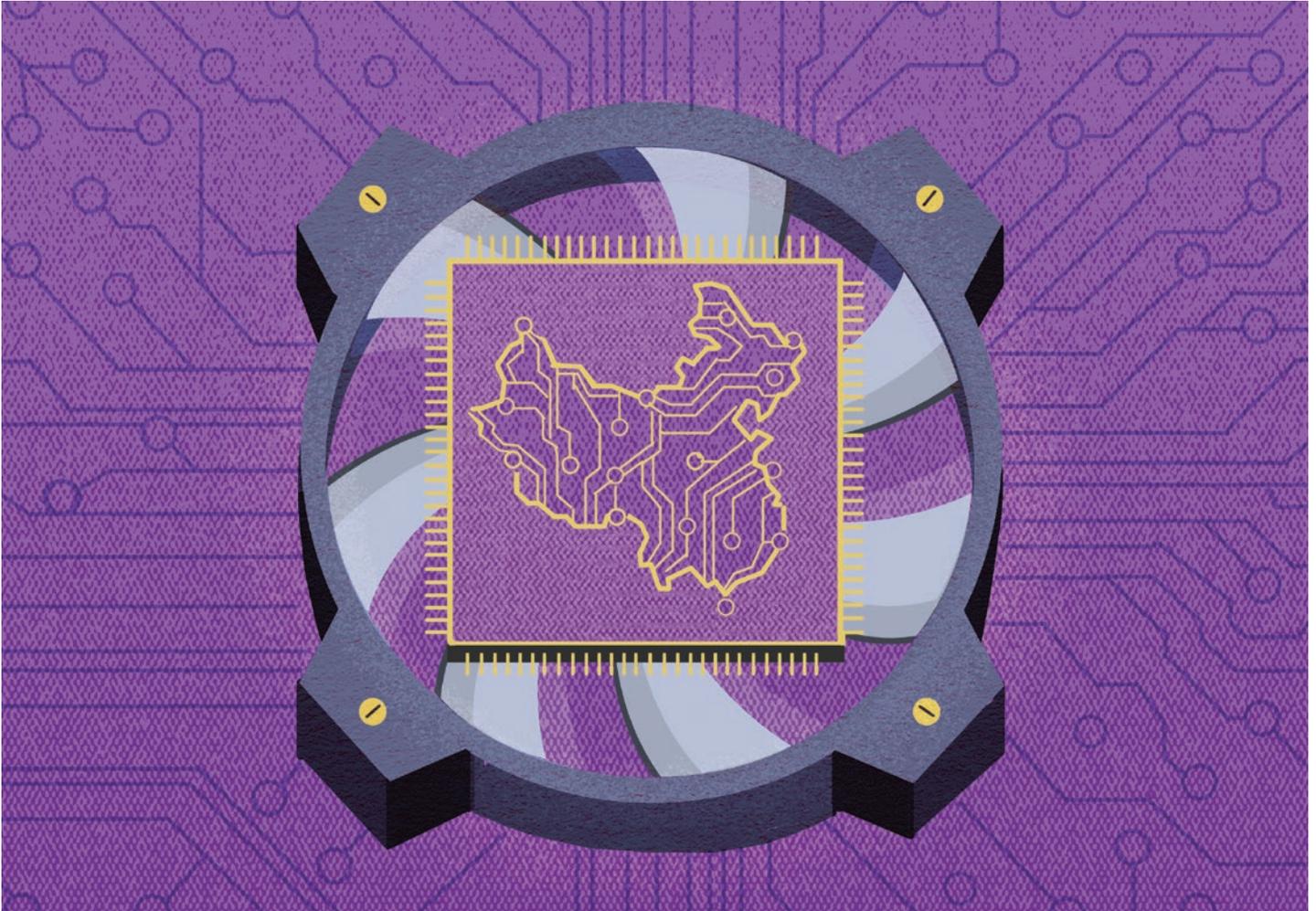
# China inside

## Chinese semiconductors will power artificial intelligence

Chris Arkenberg

ELOITTE GLOBAL PREDICTS that **revenues for semiconductors manufactured in China will grow by 25 percent to approximately US$110 billion in 2019 from an estimated US$85 billion in 2018**, to meet the increasing domestic demand for chipsets driven in part by the growing commercialization of artificial intelligence (AI). Deloitte Global further predicts that in 2019, **a Chinese chip foundry will begin**

**producing semiconductors specialized to support AI and machine learning (ML) tasks**.

With China as the leading consumer of semiconductors (it consumes more than 50 percent of all semiconductors annually, both internally and for eventual exports),[1] its growth has lifted the entire industry. And yet, Chinese manufacturers only meet around 30 percent of their own demand.[2] Amidst shifting macroeconomics and the growing value of AI, the Chinese government and leading digital businesses have signaled that greater domestic self-supply of semiconductors is a vital component of their future. They are spending and hiring aggressively to create onshore manufacturing capabilities approaching those of the top global foundries.

Many Chinese companies are designing specialized semiconductors for AI and have designed chip architectures at the bleeding edge of the mobile smartphone industry. With strong coordination between the state and domestic manufacturers, China is wielding a great deal of capital and its massive market to advance its agenda. And while China has failed to expand its semiconductor industry in past decades, this time it may succeed. Its success might be further supported by the evolving relationship between computation and emerging technologies.

## Mining for bitcoin

To better understand the modern Chinese semiconductor industry, it's worth looking at public cryptocurrencies. In December 2017, the market value of a single bitcoin[3] reached a historic high of US$17,900.[4] It wasn't an easy climb, and the value of bitcoin has fallen precipitously since, but the growth of cryptocurrencies has nonetheless captured headlines and, perhaps surprisingly, inspired Chinese semiconductor innovation.

Behind the headlines are the legions of bitminers running the computations that underlie the cryptocurrency economy. Each bitminer is potentially rewarded (in bitcoin) if he or she is the first

to solve the mathematical puzzle within each transaction. Those with the most processing power are more likely to reach the solution fastest. In the early days of cryptocurrency, miners bought graphics processing units (GPUs), built server farms, and ran up large power bills to gain an advantage over each other. Their frenzy boosted GPU sales and consumed more power than small countries.[5] But GPUs were expensive, power-hungry, and in short supply. The opportunity thus arose to introduce custom-designed chips that would be even better than GPUs for bitmining. The race was on to build application-specific integrated circuits (ASICs) that were optimized for bitmining.

# The growth of cryptocurrencies has captured headlines and, perhaps surprisingly, inspired Chinese semiconductor innovation.

In 2013, Bitmain Technologies Ltd. was founded in Beijing to meet the growing computational needs of the young bitcoin economy.[6] At the time, Chinese entrepreneurs were jumping on the bitcoin bandwagon, building server farms to help mine the cryptocurrency. Bitmain was one of the first chip designers to address this demand with specialized chip architectures. Instead of building general-purpose central processing units (CPUs) or GPUs, Bitmain developed single-use ASIC chips that could only do one thing: compute the proof-of-work calculations inside a bitcoin transaction. The popularity of its Antminer line of bitmining chipsets has earned Bitmain billions of dollars annually while stoking fears of an imbalanced cryptomarket.[7] Other chip designers soon followed with their own bitmining solutions.

The design of Bitmain's chips is advanced, with recent product lines using a 16-nanometer (nm) process (the measure of how small a transistor is), but they are still fabricated away from the Chinese mainland at Taiwan Semiconductor Manufacturing Co. (TSMC), the same foundry that produces iPhone

chips for Apple Inc.[8] This underscores the state of the Chinese semiconductor market: Local design has become competitive, but local fabrication is still behind that of global leaders.

## From bitmining to AI

As China began to regulate cryptomarkets, and as these markets' value has fallen, Bitmain announced its interest in supporting the computational needs of another emerging technology that will likely be larger over time.[9] Like cryptocurrencies, AI has its own unique computational demands—demands that can be satisfied by general CPUs but whose execution can be accelerated by different architectures. Google's Tensor Processing Unit, for example, is an ASIC for AI, and other companies are building ASICs for AI as well.[10] The rise of GPU maker Nvidia has been driven in part by the demand for chips to perform ML training and inference, key tasks underlying today's AI technologies. The massively parallel processing architectures of GPUs are better suited to common AI tasks than the serial designs of CPUs. Initially, gaming GPUs were exploited to drive ML tasks, but in the past few years of AI's global ascent, Nvidia has delivered new hardware lines that directly support ML.[11] Bitmain hopes the needs of AI might be better served by its ASICs than by GPUs.

Beijing's Horizon Robotics, founded by the former head of Baidu's Institute of Deep Learning, supplies embedded chips for machine vision. The chips include pre-trained data sets that can enable edge processors to run inference tasks (predicting how likely it is that an image matches its training set). Backed by Intel, Horizon is working with major automotive brands to provide edge processing with machine vision for vehicles.[12] Although its chips are based on 10-year-old 40 nm processes, Horizon's software enables it to be a strong competitor to much larger players in the embedded inference

market.[13] In this case, Horizon's algorithms enable capabilities above and beyond the hardware.

Another notable Chinese chip player, Cambricon, also has a line of chips specialized to support ML tasks. Previously, Cambricon contributed design support for AI in Huawei's Kirin smartphone chipset, then it delivered its own ML solution for data centers, the MLU100 line.[14] This architecture leverages TSMC's 14 nm process node for fabrication.[15]

Of course, many non-Chinese providers are also trying to sell AI chips to the Chinese market, and foreign competition may grow fiercer as the country meets more of its own demand. The largest Chinese companies will likely buy from whoever supplies the best chips, foreign or domestic. It's worth considering that, like many of the top digital platform businesses, China's largest digital companies are also pursuing their own bespoke chip architectures to meet the needs of their hyperscale digital platforms.[16]

> **Many non-Chinese providers are also trying to sell AI chips to the Chinese market, and foreign competition may grow fiercer as the country meets more of its own demand.**

However, Chinese manufacturers often still lag in fabrication for the most advanced (i.e., smallest) processes. Foundries require enormous capital investments, as they need to build incredibly large industrial processes capable of making incredibly small circuitry. Top Chinese foundries such as Semiconductor Manufacturing International Co. (SMIC) are working to scale production at 14 nm, while AMD, TSMC, and others are reaching 7 nm. By this measure, Chinese foundries are two to three generations behind global leaders.

Despite this lag, the industry in China continues to advance. Revenues for semiconductors manufactured in China have grown steadily over recent

years, reaching around US$78 billion in 2017—a growth rate of about 19 percent over 2016.[17] Over the past 15 years, this revenue curve shows more-than-linear growth, suggesting that the quality of Chinese semiconductors is getting better at meeting demand.[18]

## China meets the future

With the growth of AI and of purpose-built chips to support it, Chinese chipmakers may be able to capture more of that demand. Although China has failed to grow its own chip industry in the past, Chinese manufacturers have steadily developed greater capabilities over the years. Now, they are driven by a heavily funded state agenda, a strong domestic market, and their own hyperscale plat-form companies. As a result, China is perhaps better positioned now than ever before to become a glob-ally competitive player in both semiconductors and AI. This could have very large implications.

Why is China better positioned than ever before? Five current conditions make China's ascent in semiconductors more likely:

**Domestic demand.** China is now the largest global consumer of semiconductors, importing about US$200 billion worth each year.[19] Its large population includes 800 million internet users.[20] The size of China's population and the growth of its economy support strong domestic demand, which drives the majority of foreign suppliers' profits. And while much of the developed world is nearing saturation for PCs and mobile devices, China's demand for chips has continued to grow. Indeed, the world economy has grown increasingly dependent on demand from China, and more global investors are underwriting its future. This shift has helped enable China to have more control over how foreign manufacturers can access its domestic market.

**State sponsorship.** Although China's economy has cooled somewhat, it remains massive, and it has enabled the state and its industries to build significant war chests. And even though the Chinese

state has been criticized for its tight relationship with its largest industries, state control affords the country much tighter market coordination. In 2014, the State Council of China announced the National Guidelines for Development and Promotion of the Integrated Circuit Industry.[21] The plan addressed the technology gap between Chinese manufacturers and global leaders and was supported by a US$21.8 billion fund led by government-backed businesses.[22] In 2015, China announced its Made in China 2025 plan, which aims to grow domestic production of core technological components—including semi-conductors—to 40 percent by 2020 and 70 percent by 2025.[23] More funds have since been raised to support these goals.[24]

SMIC, the world's fifth-largest contract chip-maker, expects its state subsidies for 2018 to near US$100 million.[25] SMIC has placed an order with Holland's ASML for extreme ultraviolet lithography (EUV) equipment, one of the most advanced chip production tools, for an estimated cost of US$120 million. The Shanghai manufacturer hopes to scale production of its 14 nm process by the end of 2019, although it costs billions to build a competitive foundry.[26] It is not alone. The industry organiza-tion SEMI estimates that China will spend US$13 billion on fabrication equipment in 2018 to become the world's second-largest buyer.[27] At the end of 2017, China had plans to build at least 14 new chip foundries.[28]

## Although China's economy has cooled somewhat, it remains massive, and it has enabled the state and its industries to build significant war chests.

**Growing demand for AI.** In 2019, the global semiconductor industry will likely focus more support on the needs of AI. Advances in AI are one of the driving forces for the industry, with an anticipated 5–6 percent growth rate over the next

two decades.[29] Computation itself is undergoing more specialization to meet the needs of AI. These trends are coming together with China's strategic efforts to develop semiconductor independence and move AI into the center of its economic future. By 2018, the country led the world in patents for deep learning, though the overall value of those patents is unclear.[30] China has loudly declared that its future is to be driven by advanced technologies, with AI as a key ingredient.

Many of China's largest companies are hoping to win an edge in the market for AI. Baidu, Alibaba Group Holding Ltd., and Tencent (collectively known as BAT) have a combined market capitalization of over US$1 trillion, fielding global operations in numerous lines of business. They have invested billions in other companies, both domestically and overseas.[31] Indeed, the trio holds positions in more than half of China's 124 unicorn startups, including SenseTime, the world's most valuable pure-play AI company.[32] In some ways, the very existence of the BATs should be proof enough that the country can scale its technology companies to be globally competitive.

# China has loudly declared that its future is to be driven by advanced technologies, with AI as a key ingredient.

Perhaps unsurprisingly, each of the BAT entities are bringing AI capabilities into their own product and service lines.[33] Increasingly, each is making or planning to make its own custom chips for AI. Alibaba has announced a plan to build custom AI chips for inference at the edge, supporting its Internet of Things business lines in autonomous driving, smart cities, and logistics.[34] This builds on its acquisition of Chinese chipmaker C-SKY Microsystems. For its part, Baidu's Kunlun multicore chip solution is a field-programmable gate array chipset built specifically to support its expanding cloud computing platform.[35] The chipset will likely find its way into Baidu's ambitious autonomous driving platform, Apollo. Notably, Baidu isn't getting its chips from China, at least not yet; it's using Samsung's 14 nm process.[36]

In June 2017, China's State Council published the Next Generation Artificial Intelligence Development Plan, which states China's aim of becoming the world leader in AI by 2030. Along the way, the road map aims for parity with western capabilities by 2020 and seeks major breakthroughs in AI by 2025.[37] The plan appears to be well aligned with the agendas of China's top companies, the goals of some of its largest investment vehicles, and the aims of many of its municipal projects.[38]

**Onshoring foreign operations and hiring foreign talent.** Autonomous vehicles sit at the intersection of robotics, AI, and semiconductors. They present very difficult design challenges, and Chinese startups and the country's top hyperscale platform companies still look to Silicon Valley for expertise in driverless technologies.[39] However, while expertise in autonomous cars may remain foreign, Chinese industries are pursuing the hardware and software to build the cars by investing in foreign manufacturers and aggressively hiring and onshoring market leaders. In June 2018, Japan's SoftBank Group announced that it would sell a majority stake in the Chinese operations of Arm Holdings, a leading provider of semiconductor designs (including the Cortex line of chips for the iPhone), to a Chinese investment fund.[40] Led by Hopu Investment Management Co. and backed by a Chinese sovereign wealth fund and Beijing's Silk Road Fund, the group acquired 51 percent of Arm Holdings' Chinese business for US$775 million.[41] The move will give China more access to Arm's designs. Notably, about a fifth of Arm's 2017 earnings came from Chinese demand.[42]

To continue developing their domestic chip supply, Chinese companies should also draw more talent to the mainland. On this front, Yangtze

Memory Technologies has invested US$24 billion to build China's first advanced memory chip factory and has lured thousands of engineers away from foreign chipmakers.[43] The company recently announced progress on its 32-layer NAND memory chip—a good sign, though still behind the state-of-the-art 64-layer chip that other memory manufacturers are achieving. Similarly, to advance its 14 nm efforts, SMIC hired a senior executive away from Taiwan's TSMC, the world's largest contract foundry and one that is considered to be two to three generations ahead of SMIC.[44] Meanwhile,

TSMC has begun constructing a foundry in Nanjing to gain a stronger foothold in the Chinese market.[45]

**Chip design and intellectual property (IP).** Although Chinese companies' ability to manufacture the most advanced semiconductors is still developing, Chinese designs and IP for chip architectures are now globally competitive. Huawei designed its new mobile chipset at 7 nm and claims that it performs better and uses less energy than its top competitor.[46] The Huawei system-on-a-chip also boasts AI cores and claims to be the world's fastest modem—in time for early 5G deployments.[47] While Huawei relies on Taiwan's TSMC for fabrication[48]—similar to other top Chinese technology brands that showcase their domestic designs while manufacturing elsewhere—it signals that Chinese companies can produce specs at the bleeding edge of technology.

## Chinese startups and the country's top hyperscale platform companies still look to Silicon Valley for expertise in driverless technologies.

# BOTTOM LINE

China is moving aggressively in its efforts to define the next phase of the digital economy, with its government, manufacturing, and hyperscale digital businesses all working together. If China meets its goal of growing its domestic chip production as a percentage of total chip consumption to 40 percent by 2020, it could significantly impact the global chip market. Recall that Chinese demand in 2018 accounted for more than half of the world's semiconductor demand. If Chinese chip manufacturers and the Chinese state can buy, hire, and develop enough advanced manufacturing capabilities while meeting the demands of AI, not only could these activities spark more domestic innovation, but China just might be positioned to have a larger impact on the next generation of cognitive technologies.

Leading foundries and chip designers outside China should accelerate their capabilities to remain competitive for Chinese demand. The development of newer architectures specialized for general and discrete machine learning (ML) workflows will likely become more important, with an increasing need for lightweight inference at the edge paired with high-performing training and modeling at the core. Leading AI providers may experience increasing pressure to offer greater capabilities at cheaper prices, which could lead to the commoditization of AI.

Current leaders in AI cloud services should continue to invest in research and development to find newer approaches to learning systems. The BATs are moving quickly, and they have an eye toward a greater presence in global markets. At the service level, they will likely exert more pressure on digital platform leaders and cloud providers, and they may find stronger footholds across logistics, industrial Internet of Things, and automotive sectors. Innovation, efficiency, and pricing will likely become more important to current leaders seeking to secure their competitive advantage. The greatest advantage for semiconductor incumbents, however, may be in staying close to their customers and continually advancing their own digital transformation. This requires sensing, rapid innovation, and the ability to learn and adapt quickly.

If China is even marginally successful in advancing its semiconductor agenda, it may be even better positioned to control access to its growing consumer market. If its progress in AI advances and weaves its way through both the state and commerce, the degree of data, analytics, and insights thus enabled could drive a feedback loop of optimization, enhancement, and innovation—and further reinforce the command-and-control nature of China's economy. To execute successfully on such broad change, however, the Chinese government and China's businesses will likely demand more consulting services and knowledge transfer from developed economies and current industry leaders. A big-picture view could be to see this as a sign of China's digital transformation becoming stronger.

Ultimately, for China, technological independence is about self-determination. Only a few decades ago, China was regarded as little more than the world's cheap manufacturing and assembly hub, and considered a somewhat minor global player. Since then, it has steadily moved up manufacturing's value chain. By learning from decades of manufacturing and by supporting its strongest digital businesses, China has bootstrapped its capabilities to produce some of the world's largest companies and most advanced products. It still faces considerable uncertainties due to the shifting winds of macroeconomics and the very real challenges at the edge of Moore's Law. And yet, it's harder now than ever to doubt China's potential.

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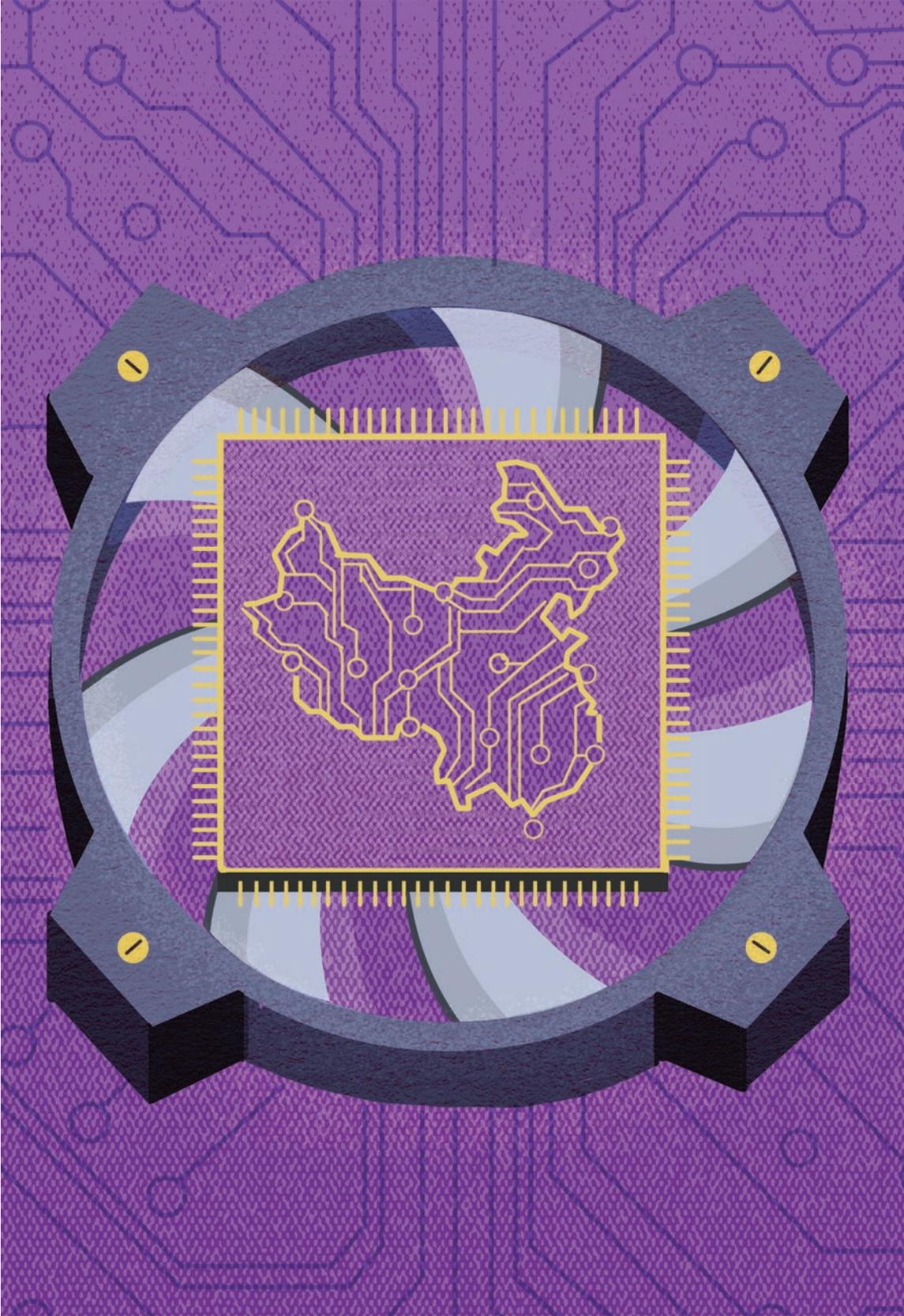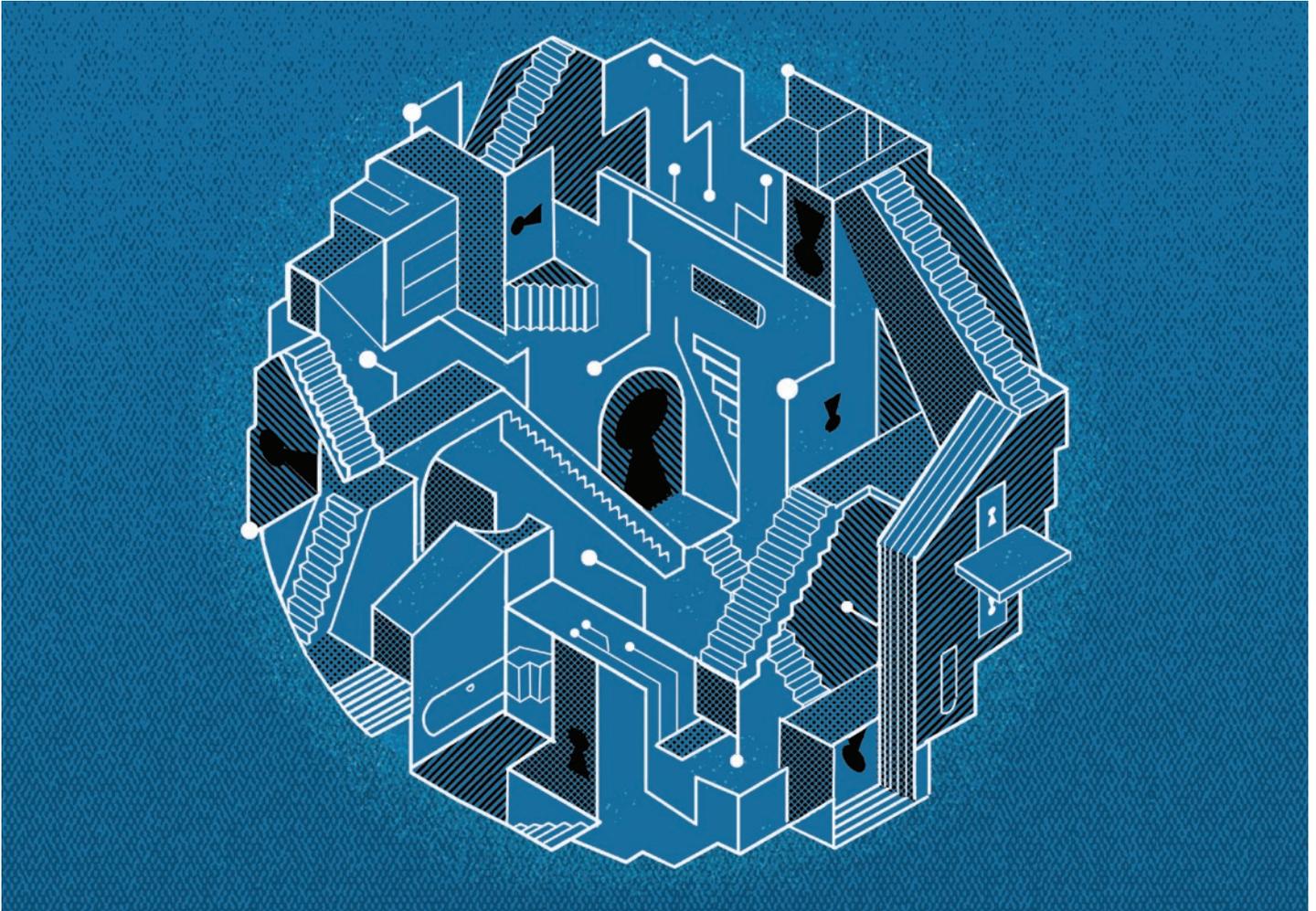
# Quantum computers

The next supercomputers, but not the next laptops

Duncan Stewart

DELOITTE GLOBAL IS MAKING NOT ONE, BUT FIVE PREDICTIONS about quantum computers (QCs) for 2019 and beyond:

1.  **Quantum computers will not replace classical computers for decades, if ever.** It is expected that 2019 or 2020 will see the first-ever proven example of "quantum supremacy," sometimes known as "quantum superiority": a case where a quantum computer will be able to perform a certain task that no classical (traditional transistor-based digital) computer can

solve in a practical amount of time or using a practical amount of resources. But while this will indeed be an important milestone, the term "supremacy" may mislead. Yes, there will be certain useful and important computational problems that will be better solved by QCs, but that does not mean that QCs will be superior for all, most, or even 10 percent of the world's computing tasks.

2. **The quantum computer market of the future will be about the size of today's supercomputer market—around US\$50 billion**. In contrast, the market for classical computing devices (ranging from consumer smartphones up to enterprise supercomputers) is expected to be worth over US\$1 trillion in 2019.[1] Even in 2030, none of the billions of smartphones, computers, tablets, and lower-level enterprise computing devices in use will be quantum-powered, although they may sometimes or even often use quantum computing via the cloud.

QC sales will reach
**TENS OF MILLIONS**
of dollars in 2019,
**HUNDREDS OF MILLIONS**
of dollars per year in the 2020s, and
**TENS OF BILLIONS**
of dollars per year in the 2030s.
But classical devices will have sales of
**\$1–2 TRILLION**
in each of those years.

3. **The first commercial general-purpose quantum computers will appear in the 2030s at earliest.** The 2020s will likely be a time of progress in quantum computing, but the 2030s are the most likely decade for the larger market to develop.[2] (It is worth noting that some serious scientists believe that a general QC will never be built,[3] although this is a minority opinion.)

4. **The Noisy Intermediate Scale Quantum (NISQ) computing market—using what could be considered early-stage QCs—will be worth hundreds of millions of dollars per year in the 2020s.** Early-stage QCs, so-called "NISQ" computers—whose computing bits are "noisy" and less reliable than the more powerful and flexible QCs that will eventually be built, but whose enhanced computing power is still useful—are likely to be commercially valuable. The full range of industries that will be able to take advantage of NISQ computing is unclear, but organizations in the biological and chemical sciences are almost certain to find it useful.

5. **The quantum-safe security industry is also likely to be worth hundreds of millions of dollars per year in the 2020s.** One area in which large QCs will almost certainly deliver an exponential speedup is the area of security and cryptography. A technique called Shor's algorithm is known (when executed by a sufficiently large quantum computer) to be able to break many current public key cryptosystems,[4] such as RSA and ECC. Enterprises and governments should start protecting against the threat of powerful QCs today, not when it happens,[5] since by then it will be too late.

## A theoretical milestone with little pragmatic impact

QCs seem to have been hovering just over the horizon for years, if not decades. For those who are getting tired of waiting, the discipline is likely to celebrate an important milestone in the next couple of years: the achievement of "quantum supremacy." When that happens, what will change?

The pragmatic answer is: not much at first. Although quantum supremacy will mark a conceptual turning point, the reality is that QCs will still be, at least in the near term, difficult to build, awkward to house, and challenging to program—and therefore not ready for the commercial market any time soon. However, progress in this domain is ongoing (albeit in fits and starts), and quantum computing holds a great deal of promise (both scientific and economic) for the future. To be able to sort through the hype that will undoubtedly surround quantum supremacy, it's useful to understand some of the fundamentals behind quantum computing more thoroughly.

## What's a quantum computer made of?

QCs are measured by their number of quantum bits, or qubits, which are the equivalent of a transistor in a classical computer. Today's QCs contain only physical qubits—embodied as two-state quantum systems such as a pair of trapped ions—which rapidly decay and are prone to error. It takes an estimated 1,000 physical qubits to make a single logical qubit—that is, a qubit that is fault-tolerant and error-corrected—and this goal is currently still far out of reach. A universal or general QC (which is what is needed to be able to solve a much larger and wider set of problems), in turn, will require hundreds of logical qubits, and therefore hundreds of thousands of physical qubits.

As of 2018, QCs containing both 20 physical qubits[6] and 19 physical qubits[7] exist whose performance specifications are known and published. Public announcements of devices with 50, 72, and even 128 physical qubits have also been made, but none of these have yet published their specs, so their level of control and error are not known. It is believed that quantum supremacy will be achieved with a machine that has 60 or more physical qubits,[8] but progress is slow, since it gets increasingly harder to add physical qubits as their number increases. Nonetheless, by 2020, a QC of more than 60 physical qubits will almost certainly have been developed and its specs published, and it is likely that the first proof of quantum supremacy achieved.

> **Although quantum supremacy will mark a conceptual turning point, the reality is that QCs will not be ready for the commercial market any time soon.**

A 200-*logical*-qubit machine, which is about the minimum size that is expected to be a commercially useful general-purpose QC (and which would be composed of 200,000 physical qubits, or three orders of magnitude more than the state of the art in 2018), is almost certainly much more than five years away, and possibly more than ten. But when it happens, the devices will be large, nonportable, cost millions of dollars, require experts to program and run, and be superior to classical for only a specific, limited set of hard computation problems. Because of this, whether it happens in 2025 (unlikely) or 2045 (more probably), the global market for general-purpose QC hardware (as distinct from the software and services enabled by them) is likely to be around US$50 billion per year. This is about the same size as the contemporary supercomputer market (which is also made up of large, nonportable million-dollar devices that are only suited to solving certain hard problems), which was worth about

US$32 billion in 2017 and is expected to grow to US$45 billion by 2022.[9]

## Quantum computing is important today

Although the QC market will take years to arrive, will not replace classical computers, and will be worth US$50 billion rather than trillions of dollars in the 2030s, this is still a lot more than what is essentially zero today. Indeed, QC will be one of the largest "new" technology revenue opportunities to emerge over the next decade. In fields where quantum supremacy has been achieved, whole industries will be transformed.

Further, it's not just quantum computing itself that is important, but also the innovations that quantum computing is prompting in traditional computing. The prospect of QCs is galvanizing the classical computing industry, with many advances occurring in the use of classical computers to simulate quantum techniques.[10] These advances

will be useful long before large commercial QCs are available.

## Quantum-safe security was important yesterday

One frightening aspect of QC development is the certainty—not merely the potential—that QCs will be used to crack previously undecipherable codes and breach previously unhackable systems. This will likely only happen when commercial QCs hit the market (probably in the 2030s,[11] although some academics even give it a one-in-six chance of happening by 2026[12]), but the time to start planning for it is now. Confidential data, over-the-air software updates, identity management systems, long-lived connected devices, and anything else with long-term security obligations must be made quantum safe *before* large QCs are finally developed. Indeed, there are several industries where the time to start quantum-proofing has already passed. Organizations in the automotive, military

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**QUANTUM COMPUTING IS COOL. REALLY COOL!**

QCs require controlling and maintaining the quantum behavior of their qubits. Because temperature is often an obstacle to achieving this stability, many physical implementations of QCs are done at extremely low temperatures.

Atoms stop moving entirely at absolute zero (-273.15° on the Celsius scale; -459.67° on the Fahrenheit scale; 0 on the Kelvin scale). Nitrogen turns liquid at 77K, and helium liquefies at about 4K. As of 2018, the most common physical implementations (devices from Google, Intel, IBM and D-wave) rely on temperatures well below 4K—usually around 0.015K (15 millikelvin), although some are operating at even lower microkelvin levels. Such machines and their associated cooling systems, by necessity, weigh thousands of kilograms, are the size of a small car, cost millions of dollars, and use many kilowatts of power. This is not just true today; any QC that requires millikelvin temperatures will continue to be roughly that large, expensive, and energy-consuming even in the 2030s.

There are, however, proposed physical implementations that require "merely" the very cold temperatures that can be achieved with liquid nitrogen. These machines would be cheaper and smaller, albeit still larger and more expensive than almost all classical computers. There are also hopes for room-temperature QC technologies, but none of these have yet been demonstrated to work at more than one or two physical qubits.

Failing those room-temperature solutions, it becomes clear that we are not going to have quantum computing on our smartphones, except through the cloud!

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and defense, power and utilities, health care, and financial services sectors are today deploying long-lived systems that are not quantum-safe, exposing them to significant liability and financial overhead in the future. And that's not the worst that could happen. From a national security perspective, malicious adversaries could store classically encrypted information today to decrypt in the future using a QC, in a gambit known as a "harvest-and-decrypt" attack.

## DEFINITIONS AND GLOSSARY OF QUANTUM COMPUTING TERMS

**Classical computer:** The traditional form of binary digital electronic computing device, almost always running on silicon semiconductor transistor and integrated-circuit hardware.

**Quantum computer:** A computer that uses quantum-mechanical phenomena, such as superposition and entanglement, to perform its calculations. Various (more than 10) contending physical implementations are being tried, many of which require ultra-low temperatures. It is not clear at this time which physical implementation will triumph. Quantum computers are not better than classical computers at everything; they can offer spectacular speedups for certain tasks, but do no better at others, or could even be worse.

**Superposition and entanglement:** This is the secret sauce of how quantum computers do what they do ... but it is not necessary to understand these terms to understand quantum computing's likely market size and timing of commercial availability. For those who wish to know more about superposition and entanglement, many online articles explain them.

**Quantum supremacy or superiority:** Both terms are used more or less interchangeably to denote the point at which a quantum computer will be able to perform a certain task that no classical computer can execute in a practical amount of time or using a practical amount of resources. It is critical to note that just because a QC has demonstrated supremacy for one problem does not mean that it is superior for all other—or even any other—problems. There are different degrees by which a QC can provide speeds greater than a classical computer (see the below entries on quadratic and exponential speedups).

**Quantum advantage:** Although quantum supremacy is an important theoretical milestone, it is possible that it will be for a computing problem that is of no or little practical importance. Therefore, many believe that quantum advantage will be the more important breakthrough: when a quantum computer can perform a certain *useful* task that no classical computer can solve in a practical amount of time or using a practical amount of resources.

**Quadratic speedup:** There are certain computational problems, such as searching an unordered list,[13] where a QC would outperform a classical computer by a quadratic amount: If it takes a classical computer N steps to run the process, the QC can do it in $\sqrt{N}$. (Grover's algorithm is the most famous example of a technique that QCs could use to show a quadratic speedup.) For example, if a given calculation would take 365 days on a classical computer, it would take only 19.1 days on a QC. However, there are few real-world computing tasks done today that take a year, so it is more realistic to say that, if a computation takes eight hours on a classical machine, then it could be done in less than three hours on a QC. That may be a big enough speedup to justify using a quantum computer that costs millions of dollars and requires specialists to run and program it ... or it might not. The business case for using a QC when the speedup is only quadratic is not always compelling.

**Exponential speedup:** The real case for QCs comes when they provide an exponential speedup, as is the case for certain problems such as breaking public key encryption or simulating chemical and biological systems. If a classical machine would take nine billion years to crack a public key by brute force, a quadratic speedup that reduces the calculation time to 3 billion years is not useful. But an exponential speedup that cracks the code in minutes, or even seconds, is potentially transformative. However, it is unclear just how often QCs will be able to offer exponential speedups. Only a small number of problems are known today where QCs would offer exponential speedups, but optimists note that more will become known over time.

**Physical qubit:** Any two-level quantum-mechanical system can be used as a qubit. These systems include, but are not limited to, photons, electrons, atomic nuclei, atoms, ions, quantum dots, and superconducting electronic circuits. As of 2018, most large QCs use either superconducting qubits or trapped ion technologies.

**Logical qubit:** A logical qubit uses multiple unreliable physical qubits to produce one reliable logical qubit that is both fault-tolerant and error-corrected. As of 2018, no one has built a logical qubit. The assumption is that a large number of physical qubits will be required to make a logical qubit; the current consensus is that hundreds or even thousands of physical qubits will be required. Large numbers of logical qubits are necessary for a universal or general QC that can solve a wide range of problems.

**Noisy Intermediate Scale Quantum (NISQ) computing:** Although a device composed of hundreds of logical qubits is the ultimate goal, devices with large numbers of physical qubits are likely to have some commercially interesting uses. These could be thought of as single-task QCs or simulators. According to a leading quantum researcher, Dr. John Preskill, "The 100-qubit quantum computer will not change the world right away—[but] we should regard it as a significant step toward the more powerful quantum technologies of the future."[14]

**Quantum simulation:** The subjects of certain problems, such as chemical processes, molecular dynamics, and the electronic properties of materials, are actually quantum systems. Classical computers are notoriously ill-suited to performing simulations of quantum systems, and they must rely on crude approximations. Since QCs are also governed by the rules of quantum mechanics, they are well-suited to performing efficient simulations of other quantum systems.

**Simulation of quantum computers by classical computers:** Everything that can be done by today's early-stage QCs can be also be done about as quickly on a classical machine simulating quantum computing. Many researchers believe that, at some specific number of physical qubits, a classical machine will be unable to match the QC device—the achievement of quantum supremacy. The twist, however, is that the technology behind the classical simulation of quantum devices is advancing more or less as quickly as the number of physical qubits in QCs is growing. In 2017, when the state of the art was a 20-physical-qubit machine, it was thought that a classical machine could match a 42-physical-qubit QC—but not a 48-physical-qubit QC—for a particular problem. In 2018, as machines with more physical qubits were in development, a mathematical advance was made that showed that a classical computer could now match the 48-physical-qubit device via simulation. So, at least for that specific problem, the "supremacy bar" has been raised, and supremacy will likely not be achieved without a 60-physical-qubit QC. But the supremacy bar cannot be raised indefinitely: For a classical computer merely to store the mathematical representation of a modestly sized (100-qubit) QC would require a hard drive made of all the atoms in the universe!

# BOTTOM LINE

Organizations and governments can take steps now to help capitalize upon—and protect themselves in—a quantum-computing world:

**Create a long-range quantum-safe cybersecurity plan.** It is definitely not too early to begin planning to fortify cyber defenses against a quantum future. The National Institute of Standards and Technology (NIST, part of the US Department of Commerce) recently assessed the threat of quantum computers and advised organizations to develop "crypto agility"—that is, the ability to swiftly switch out cryptographic algorithms for newer, more secure ones as they are released or approved by NIST.[15] Organizations should pay attention to these developments and have roadmaps in place to follow through on those recommendations.[16]

**For companies working at the atomic level, think about NISQ.** Single-task quantum devices of 50–100 physical qubits, though unsuited to most tasks, can be useful for modeling atomic behavior, and they will become available in the relatively near term. Companies in chemistry and biology will almost certainly benefit. Many companies in these fields are already investing in classical high-performance computing (HPC) computing resources;[17] adding a NISQ initiative just makes sense.

**For companies working at the regular-size level, also think about NISQ.** More fields than chemistry and biology can use NISQ computers. In the financial sector, for instance, it is believed that these intermediate QCs can perform portfolio optimization,[18] while other possible financial applications include trading strategy development, portfolio performance prediction, asset pricing, and risk analysis.[19] The transportation industry is also looking at QCs: Some car companies are testing them for traffic modeling, machine learning algorithms, and better batteries.[20] The logistics industry sees potential in QCs for route planning, flight scheduling, and solving the traveling salesman problem (a famously difficult task for classical computers).[21] And, not unlike HPCs, NISQ computers are likely to find a place in both government and academia: for weather modeling[22] and nuclear physics,[23] to name just two examples.

**Update high-performance computing architectures.**[24] Enterprises in industries that have already invested in HPCs, such as aerospace and defense, oil and gas, life sciences, manufacturing, and financial services, should familiarize themselves with the impact that quantum computing may have on the architecture of HPC systems. Hybrid architectures that link conventional HPC systems with quantum computers may become common. One company, for instance, has described an HPC–quantum hybrid for the simulation and design of a water distribution system; it uses quantum annealing, a restricted version of quantum computation, to narrow down the set of design choices that need to be simulated on the conventional system, with the potential to significantly reduce total computation time.[25]

**Reimagine analytic workloads.** Many companies regularly run large-scale computations for risk management, forecasting, planning, and optimization. Quantum computing could do more than just accelerate these computations—it could enable organizations to rethink how they operate, and to tackle entirely new challenges. Executives should ask themselves, "What would happen if we could do these computations a million times faster?" The answer could lead to new insights about operations and strategy.

As observed earlier, companies may even be able to reap some benefits from quantum computing before the machines themselves are commercially available. Quantum computing researchers have discovered improved ways of solving problems using conventional computers. Some researchers are seeking to bring "quantum thinking" to classical problems.[26] A startup that offers quantum-inspired computing technology for machine intelligence claims to be seeing increases in computational speed using this approach.[27]

**Explore academic R&D partnerships.** Companies may find it worth allocating R&D dollars to collaborations with academic research institutions working in this area, as Commonwealth Bank of Australia is doing.[28] An academic research partnership could be an effective way for an organization to get an early start on building knowledge and exploring the applications of quantum computing. Research institutions currently active in quantum computing include the University of Southern California, Delft University of Technology, University of Waterloo, University of New South Wales, University of Maryland, and Yale Quantum Institute.

Most CIOs will not be submitting budgets with line items for quantum computing in the next two years. But that doesn't mean leaders should ignore this field. Because it is advancing rapidly, and because its impact is likely to be large, business and technology strategists should keep an eye on quantum computing starting now. Large-scale investments will not make sense for most companies for some time. But investments in internal training, R&D partnerships, and strategic planning for a quantum world may pay dividends.

# Quantum Computers in the Middle East

## Science fiction meets science fact

Emmanuel Durou and Hasan Iftikhar

WITH THE NATIONAL governments in the Middle East having rolled out ambitious visions and plans for the next decade, from human development to space exploration, the region appears to be a fertile ground for the exploration and maturity of quantum computing applications. Quantum computing, though game changing, is unlikely to present any use case in the Middle East in the near future. While we expect multiple industries to ride the eventual wave of disruption that it will trigger, the financial services and transportation and logistics industries will embrace the trend in the region ahead of other sectors, driven by the former's global competitiveness and the latter's place as a strategic priority for the region's governments.

Saudi Arabia's National Transformation Plan, Bahrain's Vision 2030, Qatar's Vision 2030 and the UAE's Dubai Industrial Strategy 2030 all envision the implementation of major initiatives in e-Government, autonomous transport, traffic management, medical diagnosis, smart cities and more by 2030. Artificial intelligence, big data analytics, machine learning, cybersecurity and fintech are all key technology domains that form a crucial part of these initiatives. And yet general-purpose quantum computing has the potential to radically transform all of their implementation cases in the 2030s. This would mean disruption again, just as their previous implementations are concluded!

For the private sector, the development of cloud-based quantum computing solutions will be key in driving greater market adoption. The high costs and skill requirements (networking, programming, data science) are likely to preclude early adoptions as in the public sector. The exceptions to this will likely be in the financial services[29] and oil and gas sectors[30], where large multinationals operating in the region will be able to leverage their deep pockets and global talent pools towards utilizing quantum computing to revolutionize the way they conceptualize the processing of data. The potential for huge leaps in efficiency, financial portfolio optimization, product production and distribution means that these organizations will need to remain on the cutting edge of the technology lest they fall behind their global competitors.

However, in order to ride this new wave of innovation and maintain the region's reputation as a technology leader, concrete action is required. And some of it is already happening.

We have already seen quantum computing discussed at high-level forums in the region and research partnerships involving the Quantum Computing Research Group at Khalifa University in the UAE[31]. As with data science today, quantum computing is likely to be characterized initially by a dearth of available talent; nurturing these academic structures will give the region a head start on creating a base from which to develop the skilled workforce it will require.

The Dubai Electricity and Water Authority (DEWA) has also announced a strategic partnership with Microsoft to create quantum-inspired solu-

tions to power energy optimization and improve sustainability efforts[32]; it is the first organization outside the US to participate in the Microsoft program. The technology is still nascent[33] however, and the approach for the next decade will rightly be around building the foundation upon which the first general-purpose use cases will be established. We predict that they will likely be in public sector entities and related to the next generation of national development plans, e.g. the UAE 2071 Centennial.

Quantum computing has the potential to disrupt existing industries and to take current "next-generation" technologies (artificial intelligence, big data, etc.) into the "next-next generation". But even with general-purpose use far off, concrete actions are required now in order to make the Middle East "quantum-ready" and pave the way for its arrival.

Public entities in strategic sectors should continue to pursue collaborations with global partners to explore the use cases of quantum computing. But it is also important to examine the legal[34] and regulatory[35] policy frameworks that will be required, and to prepare for the immediate consequences of the technology. For example, there is the need to "quantum proof" data to protect personal, corporate and national security data, as quantum computers will be able to easily crack almost every classical encryption technology.

These consequences necessitate creating new policies (or updating existing ones) around data privacy, data sharing, legal contracts, competition

law, education and incentives to encourage investment and adoption. Fortunately, the region has shown the willingness to embrace best practice legislation (Qatar's Cybercrime Prevention Law) and to engage in the discussion required to react to these new developments, e.g. public consultations in the UAE (through the TRA) or Saudi Arabia (through the CITC). We have also seen sustained initiatives to attract I.T. investment through Qatar's TASMU program, Saudi Arabia's NEOM city in its Saudi Vision 2030 and in the UAE's technology initiatives connected with Vision 2021 and Expo 2020. These frameworks can be reoriented to attract quantum computing startups and provide incubation support for their development in the region.

The lead time presented by the ongoing development of the technology presents the perfect opportunity for governments in the Middle East to engage with a broad array of stakeholders and craft world-leading policy frameworks to herald the advent of the quantum age. Wedded to these initiatives will be continued encouragement for early test cases and support for quantum computing-focused educational structures that will produce the next generation of talent. With the full support of the governments of the region there is no reason why the Middle East cannot become a case for successful quantum computing development and integration that can be exported, and envied, globally.

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# About the authors

**PAUL LEE** is a UK partner and the global head of research for the technology, media, and telecommunications (TMT) industry at Deloitte. In addition to running the TMT research team globally, Lee manages the industry research team for Deloitte UK.

**DUNCAN STEWART** is the director of research for the technology, media, and telecommunications (TMT) industry for Deloitte Canada. He presents regularly at conferences and to companies on marketing, technology, consumer trends, and the longer-term TMT outlook.

**JEFF LOUCKS** is the executive director of Deloitte's Center for Technology, Media & Telecommunications. He is especially interested in the strategies organizations use to adapt to accelerating change, conducting research and writing on topics that help companies capitalize on technological change.

**CHRIS ARKENBERG** is a research manager with Deloitte's Center for Technology, Media & Telecommunications. He has dedicated his career to exploring how people and organizations interact with transformational technologies.

# Contacts

**Paul J. Sallomi**
Global TMT industry leader
Partner
Deloitte Tax LLP
+1 408 704 4100
psallomi@deloitte.com

**Mark A. Casey**
Global TM&E sector leader
Director
Deloitte Africa
+27 118065205
mcasey@deloitte.co.za

**Craig Wigginton**
Global Telecommunications
and Americas TMT leader
Partner
Deloitte & Touche LLP
+1 212 436 3222
cwigginton@deloitte.com

# About the Middle East authors

**EMMANUEL DUROU** is a Middle East partner and the leader for the technology, media, and telecommunications industry in the region.

**HASAN IFTIKHAR** is a Middle East operations director in the technology, media, and telecommunications industry in the region. He leads the digital strategy and transformation service propositions in various sectors in the region including Government, media, telcos and e-commerce.

**GAURAV GOVIL** is a Middle East strategy director in the technology, media, and telecommunications industry in the region.

# Additional contributors

**Tiago Martins**
Senior Manager, Monitor Deloitte,
Deloitte and Touche Middle East
tmartins@deloitte.com

**Mohamed Yusuf**
Senior Manager, Deloitte and
Touche Middle East
mohyusuf@deloitte.com

**Adil Parvez**
Manager, Monitor Deloitte,
Deloitte and Touche Middle East
aparvez@deloitte.com

**Jean-Louis Prevost**
Manager, Monitor Deloitte,
Deloitte and Touche Middle East
jeprevost@deloitte.com

**Nicholas Seemungal**
Manager, Deloitte and
Touche Middle East
nseemungal@deloitte.com

**Faisal Najim**
Senior Consultant, Deloitte
and Touche Middle East
fnajim@deloitte.com

**Thierry Bosnoyan**
Senior Consultant Deloitte
and Touche Middle East
tbosnoyan@deloitte.com

**George Kazan**
Senior Consultant, Monitor Deloitte,
Deloitte and Touche Middle East
gkazan@deloitte.com

**Caroline Ayes**
Consultant, Monitor Deloitte,
Deloitte and Touche Middle East
cayes@deloitte.com

**Christian Gemayel**
Consultant, Monitor Deloitte,
Deloitte and Touche Middle East
chgemayel@deloitte.com

**Kareen Kafity**
Consultant, Deloitte and
Touche Middle East
kkafity@deloitte.com

**Yasmine Attar**
Business Analyst, Deloitte and
Touche Middle East
yattar@deloitte.com

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