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2022 Predictions

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Contents

Foreword

TMT Predictions 2022

IN LAST YEAR'S *TMT Predictions* report, we called COVID-19 a catalyst for the trends we were seeing in the TMT industry. Now, nearly two years in, we still can't escape its impact. But we do expect that 2022 will be about far more than recovering from the pandemic.

It's true that COVID-19 has accelerated many of the trends we highlight: the lockdown-driven lift in console gaming, churn due to greater competition among streaming video services, the decline in viewing share among traditional TV broadcasters, the increasing adoption of health and wellness technologies, and the growth in 5G and other advanced connectivity for both enterprises and households. But we also look at new and shining opportunities that are emerging regardless of the pandemic. In this latter category sit technologies like RISC-V, bringing the advantages of open source to chip architecture; quantum computing and its cousins, quantum communication and quantum sensing; addressable TV technology that can help expand television advertising's reach; and nonfungible tokens (NFTs), which offer new avenues for monetizing sports and other media. In fact, sports NFTs started trading *after* March 2020, but already generate over a billion dollars in trades!

Some of this year's predictions are cautionary. The tech industry has continued to make progress in women's workforce representation, but sustaining this may take redoubled effort. Men and boys will likely continue to read fewer books than women and girls, with implications for academic achievement and social skills. And stricter AI regulations may be on the horizon, with the potential for restricting or even banning some AI applications.

Yet there are also many bright spots to share. Emerging privacy-enhancing technologies can help address AI's privacy and security challenges. The easing of the global semiconductor shortage may be in sight, and the billions of dollars' VCs pouring into new semiconductor companies are a spur to innovation. Smartphones are being used for longer, reducing their environmental impact. And floating solar panels, aka floatovoltaics, are poised to expand the renewable energy mix.

We hope this year's edition of *TMT Predictions* both reflects the world we now live in and illuminates the world to come.

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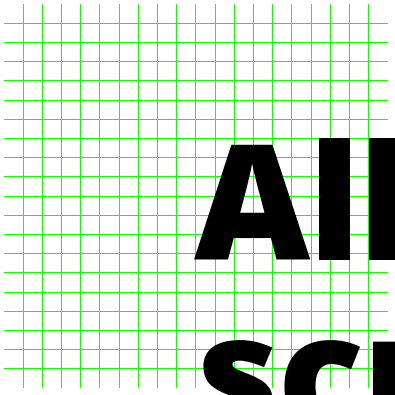
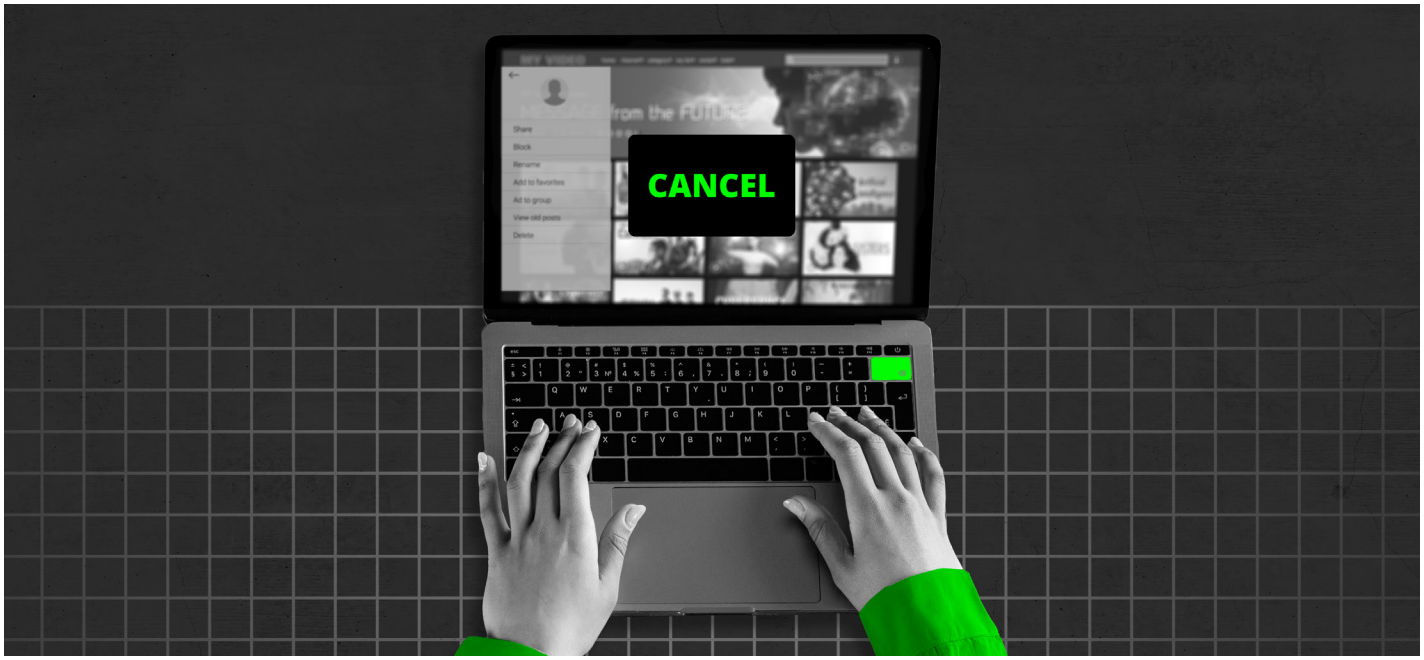


All about screens



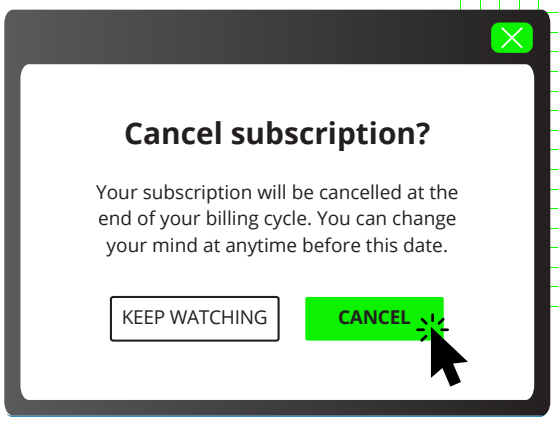
As the world churns: The streaming wars go global

Subscription video-on-demand providers' pursuit of global viewers is igniting competition and catalyzing SVOD churn. Customizing business model by market may be key to success

Chris Arkenberg, Paul Lee, Andrew Evans, and Kevin Westcott

AS LEADING STREAMING providers expand globally while national media companies spin up their own domestic streaming services, the amplified competition is creating abundant consumer choice—and churn is accelerating as a result. Deloitte Global predicts that in 2022, at least 150 million paid subscriptions to streaming video-on-demand (SVOD) services will be cancelled worldwide, with churn rates of up to 30% per market. That's the bad news. The better news is that, overall, more subscriptions will be added than cancelled, the average number of subscriptions per person will rise, and, in markets with the highest churn, many of those cancelling may resubscribe to a service that they had previously left. These are all signs of a competitive and maturing SVOD market. As SVOD matures, growth across global regions that may have different cost sensitivities will likely require different business model innovation and pathways to profitability.

Choice for consumers, churn for providers



Churn, as the term is used here, occurs whenever a subscriber cancels their subscription. This can be highly problematic for SVOD providers, which may spend up to US$200 to acquire each subscriber, though acquisition costs vary by market.[1] As the number of SVOD services grows and the pool of untapped consumers declines, acquisition costs may rise higher still, making retention even more important.

Churn has been most marked in the United States, where SVOD has the highest adoption and the most services launched. A maturing market features tentpole content spread among major services, and as new providers have entered the US market, consumers have added more premium and niche subscriptions to acquire and maintain the exact content they want. However, many have become overwhelmed by managing and paying for all those subscriptions, and they have become more sensitive to their cost. These conditions can drive customers to cancel subscriptions and/or seek less expensive ad-supported offerings, both to manage costs and as a way to pay only for the content they want by adding and cancelling services as needed.

Providers seeking to retain customers through the strength of their content are spending billions of dollars annually to develop and acquire top-tier programming.

The net result is that, in 2021, around 80% of households in the United States had a paid SVOD subscription,[2] with about 35% churn.[3] Providers seeking to retain customers through the strength of their content are spending billions of dollars annually to develop and acquire top-tier programming. But it may not be sustainable to spend so heavily, and consumers will only take so many price hikes. More US SVOD providers are hence looking to pricing as another lever to fight churn, offering cheaper or free ad-supported packages.

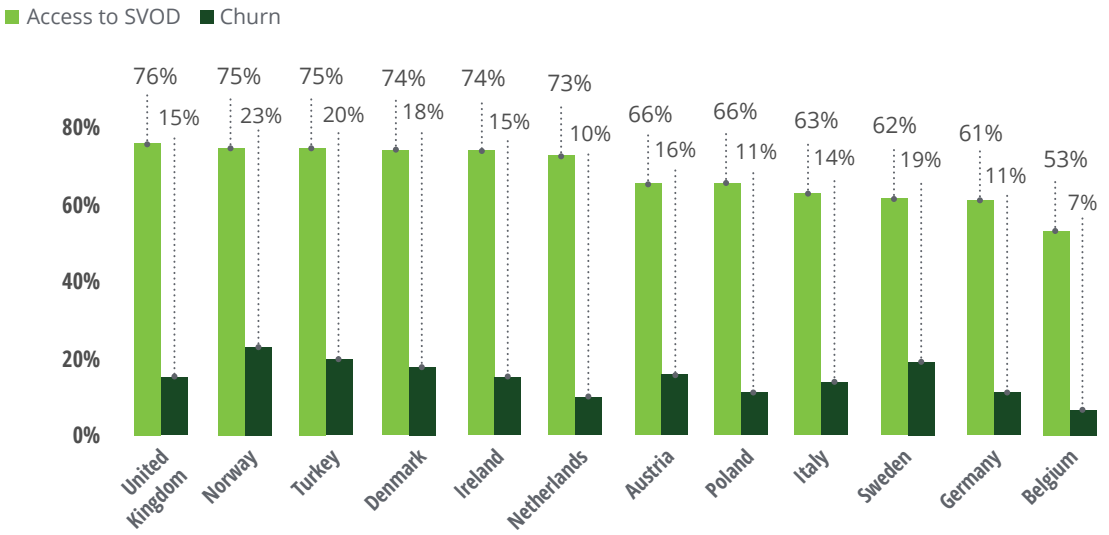
The younger European SVOD market has mostly replicated the US model. European broadcasters initially launched on-demand services with relatively small libraries, often at zero cost. But US-based providers followed with paid subscription services, much broader content portfolios, and simpler user experiences with data-driven content recommendations. The competition prompted many European providers to follow suit, yielding stronger growth. Across Europe, churn ranged from 7% to 23% as of mid-2021 (figure 1).[4] But in 2022, the European market is likely to become more competitive, and higher churn will be the probable result, although we still expect it to stay below 25%.

While paid subscriptions have worked well in advanced economies, audiences in developing economies favor free ad-supported options.[5] In Latin America, global and local SVOD providers are

FIGURE 1

Churn in Europe ranged from 7% to 23% as of mid-2021

Access to SVOD and churn rate in selected European countries, percent, 2021



Questions: "Which, if any, of the following digital subscription services do you have access to? In the last 12 months, have you or someone else in your household subscribed to any paid subscriptions for a video streaming service, or cancelled any existing ones?"

Notes: Weighted base: Respondents age 18–75 in Austria (1,000), Belgium (2,000), Denmark (1,000), Germany (2,000), Ireland (1,000), Italy (2,000), Norway (1,000), and Sweden (1,000); age 16–75 in the United Kingdom (4,160); age 18–70 in the Netherlands (2,000); age 18–55 in Turkey (1,000); and age 18–65 in Poland (2,000).

Source: Deloitte Digital Consumer Trends, June–August 2021.

delivering content that is highly tailored to those regions at lower prices than in developed economies.[6] Many use advertising to offset subscriber acquisition and content costs, reducing the effect of monthly subscription costs as a cause of churn. Some large regional players are also targeting expat communities while partnering with leading streamers to get their content to more viewers.[7]

In Asia/Pacific, free, ad-supported video-on-demand (AVOD) services predominate. AVOD subscriptions in China and India number in the hundreds of millions—much higher than SVOD. India's Hotstar, for example, has 300 million active users of which 46.4 million are paid subscribers,[8] while China's iQiyi counts 500 million viewers with 100 million paid.[9] These services offer multiple pricing tiers from free to premium; their focus is on upselling free ad-supported users into a paying tier,[10] betting that this subscriber revenue will balance out potentially higher content and acquisition costs.[11] Importantly, they also offer multiservice bundles that include innovative content and advertising, gaming and music, and mobile-first engagement.[12] This array of services allows providers to aggregate very large audiences and monetize them in various ways, not just through subscriptions and video,[13] and it can also help insulate them from churn.

The Asian model may inform how US services can expand globally and how providers in Europe, Latin America, and Africa can grow their own offerings.[14] As SVOD matures in multiple markets, we predict that their growth will be increasingly based on ad-supported models, and that the metric for SVOD success will be less about subscriber count and more about overall revenue from all services and sources. This may favor media companies that offer more than just streaming video.

THE BOTTOM LINE

Whatever the business model, providers worldwide should keep churn under control as competition intensifies. The cost of content development and acquisition is unlikely to decline, and the pressures to acquire and retain audiences will persist. To succeed, SVOD providers should work to better understand their customers and their lifetime value, develop more options for different audience segments, and offer value across an array of entertainment options.

Offer more pricing tiers. Providers could add more pricing tiers for different subscriber segments, customized to each market. They could attract viewers through multiple ad-supported and ad-subsidized tiers, then target premium subscribers with VIP tiers and access to exclusive content such as first-run movie premieres and premium sporting events. Providers could also offer reward programs to free ad-supported subscribers as a pathway to access premium content and exclusives.

Leverage partnerships. Partnering with telecom operators or cable TV can provide access to a large proportion of the population, especially in mobile-first markets. This can help SVOD providers trim distribution and customer management costs, or simply create more incentives for people to stay with a bundled option. Partnering with studios and distributors can similarly help providers manage costs and reach broader audiences, as well as develop regional content. However, SVOD providers should ensure that customer satisfaction—and access to customer data—is not diluted by such partnerships.

Understand customer value. Better data about smaller customer segments can be essential to developing more effective content personalization, acquisition, and retention tactics. It can make it easier to predict when a customer might leave due to growing cost sensitivities or indifference to content—and even lower the risk of developing new content through a better understanding of what will succeed for different segments. By using data to understand the lifetime value of a customer, providers can develop more enduring relationships, especially with more-profitable age groups: A 20-year-old customer who remains loyal can yield decades of recurring revenues.

Learn from other providers. SVOD providers can anticipate and mitigate churn by learning from maturing on-demand services around the world. They can also look to learn from telecoms, which have spent decades managing churn, as well as companies in gaming and social media—SVOD's two largest competitors.

SVOD's success was built on offering a flexible alternative to the costs and constraints of pay TV, and consumers are not likely to relinquish the freedom they have become accustomed to in assembling their own select baskets of entertainment. SVOD providers' ultimate success will likely lie in building a nuanced and granular relationship with consumers to deliver ongoing value—not finding ways to make it harder for them to leave.

Endnotes

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The games console: Fitter than ever at 50

There's no midlife slump for the video games console market. Content, experience, and business-model innovations are keeping it competitive

Paul Lee, Chris Arkenberg, and Kevin Westcott

THE GAMES CONSOLE ecosystem celebrates its 50th birthday in 2022 in robust health: record revenues, a full slate of latest-generation devices, and a strong foundation for further growth.[1] Deloitte Global predicts that the console market will generate US$81 billion in 2022, up 10% from 2021. Revenues per console player, of whom there will be 900 million by the end of the year, are expected to average US$92 per person—substantially more than the projected US$23 per PC gamer and US$50 per mobile gamer.[2]

About US$59 billion of 2022's console revenues will be from software sales, composed of video game titles, subscriptions (more than US$10 billion), and in-app payments. Console hardware sales are expected to top US$22 billion, subject to the resolution of supply chain issues that had constrained the supply of the latest-generation consoles released at the end of 2020. Importantly, pricing for the newest gaming consoles has proven resilient, with launch prices able to be maintained longer than for prior generations of consoles.[3]

Beyond 2022, console software sales are expected to continue growing, reaching close to US$70 billion by 2025.[4] Over this period, digital game purchases, including downloads, subscriptions, game passes, and in-app payments, are expected to rise as a share of sales from 65% in 2022 to 84% in 2025.

Diverse innovations are bolstering the console ecosystem

The games console is at the center of an expanding ecosystem that continues to innovate in content, experiences, and business models. These innovations are transforming the console ecosystem from one based on final products generating one-off sales—whether a physical console or a game title—to a perpetual and evolving entertainment service that encourages daily, often multiplayer gameplay, generating a steady stream of revenue.

Subscriptions are a critical development. We forecast that console owners will have more than 200 million multiplayer and game subscriptions in 2022. By 2025, these subscriptions will likely generate more than US$11 billion in revenue, up from US$6.6 billion in 2020.[5] A console owned for eight years may garner as much subscription revenue as from the sale of the console itself.

Another notable innovation is downloadable content (DLC), which offers gamers new "chapters" of gameplay and storylines, the use of virtual currency, and in-game add-ons such as better gear and distinct outfits. Some titles have also evolved into games-as-a-service with constantly updated storylines, content, and events that encourage regular play. For example, Rockstar's *Grand Theft Auto 5* began in September 2013 as a top-tier single-player experience, but has since expanded into a multiplayer service in an evolving game world—making it the bestselling game in the US market between 2010 and 2019.[6]

Another approach is the annual, rather than occasional, release. This tactic is common among sports titles such as *FIFA*, *Pro Evolution Soccer*, and *Madden*. Because players in each real-world team are constantly changing, with major transfers taking place once or twice a year, sports titles are suited to annual updates. This type of annual game can also be bundled with additional revenue streams, such as in-app payments and game passes.

Yet another innovation is that console game makers, successfully taking a leaf out the mobile playbook, are now offering free-to-play games that are monetized through in-app purchases. The best-known example of this is Epic Games' *Fortnite*, which has generated billions of dollars in spend.[7] In some cases, games that were formerly sold outright, such as *Rocket League*, have switched to this model.[8] Popular multiplayer titles are looking a bit like immersive social media, with greater socialization and personalization of avatars through purchased "skins" (clothing, hairstyle, and so on) and "emotes" (most commonly gestures and dance moves).

A final spur to console game growth is its increasing integration with mobile. While games have historically been designed for either of the two very different device types, console titles are now starting to be integrated with complementary smartphone apps, allowing players to commingle in the same game from any device. In 2022, we expect this nascent trend, called cross-play, to accelerate. An early example of console-mobile integration is *Call of Duty* one of the most popular multiplayer console franchises. The franchise has introduced a mobile version of its games, designed to keep people playing and invested while on the go and away from the big screen. According to one estimate, *Call of Duty: Mobile* boasts 200 million active users overall and about 30 million daily active users.[9]

The jury is likely to still be out in 2022 over whether console-mobile integration is net positive for consoles. Over time, cross-play might dilute the value of a given console, or at least undermine the role of new releases that are exclusive to a single platform. This highlights a mounting tension in the gaming ecosystem: Top game franchises are jostling for prominence with the hardware that runs them.

THE BOTTOM LINE

Consoles have a great deal going for them heading into 2022, with the most prominent bulge being to the revenue line.[10] The newest generation of consoles has only just launched, with three models debuting in 2020–2021,[11] and multiple major new titles are planned for launch in 2022–2023.[12] With a six-year average lifespan, new consoles will likely remain at the center of the most compelling game experiences.

Consoles also likely won't lack for future customers, and this will have implications for other media categories that are competing for the same eyeballs. The console user base is young, aging well, and expanding. Deloitte research on US consumers has found that the majority of 14-to-24-year-olds rank gaming as their favorite form of entertainment, even ahead of TV and streaming video.[13] As this generation ages, it will likely retain gaming as a prominent part of their lives. Gaming has been growing among millennials and Generation X as well. Middle-aged players who grew up with consoles as kids have remained loyal or returned to them as 40- and 50-year-olds.[14]

The pandemic has further accelerated adoption and engagement with gaming. During the pandemic, parents spent more time gaming with their kids—a social activity that may well endure.[15] As COVID-19 recedes, out-of-home activities will likely compete for entertainment time, but gaming has held strong even in cities that have reopened.[16] Even before the pandemic demanded remote socializing, the most popular games, such as *Fortnite*, *Call of Duty*: *Warzone*, and *Apex Legends*, were based around social experiences, further strengthening retention: Leaving the game may mean disconnecting from friends.

From a competitive standpoint, cloud gaming has been expected to usurp the console, but its threat level is likely to be meek in 2022. In part, this is due to network readiness: This year, most homes globally will lack the required connectivity to run high-performance cloud gaming while sustaining other home broadband needs. Even a 720-pixel (lower than HD) cloud gaming experience may require a *dedicated* 20 Mbit/s connection. Further, cloud gaming requires upstream handling of player inputs, placing additional demand on the data connection—and possibly the data plan.[17] From a game experience perspective, too, the offer of 4K from cloud gaming services will become ever less compelling as the installed base of 4K (and 8K-ready) consoles steadily increases.[18] It's small wonder that, though publishers have allowed some of their titles to be ported to cloud services, they have found little incentive to release games exclusively on a cloud platform. For cloud gaming to take off, it will likely need to clearly offer better value than the console—such as delivering on the promise of much larger and richer game worlds capable of hosting thousands of players in the same instance (most multiplayer games have a cap of 150 players in the same world).

Console makers should, however, plan for a future where a growing proportion of game execution and delivery happens over the network. The best way for the console ecosystem to compete may be to meld the best elements of the console, which is essentially a high-performance edge computing device, with the best of the cloud, which already includes online marketplaces and multiplayer play. Console makers could also develop, acquire, or license more content IP, reinforcing their role as game development studios. They can explore how the console could guarantee quality of service in the home and play a stronger role in gating content, social moderation, and purchasing for different family members. Additionally, console makers could consider offering premium hardware options or the ability to add additional graphics cards that cater to gaming communities such as those participating in competitive esports, which have typically preferred the customization and extensibility of PCs.

All in all, consoles are far from the has-beens that one might think such a venerable platform may have become. Their ability to deliver compelling and highly social game experiences, coupled with business models that allow for recurring revenue, is keeping them very much alive, well, and poised for future growth. Happy 50th!

Endnotes

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Addressable TV ads: Targeting for reach

Addressable TV advertising can deliver targeted TV ads to different households—but its best use may be to extend reach, not to differentiate messages

Paul Lee, Robert Aitken, Andrew Evans, and Kevin Westcott

TELEVISION ADVERTISING, FOR decades the largest category of advertising in dollar terms, now has the technology to target specific consumer segments in the same way as online retailers and social media platforms have been doing for years. Deloitte Global predicts that addressable TV advertising, which allows different ads to be shown to different households watching the same program, will generate about US$7.5 billion globally in 2022.[1] This is about 40 times more than the revenue we forecast it would generate in 2012, when *TMT Predictions* last evaluated the format.[2]

Now for the caveat. Though 40-fold growth in 10 years may sound impressive, it is a small part of the global US$153 billion TV ad market forecast for 2022.[3] In short, addressable TV advertising has a long way to go before it's a major part of the TV advertising landscape. And what can get it there will be its ability to show the same ad to far more viewers, rather than targeting different households with different ads.

Targeting gets the hype, but reach delivers the value

An addressable TV ad is audiovisual, intended for viewing on a large screen—typically a television, but also a laptop or tablet—and inserted into a live TV broadcast or into streamed video content from any provider.

The view that addressable TV advertising was poised for takeoff has been prevalent for years, which is why *TMT Predictions* first wrote about the format back in 2012.[4] Ten years on, expectations are even higher, largely due to advancements in the enabling technology as well as seismic growth in targeted digital ad revenues in the past decade. Pay TV players have deployed a new generation of set-top boxes with ample storage to prestore ads that can be selectively played back during commercial breaks.[5] Meanwhile, broadband speeds globally have been steadily and significantly increasing, enabling and encouraging mainstream usage of video on demand (VOD). Average speed across over 200 territories globally reached 29.79 Mbit/s in 2021, up 20% year over year.[6] With VOD services of any type, customized ads can be inserted into the stream, targeted to each device's viewer or viewers—and the amount of data on those viewers to enable targeting has exploded since 2012.

The way in which addressable TV advertising will likely grow, however, isn't likely to be through individual advertisers making different ads with which to target different households. For the next five years, Deloitte expects major advertisers—which will continue to be the major buyers, in monetary terms, of TV ads—to value addressable advertising more for its ability to *extend* reach, and so spread their message to the majority of each market, rather than for its capability to *differentiate* messages by household or individual viewer.

The traditional TV ad offers three unique attributes: the size of the screen it is viewed on, the extent of its reach, and brand safety. In 2022, no other medium is likely to be able to match TV's ability to deliver high-production-value 30-second stories to 80% or more of the population within seven days.[7] Furthermore, TV ads don't give viewers the option to comment on the content, the outputs of which may require moderation. But TV ads also have fundamental constraints, the most prominent of these being the time and cost required to create a TV ad, especially one destined for prime time. This fundamentally limits the supply of ads at any point of time, diminishing the benefit of targeting.

For the traditional TV sector, addressable ads may enable higher revenues and may also help television advertising remain viable. Linear TV's reach, though still superior to other types of media, has steadily fallen over the past decade, decreasing by 2–3% per year in major markets globally.[8] The declines have been steepest among the youngest age groups, who are becoming increasingly expensive to reach. So far, declines in viewing hours have tended to be balanced out by increases in cost per viewer, enabling TV ad revenues to stay relatively stable in many markets. In fact, spend on TV advertising globally is expected to be up 1% in 2021 despite the decline in hours watched, because average price per impression has risen 5%.[9]

But this cannot continue indefinitely. This is where addressable TV ads come in—by adding in viewers on advertising-funded VOD (known as AVOD in North America and Asia, and includes broadcaster VOD in Europe), social media, or even video games whose content is watched mostly or wholly online. In this context, addressability would be deployed to show more people the same ad by aggregating audiences across multiple platforms, both broadcast and online.

If addressable TV ads thus benefit advertisers, broadcasters, and on-demand platforms, why haven't they yet taken the TV advertising world by storm? The answer is that, like many markets, addressable TV advertising needs a full-fledged supporting ecosystem to flourish, and that ecosystem has not yet developed. The necessary elements include the way addressable TV ads are measured, aggregated, sold, and created.

Traditional TV measurement should expand to include addressable ads delivered via any service and screen

Major advertisers are accustomed to robust, trusted measurement data for broadcast and digital video recorder views on TV screens. They will likely be reluctant to spend heavily on addressable technology until they perceive that they can combine this data with equally robust and trusted data for all other devices and services on which their ads are shown.[10]

As of 2022, we expect that in most markets, unified measurement of TV ads shown on any screen via any service will still be unavailable. This will likely be one of the major constraints on addressable TV advertising attaining its potential. Some headway will be made: The United Kingdom, for instance, is likely to be one of the first markets with unified measurement, via a system called CFlight.[11] But until unified measurement is widespread, advertisers will need to wrestle with one set of viewing data for broadcast and digital video recorder (DVR) views and a separate set for on-demand views, including those from broadcasters' online offerings, as well as additional sets of viewing metrics from social media with TV apps and TV set vendors.[12] What this means is that an advertiser cannot determine exactly who or how many people have seen an ad: A single viewer would be double-counted if they saw the same ad on broadcast and on-demand. This could be a deal killer for major campaigns—such as the launch of a major new car model or food brand—where accurately quantifying aggregate reach is of paramount importance. If measurement cannot be unified, the benefits of additional inventory across multiple platforms cannot be realized.

Addressable TV ad inventory should be aggregated to simplify buying

In 2022 and subsequent years, the number of platforms that could house addressable ads should rise steadily. More and more ad-funded VOD platforms will arise; TV hardware vendors are likely to increasingly sell space on their home screens as a means of generating recurring revenue;[13] and social media platforms may create apps specifically for TV.[14] However, for addressable TV ads to thrive, advertiser access to the market should be rationalized to minimize the number of commercial negotiations required to place ads across the growing number of platforms. This will most likely occur via aggregators that act as intermediaries for the growing number of content suppliers.

The cost of creating a TV ad likely needs to fall to enable more advertisers to participate

Addressable technology enables companies to experiment with smaller campaigns reaching selected audiences, an approach well suited to smaller advertisers and larger companies new to advertising. But besides buying space, advertisers need to pay to create the content. One approach to making TV ads affordable is for ad agencies to offer a library of video content that can be used to assemble some parts, or all, of a commercial.[15] This may be good enough for advertisers targeting less discerning daytime viewers.

THE BOTTOM LINE

Addressability is important not only for TV, but for advertising in general. But attaining its potential requires its application to be tailored to what TV advertising—and the entire TV ad ecosystem, including media planners—is best at.

Advertising serves many purposes. TV advertising excels at telling a majority of consumers about brands, products, and services they did not realize existed, or did not realize they needed. In contrast, the important but different function of driving immediate sales from a single device is less suited to TV. While TV ads can prompt this behavior, smartphones or laptops, which may hold prestored credit card data and offer one-click buying, are far more cable of generating on-the-spot transactions. But no smartphone can replicate the impact of a beautifully shot ad shown in high definition on a 65-inch TV screen with surround sound on, not muted.

What's more, advertising is not, never has been, and likely never will be predicated solely on precision. Consider that a couple with a newborn may well prefer to be shown an ad for a sports car, and not a sensible sedan, precisely because it is aspirational, rather than functional. TV could be the way of planting that seed of an idea specifically because it is *not* driven by context. Indeed, it may well be that most people prefer their ads without customization. According to one Deloitte survey, only one-tenth of respondents strongly preferred ads to be tailored, while two-thirds did not want customized messages or were indifferent.[16] Extending the reach of these types of ads—novel and unanticipated rather than contextualized and expected—will likely be addressable TV advertising's most effective use.

Endnotes

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8. Nielsen, "Tracking the evolution of global TV viewing," August 10, 2021.
9. Zenith, "Ecommerce and online video to fuel 11% recovery in global adspend this year," July 26, 2021.
10. As of Q4 2020, YouTube was being measured by Nielsen in the US market; Megan Graham, "YouTube reaches 120 million people watching on TV screens per month," CNBC, March 10, 2021.
11. CFlight is a single measurement system that spans viewing for multiple broadcasters, across all devices, and provides a de-duplicated count of viewers across live, time-shifted, and on-demand platforms. At its launch, its scope is age 18+ viewers, but it needs to be able to measure younger viewers to be fully effective. It would also need to include social media viewing on TV sets. For more information on methodology and scope, see: Thinkbox, "CFlight FAQs," June 9, 2021.
12. Some TV equipment makers, such as Vizio, Roku, and Samsung, have started to sell advertising directly. For instance, Vizio sells advertising space as well as viewing data to advertisers. Net revenues from this business were US$51 million in the first quarter of 2021; Vizio, "Vizio Holding Corp. reports Q1 2021 financial results," press release, May 11, 2021.
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14. TikTok is one of the more recent arrivals on TV sets; YouTube is one of the longest established, with 100 million views in the United States in March 2020; TikTok, "TikTok on Google TV and Android TV is here!," February 4, 2021; Gina Shalavi, "More people are streaming YouTube on their TV screens. Here's what they are watching," Think with Google, September 2020.
15. Other approaches include trading airtime for equity, enabling budget to go on creative. Startups wanting to scale users quickly need TV to attain national reach fast. Broadcasters or investment firms may trade a stake in the company for airtime. For an example of airtime for equity in the United Kingdom offered by ITV, see: ITV Media, "ITV AdVentures Invest: A unique media for equity opportunity with ITV," accessed October 27, 2021.
16. Paul Lee, *Digital Consumer Trends: The UK cut*, Deloitte, September 2021; based on fieldwork undertaken from June–July 2021, conducted on 3,974 respondents, aged 16–75. The question asked was about "ads you see when using the internet and using social media. To what extent do you prefer these to be tailored to you based on your interests or online search?"

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Traditional TV wanes: Television is about to dip below half of all UK video viewing

TV's viewership decline in the United Kingdom's bellwether market heralds a new era for the video content ecosystem

Paul Lee, Klaus Boehm, and Kevin Westcott

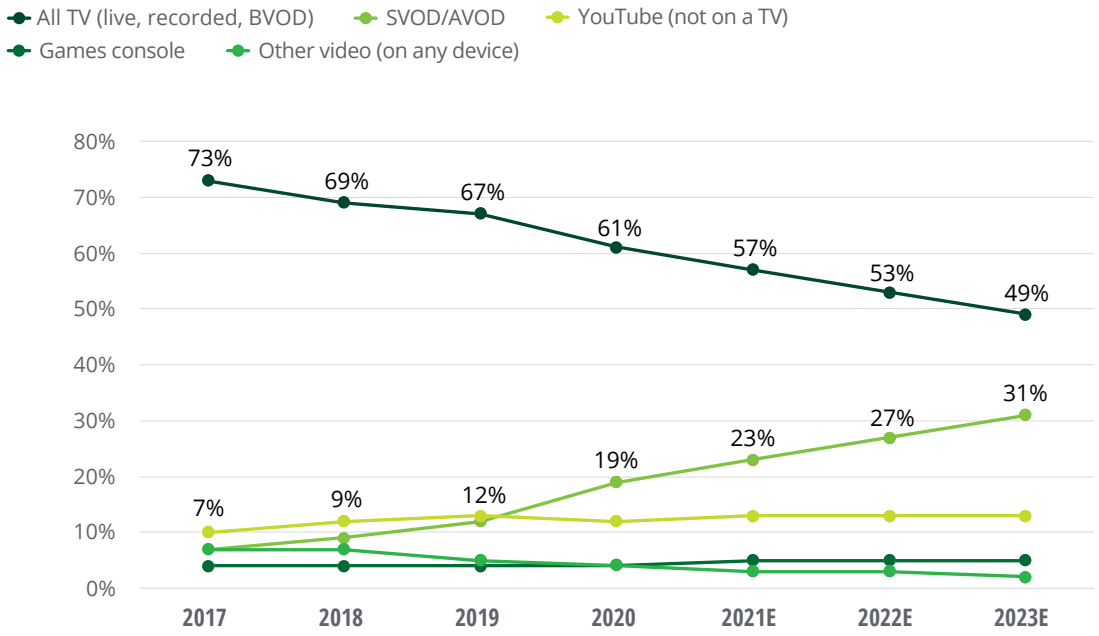
TV'S GOLDEN AGE may be nearing the beginning of its end. Deloitte Global predicts that, in the United Kingdom, 2022 will be the final year that traditional television from broadcasters, whether live, time-shifted, or on demand, collectively makes up more than 50% of video viewing on all screens. We expect traditional TV broadcasters' share of viewing hours among UK consumers, which was 73% as recently as 2017, to fall to 53% in 2022 and then to 49% in 2023 (figure 1).

Readers may be asking: Why are we focusing on just one market that, with £14 billion annual revenues from video,[1] is not even the world's largest? In short, it's because the United Kingdom's trends are likely to foretell those in dozens of other markets with a similar composition of providers: public service and commercial broadcasters,[2] pay TV companies (satellite, cable, and IPTV); video-on-demand providers (subscription, broadcaster, and ad-funded); social media; and games consoles.[3]

FIGURE 1

Broadcaster content share of viewing hours is forecast to fall below 50% in the United Kingdom

Share of UK viewing hours of broadcaster content (live, recorded, and on-demand), 2017–2023



Source: 2021 Deloitte Global analysis based on data from Ofcom, *Media Nations 2018–2021,* accessed October 7, 2021.

A long-expected event with great symbolic weight

Predicting a decline in traditional TV outputs is not controversial; broadcasters' percentage of video-watching hours has been falling for years. What sets this prediction apart is the symbolism of broadcaster content dropping under half of all viewing in one major market—and the likelihood of this trend being replicated in other similar markets around the world.

One element of these business models should be segmentation by age, as video viewership shows significant age-based variations that appear to be deepening over time. In the United Kingdom, broadcaster content made up 61% of all viewing in 2020 overall, but among 16–34-year-olds, that figure was just over half that, at 32%,[4] and among 16–24-year-olds, it was 26%. Among 16–34-year-olds, broadcaster content had made up 49% of viewing as recently as 2017: over three years, that share fell 17 percentage points.[5] Conversely, subscription-based video on demand (SVOD) share among this age group rose from 11% to 29% over the same time period.[6]

Conversely, SVOD, social media (that was not watched on a TV), and games consoles had a much higher share of viewing among 16–34-year-olds.[7] SVOD captured 29%, social media 23%, and games consoles 10% for this demographic, versus 19%, 12%, and 4% overall.[8]

Stratification by age is also evident in the US market. Among the age 18+ group, 3.7% of all video viewed in Q3 2020 was on games consoles, but viewership was tilted heavily toward youth. Children between ages 2 and 11 watched 9% of the country's games console video content in that quarter, while 12–17-year-olds watched 18%.[9]

Extrapolating five years out to 2027, video consumption patterns will likely become even more stratified by age.[10] In the United Kingdom, we expect social media to dominate among younger age groups (under 34) and broadcaster content among the remainder, with SVOD/advertising-funded VOD (AVOD) the second or third choice across all age groups (figure 2). The absence of broadcaster content from the viewing diet of the under-34 age group is likely to have wide ramifications for the efficacy of advertising, with younger viewers becoming increasingly hard to reach.

Competition will likely be feisty as TV broadcasters fight to regain lost ground while other media platforms jockey for position. Today, television broadcasters' competition comes predominantly from the combination of SVOD/AVOD, social media, and games consoles.[11] (For context, three decades ago, traditional TV's primary screen-based competitor in the home was the videocassette recorder, a technology that readers under 30 may not recognize.) This trend is comparable to that in other global markets with a similar market model.

The leading competitor over the past five years has been VOD, whose share in the United Kingdom we forecast to rise from 7% in 2017 to 27% in 2022, and again to 31% in 2023. Most of this growth has historically been in SVOD; in 2022 and beyond, we expect AVOD to increase its share as new services are launched and existing services to gain momentum.[12] But while VOD is likely to be the biggest gainer, we expect competition within the space to ratchet up, with churn being a consequence.[13] About 15% of VOD subscribers in the United Kingdom are likely to cancel at least one service in 2022, even if they resubscribe within a few months.[14]

For its part, social media has long held a sizable share of screen time among UK consumers, with more than 10% every year since 2017 and a forecast 13% share in 2022. It thrives on smaller screens and among younger viewers. Growing its percentage of all screen time will require making inroads among older viewers, whose total annual video consumption is multiples of that of younger people: 42.3 billion hours among age 55+ viewers in 2019, compared to 9.5 billion for 4–15-year-olds and

FIGURE 2

By 2027, older and younger viewers will have diverged further in their video-watching habits

Forecast for 2027 ranking of video consumption share by age group, United Kingdom

	Age 4–17	Age 18–34	Age 35–54	Age 55+
Live TV	#5	#5	#1	#1
Nonlive TV	#4	#3	#3	#2
SVOD/AVOD	#2	#2	#2	#3
Social media	#1	#1	#4	#4
Games console	#3	#4	#5	#5

Source: Deloitte forecast based on multiple inputs.

20.1 billion for 16–34-year-olds. The rate of growth among social media companies is impressive: Video-centric TikTok reached 1 billion monthly average users faster than any other social media company.[15]

As for games consoles, long a mainstream feature in UK homes, they will likely compete more strongly for attention in the medium term as the base of console gamers grows and gaming becomes increasingly continuous and less occasional. At the ripe old age of 50, consoles in 2022 are well positioned to gain more viewing time, albeit from a modest projected 5% share of 2022's total.

THE BOTTOM LINE

Despite TV's imminent fall from its historic dominance, its ebbing share of video viewing is hardly a death knell. TV ad revenues have largely held up despite the decline in hours watched. Between 2010 and 2019, TV viewing hours fell by 21% across all viewers in the United Kingdom,[16] but ad revenues declined by only 14%, from £5.8 billion to £5 billion.[17]

The main reason for this is that TV is still the only game in town when it comes to aggregating the large audiences that matter to major brands. TV's reach remains unmatched: 20 million people in the United Kingdom watched YouTube on TV sets during March 2020, but while impressive, that's far lower than TV's 91% peak weekly reach in the same month.[18] Granted, single TV shows with truly gigantic audiences are less common than they were a decade or so ago. In 2010, 170 ad-funded TV programs in the United Kingdom attracted more than 10 million viewers; in 2020, that number had dropped to 30. But in that same year, fully 569 programs boasted 5–10 million viewers each on ITV (the United Kingdom's largest broadcaster) alone.[19] No other medium comes close to this size of audience.

On the other hand, TV may find it increasingly difficult to maintain pricing for ad time that delivers acceptable value to advertisers. TV broadcasters over the past decade have been making up for revenue lost due to shrinking viewing hours by raising ads' price per thousand people reached, especially among younger demographics. If TV viewing continues to fall and the cost per thousand viewers continues to rise, advertisers may be compelled to seek alternatives. This will likely be broadcasters' preeminent concern over the next few years in any market seeing declines in viewing share similar to those forecast for the United Kingdom.

How can TV sustain itself under these circumstances? One response would be to create a single measurement system that aggregates viewing behavior across all forms of television, whether live, time-shifted, or on demand. The United Kingdom's CFlight is such a system, though it is so far unique, and broadcasters elsewhere will face challenges in replicating it: CFlight took two years to develop and required collaboration among companies that had previously competed for decades. Broadcasters could also offer advertisers campaigns that include inventory on the third-party video-on-demand services that have made the most gains in viewing time, especially among those watching on a TV set. A third tactic would be to analyze the efficacy of advertising by size of screen and type of media, betting that TV will come out ahead. While any screen can show video, the impact of an ad shown on a 50-inch screen, with sound to match, will typically be far greater than one shown on even the largest smartphone, with sound muted.

For TV to thrive going forward, the industry should regroup to face the new reality that it will be, not the dominant form of home video entertainment, but only one of many strong contenders for viewers' attention. Its market position is still strong, and its viewing experience is still compelling, and TV broadcasters may be able to make content for global VOD companies, but the industry should make sure it does the best job of selling its strengths.

Endnotes

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3. The majority of social media is watched on smartphones, tablets, and PCs; mobile games have not been included in this calculation.
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13. In 2022, we expect various factors to drive churn, including: the launch of new SVOD services, some of which may include tentpole content that was previously on another service; over the medium term, multiple niche services will launch, focused on genres ranging from Japanese anime to history documentaries; the end of introductory offers—SVOD services with scant usage may be discarded; television hardware vendors, such as Roku, are developing new revenue streams via AVOD services, some of which will displace existing services; broadcasters launching stand-alone AVOD services, such as Viacom's Pluto TV; and the lifting of lockdown restrictions, leading to less time being spent at home. For more information on churn strategies in the US market, see: Chris Arkenberg et al., *Digital media trends*, Deloitte Insights, January 19, 2021.
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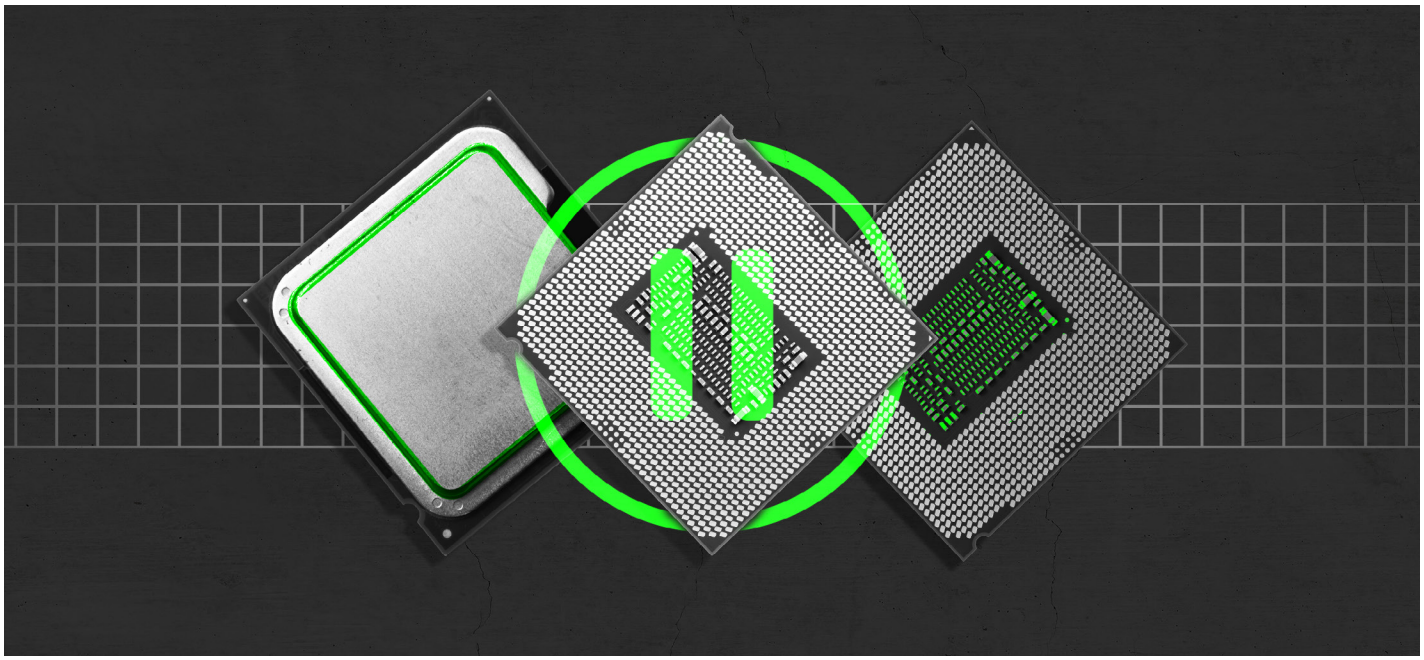
All chips, all the time



My kingdom for a chip: The semiconductor shortage extends into 2022

As consumers, industry, and government clamor for chips, the semiconductor industry is scrambling to keep up

Duncan Stewart, Dan Hamling, Ariane Bucaille, and Gillian Crossan

THE WORLD IS hungry for products enhanced by a growing volume of chips, but they'll be kept waiting throughout 2022 until supply catches up with rising demand, especially for chips made locally. Deloitte Global predicts that many types of chips will still be in short supply throughout 2022, and with some component lead times pushing into 2023, meaning that the shortage will have lasted 24 months before it recedes, similar to the duration of the 2008–2009 chip shortage.[1]

Now for the good news. While the shortage will endure through 2022, it will be less severe than in fall 2020 or most of 2021, and it will not affect all chips. In mid-2021, customers were waiting between 20–52 weeks for multiple kinds of semiconductors, causing manufacturing delays or shutdowns which led to revenue losses in the tens or even hundreds of billions of dollars. By the end of 2022, we predict those lead times will be closer to 10–20 weeks and that the industry will be in balance by early 2023.

It's a simple matter of demand and demand

The lengthiness of the chip shortage boils down to one overarching factor: A significant surge in demand, driven by digital transformation and accelerated by the pandemic. And consumer devices aren't the only thing, or even the main thing, driving this demand. Every mechanical product in industry is becoming increasingly digital, and every vertical sector is becoming ever more reliant on digitization. For example:

- Chip demand for both devices and data centers shot up in 2020 and 2021. The pandemic caused PC sales to rise by more than 50% year over year in early 2021,[2] while cloud computing data center chip purchases went up by 30%.[3] Although growth in both areas slowed a little in 2021's later months, demand in 2022 is predicted to stay well above long-term trends.
- The automotive industry's use of chips is growing fast and will probably keep growing for the foreseeable future. The average car in 2010 contained US$300 worth of microchips. As cars become increasingly digital, that figure will likely rise to more than US$500 in 2022, totaling more than US$60 billion for the year.[4] Although there were some signs that the auto industry's chip shortage was easing by the summer of 2021,[5] lead times were still longer than usual and automakers were still cutting production.[6]
- The health care industry's use of chips will likely grow. Regulators are approving connected home health care devices such as wearables and smart patches whose use may span hundreds of millions of units, especially given the rise in virtual visits.[7]
- The demand for chips specialized for artificial intelligence—specifically, for machine learning training and inference—is predicted to grow at over 50% annually across all computing categories for the next few years, with most of these chips requiring the latest and greatest manufacturing techniques.[8]

The automotive industry is perhaps most widely known to have been affected by the chip shortage. But it isn't just automakers and other end customers who care about chip shortages, the entire supply chain cares too. Most supply chains are designed to be consolidated and cost-effective, but they can be brittle as a result. Limited visibility and lack of real-time communication between supplier tiers can lead to a "bullwhip effect" where small shifts in demand are amplified, resulting in high cumulative demand volatility.[9]

Chipmakers are scrambling to catch up. The world's three largest semiconductor manufacturers announced cumulative annual capital expenditures of more than US$60 billion for 2021 and will likely spend even more in 2022.[10] Some of that is increasing capacity at existing fabs, but some is construction of new facilities, such as Intel's two new fabs in Arizona for US$20 billion-plus.[11] In addition, aggregate venture capital investment in startup chip companies will have more than tripled in 2021 and 2022 compared to the annual average of the previous 15 years. Even though they are mostly focused on designing chips rather than manufacturing them, these companies will all want to make chips to use up still-tight capacity.[12]

To guard against future shortages, governments are pushing to increase local supply. As of 2020, 81% of semiconductor contract manufacturing was based in Taiwan or South Korea.[13] The United States,[14] the European Union,[15] and China[16] have all committed to growing their country or region's semi fabricating capacity, a process called localization. Localization is not just about avoiding shortages, but also about enhancing national security: The proposed US$52 billion CHIPS for America Act was a part of the National Defense Authorization.[17]

These localization initiatives are an effort to reduce the risk created by the chipmaking industry's historic concentration of manufacturing in a very few geographic areas: Silicon Valley in the past, and Taiwan and South Korea more recently. This clustering improved efficiency, turnaround times, and profitability in good times—but as we have seen, it also amplifies risk. If, as seems likely, multiple countries decide to mitigate that risk by building their own manufacturing capacity, the overall industry capacity utilization rate may trend lower compared to the last decades, though it will likely remain volatile. In the long run, this would likely mean fewer shortages at the cost of some efficiency.

Localization efforts, however, will take time. Increasing chip manufacturing capacity is a slow process, and rightly so: Cutting-edge chips have been called the most complex devices ever made, and it takes the most expert chipmakers in the world billions of dollars, years, and all of their expertise to get a new plant up and running.[18]

Complicating things further are shortages that casual observers may not know are key parts of chipmaking. One is a shortage of packaging substrates—the miniature interface layers in packaged chips. This shortage has constrained chip manufacturing for some time now, with lead times of one year or more.[19] Additionally, to make chips, manufacturers need not just buildings and wafers, but equipment such as photolithography tools and wirebonders, which respectively print nanometer-scale patterns on semi wafers and add thin wire interconnects to chip packages. Equipment of both kinds, new and even used, is in short supply. Photolithography lead times are more than 10 months, and lead times for wirebonders, which are normally abundant, stand at over six months.[20]

> "Digital transformation is built on silicon and broadens the drivers for semiconductor innovation. Demand for semiconductors is no longer about one or two killer applications, but rather an expansive, structural shift in the economy toward digitization and automation."
>
> — Gary Dickerson, president and CEO, Applied Materials, Q3 2021 earnings call, August 19, 2021.[21]

THE BOTTOM LINE

Considering that chip shortages are likely to last through 2022, everybody should be prepared for longer lead times and possible delays. The extent of these will likely vary by industry and application.

In mid-2021, some of the more acute shortages appeared to be easing, often depending on which *kind* of chip was needed. Growth in demand for chips for hyperscale data centers, AI, and cryptomining suggests that those chips will be in relatively tight supply for the next 6–12 months.

Chip users should expect chips made on the most advanced process nodes (3-, 5-, and 7-nanometer) to be in short supply until well into next year. These chips are the hardest to make; they tend to have lower yields, fewer fabs are capable of making them, and they are in high demand. Less advanced technology nodes may see supply/demand balance restored sooner.

Meanwhile, the biggest challenge for semiconductor makers, distributors, and equipment suppliers will likely be avoiding the boom-and-bust cycle for which the industry is known. Historically, every shortage has been followed by a period of oversupply, resulting in falling prices, revenues, and profits. The cycles of the past 25 years have been like a roller coaster that no human would voluntarily ride. Between 1996 to 2021, year-over-year chip revenue soared by more than 20% no fewer than seven times. It also plunged by almost 20% year-over-year five times over the same period. The drop was especially stomach-churning in 2001, which saw revenues fall by nearly 50% from a year earlier.[22]

Taking the long view, however, up and to the right has been the consistent trend. Global semiconductor sales were up by 25% in 2021 despite ongoing shortages, and they are predicted to rise a further 10% to US$606 billion in 2022.[23] This is almost ten times greater than the 1990 figure of US$58 billion. When measured as a percentage of global GDP, 2021 chip revenues were 130% larger than they were 30 years ago.[24] Given the continuing tail wind of demand from the digital transformation of every aspect of life, semiconductor revenues look to keep gaining share of global economic output, whether chips are scarce or abundant.

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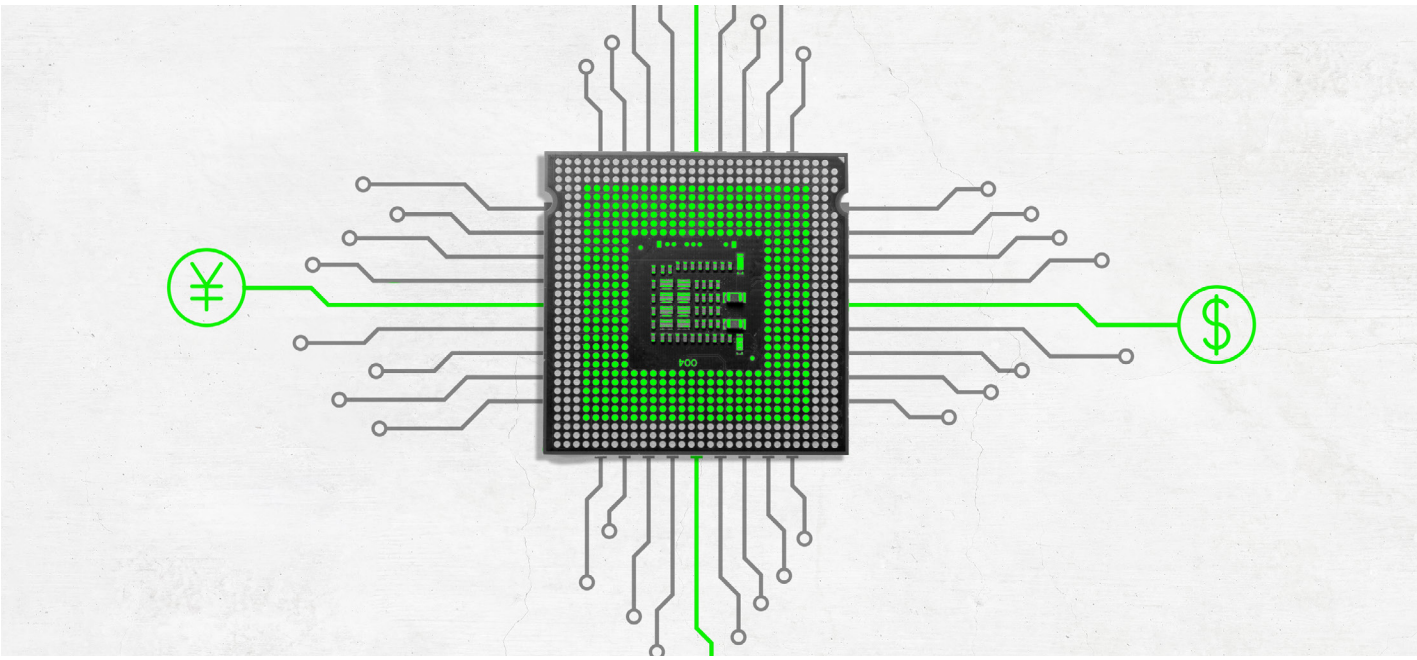


Upping the ante: Venture capital investment in chip companies reaches new highs

As VCs push gigadollars to fabless semiconductor startups, the innovation ecosystem is the sure winner

Duncan Stewart, Karthik Ramachandran, Ariane Bucaille, and Gillian Crossan

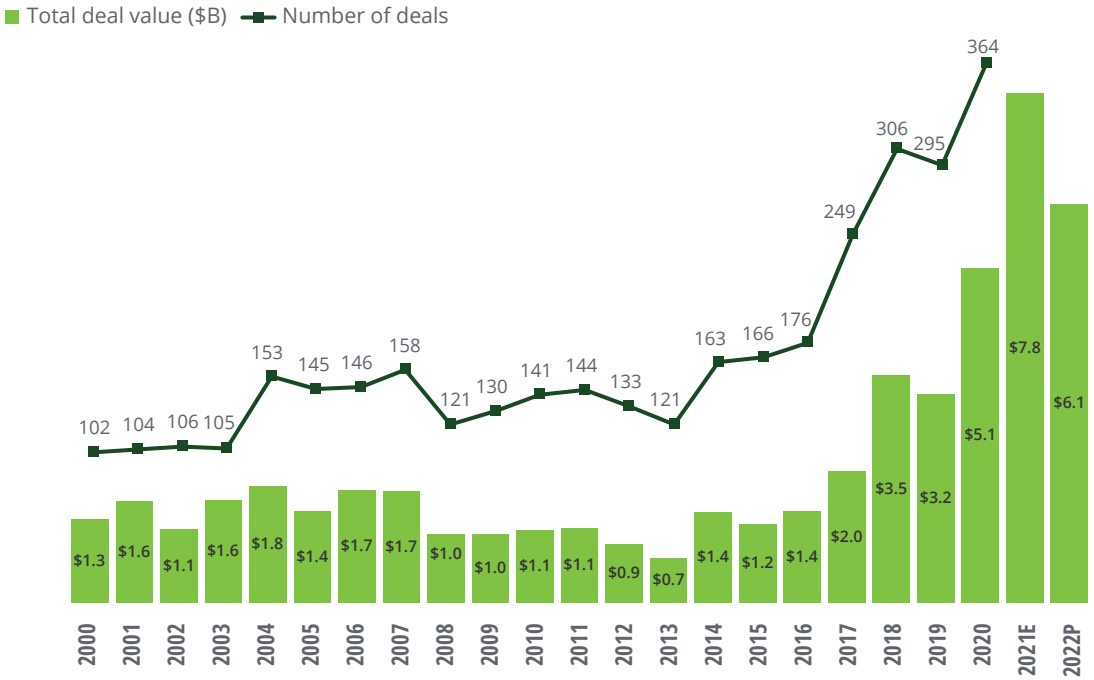
VENTURE CAPITAL INVESTMENT in semiconductors is taking off in earnest. Deloitte Global predicts that venture capital (VC) firms globally will invest more than US$6 billion in semiconductor companies in 2022. That may only be 2% of the US$300 billion-plus of overall VC investment expected for 2022 … but it would be second only to the remarkable 2021 figure of an estimated US$8 billion, and more than three times larger than it was every year between 2000 and 2016 (figure 1).

Much of this investment will likely go toward companies in China, if recent trends are any sign. Investments in Chinese semiconductor companies tripled from 2019 to 2020. And in the first half of 2021 alone, VCs from both inside and outside China invested US$3.85 billion in Chinese chip companies, equal to or larger than the amount of global investment in the entire industry in 19 of the last 20 years.[1]

FIGURE 1

Global VC investment in semiconductors is on the rise

Number of semiconductor VC deals per year and total annual deal value (US$ billion), 2000–2022



Source: Data for 2000 to Q2 2021 based on PitchBook; 2021E and 2022P values are based on Deloitte's estimate based on partial data for 2021, and our prediction for 2022.

Small investments could pay off big, VCs hope

To be clear, VCs are not investing this money to build new chip fabricating plants. Many new chip plants ("foundries") will be built in 2022 and 2023, but each new foundry costs billions of dollars, and they are being funded by governments and the chipmakers themselves. Instead, most VC investments will go toward what are called "fabless" semiconductor companies. These companies receive tens or hundreds of millions of dollars from VCs over several rounds, as well as occasional infusions of cash from larger chip companies that view fabless chips as a strategic investment.

Fabless chip companies make nothing physical (hence the name). Their business consists of hiring engineers and other key staff, buying chip design and verification tools, and producing an electronic design for a proposed chip. They then send their design to a third-party foundry that turns the design into an actual chip to be processed, tested, and, if it works, packaged. Sometimes the chip works well; other times it needs to be redone.

For VCs, not only is the price of admission lower—millions, not billions—but the returns can be much better. VCs invest in a portfolio of chip startups, following the rule of thumb that some portion will provide a lucrative exit through going public, merging with a special-purpose acquisition company (SPAC), or being acquired by another chip company. These events have been growing in both frequency and valuation over the past few years, increasing semiconductors' allure for VCs.[2]

The chip industry saw high levels of investment from corporate VCs (US$4.3 billion in 148 deals) and private equity firms (also US$4.3 billion in 30 deals, not included in the 2020 column from figure 1) in 2020. Combined, corporate VCs and private equity firms have invested US$5.2 billion as of 1H21, on track to surpass the 2020 level.[3] We expect corporate VCs in particular to stay active: Semiconductor mega-mergers are creating new companies that have even greater appetite for these kinds of deals.

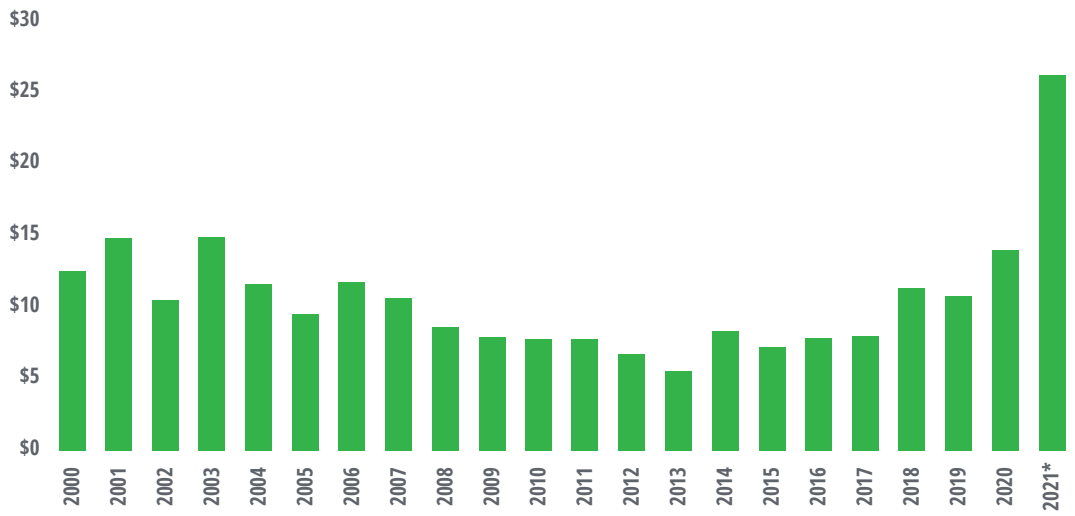
And we will almost certainly see many more home-run chips in the next few years than we have in the last 20 years. Partly, it's because the number of semiconductor deals per year has been increasing along with their total value. VCs made just under 150 deals per year, on average, between 2004 and 2016; in 2020 and 2021, that number jumped to about 380 per year. Mostly, though, it's because more money is being invested in each company. Between 2004 and 2016, the average investment per deal was just under US$9 million. In 2020, that figure rose to US$14 million, and rose again to US$26 million in the first half of 2021 (figure 2). With 2021's per-deal average being roughly triple the average for most of the rest of this century, chip startups are better funded, with more money to spend on innovation and to tide them over stumbles.

Just as an example, high-performance AI chipmaker Cerebras Systems has raised over US$100 million, and that money has helped it develop the largest chip ever built. The only wafer-scale processor ever produced, Cerebras's chip contains 2.6 trillion transistors, 850,000 AI-optimized cores, and 40 gigabytes of high-performance on-wafer memory, all aimed at accelerating AI processing.[4] That's 56 times larger than the largest GPU, with 123 times more cores and 1,000 times more memory.

FIGURE 2

Semiconductor deal size shot up in the first half of 2021

Average dollar value per VC semi investment, 2000–2021 (US$ million)



Note: *2021 figure is year to date as of Q2 2021 (period ended June 30, 2021).
Source: Deloitte analysis of PitchBook data.

THE BOTTOM LINE

VCs are not likely to pull the plug anytime soon. We expect VC investments in semiconductors to remain high beyond 2020–2021 for four main reasons:

High demand for new chips, chip designs, and architectures. New kinds of chips for high-performance computing and machine learning, the main type of artificial intelligence, are attracting investment because of strong end-market demand.[5] Companies that make specialized chips for other growing markets, such as privacy-enhancing technologies, automotive applications, and cryptomining, are also seeing demand rise.[6] The capabilities that these applications need demand fundamental changes at the hardware level that can't be addressed by the software layer alone.

High valuations. Overall tech valuations have skyrocketed, especially for semiconductor companies. Since 2016, the S&P 500 is up 121%, the NASDAQ is up 198%, and the Philadelphia Semiconductor Index is up 418%. And tech behemoths and even SPACs are starting to eye silicon, giving VCs additional exit options.

Increased government investment. Governments worldwide are directing substantial investments toward the semiconductor industry. The United States has allocated US$52 billion for investment in the semiconductor industry as part of the CHIPS for America Act.[7] The European Union has set a goal of doubling its share of global chipmaking to 20% by 2030 and has introduced its own Chips Act.[8] Billions of dollars of EU government money will flow to fabless chip startups directly or via VC funds. And China has created a US$50 billion fund of its own for investing in domestic semiconductor companies.[9] The country is hoping to boost chip production capacity and expand indigenous fabrication capabilities, in part to avoid US technology embargoes. (That said, China has been trying to grow its domestic chip business for years—and has been struggling, in part due to China lacking access to cutting-edge critical manufacturing technologies.)[10]

Growing fab capacity and expansion plans for capital and R&D. The chip industry is massively increasing its fabricating capacity. Twenty-nine new fabs have started or will start construction in 2021 and 2022: eight in each of China and Taiwan; six in the Americas; three in Europe, the Middle East, and Africa; and a pair each in Japan and South Korea.[11] As a result, global manufacturing capacity is expected to grow by 36% from 2020 to the end of 2022, from 22 million 200 mm-equivalent wspm (wafer starts per month—a measure of aggregate global chipmaking capacity) to 30 million wspm.[12] Existing chip companies will use some of this capacity, but the startups that VCs are funding will also use a fair amount.

In more detail, which kinds of new chips, and therefore which industries and customers, are likely to receive most of the VC money and drive innovation? As mentioned in the companion prediction on RISC-V, we see lots of growth and investment in the RISC-V architecture, but many other areas are attracting investment too. AI and machine learning (especially edge AI), data center and high-performance computing, 5G, and Internet of Things chips all seem poised to show above-industry growth rates for years to come. In general, foundries are also looking to enhance their chip development environments to promote faster, easier chip development for startups and other smaller players.

Pretty much everyone should care about increased VC investment in semiconductors. At a high level, more VC deals equal more money, which in turn equal more new kinds of innovative chips. Innovations in chips power innovations in computing capabilities—and we all want and need the things that those innovations drive. Think of VC investments in semiconductors as a garden: They are planting more seeds and fertilizing them better. It will be fascinating to see what grows!

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— Gary Dickerson, president and CEO of Applied Materials, "Q3 2021 earnings call," August 19, 2021.[13]

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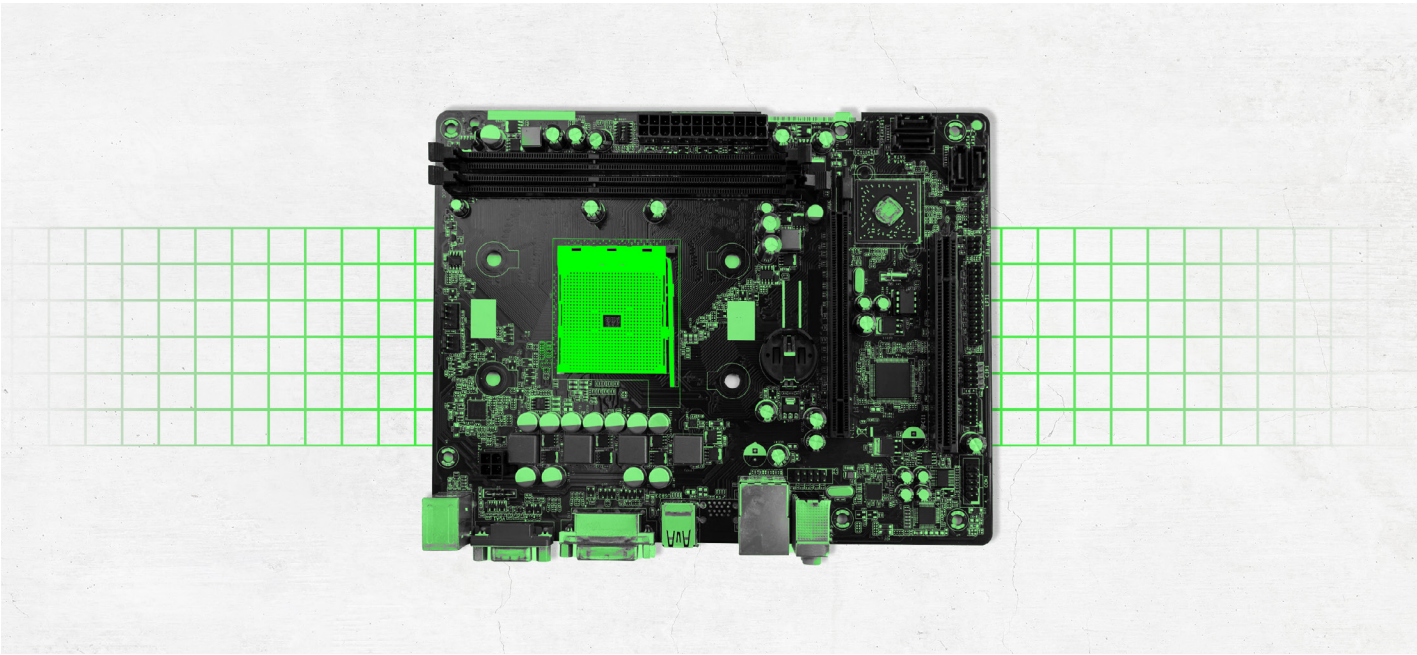


RISC-y business: Could open chip standard RISC-V gain traction against dominant incumbents?

The open-source chip architecture offers lower costs and greater access, but its future in the marketplace is anything but certain

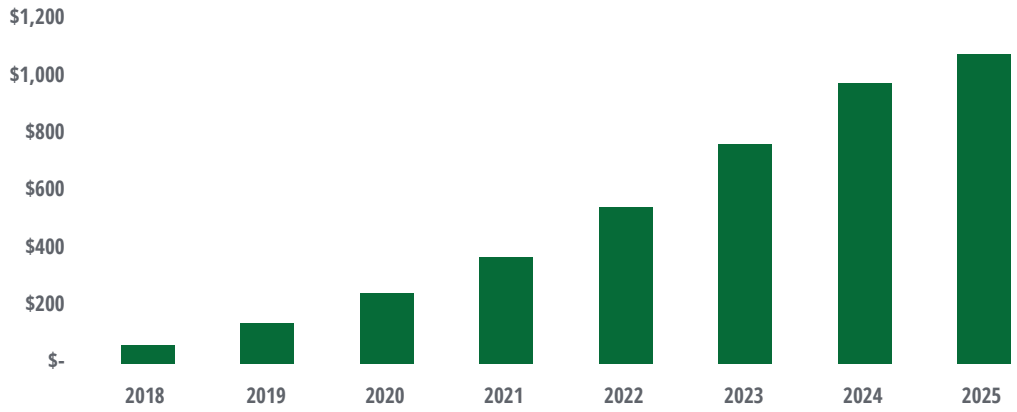
Duncan Stewart, Eiji Kodama, Ariane Bucaille, and Gillian Crossan

RISC-V (pronounced "risk five"), an open-source instruction set architecture for chip design, is creating ripples that may evolve into the wave of the future. Deloitte Global predicts that the market for RISC-V processing cores will double in 2022 from what it was in 2021—and that it will double again in 2023, as the served addressable market available for RISC-V processing cores continues to expand.[1] Revenue will grow more slowly, as might be expected from an open-source solution. Still, RISC-V revenue will likely reach close to US$800 million in 2023, up from less than US$400 million in 2021, and is expected to approach US$1 billion by 2024.[2]

FIGURE 1

RISC-V revenue is on track for exponential growth

Total RISC-V market revenue, 2018–2025 (US$ millions)



Source: Omdia, *RISC-V Processors Report*, 2019.

RISC-V is making headway—and facing headwinds

Traditionally, processing cores—the best known of which are the central processing units (CPUs) found in computers, data centers, and phones—have been closed and proprietary. Proprietary instruction set architectures (ISAs) from Intel and Arm have made up nearly all CPUs deployed globally in recent years. The open-source nature of RISC-V offers several advantages over proprietary ISAs. For one thing, it's free. This can save companies millions of dollars in license fees, which is especially important for earlier-stage companies. For a second thing, it's sanction-free: Being open-source, RISC-V is also not affected by export restrictions. This makes it appealing to companies, especially in China, that have been affected or fear being affected by those restrictions.

At a more technical level, RISC-V designs are easier to modify than traditional ISAs, allowing for greater flexibility. They are also compatible with a wide range of applications. Even though a few doubters continue to argue that RISC-V could face challenges across ecosystems, companies are tapping into RISC-V cores for all of artificial intelligence (AI) image sensors, security management, AI computing, and machine control systems for 5G. Other companies are planning on using it for different storage, graphics, and machine-learning applications. Even Intel's foundry services division is partnering with RISC-V player SiFive.[3]

At a more technical level, RISC-V designs are easier to modify than traditional ISAs, allowing for greater flexibility.

To be clear, the technology is still relatively new, and RISC-V is not yet suitable for all markets or customers. The technology has disadvantages as well as benefits: It is relatively new, has few high-profile design wins, lacks some of the features of Arm or x86 ISAs, and doesn't have the same level of support for designers. Additionally, fabricating a RISC-V chip at a foundry is not materially easier, faster, or different from making a traditional closed ISA-based chip: The manufacturing technology is

the same. Even by 2025, sales of chips from Intel (particularly its x86 chip) and Arm will likely be many times larger than the new kid on the block.

So, who cares about RISC-V? The answer differs depending on the stakeholder:

China cares. As a result of recent US sanctions, Chinese manufacturers have lost or fear losing access to x86 or Arm ISAs. Even if trade policies change, Chinese companies would remain aware that, at any future point, the "ISA rug" could get pulled out from under them. Going the RISC-V route could give them a way around that possibility, helping China meet its aggressive goals for reducing reliance on chip imports. The country has been trying to become more self-sufficient in making chips for years, although this has seen some challenges.[4] About a third of RISC-V organization members are from China, and multiple large Chinese companies have announced RISC-V chips already.

Startups care. In the three years between 2020 and 2022, venture capitalists (VCs) will invest about US$22 billion into startup chip companies of all kinds. To put this into perspective, that's more than the US$21 billion they invested in the entire 11 years between 2005 and 2016.[5] All that money means more chips being made—but startups usually must make them on a budget. A million-dollar license fee may not matter to one of the world's largest smartphone companies, but it does matter for a startup that has relatively little cash and a monthly burn rate. It's not surprising that, according to a 2020 study, more than 23% of new ASIC (application-specific integrated circuit) and FPGA (field-programmable gate array) chips from startups incorporated at least one RISC-V processor.[6]

AI cares. A number of new AI chip designs appear to be using RISC-V. Interestingly, expectations were that the technology would not be used in data centers in the near term, but some speculate that AI chips may allow RISC-V to break into the data center market earlier than expected.[7]

The automotive and IoT markets care. The served addressable market (SAM) for RISC-V in automotive was 4 million cores in 2020, forecast to rise to 150 million cores in 2022, and to 2.9 billion cores by 2025.[8] Supporting that potential, a leading RISC-V company and a leading automotive chipmaker announced a strategic partnership in 2021 targeting multiple auto applications with high-end solutions.[9] The chips in autos tend to be less powerful than personal computer or data center CPUs, so success in vehicles could augur well for RISC-V doing well in other Internet of Things markets.

PC chipmakers care less, at least for now. The PC market is unlikely to shift in a large way to RISC-V in the near term. Although there is a Chinese initiative to use the technology to build laptops that support various open-source browsers, the goal is to build 2,000 laptops by the end of 2022,[10] compared to a global annual market of roughly 300 million PCs in 2020. There is also a Russian initiative, but its goal of selling 60,000 systems by 2025 is similarly modest.[11] That said, the SAM opportunity for RISC-V in laptops is large—just under 300 million processing cores in 2022.[12]

Foundries care a bit. Although ISAs don't matter much to those who actually make the chips, it is possible that RISC-V, with its lower cost and greater flexibility, could lead to a Cambrian-style explosion in new chip designs. Hundreds or thousands of new chips may need to be manufactured by foundries, in low volumes at first, but any potential boom in new chip designs would be a tailwind for semiconductor manufacturers.

THE BOTTOM LINE

For now, large traditional chipmakers likely have little reason to worry that RISC-V will eat into their business. The cost of licensing an ISA from Arm may be rising,[13] but it is usually "only" a few million dollars at most. And though the cost of a license to Intel's x86 is unknown, largely because Intel has historically not licensed its chips except to AMD and Via, it is probably also in the single-digit millions as well.[14]

Millions of dollars may seem like a lot, but in the context of a new chip design for a popular smartphone or other application where chip volumes are measured in the millions, reducing the ISA license cost alone is unlikely to be a material consideration. Chipmaking entails multiple costs: design, verification, validation, software, manufacture, having to respin if the first design contains a mistake, and so on. All in, making a new chip of a relatively leading-edge design will likely cost more than US$500 million in 2022,[15] and a few million dollars out of that for licensing fees is just a drop in the bucket.

In the future, it will be interesting to see if RISC-V will take hold in an industry dominated by two large incumbents. It's worth remembering that there have been nearly 50 different ISAs over the years[16] … and Arm and Intel accounted for nearly 100% of the market in 2020. A few, such as MIPS, ARC, and Tensilica, still have niche roles, but the rest of Arm and Intel's competitors are just plain gone. Not because their chips were bad, or expensive, or didn't work; instead, there seems to be a technology industry imperative toward ISAs consolidation, as there is in other technology spaces. Two major players seem likely for the next decade; for those following RISC-V, the hope is that there's room for a third too.

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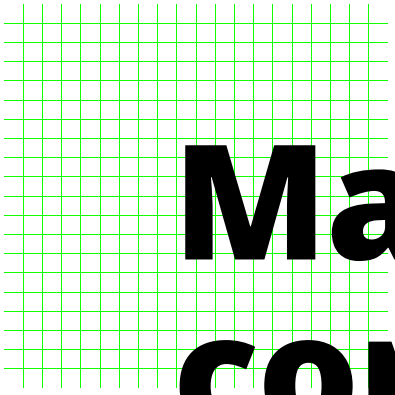
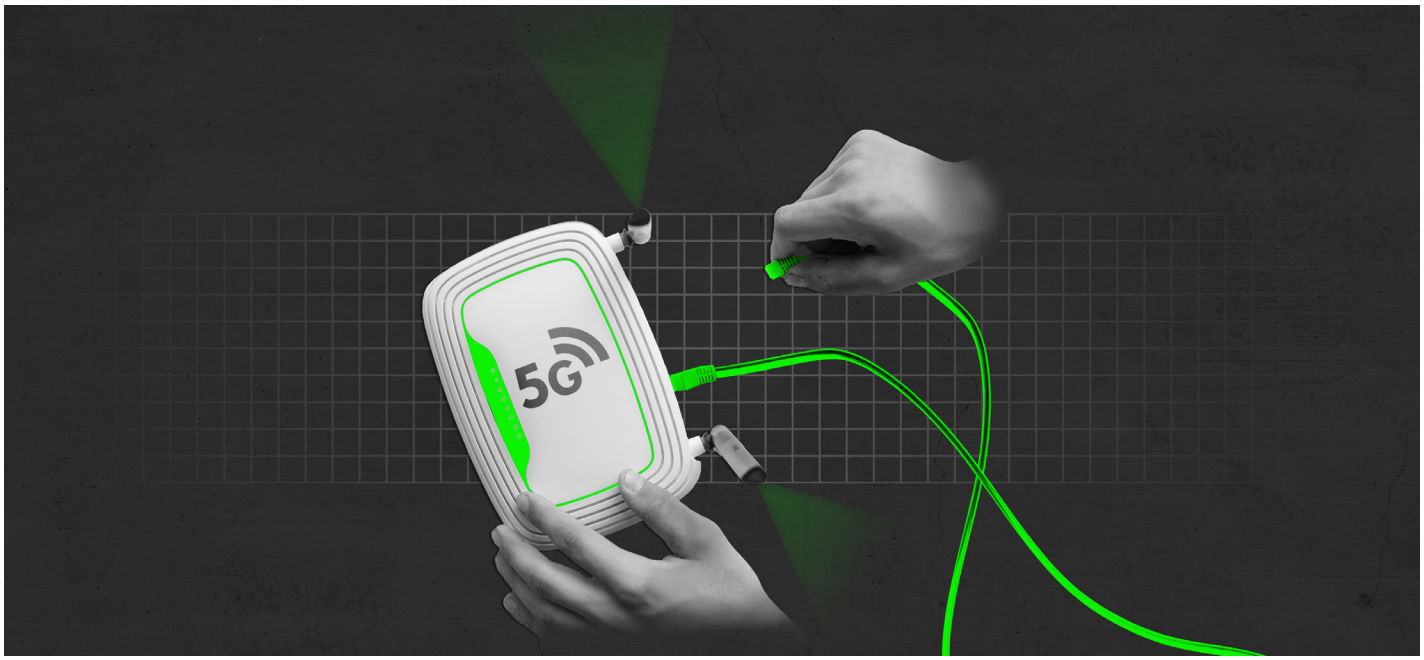


Making connections



Fixed wireless access: Gaining ground on wired broadband

The FWA market is growing strongly, with 5G powering enhanced performance. Will it be key to closing the digital divide?

Naima Hoque Essing, Duncan Stewart, Kevin Westcott, and Ariane Bucaille

THE ECONOMICS AND data rate performance of fixed wireless access (FWA),[1] which uses radio waves to deliver internet service between two stationary locations such as a mobile tower and a customer's home or office, are finally becoming competitive with that of wired internet services. Deloitte Global predicts that the number of FWA connections will grow from about 60 million in 2020 to roughly 88 million in 2022, with 5G FWA representing almost 7% of the total (figure 1). While our analysis reveals a 19% 2020–2026 CAGR in total FWA connections, 5G FWA connections will grow even faster, at a CAGR of almost 88%, over the same period.[2]

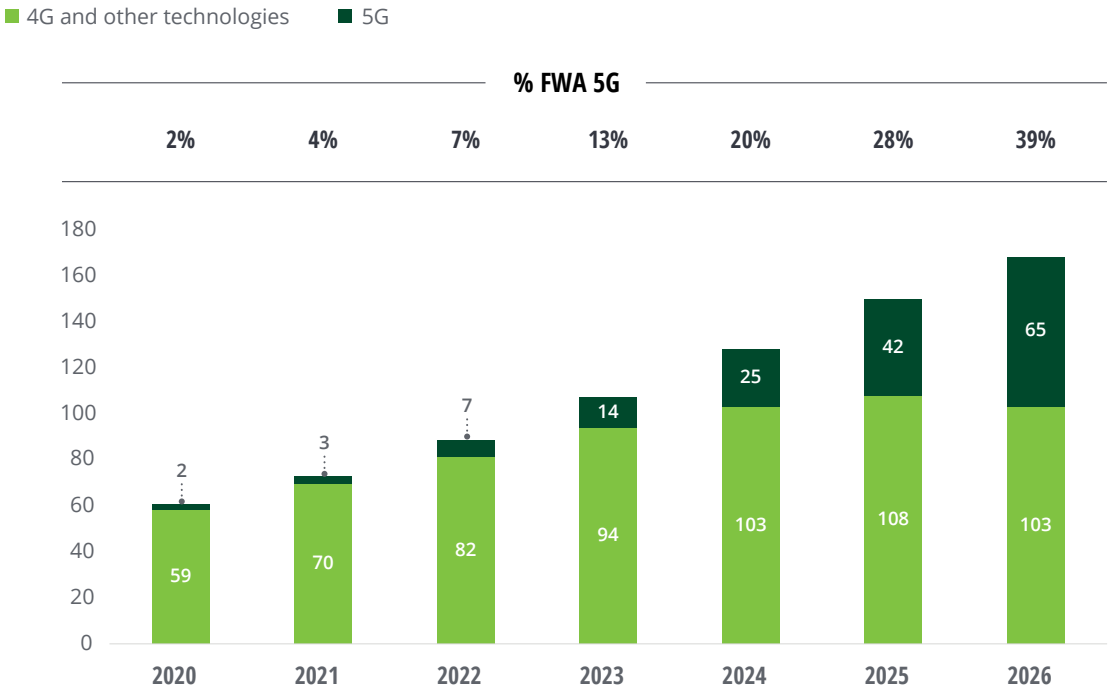
A confluence of factors is driving FWA growth

Many operators have deployed FWA selectively for decades to offer customers internet service, typically in underserved areas where wired internet connections are unavailable. But to date, FWA has not achieved widespread operator adoption outside of a few countries such as Austria or Finland. However, with more governments providing broadband funding and more regulators viewing wireless as an acceptable alternative to wireline connections, more operators are considering FWA,

FIGURE 1

The number of global FWA connections is growing rapidly, with 5G expected to make up an increasing share

FWA connections by year (millions)



Source: Deloitte analysis based on data from Ericsson, Statista, and ABI Research.

especially the enhanced 5G version, for delivering broadband internet services.

5G should further accelerate FWA's expected growth. Coupled with greater spectrum availability, 5G's deeper network infrastructure and greater spectral efficiency significantly improve the economics and technical feasibility of FWA deployments and can thus support new deployment and revenue opportunities. These traits make it far more achievable for operators to implement FWA in underserved markets, as well as more attractive to offer it in competitive markets as a replacement or alternative to existing wired internet connections (such as xDSL or cable).

FWA's most important impact may be to help narrow the digital divide by improving internet availability in underserved markets. It can be challenging to justify broadband investments in sparsely populated areas with few paying subscribers or inaccessible terrains such as mountains or islands, or even in cities where local ordinances and permitting make it challenging and expensive to connect to customer premises. FWA can provide an economical solution.[3] Being wireless, it can reduce the massive upfront cost and time needed to secure permissions, dig trenches, lay last-mile fiber, and deploy technician-installed equipment at households and businesses. Moreover, operators can often roll out FWA using their existing mobile wireless networks and fiber backhaul infrastructure, further reducing costs.

These factors have opened up markets for broadband services in places where it was previously unavailable, as we have seen in the Philippines, South Africa, Sri Lanka, and Turkey.

Recognizing high-speed internet's importance to economic development,[4] many governments across the globe are implementing sizable programs to fund or subsidize building broadband networks in underserved areas. Although these programs typically favor wired solutions, they are increasingly technology-agnostic as long as the service can meet minimum performance thresholds. In the United States, for example, the FCC's Rural Digital Opportunity Fund (RDOF) awarded US$9 billion to a broad range of wired, fixed wireless, and satellite providers.[5] The United Kingdom's £1.2 billion Project Gigabit, which aims to equip at least 85% of UK premises with gigabit-capable broadband by 2025, is being lobbied to consider wireless options.[6] And the European Union is studying FWA as a means to achieve national broadband goals.[7]

In addition to addressing households with no broadband access, network operators are also increasingly viewing FWA as a competitive alternative to existing wired internet services, especially DSL, which in some markets is no longer considered "broadband."[8] Operators in the United States, Italy, and Switzerland have explicit plans to use 5G FWA along with fiber to upgrade and replace existing DSL connections, which reduces costs by decommissioning legacy copper networks.[9]

With regard to FWA's 5G version specifically, many network operators worldwide view 5G FWA as a way to expand revenue opportunities and help monetize investments in 5G and wireless spectrum. For many, FWA is emerging as one of the leading use cases for 5G. Almost 90% of providers that have launched 5G also have an FWA offering, compared to 62% among those that haven't yet launched 5G.[10] Countries with operators early out of the gate include Australia, Austria, Canada, Finland, Norway, Switzerland, the United Kingdom, and the United States, and we expect the list to expand.[11]

Operators have multiple deployment options depending on their service area demographics, spectrum availability, and technology portfolios. For example, in dense city locations, 5G FWA can be used to augment existing fixed or mobile phone networks to offer pop-up wide area networks (such as for small or medium businesses' networks, live events, or construction sites); it also can enhance redundancy and surge capacity. As the pandemic has shown, using wireless connections as a gap filler and backup for fiber to provide uninterrupted internet access is growing in importance. FWA can also be offered more broadly as a competitive alternative to existing home internet, such as in a suburban area with no or few other options. In most cases, operators will selectively roll out 5G FWA in those areas where they have suitable spectrum, excess wireless network capacity, and adequate supporting infrastructure, but also where fixed wireline is otherwise uneconomical or slow to deploy.

THE BOTTOM LINE

The growth in FWA has ramifications for several industry players. Most obviously, network operators have an opportunity to use FWA as a source of incremental revenue. Even though mobile is currently a more profitable use of spectrum than FWA, most wireless networks, except in the densest urban areas, are underutilized. Filling this unused capacity with FWA service can thus be accretive to earnings. That said, spectrum is a scarce resource, and operators should prioritize its use to where it can generate its highest value. In addition, operators have new methods and technologies (such as small cell and site densification) that can help them address scenarios should demand exceed supply.

5G FWA specifically also has implications for network equipment providers. Unlike previous versions, 5G FWA complies with industry standards such as 3GPP; this means that it can drive greater consistency in the equipment needed to support it, since more network operators can adhere to the same standards. This, in turn, can allow the equipment vendor ecosystem to collectively develop and commercialize common, interoperable equipment and devices at scale, lowering costs and simplifying both operator and user installation.[12] By providing a larger base upon which to commercialize inventions, common standards can also support greater innovation. Small cells, beamforming, and massive MIMO (multiple-in, multiple-out) capabilities are examples of new radiofrequency (RF) technologies[13] that operators can deploy to increase their 5G networks' spectral efficiency and traffic density, particularly in areas where network capacity becomes an issue.

Finally, cable companies should be alert for increased competition from mobile network operators seeking to attract new customers and improve stickiness by bundling 5G FWA with mobile subscriptions. While 5G FWA doesn't yet pose an existential threat to cable—wired connections, when available, almost always offer a more reliable connection than wireless options—that could change as its economics and ease of use continue to improve.

FWA's commercial viability is fast increasing. Besides its growing appeal as a replacement for wired connections, its favorable cost and quality profile can make it the most sensible and economical option for bringing broadband to both underserved areas and competitive markets. Because of this, FWA may well play a key role in making the internet more widely accessible while offering telecom industry players new revenue, growth, and innovation opportunities—a potential win-win for all.

Endnotes

1. FWA is defined as a wireless internet connection between two fixed locations such as a mobile tower and customer home or office. It does not include portable battery-based Wi-Fi routers or dongles.
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10. Ibid: Ericsson, *Ericsson mobility report*.
11. OECD, "Chapter 3: Access and connectivity," *OECD Digital Economy Outlook 2020* (Paris: OECD Publishing, 2020).
12. ABI Research suggests that the 5G FWA CPE market will experience a 48% compound annual growth rate (CAGR) between now and 2025, with approximately 41 million units being shipped annually by that stage. Mark Patrick, "FWA: A truly tangible 5G use case that's already gaining traction," Electronics Media, June 20, 2021.
13. Massive MIMO integrates antennas, transmitters, and receivers to achieve better throughput and spectrum efficiency. Beamforming directs radio waves to avoid interference.

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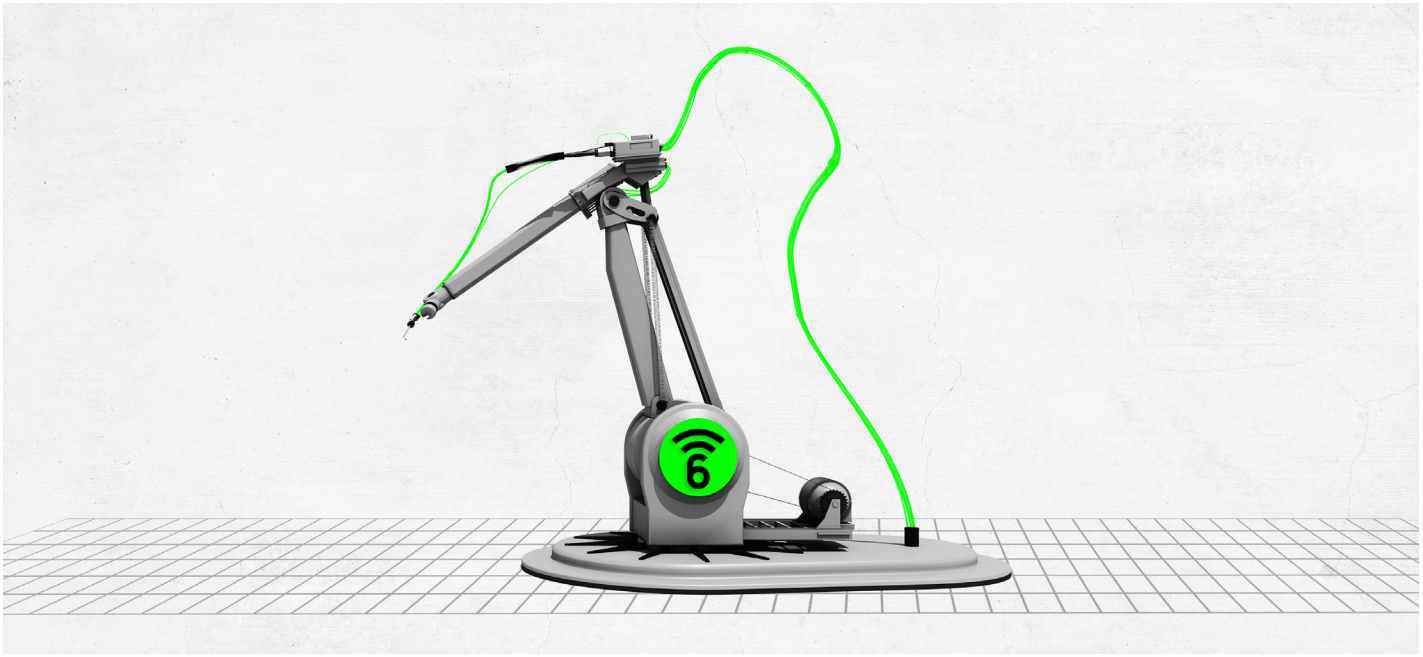


Wi-Fi 6: Unsung, underexposed—and indispensable to the future of enterprise connectivity

The next generation of Wi-Fi is set to play a pivotal role as organizations innovate with advanced networking

Susanne Hupfer, Sayantani Mazumder, Ariane Bucaille, and Kevin Westcott

5G MAY GET the lion's share of the publicity, but Wi-Fi 6 devices are quietly outselling 5G devices by a large margin and will likely continue to do so for the next few years at least. Deloitte Global predicts that more Wi-Fi 6 devices will ship in 2022 than 5G devices, to the tune of at least 2.5 billion Wi-Fi 6 devices versus roughly 1.5 billion 5G devices.[1] And for good reason: Wi-Fi 6, just as much as 5G, has a significant role to play in the future of wireless connectivity—not just for consumers, but also for the enterprise. Smartphones, tablets, and PCs are some of the most popular Wi-Fi 6–equipped devices, but Wi-Fi 6 is also used in many others, including wireless cameras, smart home devices, game consoles, wearables, and AR/VR headsets.[2]

Wi-Fi 6 and 5G are partners

With the lavish press and advertising spend devoted to 5G, one might think that next-generation wireless networks in the enterprise will revolve almost exclusively around 5G, with Wi-Fi 6

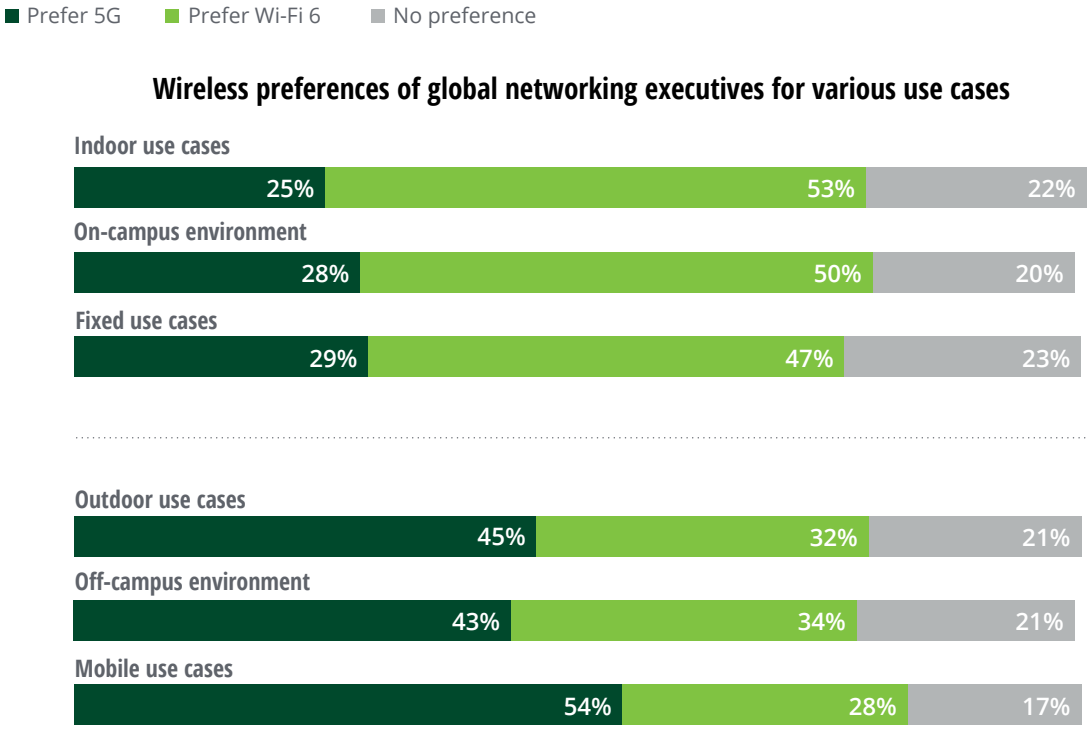
playing a supporting part at best. But that's not the reality uncovered by Deloitte's 2021 global advanced wireless survey of 437 networking executives from nine countries, which found that 45% of enterprises are concurrently testing or deploying Wi-Fi 6 and 5G for their advanced wireless initiatives.[3] Indeed, nearly all respondents (98%) expected their organization would be using both technologies within three years. Projected investment reflects coadoption as well: Over the next three years, on average, these leaders expect to allocate 48% of their enterprise wireless network spending to Wi-Fi and 52% to cellular technologies.

This is not entirely a surprise, as Wi-Fi 6 and 5G have some similar capabilities but also have different, complementary strengths. Both technologies enable higher speeds, lower latency, and increased device density and network capacity. The differences lie in areas such as range, support for mobility, and cost. Wi-Fi 6 and its predecessors tend to be used for smaller, less expensive local area networks, often for connectivity inside homes and offices, while cellular networks such as 5G are used for both indoor and outdoor wide area networks, often for devices that move across large geographic areas (for instance, for smart city applications, ports and airports, and connected vehicles).[4] Because decision-makers are targeting a blend of usage scenarios, it makes sense that they're evaluating both technologies to determine what combination will work best for their situation (figure 1).[5]

FIGURE 1

5G and Wi-Fi 6 have complementary uses

Which next-generation networking technology, 5G or Wi-Fi 6, does your organization prefer to use for each of the following scenarios?



Notes: N = 437 global networking executives. Not showing small percentages of "Don't know" responses.
Source: Deloitte's Global Study of Advanced Wireless Adoption, 2021.

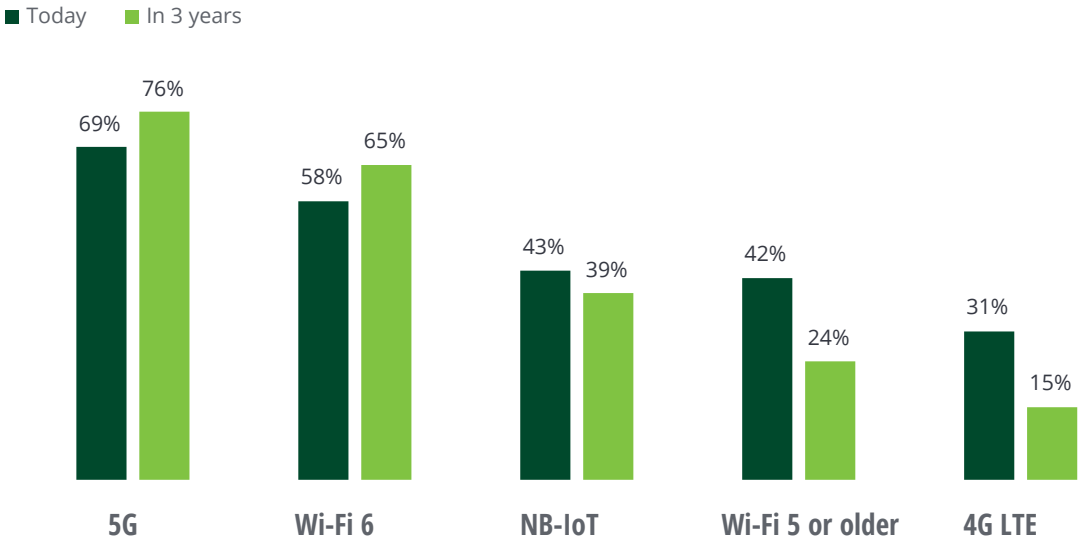
Further, unlike past generations of wireless, Wi-Fi 6 and 5G are designed to work together smoothly, and the wireless industry appears headed toward a future in which devices can roam securely and seamlessly between all types of wireless networks.[6] Industry associations and standards bodies are co-developing future network standards that will enable convergence of cellular and noncellular technologies, permitting integration of Wi-Fi 6 into core 5G networks.[7] The expected benefits of an integrated architecture include improved traffic control on factory floors and the ability to provide uninterrupted service for smart city and edge applications.[8]

What's clear is that these buildouts will not be merely tactical solutions. Advanced wireless is a strategic priority for the enterprises surveyed, with eight in 10 networking executives expecting advanced wireless technologies to transform their enterprises substantially by 2023, changing how they operate, develop new products and business models, and engage with customers. These decision-makers already regard Wi-Fi 6 and 5G as the most critical wireless technologies for their businesses (figure 2). Sixty-five percent of the networking leaders in our study expect Wi-Fi 6 to be a top-three critical wireless technology for their business by 2023, and 76% expect 5G to be in the top three as well.[9] Over the next few years, as wireless infrastructures are built out and more devices become available, leaders expect both technologies to become even more significant.

FIGURE 2

5G and Wi-Fi 6 are already seen as the most critical wireless technologies—and their importance will continue to grow

Percentage of global networking executives ranking each a top-three critical wireless technology for their organization's business initiatives



Note: N = 437 global networking executives.

Source: Deloitte's Global Study of Advanced Wireless Adoption, 2021.

Though Wi-Fi 6 and 5G are equal partners in terms of building solutions, our study revealed that enterprise Wi-Fi 6 pilots and deployments are outpacing 5G in all the countries we studied, with double-digit gaps in some regions. While those gaps may narrow, we expect the Wi-Fi 6 enterprise adoption lead to persist through 2022 (and beyond). One likely reason is cost, as Wi-Fi 6 devices are more affordable and more widely available than 5G devices.[10] Acquiring suitable spectrum may also be a challenge in some countries: Whereas Wi-Fi 6 uses free, unlicensed spectrum, 5G generally requires enterprises to license spectrum from network providers or government entities. In a number of major markets around the world, governments have set aside specific spectrum that can be assigned to a company for a particular area, such as a manufacturing campus or airport, often for a nominal cost. But policy, spectrum band ranges, conditions, and costs vary by country.

Ease of deployment has likely also contributed to Wi-Fi 6's head start. Wi-Fi networks are already widely established, along with a large base of Wi-Fi devices. As enterprises upgrade to Wi-Fi 6 networks, they can take advantage of backward compatibility, avoiding the need to replace older Wi-Fi devices all at once.[11] Familiarity may also be a boon: While there are 4G LTE private cellular networks around the world, these are outnumbered by enterprise Wi-Fi deployments, meaning that many IT departments already have expertise in deploying and operating Wi-Fi networks. Conversely, setting up a 5G network (either alone or with a network operator) generally means learning something new and potentially more complex, adjusting to a standard that is still rolling out, and perhaps working with a partner that is also just getting up to speed on 5G.[12]

Acquiring suitable spectrum may also be a challenge in some countries: Whereas Wi-Fi 6 uses free, unlicensed spectrum, 5G generally requires enterprises to license spectrum from network providers or government entities.

It's worth noting, however, that the countries reporting the highest levels of Wi-Fi 6 pilots and deployments (Germany, Brazil, United Kingdom, China, and Australia) were also those that reported the highest levels of 5G pilots and deployments. Once again, it's apparent that both technologies are being adopted concurrently and that both have a place in advanced wireless initiatives.

THE BOTTOM LINE

Three-quarters of the decision-makers in our 2021 advanced wireless survey believed that advanced wireless could create significant competitive advantage for their organization. To capture this advantage, organizations implementing advanced wireless initiatives can keep several things in mind.

A critical first step is to be crystal clear about goals. Innovation is a key objective for advanced wireless adoption. Our executive survey identified the desire to innovate using new technologies as one of the two top drivers of adoption, with four in five respondents reporting that advanced wireless was very or extremely important to their organization's ability to implement Internet of Things, AI, big data analytics, and edge computing capabilities.[13] Improving efficiency was the other top adoption driver, and enhancing customer interactions was the third most commonly cited driver.

Adopters should also determine which usage scenarios they wish to target, their application requirements, and deployment and spending constraints. Understanding Wi-Fi 6 and 5G's specific capabilities and associated costs (e.g., for devices, solutions, and customer-premises equipment) can help decision-makers determine which would be better suited to different situations.[14] For some advanced enterprise use cases, such as automated guided vehicles and autonomous robots in industrial IoT scenarios, both Wi-Fi 6 and 5G have proponents and may even be adopted side by side.[15]

Because advanced connectivity is a key enabler of other innovative technologies, leaders should increasingly treat advanced networking as a key component of their organization's end-to-end enterprise architecture. As they consider how to architect and manage a landscape with heterogenous underlying technologies, networking executives face a key question around which partners to engage in this effort. To assemble complete advanced wireless solutions, organizations generally engage with a variety of vendors, such as cloud and application providers, consulting firms and other integrators, telecom companies, and network equipment providers.[16]

Given the role that infrastructure providers and device makers have played in initial Wi-Fi 6 trials, tapping into their expertise could help an enterprise assess its capabilities and establish pilots.[17] Telecoms have a great deal to offer advanced wireless adopters too. With the benefit of holding 5G-suitable spectrum, many are seeking to extend their public networks deeper into the private setting. Given their extensive experience running cellular networks, network providers can offer key capabilities such as cybersecurity, privacy, and established relationships with other carriers to support WAN and mobility use cases. And for some mission-critical services (such as those that need to be free of device interference), dedicated, licensed 5G spectrum may have a distinct advantage. And, with better integration of Wi-Fi 6 and 5G anticipated, network operators will have the ability to direct and optimize traffic across both types of networks—for instance, offloading to Wi-Fi 6 to reduce cellular congestion.[18]

Whatever the end, Wi-Fi 6 will almost certainly be an important part of the means. As 5G's essential partner in advanced wireless solutions, Wi-Fi 6 will be increasingly central to realizing the benefits that organizations are pursuing through next-generation connectivity.

Endnotes

1. To arrive at our projections, we reviewed estimates of 2022 Wi-Fi 6 and 5G device shipments made by a variety of analysts, research firms, and industry groups. We computed weighted averages of these projections, giving relatively less weight to industry associations (which may have a vested interest in making exuberant estimates) and relatively more weight to analyst/research firms with long tenures.
2. 5G isn't limited to smartphones, tablets, and PCs either; 5G can be found in telecom base station equipment, connected vehicles/devices, broadband access gateway devices, and others.
3. To understand how enterprises around the world are adopting advanced wireless technologies, in Q4 2020, Deloitte surveyed 437 global IT and line-of-business executives who are responsible for networking at organizations in the process of adopting 5G and/or Wi-Fi 6 or planning to adopt either technology within the next three years. Nine countries were represented: China, India, Japan, United Kingdom, Germany, Netherlands, Portugal, Brazil, and Australia. See: Jack Fritz et al., *Accelerating enterprise innovation and transformation with 5G and Wi-Fi 6: Deloitte's study of advanced wireless adoption, global edition*, Deloitte Insights, March 22, 2021.
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9. A related Deloitte study of US networking executives shows a similar view of the future: By 2023, 70% of US networking executives expect Wi-Fi 6 to be a top-three most critical wireless technology for their business, and 76% expect 5G to be in their top three. See: Dan Littmann et al., *Enterprises building their future with 5G and Wi-Fi 6: Deloitte's study of advanced wireless adoption*, Deloitte Insights, June 1, 2020.
10. Giacomo Bernardi, "Why 5G won't dethrone Wi-Fi 6 anytime soon at the edge," *TechTarget*, August 18, 2021. Wi-Fi 6 devices may have some advantages when it comes to power consumption as well; see: Vertiv, "Operators are optimistic about the future services 5G will enable, but estimates suggest network energy consumption could increase by up to 170 percent by 2026," press release, February 27, 2019.
11. Bernardi, "Why 5G won't dethrone Wi-Fi 6 anytime soon at the edge."

12. At the time of writing, the final timing for the commercial launch of 3GPP Release 17, the third phase of 5G, had yet to be finalized; see: 3GPP, "Release 17 timeline agreed," press release, December 14, 2020. For a discussion of complexities involved in setting up 5G private networks, see: Lee Badman, "How to build a private 5G network architecture," *TechTarget*, accessed October 5, 2021.
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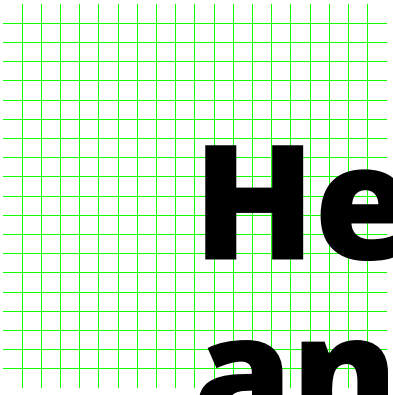


Health care anywhere

Wearable technology in health care: Getting better all the time

Smartwatches and wearable medical devices help people monitor their health 24/7. Their impact could increase if doctors trust their utility and people feel their data is secure

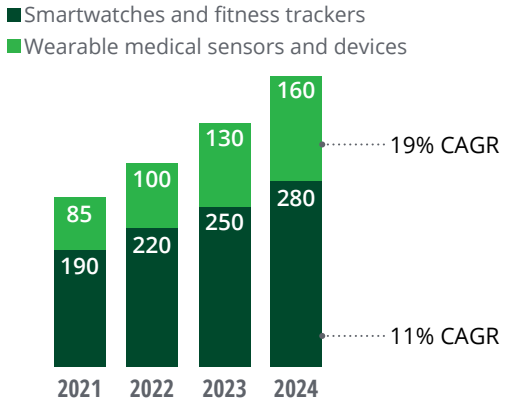
Jeff Loucks, Duncan Stewart, Ariane Bucaille, and Gillian Crossan

ADVANCES IN SENSORS and artificial intelligence (AI) are helping millions detect and manage chronic health conditions and avoid serious illness on devices small enough to be worn on a wrist or penny-sized patch. Deloitte Global predicts that 320 million consumer health and wellness wearable devices will ship worldwide in 2022 (figure 1). By 2024, that figure will likely reach nearly 440 million units as new offerings hit the market and more health care providers become comfortable with using them. These numbers include both smartwatches, which are marketed to and purchased by consumers, and medical-grade wearables—typically called "smart patches"—which are often prescribed by health care professionals but are increasingly becoming available off the shelf.

FIGURE 1

The global health wearables market is already big and expanding fast

Number of units shipped globally (millions), 2021–2024



Source: Deloitte analysis of industry market sizing data.

Smartwatches and smart patches are getting smarter about health—and more widely used

While health care companies produce a range of devices that help patients monitor health markers intermittently—including blood pressure cuffs and ECG monitors—our analysis focuses on smartwatches and smart patches, which are seeing rapid consumer adoption.

Deloitte's 2021 Connectivity and Mobile Trends survey found that 39% of respondents owned a smartwatch.[1] Their most common uses have historically been to help people get fit, lose weight, and beat their personal best in their next race (figure 2). But increasingly, people are using smartwatches to monitor their health, not just their running pace, as new hardware, software, and apps have turned them into personalized health clinics. Heart rate monitors are now standard on most smartwatches, and some have FDA approval for detecting abnormalities such as atrial fibrillation, a major cause of stroke. As these devices get more sophisticated, the percentage of consumers using them to manage chronic conditions and detect symptoms of serious diseases will likely increase.

The pandemic highlighted the value of smartwatches for monitoring health. As COVID-19 spread, smartwatches that measure blood oxygen saturation (SpO_2) became widely available, alerting people with low SpO_2—a life-threatening symptom that is hard for people to detect unassisted.[2] More than 10% of US consumers who own smartwatches are now using them to detect COVID-19 symptoms. The pandemic may even have encouraged smartwatch sales: Fifteen percent of US consumers who own a smartwatch purchased it after the onset of COVID-19.[3]

Smartwatch innovation is progressing rapidly, driven by advances in sensors, semiconductors, and AI. For example, some smartwatches now feature optical sensors that continuously measure variations in blood volume and composition using a technology called photoplethysmography (PPG). Algorithms produced and continually improved via machine learning use data from these sensors to provide insights into users' activity levels, stress, heart pattern anomalies, and more.[4]

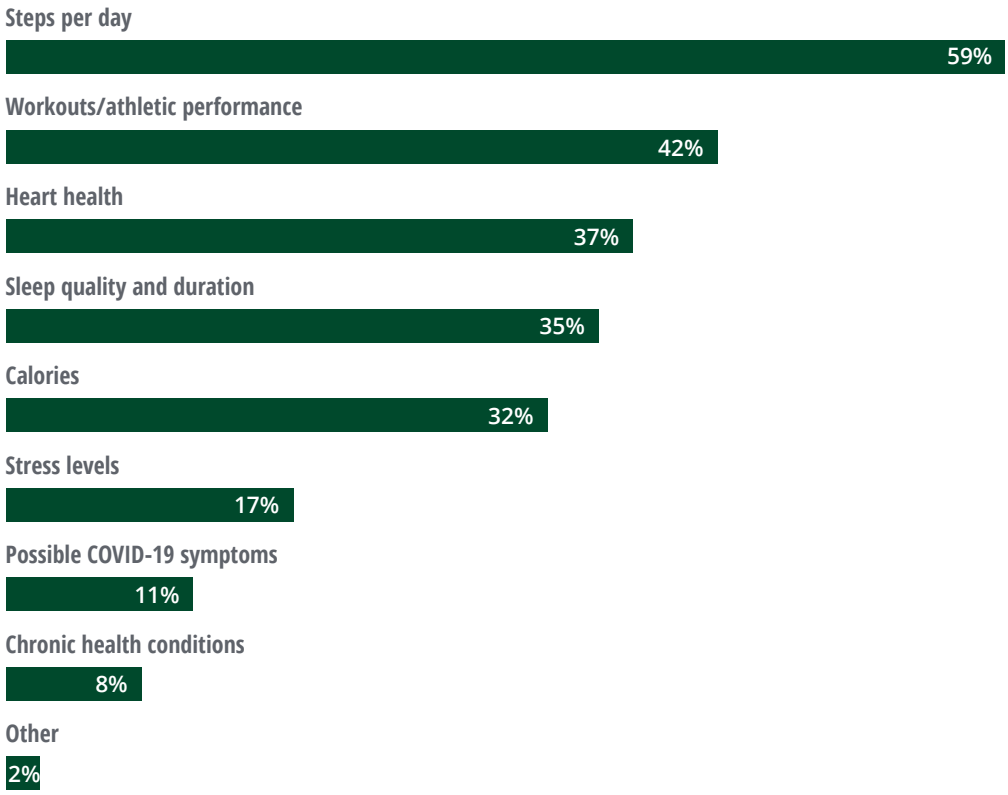
As another example, companies are getting closer to enabling smartwatches to monitor blood pressure, using PPG and other technologies such as Raman spectroscopy, and infrared spectrophotometers.[5] Measuring blood pressure with a cuff is inconvenient and uncomfortable. Most importantly, periodic blood pressure measurements can miss signs of chronic hypertension, which can cause heart disease, heart attacks, and strokes. Accurate, continuous, unobtrusive blood pressure measurement could expand the smartwatch market: 1.3 billion adults worldwide suffer from hypertension.

Of course, there are limits to what current smartwatch sensor technology can do without attaching to—or getting under—a person's skin. That's where smart patches come in.

FIGURE 2

People use smartwatches to monitor heart health, sleep quality, and chronic conditions

Which of the following do you use your smartwatch to measure? Select all that apply.



Notes: Respondents to this question both owned a fitness tracker or smartwatch personally *and* used these devices. The data reflects responses from US consumers to a survey conducted in June 2021.

Source: Deloitte 2021 Connectivity and Mobile Trends Survey.

Smart patches, developed mostly by medtech companies, are typically small and unobtrusive, affixing directly to a person's skin. Some "minimally invasive" smart patches use microscopic needles that painlessly penetrate the skin to act as biosensors and sometimes to deliver medications.

Unlike smartwatches, which provide a broad range of health data and insights, smart patches are typically designed for a single indication such as diabetes management, patient monitoring, and drug delivery. Smart patches also employ a broader range of technologies. For example, smart patches that measure heart rate variability often use electrocardiogram technology that tracks the heart's electrical activity directly and more accurately than smartwatches.[6]

Smartwatches and smartphones still play an important role. Data from smart patches is being integrated with smartwatch and smartphone apps, sending data to these devices for display and analysis. With the right technology, including interoperability capabilities, doctors could see wearable health data on a patient's health record, gaining access to more comprehensive information to inform diagnosis and care.

THE BOTTOM LINE

Companies of all kinds, from giants to upstarts, are developing new functionalities to meet growing demand for health care wearables in 2022 and beyond. But more widespread acceptance by consumers and health care providers may come slowly, as wearables are relatively new. Headwinds include:

Doctor skepticism. Health care providers who use wearable technology to monitor chronic health conditions and to track vitals, sleep quality, and medications are finding the technology helpful.[7] However, they also report three main drawbacks:

1. **Data utility.** Deloitte's latest survey of US physicians shows that if technology doesn't increase efficiency and isn't incorporated into their workflow, clinicians aren't interested in using it.[8] Only 10% of responding physicians said that they had integrated data from patient wearables into their electronic health records (EHRs). This is slowly changing: Major EHR vendors are now enabling consumers to share data from their health apps with their doctors.[9] For now, however, most doctors either don't have access to data from patient wearables or need to enter it manually.[10]

2. **Data accuracy.** Some doctors don't trust data from consumer wearables. For instance, those who have already been diagnosed with atrial fibrillation can be alerted of episodes by various smartwatches, an application cleared by the FDA and other regulators globally.[11] But this smartwatch capability is less useful as a mass screening tool, generating many false positive results and sending healthy patients for unnecessary further tests, putting both the patient and the health care system under stress.[12]

3. **User error—and anxiety.** When wearables aren't worn correctly, they can be inaccurate. Some who use wearables to monitor their health also fall prey to anxiety and obsessive behavior. Paying too much attention to pulse rate and heart rhythm, for example, can cause physical reactions that mimic symptoms of serious conditions such as atrial fibrillation, leading to unnecessary admissions and patient distress.[13]

Data privacy concerns. Since the COVID-19 pandemic began, consumers have become more willing to share health data.[14] Data privacy remains a hurdle, however. Forty percent of smartwatch or fitness tracker owners are concerned about the privacy of data these devices collect, according to Deloitte's 2021 Connectivity and Mobile Trends survey. That figure rises to 60% among smartwatch owners who use them exclusively to track their health.

Cybersecurity threats. Like all connected devices, health and wellness wearables are vulnerable to cybersecurity threats. The consequences for users could be severe. Fake smartwatch alerts could prompt patients to overdose on medications. [15] Medical devices such as drug infusion pumps and pacemakers have been hacked, too.[16] As more smart patches administer medications, millions more people could be vulnerable to threats. Finally, hackers have recently stolen millions of health and fitness records originally collected on smartwatches.[17] With health and wellness wearables, it's critical that companies integrate cybersecurity into their product development, software, supply chains, and cloud computing.[18]

Increased regulation. Currently, tech companies can decide not to classify smartwatches as health care devices to avoid regulations such as the United States' Health Insurance Portability and Accountability Act, which requires people's explicit knowledge and consent to share sensitive health information. But as these devices and their outputs are integrated into EHRs, and their alerts direct more patients into the health care system, regulators could require companies to adhere to more restrictive rules.[19]

These headwinds are not insurmountable barriers, and likely won't stop consumer health and wellness wearables from growing in the next two years. Devices will get more accurate, and the apps will get smarter, enabling people to monitor a broader range of health indicators and conditions. It also seems likely that regulators will approve wearable devices for additional indications. For these reasons, big tech, medtech, and a legion of startups believe that the health wearables market is a strong one, and their investment and innovation could make it a self-fulfilling prophecy.

Endnotes

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Mental health goes mobile: The mental health app market will keep on growing

Mental health care needs are pressing around the world. Apps can deliver support on demand and on the go

Brooke Auxier, Ariane Bucaille, and Kevin Westcott

THERE SEEMS TO be an app for everything these days, and mental health is no exception. Deloitte Global predicts that global spending on mobile mental health applications will reach close to US$500 million in 2022.[1] That's assuming an annual growth rate of 20%—a conservative figure, considering the 32% growth these apps enjoyed, from US$203 million to US$269 million, from the first 10 months of 2019 to the same period in 2020.[2]

A growing market with a big impact

Though US$500 million may not seem like much compared to the estimated US$1.6 billion 2021 global market for health and wellness apps overall,[3] it's impressive given that many emotional and mental well-being apps are free or low cost. Typically, they are also easy to access and integrate into daily habits, require little effort to use, provide

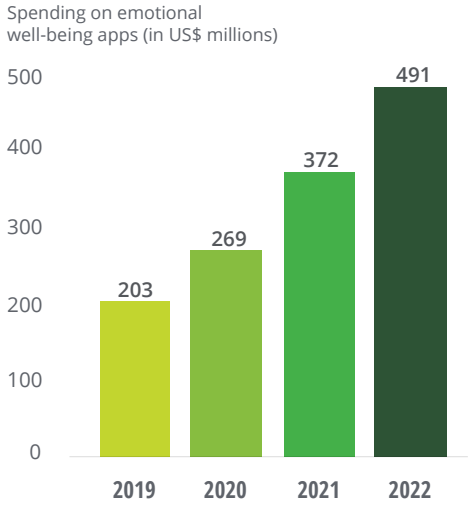
an enjoyable experience, and—best of all—they can work.[4] They are also more resistant to disruption than traditional therapies, though they are not a replacement for professional mental health treatment. All of these factors likely contribute to their growing popularity.

App developers are taking notice. As many as 20,000 mental health apps may exist today,[5] with two of the most popular being Calm[6] and Headspace.[7] Both of these focus on mindfulness and meditation, and are meant to help individuals get support other than from connection to a therapist or other traditional mental health services. Additionally, many mental health app developers are launching collaborations with other online services and apps, such as Snapchat[8] and Bumble,[9] which will likely make them more accessible to a larger share of consumers.

FIGURE 1

Mental health and well-being apps will see strong growth through 2022

Global spending on mental health and well-being mobile apps, 2019–2022, US$ millions



Note: Spend estimates for 2021 and 2022 are predictions.
Source: SensorTower, Mobile Wellness Market Trends 2021.

Apps can be used to manage mental health conditions such as anxiety or depression either on their own—enabling individuals to learn about and self-manage their mental health—or in conjunction with more traditional talking therapies, by providing a channel to access asynchronous or synchronous support from a mental health professional through means such as live chat, video, and telephone. Beyond supporting individuals with mental health diagnoses, apps can also be used to improve general well-being by encouraging behavior change, including practicing mindfulness and meditation.

Beyond supporting individuals with mental health diagnoses, apps can also be used to improve general well-being by encouraging behavior change, including practicing mindfulness and meditation.

The potential market for these apps is considerable. Nearly 800 million people worldwide, or 11% of the global population, live with a mental health condition.[10] Moreover, data shows that the COVID-19 pandemic has exacerbated mental health concerns and triggered declines in well-being, with a dramatic rise in the prevalence of problems such as depression, anxiety, post-traumatic stress symptoms, and stress.[11] About four in 10 adults in the United States, for example, reported symptoms of anxiety and depression from June 2020 to March 2021, compared to a much smaller share reporting these symptoms from January to June 2019.[12] While this may not reflect an actual increase—some medical professionals and researchers suggest that the pandemic has helped

people open up about their mental health and made accessing treatment more socially acceptable[13]—it points to the prevalence of the issues that mental health apps address.

Apps can not only help address the volume of need for mental health support, but also make that support more accessible. Professional mental health resources such as talking therapies are hard to access or are stigmatized in many countries and communities, and in some of these cases, people are using mobile applications to replace or supplement traditional methods of treatment. In China, for instance, where human resources for professional mental health treatment are often low and stigma around mental health conditions is high,[14] consumer spending on wellness apps grew by more than 60% in the first 30 days of the COVID-19 pandemic (March 7–April 5, 2020) versus the 30 days prior (February 6–March 6, 2020).[15] We believe that this dynamic will drive strong mental health app growth in China and many other Asian countries. It is worth noting, however, that there is very little regulation around mental health or medical apps, which is cause for growing concern internationally.[16]

Again, the pandemic exacerbated the access problem by disrupting access to traditional mental health support in most countries and communities.[17] Sixty percent of respondents in 130 countries participating in a summer 2020 World Health Organization survey reported disruptions to mental health services for vulnerable populations, including children, adolescents, older adults, and women requiring prenatal or postnatal services.[18] In some cases, digitally enabled services helped to fill the gaps, but adoption of these interventions shows wide disparities, with the divides generally negatively impacting those in low-income countries.

Digitally enabled health services, including mental health services, can also expand access to care to a more diverse population. US-based research shows that for individuals who identify as Black, Hispanic, Asian, or Native American, having a provider who is empathetic, culturally competent, or who looks like them is a top priority.[19] About half of participants in this study said they would be willing to use a virtual visit instead of seeing someone in person if it meant they would get access to a provider who looks like them, talks like them, or has a shared life experience.

Research shows that mental health apps have clear clinical advantages for their users.[20] Meta-analyses of trials covering more than 20 mobile apps found that using them to alleviate symptoms and self-manage depression significantly reduced depressive symptoms.[21] A similar analysis of anxiety treatment apps found that users experienced a reduction in anxiety symptoms after use, with the greatest reduction occurring when the apps were paired with face-to-face or internet-based therapies.[22] Apps that focus on mindfulness and meditation have also been shown to deliver benefits. A study of one of these apps found that users experienced decreased depression and increased positive emotions after just 10 days of use.[23] Other research tied the use of another app to reductions in stress and sleep disturbances and improvements in mindfulness and compassion.[24]

Improved well-being has economic as well as personal benefits. Poor mental health puts a strain on the global economy. Prepandemic estimates suggest that poor mental health costs the world economy US$2.5 trillion per year, a cost that was projected to increase to US$6 trillion by 2030.[25] Lost productivity as a result of anxiety and depression accounts for US$1 trillion of this yearly sunk cost. Without action, these impacts will continue to be felt across economic sectors in terms of both lost consumer spending and lower workforce productivity. While most countries allocate only a modest share of their government health budgets to mental health care and support,[26] opportunities exist for app creators and corporations alike to step in.

The financial implications of poor mental health are not lost on businesses. In part, we expect mental health app adoption to continue to grow due to the many corporations that are recognizing the importance of supporting employee well-being and partnering with mental health apps to make them accessible to their workforce.[27]

THE BOTTOM LINE

To meet growing demand and capture interested audiences, mental health app creators and developers can pursue novel methods for monetization, such as subscription tiers or tailored paid programs and offerings. They could also explore personalizing these services for users and customizing apps to encourage regular use and check-ins. And finding ways to integrate socialization and network support into the user experience may increase app stickiness and integrate desirable community and connection interventions into the oft-isolating state of poor mental health.

On their side, mental health care providers might leverage apps to improve care quality and accessibility. They could make treatment available to broader populations, making mental health care and well-being easier to manage for millions of consumers. Research partnerships between app developers and health care providers should help improve the quality of these services.

Transparency is also key. Developers and care providers should work to help ensure that the methods used to design mental health apps are clearly communicated to consumers. They should also provide transparency around privacy practices and data collection, especially given the potentially sensitive nature of these apps and the user data collected.

Mental health apps can be a boon for those who cannot access—or would not seek—traditional care, as well as for people using them to supplement other therapeutic methods. The market's strong growth points to a significant unmet need that these apps can fill. Going forward, mental health apps can offer opportunities not only for app developers to monetize new and existing products and services, but also for organizations worldwide to engage in corporate social responsibility efforts to increase well-being and improve access to care.

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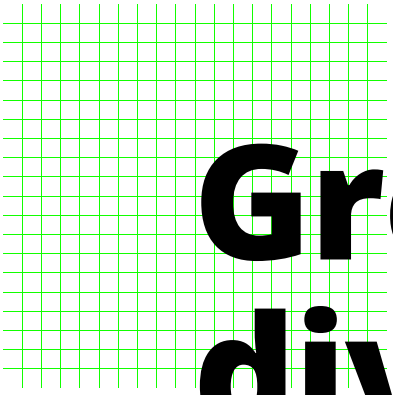


Green and diverse

Making smartphones sustainable: Live long and greener

Lengthening phone lifetimes would help reduce the environmental impact of smartphones. But could smartphone vendors find other revenue sources?

Paul Lee, Cornelia Calugar-Pop, Ariane Bucaille, and Suhas Raviprakash

DELOITTE GLOBAL PREDICTS that smartphones—the world's most popular consumer electronics device, expected to have an installed base of 4.5 billion in 2022[1]—will generate 146 million tons of CO_2 or equivalent emissions (CO_2e) in 2022.[2] This is less than half a percent of the 34 gigatons of total CO_2e emitted globally in 2021, but it is still worth trying to reduce.[3]

The bulk of these emissions, 83% of the total, will come from the manufacture, shipping, and first-year usage of the 1.4 billion new smartphones forecast to be shipped in 2022.[4] Usage-related emissions from the other 3.1 billion smartphones in use during 2022 will generate an additional 11%, and the remainder will come from refurbishing existing smartphones (4%) and end-of-life processes (1%),[5] including recycling.[6]

Making smartphones is an emissions-laden process

A brand-new smartphone generates an average of 85 kilograms in emissions in its first year of use. Ninety-five percent of this comes from manufacturing processes, including the extraction of raw materials and shipping. Exactly how much CO2e this releases depends on several factors, mainly:

- **How much recycled material is used.**[7] Reusing materials implies a reduction in carbon-intensive mining. Tin can be reused for circuit boards, cobalt for batteries, and aluminum for enclosures.[8] Technology now also exists to recycle rare-earth elements, which go into components such as speakers and actuators; up until a few years ago, extracting rare-earth elements from these components was considered commercially unviable due to their small size.[9]

- **How energy-efficient manufacturers' facilities are.** The production of the integrated circuits used in smartphones consumes significant amounts of energy. For example, up to 30% of a semiconductor fabrication plant's operational costs comes from the energy needed to maintain constant temperature and humidity.[10]

- **How heavily the manufacturing ecosystem relies on renewable energy.** This relates to owned facilities as well as to third parties to which vendors outsource manufacturing. Vendors may need to convince and assist their outsourced supply chain to migrate to renewable energy sources such as wind, solar, and hydro.[11]

After it is manufactured, a smartphone generates an average of 8 kilograms of emissions from usage during its working life, which is most commonly between two and five years.[12] At the end of that time, its end-of-life CO2e emissions are determined partially by the ease with which its components can be recycled.[13]

Because manufacturing accounts for almost all of a smartphone's carbon footprint, the single biggest factor that could reduce a smartphone's carbon footprint is to extend its expected lifetime.[14] There could still be just as many smartphones in use; what would change is that each smartphone would be used for longer, regardless of the number of individual owners of each smartphone during its lifetime. Even accounting for the CO2e emissions resulting from refurbishing and shipping a used phone, prolonged ownership, whether by the original owner or a series of owners, provides a clear-cut benefit.

Several trends point to the likelihood that smartphone lifetimes will likely indeed become longer in the medium term:

Smartphones are becoming physically tougher, reducing the need for unplanned replacement. Screen breakages and water damage have historically been common causes for a phone to be written off. But screens can now cope with multiple short drops, and resilience to being dropped is a point of differentiation.[15] And flagship-model smartphones, whose higher sales price enables the use of higher quality, are becoming more resistant to water damage every year. The latest flagships can now survive immersion at up to 6 meters' depth for half an hour.[16]

Software support for smartphones is being offered for longer. The period over which a vendor maintains software support has a strong impact on the resale value of a device: It is hard to sell a phone that is unlikely to be useful. To enable older phones to work well, smartphone vendors create or source specific versions of each operating system (OS) for each model of phone. Such an OS refresh may well include design changes that make an existing phone "look" new; updated code can

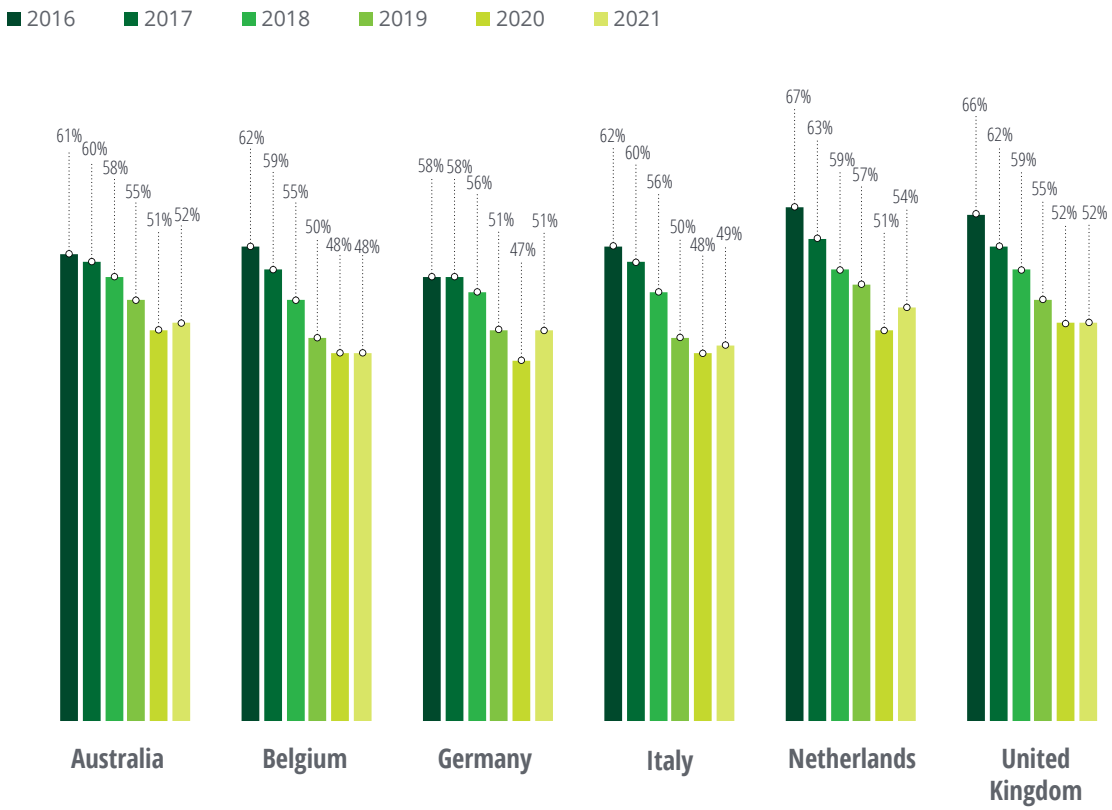
also make existing processes flow better and consume less energy. Vendors also need to provide regular security updates to patch vulnerabilities. As of the start of 2022, the length of this kind of support for a given smartphone's OS is likely to vary between three and five years, depending on vendor, but we expect that by 2025, competitive pressures may have made five years commonplace for most flagship models.[17] In the EU, all smartphone vendors may need to provide security updates for five years beginning in 2023.[18]

Consumers are keeping phones for longer. The average ownership time for smartphones has steadily been lengthening in developed markets. Figure 1 shows that between 2016 and 2021, there was a decline in the proportion of respondents whose smartphones had been bought in the prior 18 months (the trend reversed in markets in 2021, which we attribute to forced savings on services as a result of the pandemic leading to greater spend on devices). Over the same period and in the same markets, the percentage of smartphones

FIGURE 1

Consumers are keeping their smartphones for longer

Proportion of smartphone owners who had purchased their phone in the prior 18 months, 2016–2021



Source: Deloitte Digital Consumer Trends, May–June 2016, May–June 2017, June 2018, May–June 2019, May 2020, June–August 2021.

purchased over 3.5 years ago doubled on average from 5% to 10%.[19]

Flagship phones now commonly cost US$1,000 or more. One powerful motive to keep a smartphone for longer has been the high cost of new devices, which may require three years versus the former typical two years to pay off fully. In 2017, the idea of a US$1,000 smartphone raised skeptical eyebrows. But just one year later, that price point had become commonplace for flagships, with most vendors offering multiple smartphones at US$1,000 or more.[20]

The global market for refurbished and handed-down phones is growing. The higher a phone's nominal resale value, the more likely it is to be traded in. A US$1,000 phone could retain half its value after the first year, providing the minority of smartphone users who swap out premium phones annually a strong incentive to trade them in.[21] Companies also have an incentive to refurbish: a one-year-old, pristinely refurbished phone may retail for 80% of the price of a brand-new one. A four-year-old premium phone may be unwanted in wealthier markets but be in significant demand in emerging ones. Premium phones are also likely to be more water and dust resistant and use better quality glass than lower-priced phones.[22] Indeed, the refurbished smartphone market is expected to grow annually at 11.2% per year through 2024, at which point it will be worth US$65 billion and comprise 352 million units.[23]

THE BOTTOM LINE

Longer smartphone lifetimes could reshape how the smartphone industry generates revenues and profits.

Smartphone vendors could offer higher-priced devices to balance out a fall in the quantity of devices sold, and they may be able to charge a green premium among consumers who favor vendors that have more sustainable approaches. However, vendors should also think about how to grow revenue from sources other than device sales, which could include:

- Media services and applications stores
- Online storage—demand for which will grow steadily over time as photos and videos accumulate
- Sales of complementary hardware with lower emissions per unit than smartphones (such as Bluetooth headphones, whose sales are forecast to grow by 35% in 2022)[24]
- Commissions on insurance premiums[25] and financial products related to the purchase or lease of smartphones

Over time, smartphone buyers may differentiate their purchases on the basis of a vendor's green credentials. But this is unlikely in the short term. According to a Deloitte multinational study, fielded in mid-2021, use of recycled materials was the least important factor when choosing a smartphone in 10 out of 13 countries.[26]

For carriers, which have long generated sales by bundling smartphones with new multiyear contracts, a reduction in the sale of new phones could be punitive. But mobile operators could also bundle contracts with refurbished devices, as well as sell ancillary services, such as insurance. Furthermore, many operators already have a significant proportion of customers on SIM-only tariffs, which only include airtime and are not linked with sales of new smartphones.

For the smartphone industry as for others, reaching decarbonization targets often requires companies to change the way they do business. However, the ultimate payoff can be much bigger than the smartphone industry alone. Initiatives taken by the smartphone industry are likely to influence emissions reductions in other device categories. Innovations that reduce emissions for smartphones, such as using recycled materials, could be applied by the same vendor to other devices, such as tablets, in its portfolio. And efforts to prolong smartphone battery life by reducing energy consumption could be applied to reduce energy consumption in other devices, from laptops or smart speakers that historically have had less need for energy-efficient design due to being plugged into a wall socket.[27] The sum of all of these reductions may add up to a figure far greater than what smartphones alone produce—and even if it doesn't, every little bit counts.[28]

Endnotes

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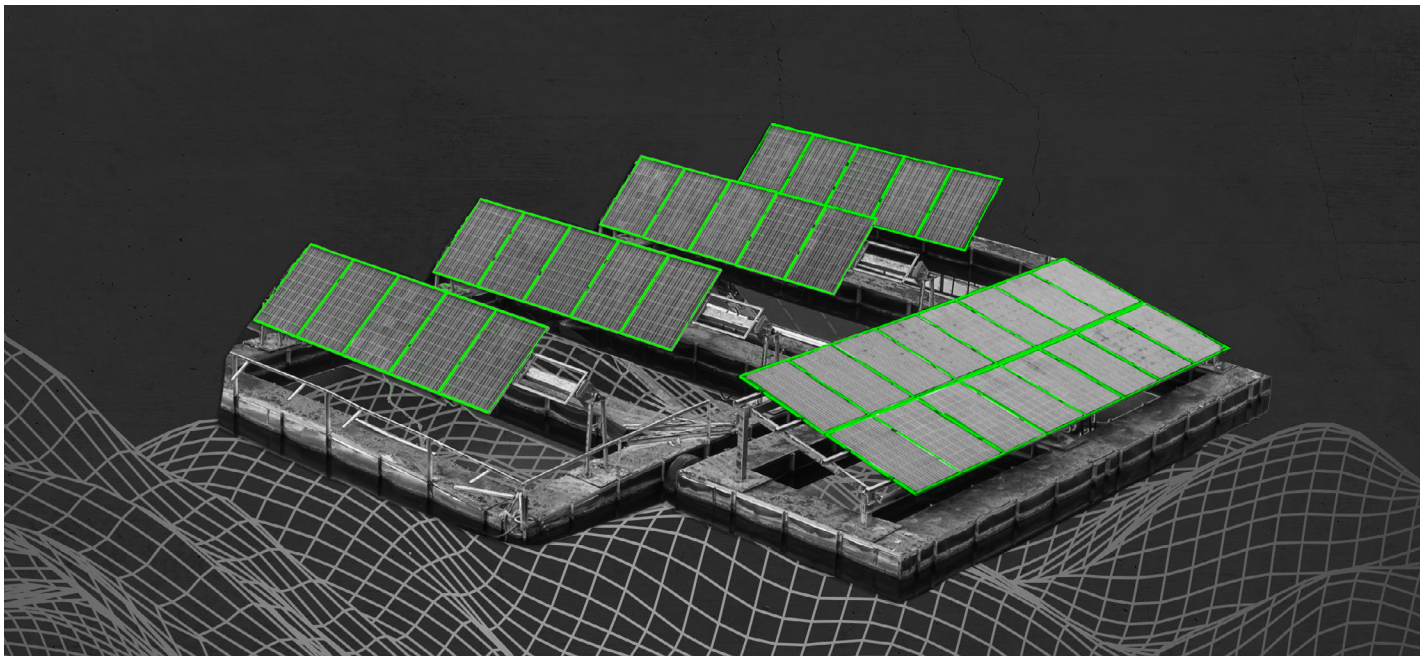


Floatovoltaics enters the renewable energy mix: Floating solar panels are now commercially viable

Asia/Pacific is taking the lead in deploying floating photovoltaic arrays as the technology advances and its economics improve

Karthik Ramachandran, Paul Lee, and Marlene Motyka

PLACES THAT DON'T have enough land to build large solar arrays will soon be able to build them on lakes and reservoirs instead. Deloitte Global predicts that the aggregate installed capacity of floating photovoltaics (FPVs)—solar panels floating on water rather than installed on land—will reach 5.2 gigawatts peak (GWp)[1] globally by the end of 2022, representing US$4–5 billion in spending.[2] Also known as "floatovoltaics," new FPV installations in 2021 and 2022 alone are anticipated to add a total capacity of 2.9 GWp, more than in the 13-year period from 2008 to 2020 combined.[3] Cumulative global FPV capacity could reach 13 GWp by 2025 (figure 1).

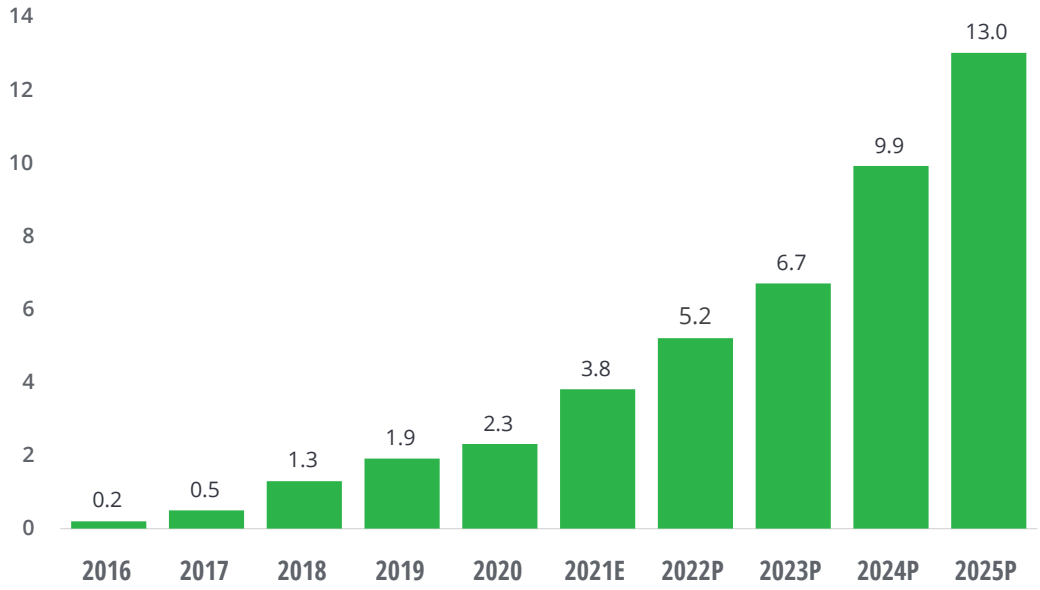
FPVs broaden the range of options for solar power generation

We predict that several factors will drive continued FPV growth across regions after an extended period

FIGURE 1

Global FPV capacity could reach 13 GWp by 2025

Global cumulative installed FPV capacity, 2016–2025 (GWp)



Note: 2021E and 2022–2025P values are based on Deloitte's estimate based on partial data for 2021, and our prediction for 2022–25.

Source: Deloitte analysis based on data from publicly available sources.

of sluggish progress.[4] In Asia/Pacific, several governments have set aggressive renewable energy (RE) targets, and solar power typically plays into these countries' plans to meet those targets. However, competing needs for scarce land from sectors such as agriculture and real estate are pushing up land acquisition costs.[5] High population density also limits land availability, making land-based PV commercially challenging. Under these circumstances, FPV will likely emerge as a feasible alternative for Asia/Pacific countries with suitable bodies of water. In addition, electricity shortages in a number of the region's developing countries, coupled with their anticipated strong economic growth, will likely escalate energy demand.[6] In fact, Asia/Pacific accounted for more than 90% of global installed FPV capacity in 2020, and it is currently leading the charge in FPV adoption, with the majority of new FPV capacity additions in the next 3–5 years expected to be in that region (figure 2).

New floating panel installations in 2021 and 2022 alone are anticipated to add a total capacity of 2.9 GWp, more than in the 13-year period from 2008 to 2020 combined.

Africa may be another market ripe for FPV. The continent struggles with unreliable electricity supplies and drought in several countries. Moreover, reservoirs face issues with evaporation due to high sunlight exposure, which floating solar panels would combat. One scientific study found that covering

FIGURE 2

Asia/Pacific is home to many of the world's largest FPV projects

Select major FPV projects with a capacity of at least 300 MWp, 2020–2025

Country	Type of water body	Capacity (MWp)	Status
China	Reservoir	320	Completed in 2020
South Korea	Estuarine tidal flat (Yellow Sea coast)	1,200	Phase 1 expected to be completed in late 2022/early 2023
Vietnam	Freshwater pond/lake	500	Expected to be completed in 2023
India	Hydropower reservoir	600	Expected to be completed in 2023
India	Hydropower reservoir	300	To be completed in 2023 (feasibility studies done)
Indonesia	Reservoir	2,200	Work to start in 2022, and to be completed during 2024–2025
South Korea	Estuarine tidal flat (Yellow Sea coast)	900	Phase 2 to be completed by 2025
Vietnam	Hydropower reservoir facilities	400	Auction to be conducted
Portugal	Reservoirs near to various hydropower plants	500	Auction to be conducted

Source: Compiled using data from publicly available sources.

even 1% of Africa's hydropower dam reservoirs with FPVs could double the continent's hydropower generating capacity to 58 GWp.[7]

FPV could also gain ground in Europe, where favorable policies toward RE, such as Fit for 55[8]—the EU's commitment to cutting emissions by 55% by 2030—could accelerate the adoption of new RE technologies such as FPV. Potential decarbonization agreements arising from the November 2021 COP26 climate change conference could also prompt greater interest. Western European countries, with high penetration of RE deployments, currently view FPV largely as a complement to existing RE installations, but some early European pilots point to growing interest. For instance, Portugal, Netherlands, France, and Norway are looking at deploying FPVs on hydropower dam reservoirs and along shorelines on the open sea. There are also ongoing pilots in the North Sea and the Adriatic Sea to assess the feasibility of using FPV to complement offshore wind farms.[9]

In several parts of the world, government support for FPVs include exclusive tenders/auctions and feed-in-tariffs to encourage new capacity buildouts. However, even with these incentives, FPV adoption will likely be slower in some regions. In the United States, for instance, a relative abundance of land continues to favor ground-mounted solar PV projects—although FPVs have started to attract some initial attention (for example, Fort Bragg announced a 1.1 MWp FPV project in late 2020).[10]

FPVs offer RE project developers distinct operational and environmental benefits that, in combination, make them commercially viable. For one thing, FPVs present a range of deployment options compared with traditional land-based solar systems. Floating panels can be set up on lakes, basins, water treatment plants, drinking water reservoirs, dam reservoirs, estuarine tidal flats, or even nearshore along a coast.[11] Pilot projects have shown that they can be deployed on fish farms as well, with no impact on the welfare of the fish.[12]

Hydropower developers and operators could also stand to gain much from FPVs. Several countries in Asia/Pacific and Europe are planning to install 100 MWp+ FPVs systems on hydropower dams to enhance hydro energy generation by reducing water loss due to evaporation.[13] Installing FPVs on a dam's reservoir requires less effort than implementing land-based solar PV, as the hydropower plant is already connected to the grid and the substation and infrastructure are also available. A hybrid hydro and solar power system can also enable overall energy output to be managed better across seasons.[14] And some hydropower plants are looking at tapping into FPV to address peak demand—by, for example, using pumped storage hydropower to store excess solar output.[15]

FPVs could also be an option for residential and small-scale users with energy requirements in the range of 5–20 kilowatts peak, as long as they are located near a water body. Even though rooftop solar panels are far easier to install, as it only involves putting a panel on top of the roof, floating panels overcome the limitations dictated by a roof's angle, which can affect energy capture and yield.[16] Moreover, FPVs on a nearby lake or reservoir could generate enough energy to power nearby residential and small-scale commercial units on a broader scale, and with greater ease than putting panels on every single building.

Of course, FPV also poses risks and uncertainties. Few technicians would likely be familiar with FPVs' operations and maintenance procedures, making their upkeep challenging; the long-term environmental impact is unknown; weather-related challenges to floating panels are of concern (e.g., strong winds in Northern Europe); and regulations and permitting for FPV projects are often complex to navigate.

Floating panels can be set up on lakes, basins, water treatment plants, drinking water reservoirs, dam reservoirs, estuarine tidal flats, or even nearshore along a coast.

For the FPV market to become self-sustaining in the longer term, FPV producers and operators likely need to experience an overall increase in demand. RE power purchase agreements (PPAs), which lock in capacity through multiyear agreements, continue to be critical in securing financing and generating revenue streams. As is the case with land-based solar PV, buyers of FPV projects will also likely be exposed to risks such as weather fluctuations and the financial and cost implications of multiyear PPAs.

Due to these factors, coupled with the fact that FPV technology is still nascent, energy producers might view FPV projects as riskier than implementing more-established, conventional RE technologies. Nonetheless, a particular FPV project's operational, environmental, and technological benefits could still outweigh the risks enough to make the project attractive to the financiers and banks that would fund it.

THE BOTTOM LINE

Energy ecosystem players—solar and hydropower producers and operators, photovoltaic system developers, enterprises, residential consumers, clean energy companies, and technology solution providers—all have an opportunity to tap into FPVs' emerging value based on each player's role in the value chain.

Technology companies could help organizations plan, develop, and deploy the foundational infrastructure for FPVs, maintaining the infrastructure once it is deployed, and measuring and monitoring its performance. Semiconductor companies could design and develop core manufacturing equipment and chipsets for solar panels. Software providers might help businesses and governments use AI-based dashboards that allow them to design, plan, review, and dynamically change their energy efficiency targets and goals for RE sources, including FPVs; they could also develop products that monitor weather and provide situational awareness when managing FPV panels. Analytics providers could partner with RE end users to offer them insights on where and how panels can be deployed, and they could help FPV operators assess grid operations and discover system issues early on.

Apart from these potential revenue opportunities, FPVs could be a part of the overall mix of clean energy investments that companies can contract for in the form of PPAs. One emerging use case is for data center and cloud service providers to tap into FPVs to supply energy for their operations. Some countries in southeast Asia are already experimenting with submersible data centers that use the surrounding water as a cooling agent. FPVs could be installed on top of or adjacent to these data centers as a backup or primary source of power.[17]

With the technology advancing and commercial interest and adoption increasing, FPV is poised to gain a firm foothold in the RE space. The day may fast be approaching when floating solar panels will play a prominent role alongside other RE sources in powering a cleaner world.

Endnotes

1. Watt-peak (Wp) indicates the maximum electrical power that one PV panel can supply—under standard temperature and sunlight conditions. Standard conditions imply a solar radiation of 1,000 watts/square meter, a temperature of 25°C or 77°F, a clear sky, and around midday/noon—for example.
2. Based on data and information from secondary research, average project cost ranges from US$80 to US$120 million for a 100 MW floatovoltaics plant. Therefore, aggregate investments could reach US$4–US$5 billion, worldwide, in 2022.
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4. Though the first FPV installations were completed in 2007, only a little over 1 GWp of capacity had been installed worldwide through 2018.
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6. As a case in point, between 2021–2025, South Korea, India, Vietnam, Thailand, and China are cumulatively planning to add more than 5 GWp of FPV capacity. South Korea alone is planning to install an additional 2.1 GWp capacity by 2030. Greater interest in FPV over offshore wind can be attributed to the relatively lower wind velocity in Asia/Pacific countries compared with what is typically seen in the wind-rich areas of Northern Europe.
7. Fred Pearce, "Floating solar ready for take-off," *Eco-Business*, May 21, 2021.
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15. National Renewable Energy Laboratory, "News release: Untapped potential exists for blending hydropower, floating PV," press release, September 29, 2020.
16. Bruno Paixão Martins, *Techno-economic evaluation of a floating PV system for a wastewater treatment facility*, KTH Industrial Engineering and Management, 2019.
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The gender gap in reading: Boy meets book, boy loses book, boy never gets book back

Why do boys and men read fewer books, and less often, than girls and women?

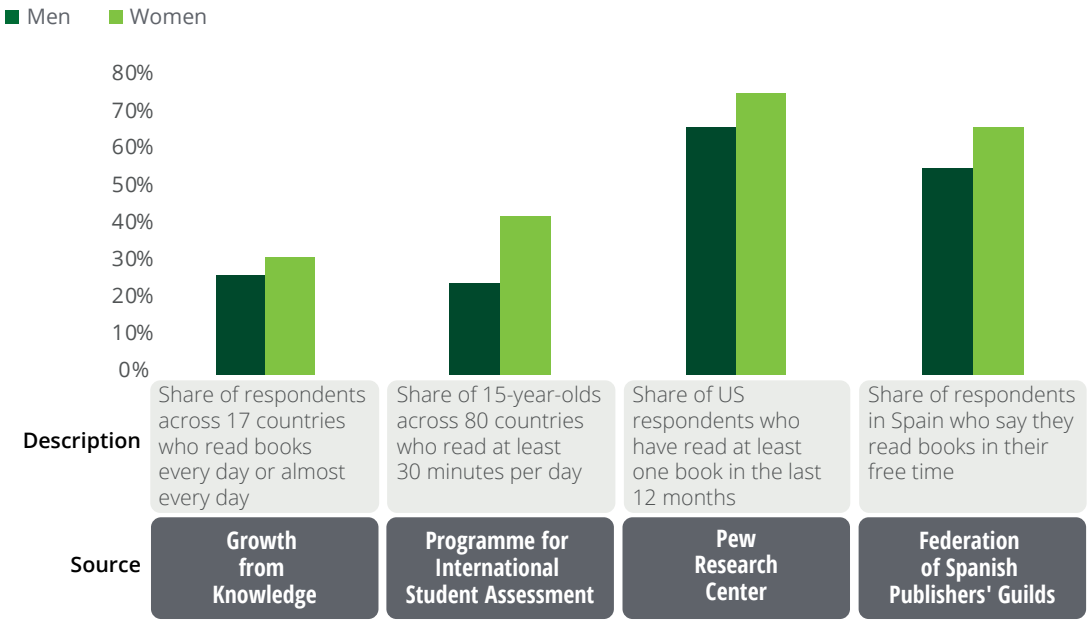
Brooke Auxier, Duncan Stewart, Ariane Bucaille, and Kevin Westcott

FIRST THE GOOD news: Partly due to the COVID-19 pandemic, people around the world are reading more print books, e-books, and audiobooks than ever before.[1]

Now the bad news: Boys and men are, and historically have been, less drawn to this activity (figure 1). This trend persists despite global illiteracy impacting women more than men.[2] In the coming year and beyond, Deloitte Global predicts that boys and men in almost every country will continue to spend less time reading books, and read them less frequently, than girls and women. That is, the story will not diverge too much from the usual plotline. We're not saying that this gender divide will widen significantly … but neither does it appear to be shrinking.

FIGURE 1

Women (and girls) outpace men (and boys) in the global book reading divide



Note: This data is from four different sources and years and is not meant to be directly comparable.
Sources: Growth from Knowledge, *Frequency of reading books*, March 2017; Andreas Schleicher, *PISA 2018 insights and assessments*, OECD, 2019; Andrew Perrin, "One-in-five Americans now listen to audiobooks," Pew Research Center, September 25, 2019; Porter Anderson, "Spain's publishers cite rising readership, digital reading 'more intensive,'" *Publishing Perspectives*, January 22, 2019.

Boys and men are disadvantaging themselves by reading books less often

When we talk about a reading gap throughout this piece, we are referring specifically to the gap in reading long-form content: books rather than news articles and other shorter texts. You might think it doesn't matter—reading is reading, right?

Wrong. Studies show that people who read books not only live longer than people who don't read books, but also have a longevity advantage compared to those who read newspapers or magazines—even after adjusting for covariates such as age, education level, wealth, and health.[3]

Multiple studies also show that reading fiction books increases empathy and understanding of others more than reading nonfiction.[4]

So why is book reading more prevalent among women than among men? Several converging factors are likely behind the disparity. Reading habits are often formed in childhood and adolescence, and studies show that fathers are less likely to read themselves, which means that at a formative stage, children are less exposed to male reading role models. Fathers of sons are also less likely to read to them than fathers of girls.[5] In addition, men and teenage boys are more likely than women and teenage girls to choose other entertainment activities, such as gaming, over reading.[6]

In addition to reading substantially less than girls, boys also report enjoying reading less. A 2018 study of children at age 15 found that more than 40% of girls reported reading at least 30 minutes a day, compared to only about a quarter of boys who did the same. The same study found that 44% of girls said that reading was one of their favorite hobbies, while only 24% of boys said the same.[7]

We predict that this gender divide in ability isn't going away, and won't until boys and men start reading as much and as often as girls and women do.

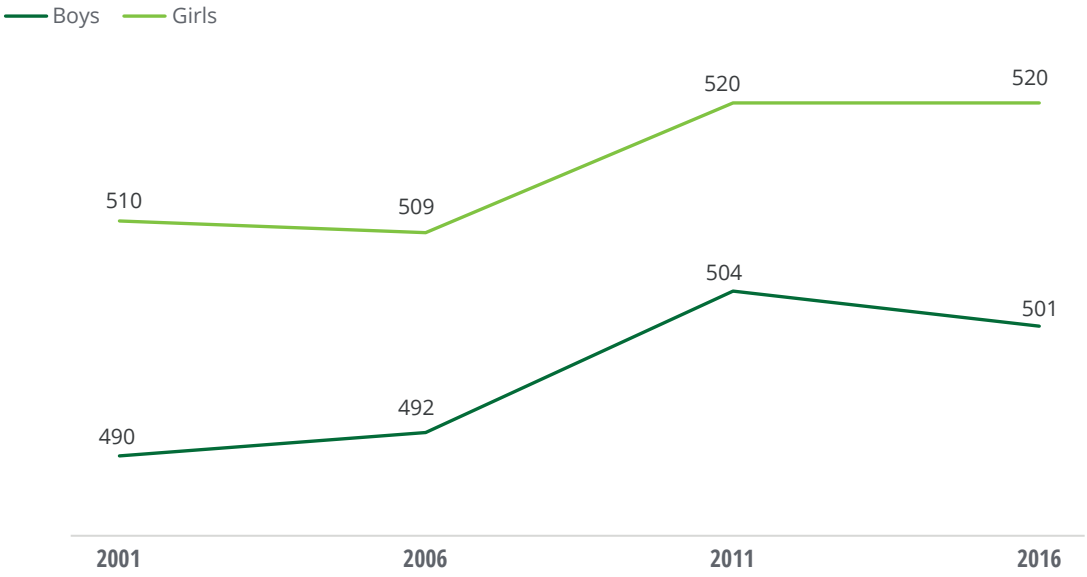
The really bad news is that there is also a gender gap in reading ability and comprehension, perhaps unsurprising if boys and men are getting less practice. One global study found that fourth-grade girls had higher average reading achievement levels in almost all of the 50 countries surveyed than boys in the same grade—a trend that has held since 2001 (figure 2).[8] We predict that this gender divide in ability isn't going away, and won't until boys and men start reading as much and as often as girls and women do.

Interestingly—and perhaps importantly—men and boys read fewer books written by women. A study by Nielsen Book Research found that, of the 10 bestselling male authors, readership was roughly evenly divided by gender, with 55% male readers and 45% female readers. In contrast, only 19% of the 10 bestselling female authors' readers were

FIGURE 2

Internationally, girls continue to score higher than boys in reading achievement

PIRLS reading literacy scores among fourth-grade students in multiple countries



Source: National Center for Education Statistics, *Progress in international reading literacy study (PIRLS)*, 2001, 2006, 2011, 2016.

male, compared to 81% female.[9] Men also read fewer books with female protagonists than do women—a problem compounded by the fact that fewer books feature female protagonists overall. For example, in the top 100 children's books, male characters (human and nonhuman) in leading roles outnumber female characters two to one.[10]

There is also a long history of women writers masking their gender—including the author of the wildly popular *Harry Potter* novels, Joanne Rowling, who writes under the gender-neutral moniker J. K. Rowling—in an effort to be taken seriously and attract a wider share of readers.[11] (However, more recently, some male authors have done the same and adopted gender-neutral pen names, in hopes of gaining more credibility with women and increasing their female readership).[12]

Not only does reading fewer books hurt men and boys, but not reading books by and about women can hurt society. If female book characters are portrayed largely through the gaze of men, or with a male lens, this can reinforce a lack of understanding of, and discrimination against, underrepresented and non-male groups. Reading books, especially fiction, is related to social acuity, helping readers learn about other people and comprehend their motivations.[13] When we read, we put ourselves in the characters' shoes to see their points of view, fears, hopes, and experiences. For female authors and protagonists to be a closed book to many male readers can be unhelpful in an era where we strive for greater diversity, equity, and inclusion. Not to mention that capabilities developed by reading—including emotional intelligence, empathy, and imagination—are in high demand in the workplace and will likely be critical to employability in the future of work.[14]

THE BOTTOM LINE

The gender reading gap impacts not only men and boys—and their enjoyment of reading and their reading comprehension and ability—but society as a whole. To shrink it, book publishers can think about how to appeal to their male customers through both content and format. There may be an opportunity, for instance, for publishers and production studios to work together to adapt popular action-movie franchises and video game worlds, especially those that largely appeal to boys and men, into children's books, young adult novels, and other reading or audiobook formats. Diversifying book formats may also help to shrink the gender reading gap. For instance, audiobooks may be leveling the playing field between men and women, with some research suggesting that men consume audiobooks about as much,[15] if not more,[16] than women. Publishers and content creators could utilize the audiobook format to better engage and reach male readers.

Ultimately, though, it's up to parents, caregivers, and educators—and others on the front lines of child development—to actively work to encourage reading habits for both boys and girls equally. Providing boys with positive role models for reading, such as dads, coaches, and athletes, and identifying writers and characters boys can relate to may be a good place to start.[17]

LITERACY EQUITY GOES BEYOND THE READING GENDER GAP

Boys and men reading fewer books and spending less time reading is not the only concern associated with books and reading. Female characters are underrepresented as main characters in books,[18] but so are certain other racially and ethnically diverse populations.[19] Yet equitable representation in books (as well as in digital media such as television, movies, and video games) is critically important, especially for children. When children don't see people like them represented, or see harmful depictions of people who are like them, they can suffer negative long-term outcomes, including lower self-esteem.[20] Content creators and distributors such as publishing companies and production studios have an opportunity to advance literacy parity because they can directly influence the content available in the market. Though there has been some progress in this area,[21] expanding how racial and gender diversity is represented in books and other formats can be key to providing positive role models for children regardless of their racial or ethnic background, gender, sexual orientation, or socioeconomic status.

Publishers, too, have a role to play in how they market their products. Books are generally marketed in gendered ways. Children's books about princesses, mothering, and romance are typically targeted toward girls and women, whereas books about superheroes, science fiction, and horror are typically marketed to boys and men. What if, instead of focusing on gender, publishers and content creators targeted consumers by their interests and preferences? Steps like these can be essential if books are to reflect and encourage the kind of equitable society that many of us want to create.

Broadening the discussion still further, governments and corporates alike have an opportunity to tackle the challenge of increasing literacy globally. Though most governments invest in their education systems, expenditure on education globally was less than 4% of global GDP in 2019—with some countries investing far more resources on education than others.[22] Raising the bar on education funding and pursuing parity across nations should be a priority moving forward. In the private sector, corporations could use their lobbying power and capital to support and fund education and literacy initiatives nationally and internationally. For instance, such funding could support more initiatives that get books and e-readers—and literacy instruction—into the hands of more youth and adults across the globe. Initiatives that work to distribute books to children, such as Dolly Parton's Imagination Library[23] and Marcus Rashford's Book Club, are examples of foundations and partnerships tackling the issue of childhood literacy.

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Women in the tech industry: Gaining ground, but facing new headwinds

Technology companies should renew their commitment to advancing gender diversity in tech as the pandemic recedes

Susanne Hupfer, Sayantani Mazumder, Ariane Bucaille, and Gillian Crossan

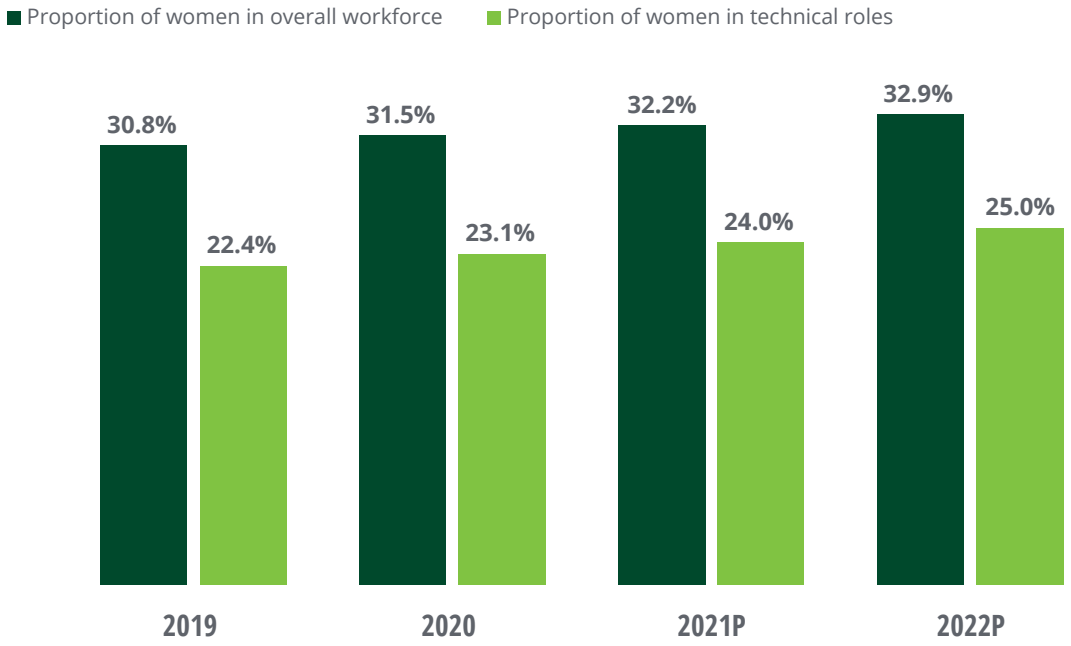
THE TECHNOLOGY INDUSTRY—or at least its largest players—will likely continue to close the gender gap in the year ahead. Deloitte Global predicts that large global technology firms, on average, will reach nearly 33% overall female representation in their workforces in 2022, up slightly more than 2 percentage points from 2019 (figure 1).[1] The proportion of women in technical roles will also nudge up, though it has tended to lag the overall proportion of women by about 8 percentage points.

A 2-percentage-point increase, though small, actually represents notable progress. Moving the needle is difficult, and even aggressive campaigns to recruit, hire, retain, and promote women have been found to work slowly. But while this progress is a step in the right direction, going forward, tech companies may need to work even harder to improve these numbers.

FIGURE 1

Large technology companies are making slow but steady progress in increasing female workforce representation

Female workforce representation in large technology companies



Source: Analysis and 2021 and 2022 predictions based on published diversity reports from 20 large technology companies (with an average workforce of more than 100,000 employees).

Large tech companies are making progress, but they may be at risk of stalling

With research showing that diverse teams perform better and are more innovative, leaders across industries recognize that a diverse workforce—by gender, race, age, and other social factors—is good for business.[2] As the tech industry seeks to shape a prosperous future for themselves, it is aiming to be more representative of that future.

Our analysis of 20 large technology companies that provide annual workforce diversity reports shows that they have maintained their momentum on the gender front in the past two years.[3] Despite women being disproportionately affected by pandemic-driven spikes in global unemployment and reductions in labor force participation,[4] many of these organizations have managed to keep female representation on an upward trajectory. In part, this may have been because the technology sector was better prepared than most to pivot quickly to remote work and flexible work models when the pandemic began, relying on already familiar connectivity and collaboration tools. Moreover, many large enterprises have had workforce diversity pledges and programs in place for several years, and this prior commitment to diversity (gender and otherwise) may have helped them weather the crisis. Further, employment in the tech sector, including for women, began to recover earlier than many other industries, possibly making it easier to maintain progress in gender equity.[5]

While high-profile tech players will likely continue to make and report gains in gender diversity, smaller tech companies with fewer resources and less stature to attract and keep women may find it harder.[6] It's difficult to pinpoint how these smaller companies are faring, since they don't typically report diversity data, but a late 2019 study of global tech startup executives found that only 43% had established companywide hiring and promotion goals to increase diversity.[7] Without targets and transparency, smaller tech organizations may well be underperforming on gender diversity compared to their larger peers—and they may have fallen even further behind during the pandemic.[8]

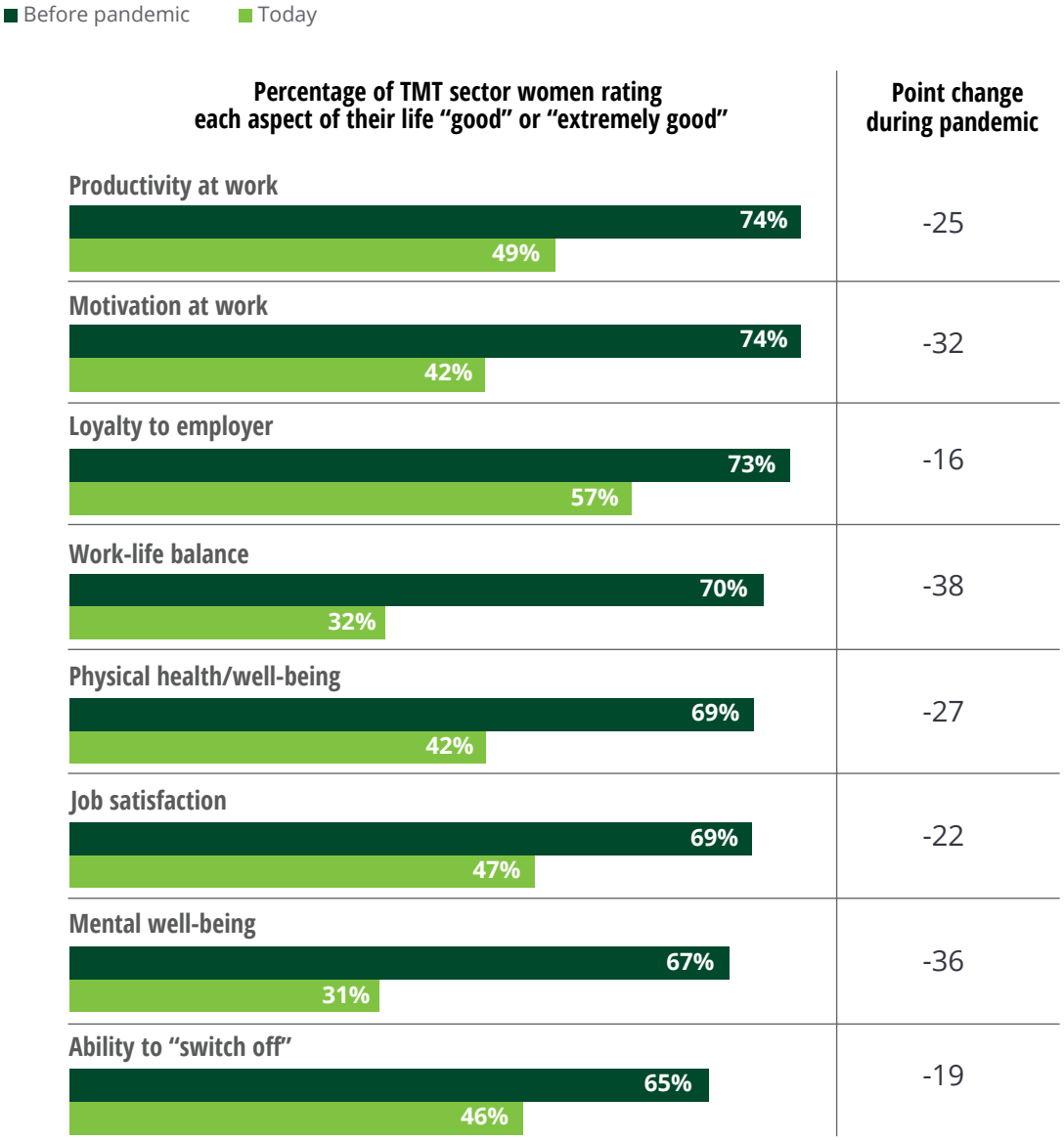
Continued progress will likely require renewed commitment and greater effort. Well-known challenges to equitable female representation persist, including factors related to the educational pipeline, recruitment and hiring, retention, pay, and promotion.[9] Adding to these challenges, the COVID-19 pandemic has taken a heavy toll on workers' well-being and professional prospects. Deloitte's 2021 *Women @ Work* study, which polled 500 women in the global technology, media, and telecommunications (TMT) workforce, found that, compared with how they felt prior to the crisis, TMT women have experienced dramatic drops in motivation and productivity at work, job satisfaction, work/life balance, and feelings of loyalty to their employers (figure 2).[10] Eighty-three percent of the TMT women surveyed reported that their workload had increased, and a majority said that they were spending more time on household chores and dependent care as well.[11] Boundaries between life and work collapsed: Satisfaction with work/life balance dropped by 38 points, and the ability to "switch off" work dropped by 19 points. Perhaps more alarmingly, only 38% of women in the TMT industry feel their organization's commitment to supporting them has been sufficient.[12] Just 30% say their employer increased their access to flexible work (such as the freedom to work around caregiving responsibilities or other commitments), and only 22% say that their employers made it clear they're not expected to be "always on."[13]

Well-known challenges to equitable female representation persist, including factors related to the educational pipeline, recruitment and hiring, retention, pay, and promotion.

Racially and ethnically diverse TMT women appear to be even more negatively affected by the pandemic than their peers. Compared to other women working in TMT, they are more likely to report spending increased time on work and home responsibilities. They're more likely to report poor or extremely poor satisfaction with their mental and physical well-being, as well as their motivation and productivity at work and ability to switch off. Startlingly, over half of racially and ethnically diverse TMT women (52%) rate their work/life balance as poor or extremely poor versus 43% of other TMT women, and 59% feel less optimistic about their career prospects today than before the pandemic versus 48% of other TMT women. Since few tech companies report in detail on the composition of their female workforces (that is, race, age, or other social identities), it's difficult to gauge if representation is improving in other dimensions, but it's plausible that the pandemic's differential impacts on racially and ethnically diverse women may be complicating diversity efforts.

FIGURE 2

During the pandemic, women in the TMT sector became much less satisfied with many aspects of their life and work



Source: Analysis of TMT sector respondent data from Deloitte's *Women @ Work* global study, 2021.
Note: The survey polled 500 women in the TMT workforce across 10 countries between November 2020 and March 2021.

These pandemic-driven pressures may result in job churn among women and may even prompt some to leave the workforce entirely. A majority of TMT women (51%) feel less optimistic about their career prospects now than before the crisis broke, and 57% expect to leave their current employer for a new role within two years, citing lack of work/life balance as the biggest reason. What's more, a startling 22% are considering leaving the workforce altogether, motivated chiefly by workload increases that are affecting their well-being.

But these are factors organizations can mitigate. Some tech companies, including Google, Salesforce, and IBM, have responded to the pandemic by expanding programs for backup child care and paid family caregiver leave.[14] Some have created new flexible-work and well-being programs, such as job sharing, free mental health counseling, collective disconnect days, and video programs with child-focused educational content.[15] Tech companies that proactively craft programs and policies to help workers balance their caregiving and well-being needs with work responsibilities may be able to avoid burnout, build greater loyalty, and retain diverse talent through the crisis and beyond.

THE BOTTOM LINE

Looking past the pandemic, organizations should consider how their future work model could help them reach a wider and more diverse talent pool. Drawing on lessons learned during the pandemic, several major tech companies are embracing a remote-first work model, while others are settling on a hybrid of office- and home-based work, and some are even experimenting with smaller distributed offices.[16] Beyond increasing work/life flexibility, "work from anywhere" models expand the available pool of exceptional, diverse talent to nationwide and even worldwide, not just within commuting distance of the office.[17]

Having a larger talent pool to choose from can be especially important for an industry that doesn't have enough qualified women to go around. Building up the next generation of tech talent by diversifying the STEM pipeline is a laudable goal, but one that will likely take many years of sustained effort. In the meantime, some tech companies are aiming to attract and recruit women from overlooked worker segments such as those returning to work or transitioning from other industries. Some are partnering with organizations that run "returnship" programs, providing training and mentorship to women resuming their careers after a pause.[18] Others have established apprenticeships that aim to recruit and upskill "unconventional talent" such as career-switchers who lack a traditional tech background.

Beyond hiring more women, closing the gender gap will likely require solving challenges of retention and equitable promotion. Research indicates that about half of the industry's female workers drop out of technology employment by mid-career, and women hold less than a quarter of the industry's senior leadership roles.[19] According to a 2020 Deloitte report, gender bias is the top obstacle preventing tech women from moving into leadership positions.[20] Yet diverse leadership can be critical for enabling more creative thinking and better business outcomes, as well as for providing role models.[21] Formal mentorship programs and development opportunities for women, along with gender targets for promotions, could go a long way toward improving retention among women and enabling them to progress to senior executive levels. But less than a quarter of TMT companies have established these measures, according to Deloitte's *Women @ Work* research.[22]

When all is said and done, improving women's representation in technology calls for the same kind of leadership commitment and strategic focus that underlies other critical organizational initiatives. Companies should identify a responsible executive and commit to a holistic diversity, equity, and inclusion strategy that cultivates an inclusive culture. Accountability and transparency—identifying metrics, reporting results, and tracking progress—are essential. Only then can companies take stock of what is and isn't working, revise their approach, and improve.

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11. Ibid. Sixty-two percent of TMT women report the amount of time spent completing chores and house-management tasks has increased during the pandemic; 53% say the amount of time spent looking after other dependents (such as elderly or disabled relatives) has increased, and 49% say the amount of time spent looking after children has increased.

12. Ibid.

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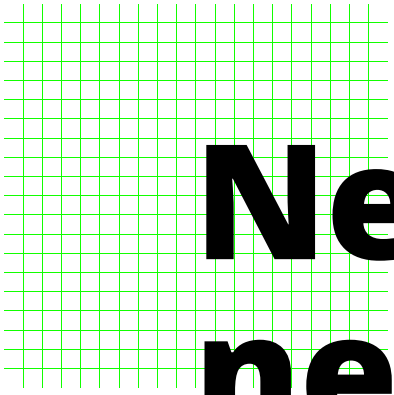

New and next

From trading cards to digital video: Sports NFTs kick sports memorabilia into the digital age

The chance for fans to acquire, not just view, licensed digital media of their favorite sports moments will likely cement non-fungible tokens' place in the sports content marketplace

Paul Lee, Theo Ajadi , Kevin Westcott, and Gillian Crossan

WHAT FAN WOULDN'T want to buy an unforgettable sports moment? Nonfungible tokens (NFTs), unique digital identifiers that use blockchain to record ownership of media, are now letting them do just that. Deloitte Global predicts that NFTs for sports media will generate more than US$2 billion in transactions in 2022, about double the figure for 2021.[1] By the end of 2022, we expect that 4–5 million sports fans globally will have purchased or been gifted an NFT sports collectible. Interest in sports NFTs is likely to be spurred by activity in the wider NFT market, including that for digital art, the top five most valuable sales of which had generated over US$100 million by August 2021.[2]

NFTs will likely create significant new revenue streams

NFTs allow ownership and use rights to be demonstrated for any piece of digital content by assigning the content a specific, nonduplicable identifier that is recorded on a distributed database, or blockchain, typically Flow or Ethereum. Ownership of an NFT *may* include ownership of the underlying digital asset, though most sports NFTs sold to date have no ownership or use rights in the underlying media. Each NFT includes a smart contract whose terms are applicable indefinitely and that executes immediately and irrevocably with each trade.

Each NFT is unique in the same way that each limited run of a physical print is individually numbered, yet otherwise identical. In this way, NFTs bring predefined scarcity to digital content. They're the digital equivalent of printed sports trading cards—which were selling for up to millions of dollars each in 2021[3] and which have long been a major revenue source for teams and leagues, especially in the US market. NFTs effectively address the same needs as cards, but swap still images with digital stills or video, cardboard with pixels, binders with digital displays (mostly smartphones), collectors' fairs with online trading platforms, and third-party authentication agencies with blockchain.[4]

It may appear illogical that someone would pay for an NFT version of the same video clip that anyone in the world could watch for free.[5] But it is arguably also irrational for a printed card to sell for seven-figure sums when the intrinsic value of the card is zero.[6] Value in each case is a function of demand and scarcity, and it should also be noted that demand can wax and wane, and is subject to multiple factors, both endogenous and exogenous.

In 2022, the most common and lucrative application of NFTs in the sports industry will likely be the sale of limited-edition video clips of sporting moments or player cards.[7] The value of each NFT will depend on the prominence of the athlete, the significance of the event, any additional content included within the NFT, and demand. An NFT limited to a single edition of a major event—say, a winning goal, home run, or dunk by a legendary star, bundled with a commentary by that star—could be sold at auction, while the same video but with no additional content and 20,000 available copies would be sold and traded via an online marketplace.[8] This is analogous to some aspects of the art world, in which variants of the same work of art, but with differing numbers of certified copies, have different values.[9]

Value in each case is a function of demand and scarcity, and it should also be noted that demand can wax and wane, and is subject to multiple factors, both endogenous and exogenous.

In 2022, platforms and rights creators are likely to continue testing different ownership models to determine the optimal balance of stoking consumer demand and maintaining intellectual property rights (IPR) that respect existing third-party rights over the underlying digital assets. So far, the offer of limited IPR within sports NFTs has not dampened appetite, suggesting that demand may well be driven by the ability to demonstrate status: Scarcity drives inherent value in and of itself.

NFTs can bring additional revenue to sports leagues, teams, and individual athletes whose income has declined during lockdown:[10] The largest football (soccer) NFT platform enabled US$128 million in sales in the first nine months of 2021.[11] An NFT contract may stipulate that a commission on each transaction be paid to the owner of the platform that sold the NFT, and a share of that commission may then flow back to the aforementioned rights holder(s). Further, if the smart contracts enabling the NFTs are accessed via crypto, they may enable real-time remuneration to the current owners of the preprogrammed rights. This is particularly valuable given the frequently complicated rights management associated with sports.

NFTs are also an opportunity to enhance relationships with fans. Rights holders should consider how best they could apply NFTs to enhance the fan experience by enabling them to acquire and display NFTs of their team, as well as to contribute to decisions such as player of the month (in Japan), or even which songs are played during game intervals (in Italy).[12] In some cases, NFTs can also be used within fantasy sports league applications, with each NFT representing a player who could be part of a team entered into season-long competitions.

As NFTs' scope evolves, an additional category may include athlete-designed or -branded digital versions of physical world objects, such as sneakers, that only exist digitally. As an example, the Gucci Virtual 25 is a digital shoe design that can only be worn using augmented reality.[13] Again, some may question the logic behind this, but others may be equally perplexed by the sale of a pair of physical shoes for US$1.8 million, or the purchase of digital skins by tens of thousands of video game players.[14]

Paying for digital-only content may feel unfamiliar to some. A decade ago, this behavior was niche. But the evolution of spending within video games points to a burgeoning, now mainstream acceptance of the concept. In 2022, gamers will likely spend tens of billions of dollars on virtual currencies that they then use to purchase game-related artifacts and capabilities that only exist virtually, for which there is infinite stock, which is only displayed on a screen, and for which the marginal cost of "manufacturing" is close to zero.[15]

THE BOTTOM LINE

Most sports-related NFT activity in 2022 is likely to take place in those sports with the largest fan bases and revenues, namely, football (soccer),[16] basketball, baseball, American football, and ice hockey. Over time, however, all sports are likely to have some form of NFT offering. These can be to commemorate a single event, be it a Formula 1 driver attaining a record number of world championships or a football player scoring their hundredth international goal. A major initial consideration will be whether NFT activities are best carried out at the league, team, or athlete level.

Creating an NFT-based sports collectible platform will likely remain a complex, challenging exercise in 2022. Ten key steps to help create a successful platform include:

- Confer a specific set of rights for content that could be sold as video clips and associated metadata within an NFT.[17]
- Build or work with an online platform that can cope with surges in transaction volume and global demand.
- Identify a partner that can mint content into an NFT, noting that costs for minting vary considerably.[18]
- Generate a scalable process, assisted by artificial intelligence, to identify and grade clips that could be sold as a set.[19]
- Incorporate a robust "know your customer" process, as any tradable asset could become a vector for money laundering. Don't overlook the unique compliance considerations such as VAT, sales tax, withholding taxes, and accounting principles that may apply to the issuer or holder of the NFTs. Implement procedures to thwart insider trading.
- Make the service as attractive to those on pocket-money budgets as to high-net-worth individuals looking for long-term investments. The price of entry should start at a few dollars, but occasional high-value trades will add sizzle to the service.
- Iterate tirelessly, experimenting with ways to keep different types of collectors engaged, such as team-building sprints, sports betting, and other challenges.[20]
- Consider complementary activities such as fantasy team-building competitions, an activity that could also be used to collect data about fans, with their permission.
- Have a zero-carbon plan. As transactions are recorded on blockchain, which as of 2021 was renowned for being carbon-intensive, sports entities should identify approaches that are energy-efficient—for example, by using a proof-of-stake consensus model such as Flow, as used in the NBA's Top Shot platform—rather than proof-of-work approaches such as Ethereum.[21]
- Finally, consider video clips as just the beginning of an NFT strategy. NFTs can also be applied to other sports products such as tickets to a game and physical collectibles. NFT tickets can include a smart contract that directs a percentage of any resale of the ticket back to the issuing club.[22] Additionally, NFTs could be applied to physical collectibles such as autographed baseballs or cyclist jerseys, further increasing the technology's ability to generate revenues for sports entities. Finally, sports entities should also consider other blockchain applications, such as currencies.

The 2021–2022 season could be the first in which NFTs start to make a major mark from a revenue perspective. If the experience of early adopters proves positive, the market should continue to grow and be an important part of the digitization, globalization, and commercialization of the fan experience.

Endnotes

1. As of September 2021, NFTs were available or expected for the NBA, UFC, and baseball. The NBA's Top Shot was the most established of all the platforms, with trading volumes of about US$700 million by August 2021. LaLiga in Spain is reported to be launching it in June 2022. See: Eben Novy-Williams, "UFC to sell first NFTs as fighters gain share of licensing," *Yahoo News*, August 5, 2021; Tracy Hackler, "Panini America unveiling 2021 Prizm Baseball NFT Blockchain packs Monday," Panini America, August 22, 2021; Cryptoslam.io, "NBA Top Shot sales volume data, graphs & charts," accessed October 7, 2021; Jacob Feldman, "NBA Top Shot maker to create LaLiga NFT collectibles," Sportico, August 23, 2021.

2. The definition of art is both subjective and in a current state of flux. At the time of writing, in early September 2021, art included penguins, drawn digitally, and selling for thousands of dollars each. As well as penguins, there are kittens, ducks, apes, and more. New forms of art are always controversial, and NFTs are just the latest trigger for a chorus of disapproval. Trading volumes on the OpenSea marketplace, the largest for NFTs, was US$2.5 billion in the first half of 2021. The value of the top 5 art sales was US$102.83 million as of August 26, 2021. See: Olga Kharif, Vildana Hajric, Justina Lee, and Bloomberg, "Rolexes and Lamborghinis are so yesterday. NFTs are the new digital 'flex'," *Fortune*, August 28, 2021; Nfttrending.com, "NFTs are going mainstream as trading volume reaches new record level," August 3, 2021; Daniel Phillips and Stephen Graves, "The 15 most expensive NFTs ever sold," *Decrypt*, August 26, 2021.

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6. One of the best-known names in physical sports cards has launched an NFT series for UFC. See: UFC, "UFC and Panini America to deliver first-ever UFC NFT trading cards," press release, August 4, 2021.

7. Each video moment is likely to be accompanied by a wide array of data explaining the context in which the play happened. See: SportsPro, "What is NBA Top Shot? Dapper Labs' Caty Tedman explains the NFT platform everyone is talking about," May 4, 2021.

8. For NBA Top Shot, tiers are Common, Fandom, Rare, Legendary, and Ultimate,, each of which has differing levels of scarcity. See: NBA Top Shot, "Moment Collectible tiers," October 2021.

9. There are often limited, numbered editions of prints made from an original artwork; an individual number and a signature are two indicators of authenticity. These prints are identical, save for the number, in the same way that a video clip is made unique via its incorporation into an NFT. See: S&P Gallery, "How do limited editions work?," May 17, 2021.

10. As an example, revenues for European football contracted by 13% in the 2019/2020 season. See: Dan Jones and Chris Wood, *Riding the challenge: Annual review of football finance 2021*, Deloitte, July, 2021.

11. Tom Bateman and Reuters, "Sorare football NFT game raises €580 million in record-breaking fundraising round - but what is it?," *Euronews*, September 21, 2021.

12. Fan tokens can be offered that provide owners with votes to make these kinds of decisions. In Japan, the full legality of each service has not yet been established. One of the players in the space, FiNANCiE, is not regulated by the Payment Services Act or Financial Instruments and Exchange Act. See: Jeff Wilser, "In Europe, football NFTs and tokens are no fantasy," CoinDesk, September 14, 2021; Tim Alper, "Fan tokens booming at Japanese pro football clubs," *Cryptonews.com*, July 22, 2021; FiNANCiE, About page, accessed October 7, 2021.

13. Gucci, "Gucci sneaker garage," accessed October 7, 2021.
14. Kanye West's first pair of Yeezys sold for US$1.8 million. See: Bryan Hood, "Kanye West's $1.8 million Yeezys are now the most expensive sneakers ever sold," *Robb Report*, April 26, 2021.
15. In the first quarter of 2021, spend on mobile video games was estimated at US$22.2 billion, up 25% year over year. The majority of this spend would be on in-game content, rather than to pay for the download. Spend would be on a range of content, from double-point multipliers to seeds for virtual farms or custom colors for digital cars. Spend on in-game content on console and PC games is additional to this. Revenues for *Fortnite* in its first two years of operation were about US$9 billion, all of which was from in-game spend. Revenues for EA's *Ultimate Team* service were US$1.62 billion in 2020. See: Mike Minotti, "Sensor Tower: Mobile game spending hit $22.2B in 2021 Q1, up 25% from 2020," *VentureBeat*, April 5, 2021; Mitchell Clark, "Fortnite made more than $9 billion in revenue in its first two years," *The Verge*, May 3, 2021; Ronan Murphy, "How much money does EA Sports make from FIFA & Ultimate Team?," Goal, June 10, 2021.
16. In September 2021, Spain's LaLiga announced a deal with Sorare for the creation of NFT cards for players. See: Sorare, "LaLiga partners with Sorare to enter the world of NFTs," press release, September 9, 2021.
17. Manchester City, which won the English Premier League in 2020–2021, launched a commemorative NFT. See: Man City, "City drop NFT collection to mark Premier League win," press release, May 19, 2021. A series of Lionel Messi NFTs was launched in early August 2021. See: ESPN, "Messi has an NFT of his own: One-of-a-kind art for a one-of-a-kind player," August 5, 2021.
18. The cost of minting can be several hundred dollars per item, or can be zero, as per the charges for using Blockparty, which is based on the Flow blockchain. See: Flow, "Partner spotlight: Blockparty – premium NFT marketplace," July 20, 2021.
19. This selection process could otherwise be very time-consuming: For example, each weekend of the UK's Premier League, Spain's LaLiga, or Germany's Bundesliga could require the analysis of 900 minutes of game play per league, not counting extra time and after-match interviews. With a sport such as basketball, which features multiple point-scoring moments during each game, identifying clips may be easier than for soccer, where a game may conclude goalless after 90 minutes, and have fewer memorable moments for an algorithm to discern, or a Formula One race, which may see little overtaking on some circuits.
20. As an example, for the 2021–2022 season, fans attending an NBA game will be able to preorder NFTs of plays they saw live. These will be on sale at a physical kiosk, and NFTs will belong to a new tier called Fandom. See: Ledger Insights, "Dapper Labs' NBA Top Shot to launch NFTs at live games," August 5, 2021.
21. Justine Calma, "The climate controversy swirling around NFTs," *The Verge*, March 15, 2021.
22. The Dallas Mavericks NBA team is already considering this approach. See: Kai Morris, "Dallas Mavericks to provide NFTs with tickets starting next season," *The Tokenist*, June 16, 2021.

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Keeping AI private: Homomorphic encryption and federated learning can underpin more private, secure AI

These emerging technologies for safeguarding the data used in AI applications are available and effective today. Now, the challenge is to make them more practical

Duncan Stewart, Ariane Bucaille, and Gillian Crossan

HOMOMORPHIC ENCRYPTION (HE) and federated learning (FL) are two different but related technologies that aim to solve the same problem: How can AI tasks such as machine learning be performed more privately and securely? Deloitte Global predicts that, driven by the increasing urgency of this issue, the combined market for HE and FL will grow at double-digit rates in 2022 to more than US$250 million. By 2025, we expect this market to top US$500 million.[1]

The safer data is, the more widely AI can be used

HE and FL, part of a group of technologies known as privacy-enhancing technologies (PETs),[2] are tools to make AI more private and secure. HE allows machine learning to use data while it is encrypted; all other machine learning needs to decrypt the data first, making it vulnerable. FL distributes machine learning to local or edge

devices rather than keeping all the data in the same place where one hack could expose it all, which is the case with centralized machine learning. They are not mutually exclusive: HE and FL can be used at the same time.

The major driver for growth in the HE/FL market is the burgeoning demand for more private and secure approaches to AI. Everybody knows that AI is a key technology in many industries, but multiple players are now focusing on privacy and security as never before. Companies that were using AI are looking at HE and FL as a way to reduce future risk. This is particularly true of cloud companies using AI, since data needs to be transmitted to and from the cloud and processed off-premise, both of which introduce potential privacy and security issues. Regulators are regulating AI in new ways,[3] and HE and FL may allow companies to better comply with those regulations. Very large markets, especially health care and public safety, are highly sensitive to AI's implications for privacy and security, and they are beginning to investigate HE and FL to address these concerns.

Regulators are regulating AI in new ways, and HE and FL may allow companies to better comply with those regulations.

Both HE and FL are relatively new technologies, and both are more complex than traditional AI solutions. Each, though effective, comes with drawbacks. Computing with HE is slower than computing with unencrypted data; FL requires more powerful processors on edge devices as well as fast, highly reliable connectivity between the core hardware in data centers, where the main AI software resides, and the edge, where the learning happens. ("Edge" in this case could refer to a device such as a smartphone or an appliance sitting a few hundred meters from the robots in a factory, for example).

The barriers are lower now than they were a few years ago, however. For one thing, Wi-Fi 6 and 5G wireless technologies, with their increased speed and reliability, are becoming more widely available, which makes relying on edge devices more practical. Some providers are also making HE and FL easier to use by releasing open-source tools to make the process more accessible to non-experts.[4] But the real gains in practicality are coming from improvements in processor cost/performance. While HE used to be a trillion times slower than unencrypted computing, it is now, in some cases, only 20% slower as a result of new specialized processors.[5] Similarly, the edge processors needed to power FL are becoming more powerful as well as cheaper and more widely deployed. Full HE is currently processor-intensive, and significant advances in HE-optimized processors could dramatically decrease its time and cost.[6]

We normally don't bother with predictions about technologies that are as small in dollar terms as HE and FL. Why are we making an exception? Part of it is that the two technologies are sitting at a crossroads. Regulators globally are beginning to craft AI-specific rules, and although GDPR has been around since 2016, it was not the final word in privacy regulation: New rules on the topic come out monthly, and GDPR enforcement may be ratcheting up to a new level. Because of these regulations, both vendors and users are likely to see that using AI will get more difficult in a growing number of jurisdictions and industries. And HE and FL could help companies meet those regulatory requirements, significantly expanding their opportunities to use AI.

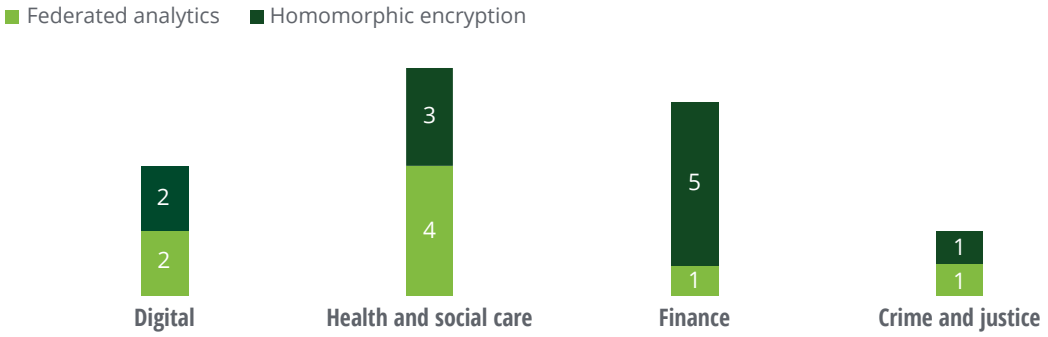
The other major reason we're talking about HE and FL now is who is using them. According to a recent repository of PETs, there are 19 publicly

announced pilots, products, and proofs of concept for homomorphic encryption and federated analytics (another term for federated learning) combined. That doesn't seem like a lot … but the companies offering them include Apple,[7] Google, Microsoft, Nvidia, IBM, and the National Health Service in the United Kingdom, and users and investors include DARPA, Intel, Oracle, Mastercard, and Scotiabank. Also, the industries involved in these early projects are among the largest. Use cases are led by health and social care and finance, with their use in digital and crime and justice also nontrivial (figure 1).[8]

FIGURE 1

HE and FL are attracting attention from some of the world's largest companies and industries

Distribution by sector of publicly announced pilots, products, and proofs of concept for homomorphic encryption and federated analytics



Source: Deloitte analysis of data from the Centre for Data Ethics and Innovation's "Repository of use cases," accessed September 30, 2021.

THE BOTTOM LINE

With some of the largest companies in the world embracing HE and FL, organizations interested in the privacy and security of sensitive data should continue to monitor these and other PETs, even though most are unlikely to find HE or FL immediately useful in 2022. Those most interested will likely be:

- Cloud providers and cloud users[9]
- Organizations in particularly sensitive industries such as health care, finance, and public sector, especially crime and justice
- Companies that want to share and compare data with competitors, but without exposing "crown jewel" intellectual property
- Chief information security officers and their teams

As with other emerging technologies such as quantum computing (discussed elsewhere in *TMT Predictions 2022*), organizations exploring HE and FL can do several things to plan for what likely lies ahead:

Understand the industry impact. What repercussions could PETs, including HE and FL, have on one's own industry as well as adjacent industries? What would more private, secure AI mean from a strategic, operational, and competitive standpoint? To understand this, leaders should keep abreast of the technology's progress, and they should monitor how peers, competitors, and ecosystem partners are investing in and experimenting with it.

Create a strategy. Organizations should convene appropriately knowledgeable people to develop a PET strategy. For now, the strategy may well be to do nothing, but leaders can prepare for the future by identifying a trigger event—such as a competitive or technological development—that signals the need to begin or increase investments and exploration. Someone should be put in charge who has the skills, knowledge, and organizational status to execute the strategy when the time comes.

Monitor technology and industry developments. The HE and FL strategy should evolve as the state of the technology and market changes. Leaders should adjust the strategy to reflect these changes and be sure not to allow their trigger event to pass by without acting on it.

Bring cyber inside earlier. Cybersecurity is often only brought into AI processes during the deployment phase. Instead, companies may want to pull cyber in earlier, at the same time as when they are using HE and FL. This more collaborative approach between AI and cyber is likely to enhance both privacy and security while minimizing transparency and accountability risks.

Privacy and security technologies, including HE and FL, are tools, not panaceas. But while no tools are perfect, HE and FL are valuable additions to the mix. By helping to protect the data that lies at the heart of AI, they can expand AI to more and more powerful uses, with the promise of benefiting individuals, businesses, and societies alike.

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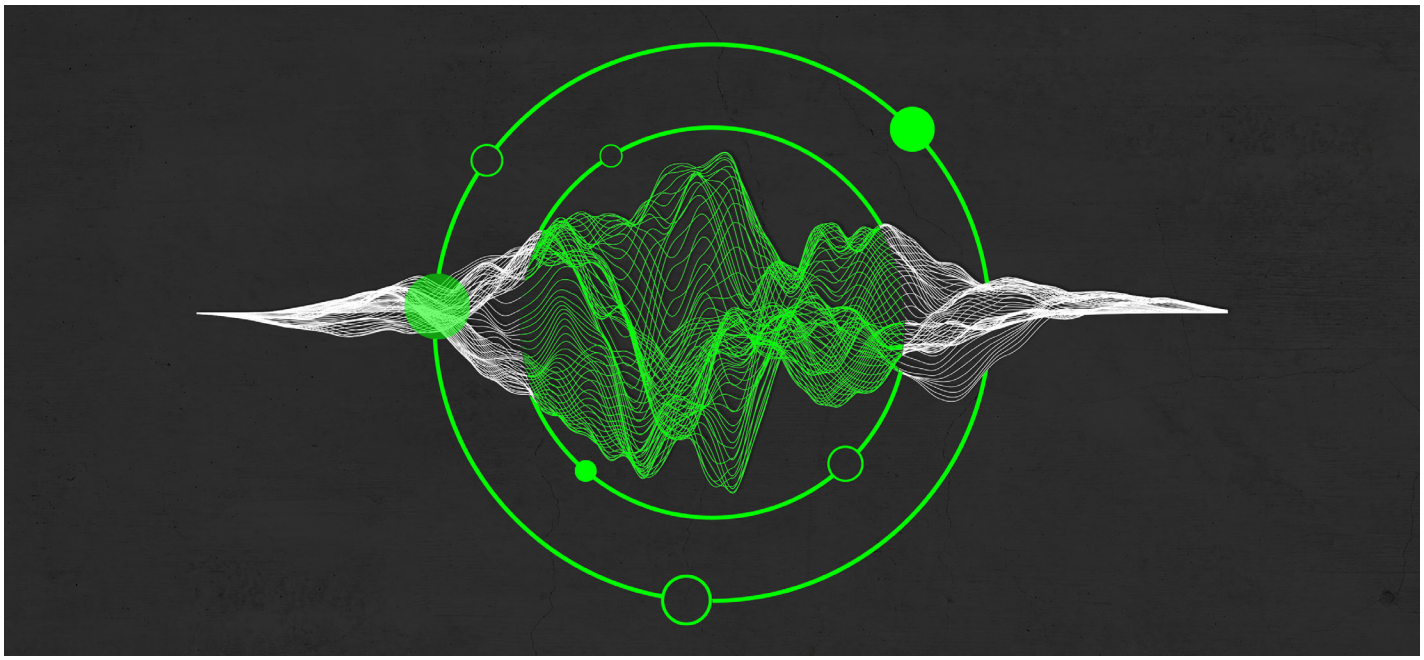

Quantum computing in 2022: Newsful, but how useful?

The future of quantum computing isn't quite here yet. But that doesn't mean that companies shouldn't prepare

Duncan Stewart, Scott Buchholz, Ariane Bucaille, and Gillian Crossan

THOUGH THE TECHNOLOGY is steadily improving, quantum computing will likely continue to boast more media coverage than practical applications in 2022. Deloitte Global predicts that the multiple companies making quantum computers (QCs) will double their QCs' quantum volume—the number and reliability of the quantum bits (qubits) available for computation—from what it was in 2021. VCs invested more than US$1 billion into the sector in 2021, and one company even went public with a multibillion-dollar valuation.[1] Further, investment in quantum by governments, including China, India, Japan, Germany, Netherlands, Canada, and the United States, will likely bring the total to more than US$5 billion for the year.[2] Although we expect these developments to attract a great deal of news coverage, we also predict that fewer than a dozen companies worldwide will be using QCs as part of their day-to-day operations[3] and only for a limited number of use cases mainly around optimization problems. The 2022 revenues for QC hardware, software, and QC-as-a-service will likely be less than US$500 million.[4]

Quantum has great potential, but it's hard to execute

Current QCs are roughly where heavier-than-air flight was on December 17, 1903. Nobody doubted that there were multiple uses for airplanes, and everyone was excited that powered flight had been achieved … but the Wright Flyer's best flight that day covered 255 meters in about a minute, a speed of about 15 km/h, with one pilot, no cargo, and no turns. It was a historic achievement, but not useful.

That said, a little more than a decade later, airplanes were instrumental in World War I, and technology advances faster now than it did then. It's an open question, however, whether quantum computing will follow the same path.

Although QCs are orders of magnitude better than they were five years ago, they remain uneconomic for solving real-world problems. Many of the tasks that they currently do can be replicated on a standard laptop computer at a fraction of the cost.[5] The problem with QCs' usefulness is not a lack of use cases, money, effort, or even progress. It's that current QCs are not yet powerful enough to tackle problems that *can't* be performed by traditional computers. We don't yet know the "magic number" of quantum volume—a measure of the combined quantity and reliability of the "qubits" that drive a QC's computing capacity—that will make QCs useful in the real world.

Companies vary in the way they measure quantum volume, but it seems to be a sign of progress that apples-to-apples quantum volumes are doubling, or even growing more quickly, every couple of years. But it is unclear if we need a quantum volume of a thousand or a million or a billion to make QCs that can be used for multiple real-world applications.

Normally, this is the part of our prediction where we discuss which readers should care and why. Some industries do need to pay attention and get their foot in the quantum door: For them, having small teams doing pioneering work may be useful as a risk hedge. But unusually, the key takeaway for most readers in many industries is that they do not need to care about the likely news announcements coming from various quantum computing companies over the next year or two.

Don't get us wrong. Those companies are investing billions of dollars in research and development; they are pushing the boundaries of engineering and science, and when a useful QC is built at some point, the advancements in 2022 and 2023 will turn out to have been critical steps on the path to utility. But it is not likely that making more qubits, making more stable qubits, or even doing both at the same time will produce a broadly useful QC in the next couple of years.

Should people ignore QCs entirely, then? Not quite. There are a few areas where QCs' usefulness and dollars are here already. These include:

- **Optimization.** There have been some public announcements of a special type of QC solving real-world optimization problems, such as bus routing and radio cell planning. Most of these appear to have been more proof-of-concept trials rather than large-scale or active deployments:[6] The technology worked, benefits were seen, but the solutions do not appear to be being used on an ongoing basis, as it is possible to do similar optimizations much more cost-effectively using classical technologies. However, more recently, a Canadian grocery chain used a QC to reduce optimization computing time "from 25 hours to seconds" and plans "to apply quantum in production daily."[7] It is possible that we will see more logistics and supply chain real-world implementations over the next few years.

- **Quantum chemistry and materials science.** Designing new materials atom by atom is too hard for classical computers, but

QCs may have a head start at modeling quantum effects, whether for new semiconductor materials, catalysts in industrial production, or health care applications. It was first thought that studying a usefully large molecule with hundreds of atoms would require a QC with 800–1,500 qubits, which would be many years away.[8] But more recent innovations in hardware and software suggest this may be conservative, and that real-world applications may be possible in the 3–5-year horizon.[9]

It's worth noting, too, that QCs aren't the only quantum devices that are useful and economically viable for certain purposes. In particular, quantum technology is being used in two applications that, because they were developed earlier than QCs, are bigger markets, at least for now:

- **Quantum sensing.** Subatomic particles can be used to make very responsive sensors whose accuracy and performance exceed that of conventional sensors. These quantum sensors

FIGURE 1

Quantum computing has many uses across industries

Examples of QC applications and industries

	Optimization algorithms	Quantum chemistry/materials science
	Identification of the best solution or process among multiple feasible options	*The simulation and modeling of molecular, atomic, and subatomic systems*
Cross industry	◆ Supply chain optimization ◆ Logistics optimization and vehicle routing ◆ Process planning and optimization	◆ Reduced data center energy consumption ◆ Materials discovery
Consumer	◆ Distribution supply chain ◆ Pricing and promotion optimization ◆ Product portfolio optimization	◆ Quantum LIDAR/improved sensors
Natural resources and industrial production	◆ Fabrication optimization ◆ Energy distribution optimization	◆ Surfactants and catalyst discovery ◆ Process simulation/optimization
Financial services	◆ Financial modeling and recommendations ◆ Credit origination and onboarding ◆ Insurance pricing optimization	
Government	◆ City planning and emergency management ◆ Case assignment optimization ◆ Command logistics	◆ Advanced materials research
Health care and life sciences	◆ Medical/drug supply chain ◆ Improving patient outcomes ◆ Protein folding predictions	◆ Precision medicine therapies ◆ Protein structure prediction ◆ Molecule interaction simulation
Technology, media, and telecommunications	◆ Network optimization ◆ Semiconductor chip layout	◆ Semiconductor materials discovery ◆ Materials process optimization

Source: Deloitte analysis.

have the potential to replace existing sensors in many applications, including locating and monitoring oil, gas, and mineral deposits; surveying construction sites; and detecting the slightest environmental, seismic, or weather changes. Due to these current and imminent real-world uses, the quantum sensing market was over US$400 million in 2020, has been growing, and will likely be larger than the QC market in 2022[10]—and it is growing.

- **Quantum communications.** Quantum communications is a hardware-based solution leveraging the principles of quantum mechanics to create secure, theoretically tamper-proof communication networks that can detect interception or eavesdropping. Quantum key distribution (QKD) is currently the most mature, and it provides a very high level of security. Communication using QKD can be delivered through fiber-optic networks, over the air, or via satellite.[11] Though it has limitations in speed, distance, the need for repeaters, and cost, QKD is being used in multiple countries by both public sector (military and government) and private sector groups.[12] The QKD market is still niche, but it is expected to be worth US$3 billion by 2030.[13]

THE BOTTOM LINE

As with other emerging technologies such as homomorphic encryption and federated learning (discussed elsewhere in *TMT Predictions 2022*), companies should start putting some thought into QC's implications now, even though most are unlikely to find QCs useful in 2022:

Understand industry impact. What repercussions could quantum have on one's own industry as well as adjacent industries? QCs may be able to solve complex problems uncrackable by traditional computers; what would this mean from a strategic, operational, and competitive standpoint? To understand this, leaders should keep abreast of the technology's progress, and they should monitor how peers, competitors, and ecosystem partners are investing in and experimenting with it.[14]

Create a strategy. Leaders should convene appropriately knowledgeable people to develop a quantum strategy. The strategy may well be to do nothing for now, but to prepare for the future by identifying a trigger event—such as a competitive or technological development—that signals the need to begin or increase quantum investments and exploration. It's important to put someone in charge who has the skills, knowledge, and organizational status to execute the strategy when the time comes.[15]

Experiment. There are various affordable and flexible services that allow companies to play around with quantum algorithms and even compare different quantum hardware architectures.[16]

Monitor technology and industry developments. The quantum strategy should evolve as the state of the technology and market changes. Leaders should adjust the strategy to reflect these changes and be sure not to allow their trigger event to pass by without acting on it.[17]

People sometimes say that quantum computing becoming useful is a marathon, not a sprint. That's both true and untrue at the same time, which makes sense given that we're talking about quantum mechanics. Like a marathon, QC technology's development and commercialization will likely be a long, hard road. But in a real marathon, though we often don't know who will win until the last 100 meters, we do know how long the race is, where the halfway mark is, and that if a runner can run the first 21.1 km in an hour, they're likely to be able to run the whole thing in about two hours. None of that is true about the quantum usefulness marathon. We don't know if we've passed the halfway mark, and the finish line is not in sight.

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AIs wide shut: AI regulation gets (even more) serious

AI in 2022 will face intensifying regulatory scrutiny, with implications that resonate across industries

Duncan Stewart, Paul Lee, Ariane Bucaille, and Gillian Crossan

THOUGH REGULATION TYPICALLY lags behind technological innovation, it appears to finally be catching up with artificial intelligence (AI) applications, including machine learning, deep learning, and neural networks. Deloitte Global predicts that 2022 will see a great deal of discussion about regulating AI more systematically, with several proposals being made—although enacting them into actual enforced regulations will likely happen in 2023 or beyond. Some jurisdictions may even try to ban whole subfields of AI, such as facial recognition in public spaces, social scoring, and subliminal techniques, entirely.

We know why, but do we know how?

Normally, predictions are precise and quantified, but that's generally not possible when talking about regulatory changes. Still, we have good reasons to believe that AI regulations will be on their way to becoming more prevalent and stricter

in the next year. As of 2021, there are detailed proposals from the European Union[1] and policy papers from the Federal Trade Commission (FTC) in the United States[2] on regulating AI more heavily. And China is proposing multiple regulations around technology companies, some of which include AI regulation.[3]

Why now and not before? We see several reasons:

- AI in 2022 will be more powerful than it was only five years ago. Thanks to vastly faster specialized processors, better software, and larger data sets, AI can do more, and more affordably, than ever.[4] As a result, AI is becoming pervasive and ubiquitous—which in turn is attracting greater regulatory scrutiny.

- Some regulators have concerns about AI's implications for fairness, bias, discrimination, diversity, and privacy. For example, the fundamental tool behind today's AI is machine learning, which has received significant scrutiny from regulators and others for potential social bias.[5]

- AI regulations are a competitive tool at the geopolitical level. If one country or region can set the global standard for AI regulation, it may give a competitive advantage to companies operating in that country or region and disadvantage outsiders.

Some regulators have become quite vocal about AI's perils. For example, in an August 2021 paper, US FTC Commissioner Rebecca Kelly Slaughter wrote: "Mounting evidence reveals that algorithmic decisions can produce biased, discriminatory, and unfair outcomes in a variety of high-stakes economic spheres including employment, credit, health care, and housing."[6] She went on to say that although the FTC has some existing tools that can be used to better regulate AI, "new legislation could help more effectively address the harms generated by AI and algorithmic decision-making."[7]

Figuring out how to effectively regulate AI will be challenging. One fundamental problem is that many AI computations are not "explainable": The algorithm makes decisions, but we don't know *why* it made a particular decision. This lack of transparency makes regulating AI exponentially harder than regulating the more explainable and auditable technology that often informed decision-making in the last century. Regulations aim to prevent AI-powered decisions from having negative outcomes, such as bias and unfairness, but because the AI systems responsible for those decisions are hard to understand and audit, it can be difficult to predict when negative outcomes will occur—until after people or institutions have been impacted.

Another potential problem is the quality of the training data. The draft of the European Union's AI regulation specifies that "training, validation, and testing datasets shall be relevant, representative, free of errors, and complete." However, at the scale of the data required for machine learning, this standard, especially the stipulation that it be "free of errors and complete," sets an extremely high bar that most companies and use cases may not be able to meet.[8]

As AI becomes used everywhere, everybody has reason to care about how it is regulated, because those regulations can shape the extent of the good and harm that its use could bring about. The following big stakeholders should be especially interested:

AI tool users. Regulators are likely to crack down on cases where algorithmic bias or other issues harm classes of people. Multiple studies show that AI-encoded bias can discriminate by gender, race, sexuality, wealth or income, and more. The bias usually works to further disadvantage the already disadvantaged. This is because artificial intelligence isn't actually 100% artificial at all: It needs to be trained on datasets, which can reflect human biases. The result is that AI trained on

those datasets doesn't eliminate human bias, but often amplifies it.

One famous example of dataset-driven bias is a company that was trying to hire more women but knew that the AI tool kept recruiting men. No matter how hard the company tried to eliminate the bias, it persisted due to the training data, so the company stopped using the AI tool entirely.[9]

AI regulations will affect the use of AI tools by different industries and functions within them to different degrees. For instance, AI in human resources, specifically for hiring or performance management, is likely to be profoundly affected.[10] There are already multiple cases where AI-powered decisions about recruitment, hiring, promotion, disciplining, termination, and compensation have been problematic.

The financial services industry will likely face substantial implications as well as it uses AI to inform everything from credit scores, loans, and mortgages to insurance and wealth management.

Regulators may also be particularly concerned by internet platforms that moderate user-generated content, many of which rely heavily on AI to do so. Moderating millions of pieces of content daily in real time is essentially impossible, or at least unaffordable, without AI. However, a 2020 study claims that algorithmic moderation systems "remain opaque, unaccountable and poorly understood" and "could exacerbate, rather than relieve, many existing problems with content policy as enacted by platforms."[11]

From an industry standpoint, the public sector—health, education, government benefits, zoning, public safety, the criminal justice system, and more—can be deeply affected. For example, facial recognition in public spaces for law enforcement and criminal justice is already in wide use, but it is one of the technologies that the European Union regulations are looking at banning, with certain exceptions.[12] Regulation will also be a big issue for private-sector health care and education, affecting matters such as grades, scholarships, student loans, and disciplinary actions. The financial services industry will likely face substantial implications as well as it uses AI to inform everything from credit scores, loans, and mortgages to insurance and wealth management.

Industries such as logistics, mining, manufacturing, agriculture, and others may feel less of an impact. These industries' AI algorithms can of course have problems, but they tend to be around accuracy and errors rather than bias. However, although these issues are less apt to lead to direct human harm, they may have an environmental impact.

AI tool vendors. Dozens of tech companies sell pure-play AI tools or solutions. Some of these include subsets of AI technology likely to be more heavily regulated or banned; some even consist of nothing but those subsets. Dozens more provide overall solutions that have AI components or features that could be affected by regulation. Hyperscalers, especially, have reason to watch regulators closely. All of them have AI-as-a-service offerings that could be affected to varying degrees; regulations could prevent them from selling some services in some geographies, or companies could even be made liable for customers' use of their AI services.

AI users that are also vendors. Many technology internet platforms and apps are heavy users of the same AI technologies that they sell outright, use to execute their business model, or both. Common among these technologies are facial recognition, sentiment detection, and behavior prediction, all of which are possibly contentious AI features.

Regulators and society. Those making the rules face challenges of their own in balancing rapidly changing technological advances with a range of stakeholder concerns. They will need global and national policy objectives to be clearly articulated, so that they can develop legislation, regulations, and codes of conduct that speak to them. An agile, improvement-based regulation approach will likely be more effective than inflexible rules-based legislation. Finally, although regulators and societal goals overall are linked, they are separate, distinct, and sometimes not aligned.

THE BOTTOM LINE

The next two years could see a number of scenarios play out.

First, stakeholders affected by regulations that are adopted and enforced may shut down AI-enabled features in certain jurisdictions or cease operating in some jurisdictions entirely—or they may continue to operate, get fined, and pay those fines as a cost of doing business.

Second, it's possible that large and important markets such as the European Union, the United States, and China will pass conflicting AI regulations, making it impossible for companies to comply with all of them.

Third, it's also possible that one set of AI regulations will emerge as a gold standard, as has happened with the European Union's General Data Protection Regulation around privacy, which could simplify cross-border compliance.

Fourth, it's even possible that AI vendors and platforms could group together in a consortium and lead a conversation about how AI tools should be used and how they can become more transparent and auditable—adopting a degree of self-regulation that would lessen regulators' perception that oversight needs to be imposed from above.

Even if that last scenario is what actually happens, regulators are unlikely to step completely aside. It's a nearly foregone conclusion that more regulations over AI will be enacted in the very near term. Though it's not clear exactly what those regulations will look like, it is likely that they will materially affect AI use.

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