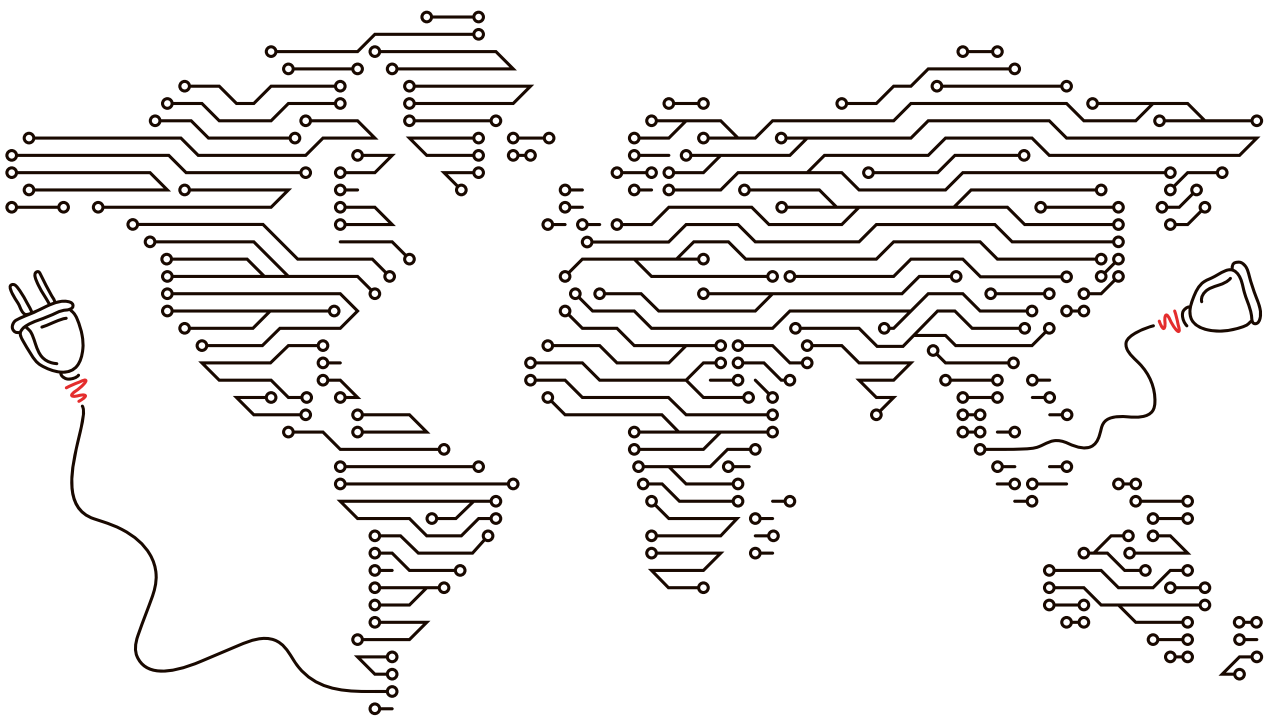


Future of the Tech Economy

Investing where **technology meets economy**



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Future of the tech economy

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John Savercool Managing Director and Head of the US Office of Public Policy

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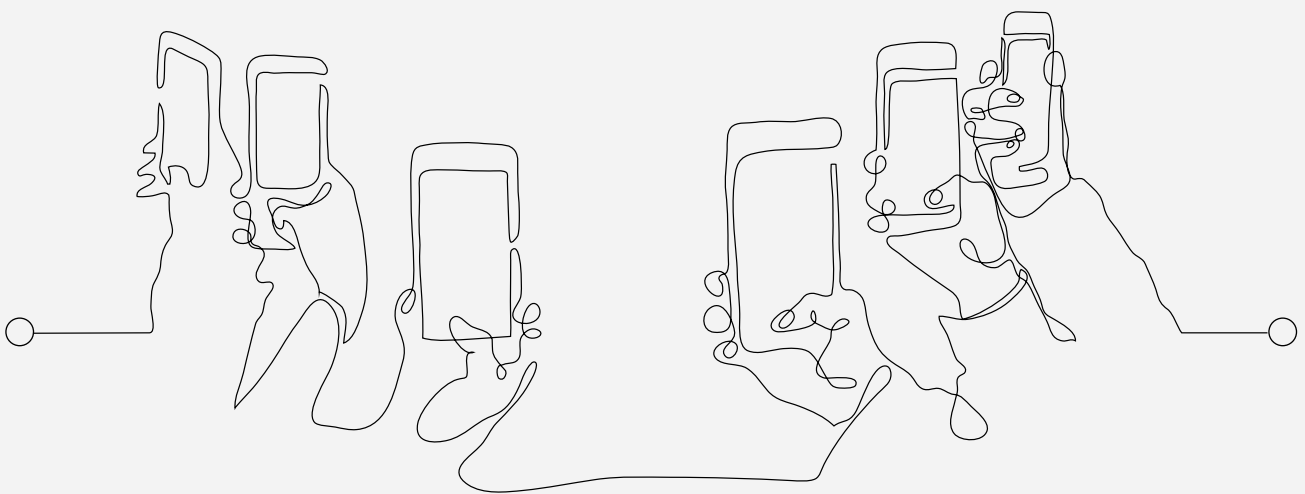


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What is the tech economy and why is it important?

Introduction



The tech economy is the confluence of technology and economic forces. It touches everything in society, from how we work, live, and play to our investment decisions. This report dives into the global tech economy and explores how investors can benefit from its disruptive power which, if anything, will accelerate in the post-COVID-19 world.

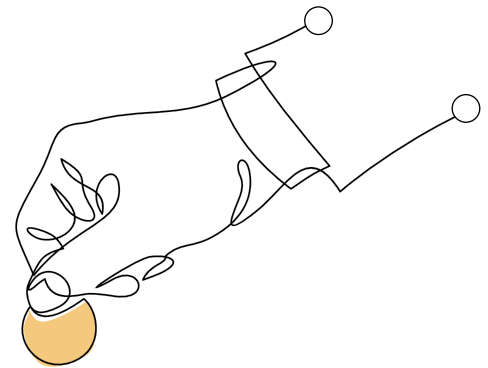
We live in very exciting times. While a potentially transformative innovation used to be a once-in-a-century phenomenon, the pipeline is now packed. Moonshots like quantum computing, neural interfaces, solid-state batteries, and fuel cells offer incredible potential to upend the global economy. Closer to the ground, areas like artificial intelligence (AI), the Internet of Things (IoT), 3D printing, drones, and big data are already providing a glimpse into what the future may look like.

The ramifications of people's increasing reliance on (and comfort with) digital business models are reverberating throughout the world – from retail and real estate to agriculture and e-commerce. These trends tend to be structural in nature, are just getting started, and have been accelerated by the coronavirus pandemic, during which people have turned to the internet for many of their daily needs. And, as with every technological revolution, there will be winners and losers along the way.

This confluence of technology and economic forces is what we call technomics, or the tech economy. Increasingly, the tech economy is dictating everything from growth rates and incomes to inflation and how much we need to work each week. Its importance has even led to a contest for technological supremacy between the world's two superpowers: the US and China.

Originating from the Greek words for craft and science, we can define technology as techniques, skills, methods, or processes to produce goods or services. Other definitions are more complex, but ultimately an input is being transformed into a higher value-added output by means of technology. High tech and information technology (IT) are often used synonymously to describe technology. In this report, we also consider technologies in other areas to open up a universe of opportunities for investors.

Computing cycles have progressed such that the addressable market has jumped by a factor of almost 10 during each cycle. But the very nature of technology makes it nearly impossible to forecast with certainty, even for experts. As Alibaba founder and former CEO Jack Ma summarized in a speech, first we thought that IBM was the innovator to beat, but then came Microsoft. Afterwards, Netscape arrived on the scene, and we



thought no one could top them. Then Yahoo showed up, and Amazon and Ebay took off. When Google later appeared, we thought that was the end, but soon came Alibaba and Facebook. The question that remains now is when – not if – the next tech titan will emerge.

Indeed, in the past decades seemingly infallible market leaders in mini-computers, internet service provision, and mobile telephony have become shadows of their former selves. Likewise, ostensibly plausible technologies, such as self-ordering fridges or flying cars, touted over two decades ago have failed to take off despite being technologically feasible. Internet platforms look invincible today, but even they will need to adjust when the next disruption strikes. And as technological superpowers continue to evolve and diverge from one another, the landscape will become even more complex with different specializations in different regions.

The tech economy offers investors exposure to technological trends with the potential to transform the world, and COVID-19 becomes a catalyst for some of them. But riding the wave of change is not a simple feat, given the plethora of risks involved and the abundance of unknown variables at play.

“So investors should not invest in one trend or concentrate in a single region. A wiser strategy is to invest broadly across industries and geographies.”

Investment table

What is the tech economy? → page 04	<p>Summary: Faster rates of change and growth come with higher rates of failure. Investors should diversify across trends and technologies, and can consider both mainstream and moonshot technologies.</p> <p>How to invest: Choose disruptors, avoid laggards. Diversify among leaders in different spaces and across the themes identified in this report.</p>
The age of the tech economy → page 07	<p>Summary: The fourth industrial revolution is just beginning, and yet it has already reshaped entire industries. Meanwhile, the COVID-19 pandemic is accelerating e-commerce and digital data penetration.</p> <p>How to invest: Seek exposure to big platforms and key enabling technologies like mobile, cloud, big data, and social, as well as emerging ones like blockchain and AI.</p>
How land use is changing → page 12	<p>Summary: Land use is radically changing as more people shop online and work from home. Winners of this trend include warehousing players and data centers, as well as innovative and more sustainable smart food farming methods.</p> <p>How to invest: Look for names involved in warehousing and related infrastructure, as well as cloud providers and data center operators. <i>The food revolution</i> Longer-term Investment theme offers exposure to the intersection of tech and agriculture.</p>
How the way we work and learn is changing → page 20	<p>Summary: Automation and robotics are changing the way we work, while new ways of learning are becoming more scalable, personalized, and cost-effective.</p> <p>How to invest: Consider the <i>Automation and robotics</i> Longer-term Investment theme. Seek exposure via education services and EdTech companies.</p>
How the economy is changing → page 26	<p>Summary: Everything is going digital, even money. This shift has significant ramifications for the global economy, from retirement ages to productivity.</p> <p>How to invest: The Fintech Longer-term Investment theme offers exposure to the transforming financial industry.</p>
The race for tech leadership is on → page 29	<p>Summary: The world's major regions have developed unique strengths in technology and labor. In the race to secure technological leadership, governments are looking to enhance their competitive advantages.</p> <p>How to invest: Investors should diversify across regions to combine these different strengths in their portfolios.</p>
What are the moonshots? → page 35	<p>Summary: Still nascent but potentially groundbreaking technologies offer glimpses into the future tech economy. Some of the more promising moonshots include quantum computing, neural interfaces, solid-state batteries, and fuel cells.</p> <p>How to invest: Plant some seeds now to get in early on possibly transformative technologies.</p>
The technologies shaping society → page 45	<p>Summary: Promising new tech areas like AI, 3D printing, drones, and cybersecurity are on the way to becoming mainstream. Even the big IT platforms will need to adapt in the decade ahead.</p> <p>How to invest: Select leaders in each of these spaces. Attractive opportunities can be found among mid-cap and big platform companies alike.</p>
The tech economy and sustainable investing → page 53	<p>Summary: The tech economy is not just about innovation and growth—sustainability is also critical. Several of the key technologies in our report, such as agritech and EdTech, open the door to more sustainable technonomies.</p> <p>How to invest: SI strategies vary, from investing directly in listed companies and ESG indexes to buying green bonds. See our SI reports for more detailed information.</p>

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled 'Future of the Tech Economy – How to invest' provides suggestions for investors who wish to pick single stocks.

The age of the tech economy



We are now living in the age of the tech economy. The fourth industrial revolution has transformed manufacturing, as the divide between the digital world and our physical one continues to blur. The result: a global economy built on the back of bits and bots.

How technology shapes economies – in the past and in the future

- Technology enables us to do more with less.
- Efficiency gains improve likelihoods and boost profits.
- Companies able to rapidly implement tech may outperform the economy.

Although technology inevitably gets the headlines in any industrial revolution, the important thing (economically speaking) is how the technology is used. The introduction of electric motors after 1880 changed very little at first because factories were designed for steam engines. Swapping a steam engine with an electric engine failed to make the most of the versatile nature of the electric motor. It is only when the technology was used more effectively and people started to change the way they worked that the productivity benefits started to appear.

Technological change, when properly used, can lower the cost and price of the relevant products, relative to other goods and services. In other words, technology enables us to do more with less. This can cause changes in demand patterns throughout an economy and may spur more innovation. The invention of the “spinning jenny” in the first industrial revolution led to an increase in the demand for bricks because mechanical weaving took place in factories in towns (not in cottages in villages), and factories are generally built of brick. The jump in the demand for bricks then, in turn, increased the demand for brickmakers. As demand pushed up the cost of brickmaking, technology was introduced to replace brickmakers and lower the cost of bricks.

In the fourth industrial revolution, the application of technology to increase efficiency does not automatically increase the trend rate of growth. The world economy is also wrestling with an environmental credit crunch – global growth today is dependent on the unsustainable use of nonrenewable resources. Over the next 20 years, in the absence of efficiency increases, global living standards would have to fall sharply. Unlike previous industrial revolutions, the fourth is about raising efficiency to maintain living standards in a sustainable way. If living standards are sustained through better efficiency, GDP would not measure that success.



Technology might break down barriers to entry for an industry, with large established companies being challenged by smaller new entrants. In that case, listed companies would underperform the economy. Alternatively, large companies with access to cheap funding may be able to implement technology more rapidly, in which case they would outperform the economy. The continued rise of the service sector may not be properly reflected in GDP statistics, meaning that economic activity is better than the officially reported data. In that case, earnings growth should exceed the official GDP number.

Digital lifestyles: not a choice, but a necessity

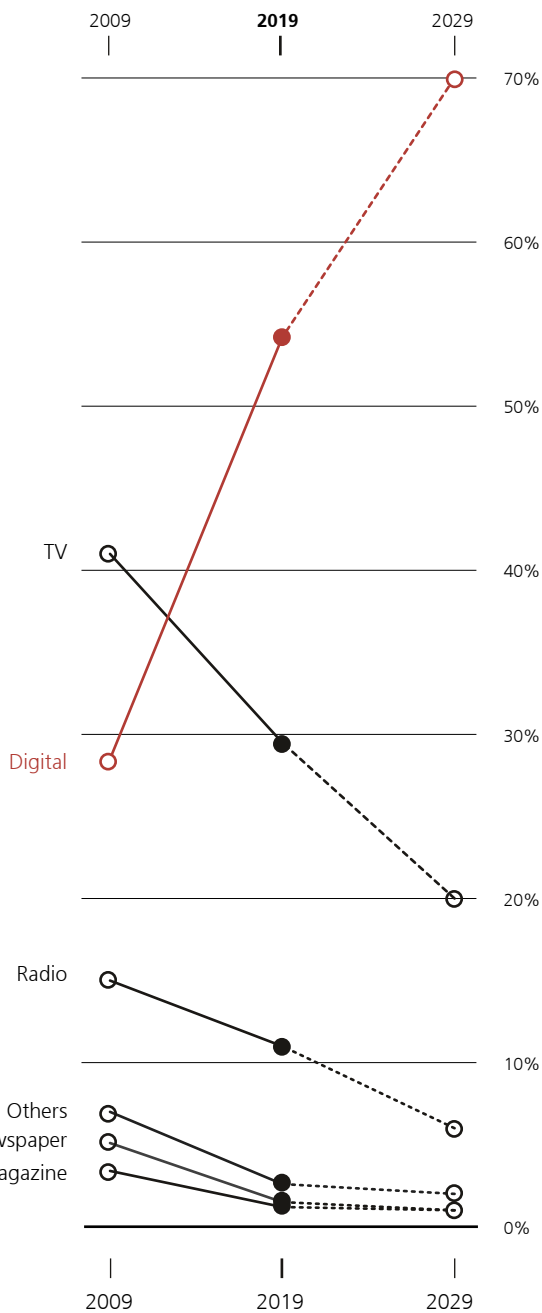
- COVID-19 has shown that access to digital tools is essential to everyday life.
- We see a 70%/30% split between time spent on digital and traditional media by 2030, vs. about 54%/46% now.
- This will have broad implications across industries like advertising and e-commerce.

The COVID-19 pandemic and the resulting lockdowns implemented across the world came as a major shock to many companies. To maintain business continuity, firms had to ensure employees could work seamlessly from home – a big test for IT systems worldwide. The consumer impact was much milder, as people took the measures in stride by enhancing their digital engagement. Many countries saw an almost 20%–30% increase in app usage during the outbreak, with notable rises in digital entertainment (like video streaming), online gaming, and online shopping.

Smart devices have become great productivity tools and are serving as storehouses for our desires and memories. The most important factor that makes smart devices popular is their ability to replace multiple traditional devices by combining portability

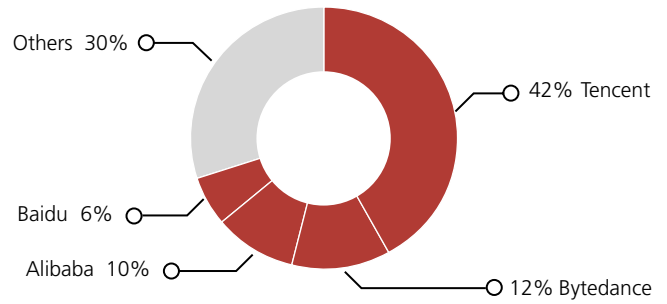
Consumers spend most of their media time on digital today

How consumers spend their media time every day.



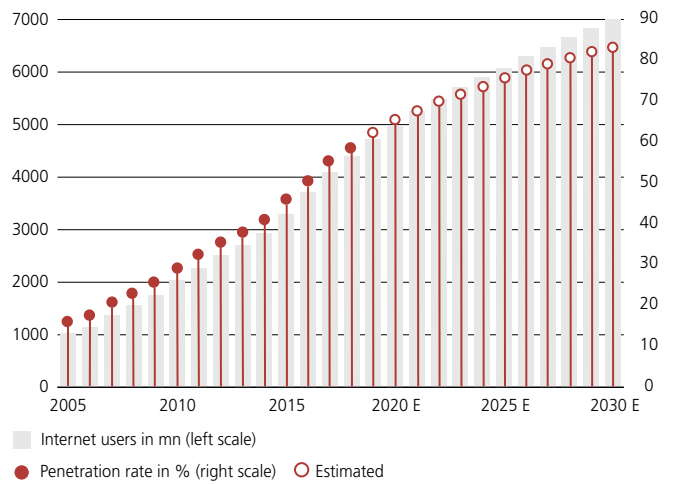
Source: eMarketer, Bloomberg Intelligence, UBS estimates

Mobile time spent by Chinese consumers across key platforms



Source: QuestMobile, Bloomberg Intelligence, UBS, as of June 2019

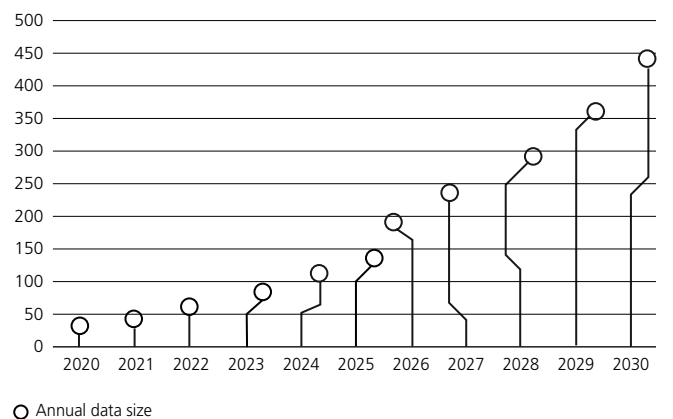
Robust growth in internet users to boost technology penetration across industries



Source: World Bank, UBS estimates

More than 10x growth expected in data from 2020 to 2030

Digital universe in zettabytes



○ Annual data size

Source: IDC, EMC, Bloomberg Intelligence, UBS

bility with powerful computing functionalities in a sleek form. Today there is an app for everything, whether to communicate (instant messaging), shop (e-commerce), transact (mobile payments), travel (ride-sharing), eat (food delivery), or exercise (fitness, telepresence apps).

Time spent on digital activities and on personal computing devices each day jumped from only 28.5% in 2009 to 54.2% in 2019, according to eMarketer and Bloomberg Intelligence. The increase in time spent on digital pursuits came at the expense of traditional media platforms. And people will continue to spend more time online, in our view, because across all age groups (beyond just millennials and teenagers) technology is now seen as the primary way to socialize, navigate, work, and otherwise pass time. During the recent lockdowns in response to the COVID-19 crisis, for instance, many e-commerce and video-streaming platforms reported a surge in new users above 60 years old.

Digital penetration is also on the rise. We foresee a 70%/30% split between time spent on digital and traditional media by 2030, versus about 54%/46% now. And our estimates may prove to be conservative: Stronger-than-expected innovation in new technologies like augmented reality, AI, and other

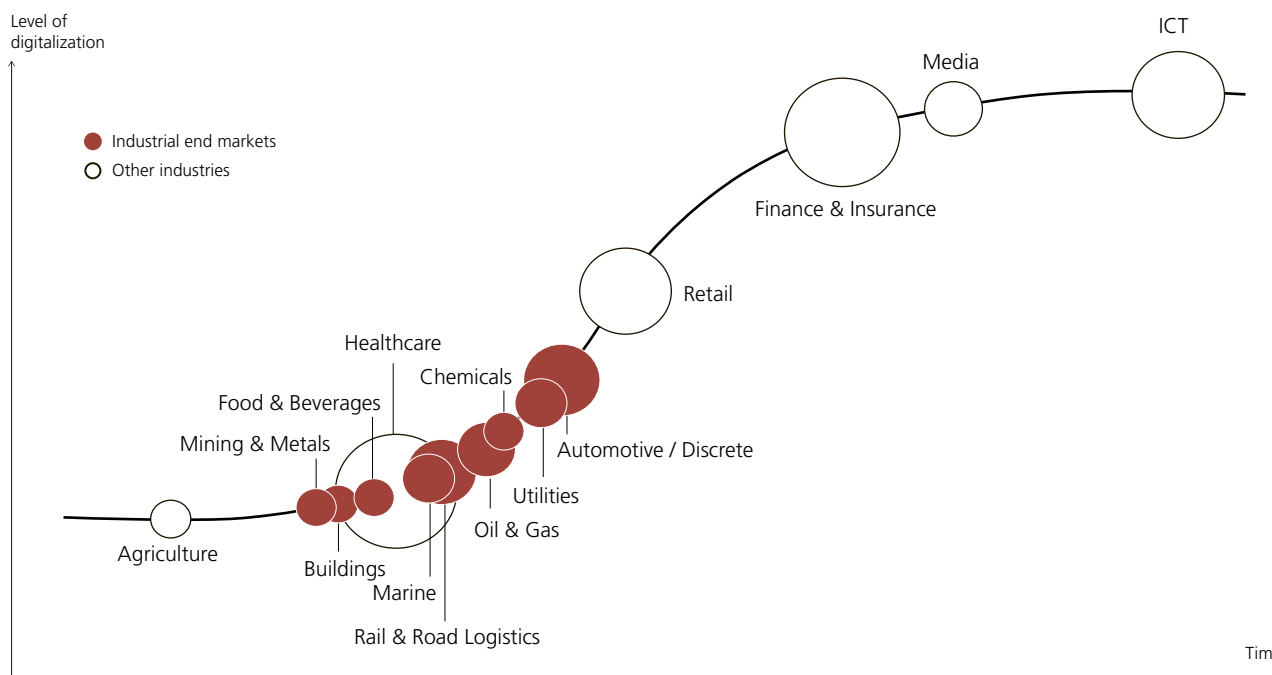
online services could potentially push the digital share to 75%–80%.

More time spent on digital platforms will have broad implications across industries. For instance, advertising spend will move further online as advertising dollars chase eyeballs. Content generation will likely become “digital first” and may require totally different skillsets to produce, making workers’ experience in traditional media less relevant.

China provides an early glimpse into how the digital world might look in the next 5–10 years. China is at the forefront of digital penetration, with almost 60% of the media time of its citizens spent on digital platforms, based on eMarketer and Bloomberg Intelligence data. Mobile devices, rather than personal computers, likely constitute the bulk of digital time spent in China. Unlike people in developed countries, whose internet journeys typically began with computers, those in emerging markets like China and India tend to use their phones as their primary – or only – method of connecting to the internet.

The other early trend we can spot in China is the disproportionately higher amount of time spent on the big platforms, where “super apps” provide one-stop solutions for everything

Significant room for technology penetration to increase across industries



Note: ICT = Information and Communications Technology
 Source: Based on ABB, adjusted by UBS, as of May 2017

on the internet. Chinese consumers spend almost 70% of their mobile media time on the top four platforms. The rest of the world will likely follow China's lead in this regard, if the big global platform companies work toward developing their own super apps.

The decade of digital transformation

- Tech and non-tech firms are now investing heavily in enabling technologies.
- The decade ahead will see digital disruption across the spectrum.
- Data is set to boom: we expect the global data universe to grow more than 10 times by 2030, reaching 456 zettabytes.

The last decade was defined by technology disruption. But technology penetration in many industries is still very low. So we think that the technology adoption curve is just at its beginning and that digital penetration is set to accelerate. Tech firms have dominated digital innovation, but now tech-enabled incumbents are striving to make up for lost ground and to wrest back control of their industries' future. They are prioritizing investments in key enabling technologies like mobile, cloud, big data, and social, as well as emerging ones like blockchain and AI.

Together with tech firms, which will continue to push the envelope of what's possible, such forward-thinking incumbent companies should drive the future of digital transformation and accelerate the pace of disruption. On the one hand, this momentum should put technology laggards and companies that fail to adapt at significant risk of losing market share. On the other hand, it should fuel innovation and provide significant growth opportunities for businesses and investors alike.

Summary

The fourth industrial revolution is just beginning, and yet it has already reshaped entire industries. Meanwhile, the COVID-19 pandemic is accelerating e-commerce and digital data penetration.

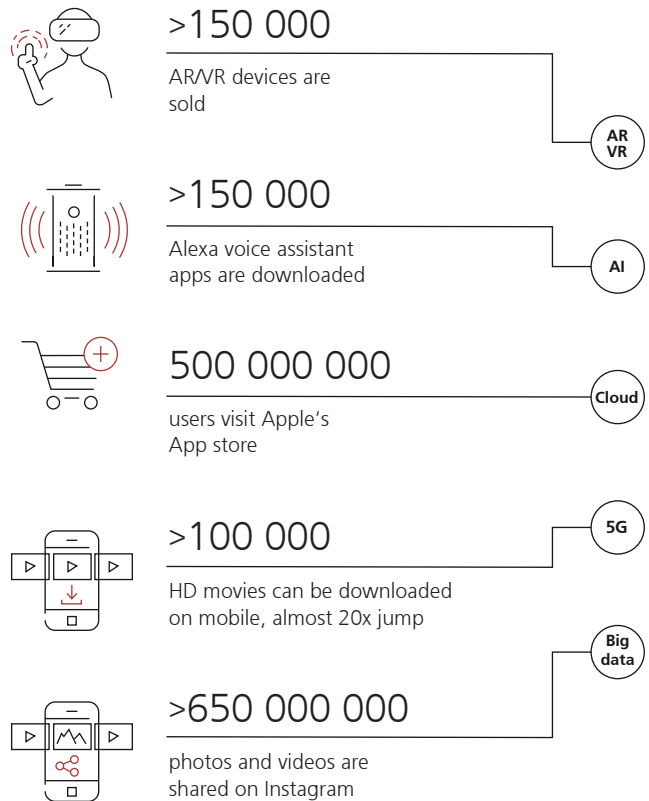
For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled 'Future of the Tech Economy – How to invest' provides suggestions for investors who wish to pick single stocks.

How to invest

Seek exposure to big platforms and key enabling technologies like mobile, cloud, big data, and social, as well as emerging ones like blockchain and AI

An average week in the life of enabling technologies

Activities across industries



Source: Company reports, Facebook, Apple, IDC, Bloomberg Intelligence, UBS

We think two powerful trends will propel digital transformation: rising internet penetration and exponential growth in data. We expect 2 billion additional internet users over the next decade, with the majority coming from emerging markets, and we think global internet penetration will increase in tandem. Data is the new oil, and in the decade ahead we anticipate the global data universe will grow to be more than 10 times as large as it is now, reaching 456 zettabytes in 2030 – equivalent to 840 64GB iPhones per person.

Is this the decade of digital transformation?

Read more
www.ubs.com/cio



How land use is changing



The COVID-19 pandemic has confirmed that we need not venture out to live, as many of us can work, shop, and socialize from home. The gradual shift to digital is having significant ramifications for the real estate market and, more broadly, for the way we use land.



How technology and the fourth industrial revolution are reshaping the use of land

- The digital era is having profound consequences on the way we use land.
- More people working from home will result in less time spent at and around offices.
- Businesses and infrastructure servicing these areas will need to adapt.

The fourth industrial revolution is reversing patterns introduced in the first one, which required people to leave rural areas and cluster together in towns and cities to manufacture in large factories. That pattern has continued for over 200 years. But the fourth industrial revolution means that, for many people, urban living is becoming a lifestyle choice rather than an economic necessity.

The rise of flexible or home working (accelerated by the lockdowns triggered by the COVID-19 pandemic) means that there will be more efficient use of land. At the moment, most real estate is unused for most of the time. People split their time between home, the office, and leisure. If flexible working or self-employment allows people to work from home more, the demand for office space will fall. Office density rates have increased steadily in economies that have moved toward flexible working.

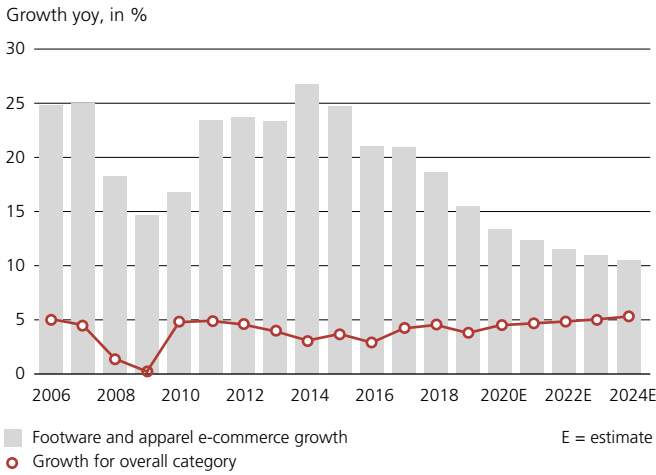
As more people work from home, businesses servicing office space (e.g., sandwich shops, bars) will suffer a decline in demand, which will cause a further reduction in demand for land in central urban locations. Infrastructure needs will also change. The focus on transporting large numbers of people to and from urban centers is likely to fade. An increase in digitalization and the rise of online retail will also change demand for urban real estate. The decline of physical shopping will curb demand for retail space in town centers, while demand for warehouse space and data centers will increase.

The changing retail real estate landscape

- Warehouses are well positioned to benefit from the accelerating shift to e-commerce.
- Warehouse automation is set to rise from 41% today to 55% over the next five years.
- We think industrial real estate demand will grow as the economic outlook improves.

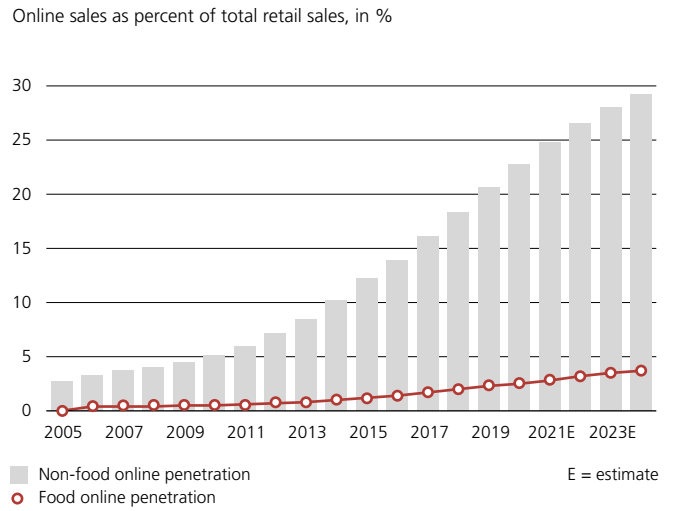
Brick-and-mortar shops have steadily lost market share to online businesses over the years, and this trend continues unabated today. With most people forced to stay home because of the pandemic, people took to the internet more than usual to fill their shopping carts.

Global footwear and apparel sales – e-commerce remains at a growth premium



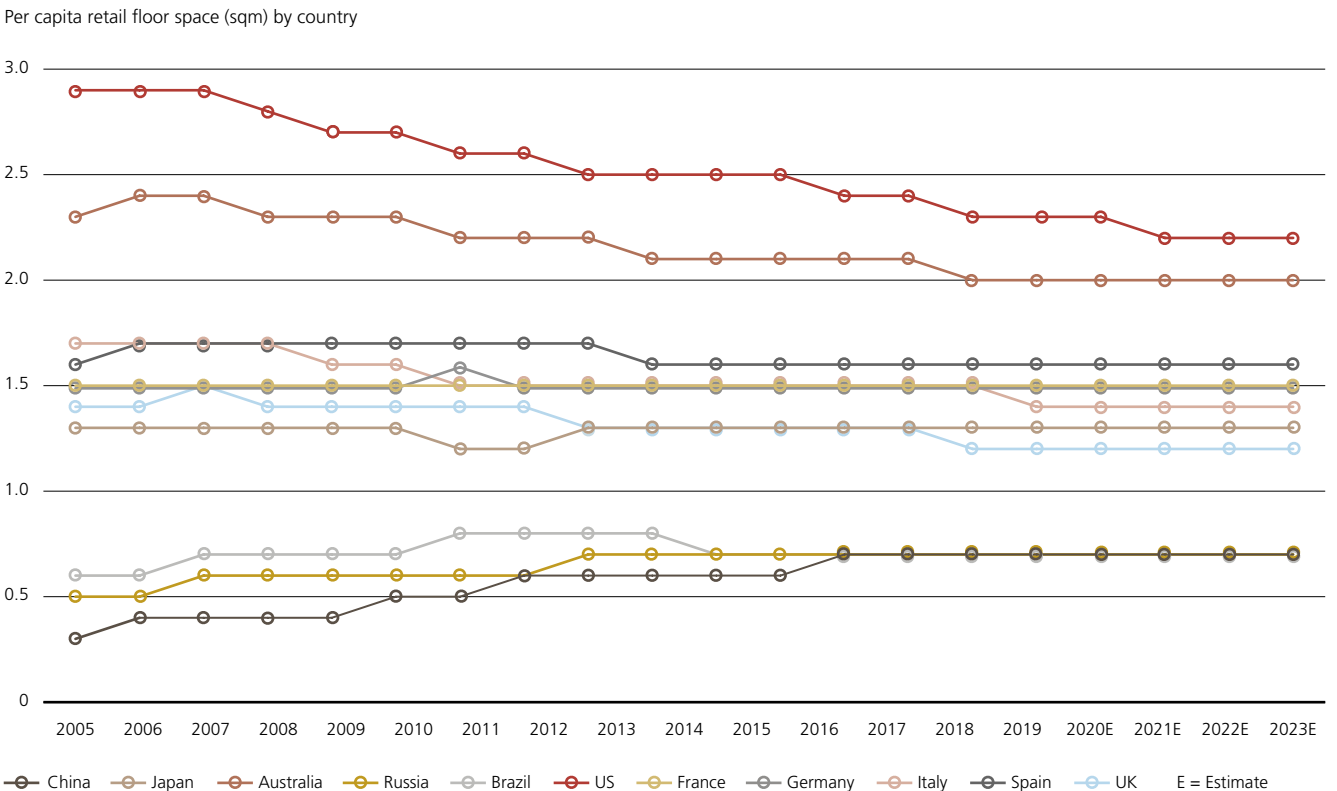
Source: Euromonitor, Citi, UBS estimates

Online penetration rates set to continue soaring



Source: Euromonitor, Citi, UBS estimates

Retail selling space either stagnating or retreating globally



Source: Euromonitor International, Citi, UBS estimates

In the US, for example, brick-and-mortar outlets and occupied space are on the decline, forcing former retail juggernauts like Toys “R” Us and Payless out of business. We anticipate that, out of the 883,000 retail outlets that existed in the US in 2019, 100,000 will be forced out of business by 2025. Even in emerging markets like China and Brazil, the curve for retail space per capita growth has flatlined – and likely for good.

Warehouses, in particular, are well positioned to benefit from this trend. Demand is booming both for logistics and for the space to store inventory, in part because the rising popularity of just-in-time delivery is shortening supply chains. Subscription models for faster premium services are accelerating this trend, as are store-based click-and-collect models. In fact, while many shipped products are often very similar across online platforms, delivery speed can be a differentiating factor.

Prologis estimates that e-commerce sales can require up to three times the warehouse space that brick-and-mortar sales require. In a UBS Evidence Lab survey of over 100 global warehouse occupants, respondents expected overall demand to grow 7% over the coming years (10% in the US, followed by 6% in Asia Pacific and 4% in Europe) and demand from e-commerce to jump by 13%. Demand for storage in properties close to cities or ports is the highest.

Warehouse automation, according to our forecasts, is set to rise from 41% today to 55% over the next five years, which should make the business model stickier for owners. Logistics rental costs tend to account for a mere 1% of revenues for online retailers, versus around 7% for physical retailers. Thus, rent is not the key decision driver and tenants tend to be less price-sensitive. As a result, warehousing has become a rather stable, growing, and dividend-yielding business over the long run.

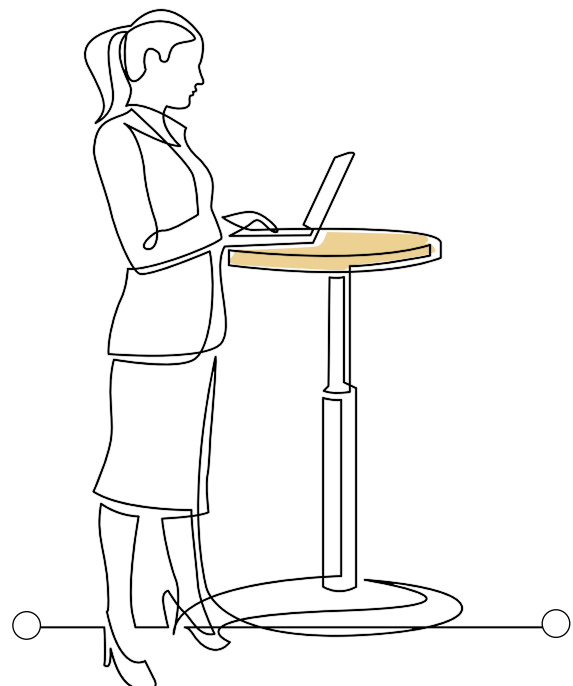
Based on Duke Realty’s findings (from September 2018, presented on the next page), we think industrial real estate demand will grow as the economic outlook improves.

How the COVID-19 pandemic may affect real estate demand

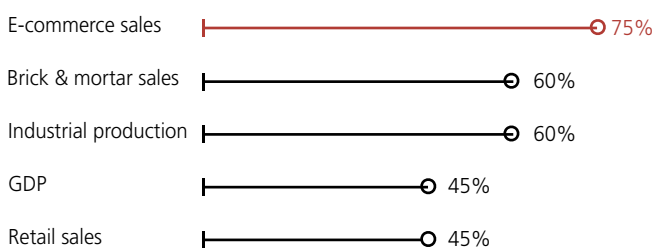
- The golden era of the flexible workspace industry is largely behind us due to oversupply and longer-term trends like telecommuting.
- Data centers, on the other hand, are expanding rapidly to cope with increasing demand for cloud applications.
- We expect investment in data centers to continue growing by double-digit rates over the coming years.

Spotlight on co-working office space and data center demand

To comply with stay-at-home orders announced in response to the coronavirus pandemic, more people around the world are working remotely. Bloomberg Intelligence estimates that more than 200 million employees have had to work from home in China. Prior to the crisis, the Bureau of Labor Statistics reported that 5%–7% of the US’s 118.3 million salaried workers had the capability to work from home; that number shot up to 60% once lockdowns were imposed.

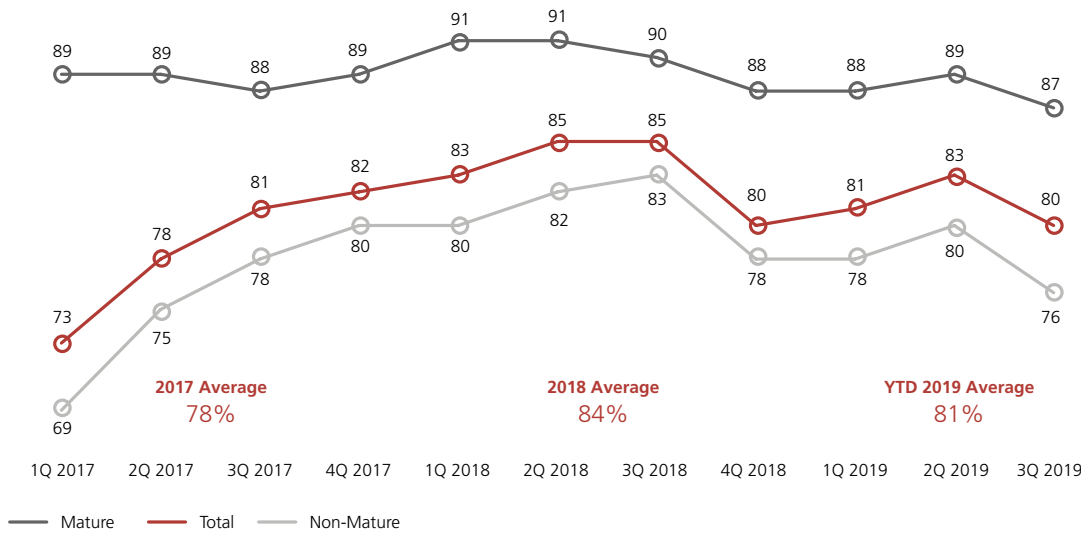


Correlation between warehouse demand and economic variables



Source: Duke Realty, UBS CIO

Recent data shows a slight decline in flexible workspace occupancy rates, even before the COVID-19 pandemic



Source: The We company, Bloomberg Intelligence, UBS

The result has been a surge in demand for telecommuting services, with many people questioning whether office life will ever be the same again. But for the real estate industry, the tectonic plates were shifting well before the pandemic struck.

Co-working spaces: A new office experience

Sentiment toward the flexible workspace industry, otherwise known as co-working spaces, was mixed at the start of 2020. With supply flooding the market, occupancy rates were falling, and the COVID-19 pandemic has pushed the industry toward a crossroad. The bulls argue that the swift increase in remote working capabilities across companies is supportive of flexible workspaces, as large offices will now try to de-densify. The bears think the shift to home will become permanent for many, reducing the emphasis on co-working.

It's still early days, but at this juncture, it appears the golden era of the flexible workspace industry is largely behind us. The supply additions, for one, will make it difficult for the market to recover in general. Longer-term trends are also working against it, with remote working capabilities set to advance rapidly. Indeed, the recent surge in telecommuting is unlikely to end as a one-off experiment. In response to the stay-at-home measures implemented to combat the pandemic, companies

are accelerating their investments in telecommuting areas like remote video conferencing, unified communications, and cloud-based work productivity software.

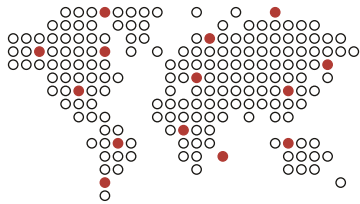
Data centers: The beating heart of the new economy

As a result of the ongoing shift in IT architectures from office-only to office-plus-home access, existing data centers will need to be expanded and new ones built. These investments will not be driven only by verticals like finance and healthcare that are at the forefront of remote working, but rather even laggards like retail and government are likely to join the movement.

To keep their services humming, big hyperscale cloud players, like the major platform companies, will need to continue investing in and building data centers. The group has been driving global data center demand over the past few years, with the top seven hyperscale companies projected to spend nearly USD 90bn combined in 2020, according to company reports (versus USD 30bn in 2015). Data center leasing remains strong globally – annual growth rates have been in the double digits – with cloud providers spending big on co-location. So we expect investment in data centers to continue growing by double-digit percentage rates over the coming years.

Key demand drivers for data centers

Data center industry fundamentals



Cloud provider spending on co-location and data center leasing



2 bn
Actively connected cars expected to increase to 2 billion by 2025



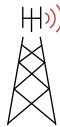
25%
Global cloud infrastructure market expected to grow at 25% CAGR from 2019–2023



3.5x
Mobile data traffic expected to increase by up to 3.5 times from 2018 to 2021



13.6%
Worldwide IoT spending to grow at 13.6% CAGR from 2017–2024



2.6x
5G connections to generate 2.6 times more traffic than the average 4G connection and take up 12% of mobile traffic by 2021

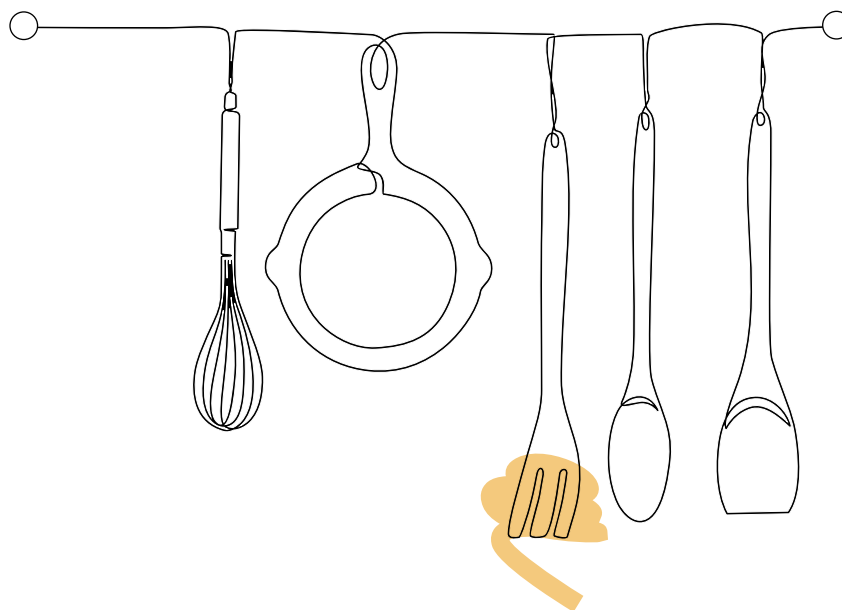
Source: Synergy Research, Cisco Research, Ericsson, IDC, HIS Automotive, Bloomberg Intelligence, UBS

Technical requirements of a typical data center

How consumers spend their media time every day

Requirement	Details
Internet connectivity	Physical telecommunication cables brought into the data center to allow direct connectivity
Uninterruptible power systems (UPS)/generators	To provide continuous power supply in the event of outages from local power grids
Cooling equipment	To maintain a facility's temperature, typically at 18 to 24 degrees Celsius
Fire suppression and building monitoring systems	Hardware and associated software to monitor and control elements such as the facility's temperature, humidity, security and operations
Client servers	Enclosures to house client's computer servers and connect to power and cooling sources
Raised flooring	An elevated structural floor to allow the passage of mechanical and electrical services

Source: SUNeVision's company presentation, Bloomberg Intelligence, UBS



What (and how) we will eat

- The food system is undergoing a technological revolution, from the farm to the table.
- Areas of opportunity are emerging in farm tech, supply chain innovation, and dietary preferences like plant-based protein.
- We expect the addressable market of the “future of food” to increase from USD 135bn today to USD 700bn by 2030.

Our ability to produce high-quality, nutrient-dense, affordable food is under threat. Technology not only lies at the heart of a sustainable food system, but is also key to meeting many of the UN’s Sustainable Development Goals for 2030.

For one, the integration of digital technology into all aspects of farming systems should soon be indispensable. Concerns about long-term human health and environmental sustainability have spurred technological developments that have given rise to a plethora of new foods such as plant-based proteins and lab-grown meat. The way we get our food is also changing, from food delivery to pre-cooked packaged foods.

Many of these trends have been accelerated by the pandemic. With supply chains stretched, food security and waste are renewed focuses for many countries that need simplification and, potentially, localization. Here, distributed ledger technologies (i.e., blockchain), the IoT, and big data can help rebuild trust in the food system, reduce waste, and more seamlessly link consumers with producers.

We expect the addressable market of the “future of food” to increase more than fivefold, from USD 135bn today to USD 700bn by 2030. Food and the tech economy can be divided into three categories: 1) farm tech, 2) supply-chain innovation, and 3) the rise of the millennial consumer.

Farm tech:

Transforming where, how, and what we farm

Precision agriculture, or smart farming, uses technology to optimize the use of resources to boost production and profits. We expect this category’s addressable market to grow, on average, 16% a year over the next decade, notching up at least USD 90bn by 2030. Indeed, platforms already exist that allow farmers to combine satellite, yield, and nutritional data to figure out what to produce for the highest profit sustainability at the lowest risk.

Large-scale automation using agricultural robots (agribots) will eventually replace human labor at the harvesting stage and automate single processes. In the next decade, agribots will weed, fertilize, and control pests and diseases, all while collecting valuable data used to correct and improve processes. New-generation biotech – e.g., CRISPR (gene-editing), genetic modification, and enzyme technologies – could be game-changers for producers confronting a number of agronomic challenges and climate change.

New agricultural models are emerging in cultured protein, indoor farming, regenerative farming systems, and high-tech aquaculture, which include alternative water-based sources of protein like algae. Vertical farms also reduce carbon emissions associated with transportation by locating farms in close proximity to the point of consumption and minimizing resource use. The Institute for Transformative Technologies and other expert organizations have highlighted alternative meat production as a key breakthrough technology to further sustainable development.

Supply-chain innovation:**Building trust, increasing efficiency, and reducing waste**

As most consumers are in the dark about how the food they eat gets to the table, a range of technology-driven data platforms are being developed across the supply chain to improve the traceability of food, reduce waste, and increase the efficiency of marketplaces. Distributed ledger platforms like blockchain offer a powerful way to improve the traceability of food, which can reduce waste, improve the matching between food and the (ideally local) end consumer, and build consumer trust in the industry. The broader application of IoT technologies can also tackle waste in key areas.

How food is packaged and disposed of must also be considered. Developments in bioplastics could be crucial in reducing greenhouse gases, cutting pollution in waterways and oceans, and fighting against ballooning landfill volumes. The World Bank points out that agricultural growth can be at least twice as effective in reducing hunger and poverty, particularly in cases when smallholder farmers are directly included in the growth process.

The rise of the millennial consumer

By 2050, millennials will be the biggest generational consumer. Issues of sustainability, animal welfare, supply-chain transparency, and environmental impact should therefore continue to demand attention, leading to more efficient food sources and a lower ecological footprint.

We expect the market for plant-based protein alternatives to expand by 28% per year on average over the next decade, reaching USD 85bn by 2030. The growing focus on “mindful eating” – that is, choosing brands and foods that come from sustainable sources – is an important driver of shifting consumer preferences. We think products that use regenerative practices will overtake interest in organics over the next few years. Designing products that appeal to different age groups will be key for food companies.

Food supplements and wellness services, as well as personalized food, are benefiting from the overall aging of the population, while on-demand food-delivery and logistics platforms should dramatically change the way we buy and eat food.

Summary

Land use is changing radically as more people shop online and work from home. Winners of this trend include warehousing players and data centers, as well as innovative and more sustainable smart food farming methods.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled ‘Future of the Tech Economy – How to invest’ provides suggestions for investors who wish to pick single stocks.

How to invest

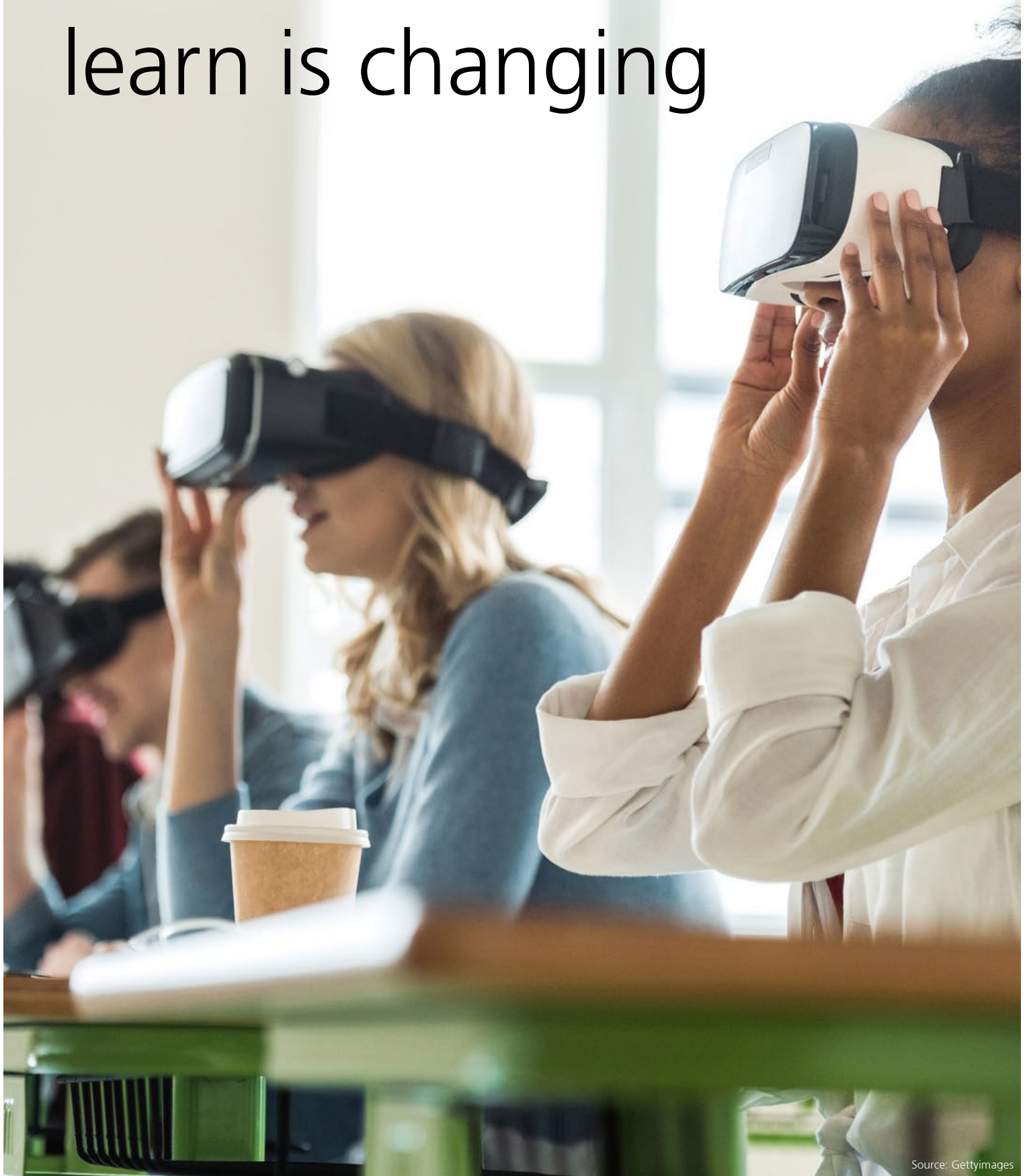
Look for names involved in warehousing and related infrastructure, as well as cloud providers and data center operators. The food revolution Longer-term Investment theme offers exposure to the intersection of tech and agriculture

How will the retail real estate landscape change?

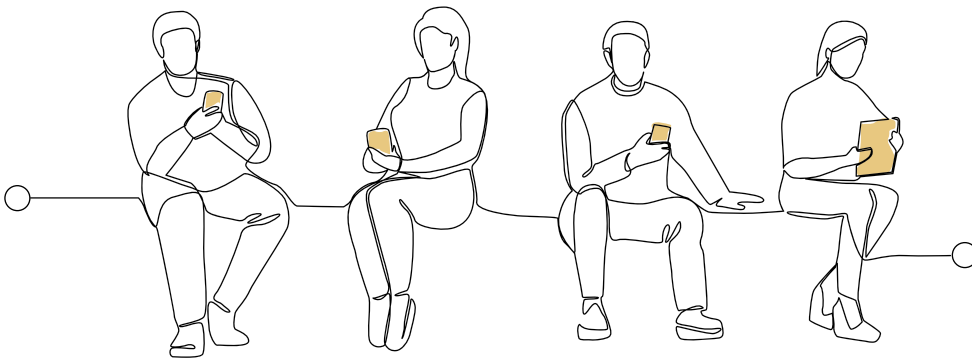
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How the way
we work and
learn is changing



Technology allows people to hold multiple jobs and work longer, spurring changes in compensation and labor market structures. It also enables students to learn from afar and more easily acquire new skills, resulting in investment opportunities.



How technology changes the way we work – is GDP still the relevant measure?

- More people are self-employed and hold multiple jobs than they did in the past.
- These structural changes are not being reflected in economic statistics like wage growth.

Most economic statistics today were designed for the second industrial revolution, with the focus squarely on “making things” in large companies. That framework has already become less relevant as the service sector has increased in importance. But other structural changes are also affecting the accuracy of the data that we use.

People are more likely to be self-employed and hold multiple jobs than in the past. Neither of these labor market structures are unusual, historically speaking. Rather it is the pattern of paid employment for a single employer, which emerged from the second industrial revolution, that is the unusual labor market structure.

There has been a trend for tax revenue growth to exceed GDP growth in some countries, for instance. As people rarely voluntarily pay more taxes than they need to, this suggests that some economic activity is not being counted properly. Structural shifts, for example toward self-employment, may not be accounted for in the underlying assumptions of economic statistics.

Further complications arise from structural change. Self-employed people may save in corporate accounts rather than personal accounts, giving a misleading impression of the financial security of households. Self-employed people may also

have an incentive to pay themselves a low, unchanging wage, topped up with variable dividend or bonus payments as their work patterns change. Thus, wage growth is less reliable as a measure of household income.

Thanks to technology (most) humans can work longer – societal perceptions need to change too

- Thanks to technology, people can work longer than ever before.
- This has ramifications for employers, who must pay higher wages for longer, and for younger employees, who may have to wait longer for promotions.

Aging populations in several large economies have led to lower trend growth rates, as trend growth is a function of how many workers there are and how hard they work. Getting people to work longer slows the drop in GDP growth, and technology makes bringing this about easier.

Manufacturing, agriculture, and some service jobs were once physically demanding. As physical strength tends to decline with age, the productivity of older workers would decline rapidly (it was all downhill after your twenties). Robotics and automation change that, as they enable people to work later in life without a negative impact on productivity. Indeed, the increased experience that comes with age (when combined with labor-saving technology) can increase productivity.

The problem with people working for longer is that modern economic structures are based on the idea that people become obsolete at age 65. This assumption has underpinned a lot of

the legal structures around the modern labor force. While it's relatively easy to promote people or give them a pay increase, it's very difficult to demote workers or to cut their pay.

This dynamic is problematic for the younger generation of workers. If the older generation is working for longer, the career prospects of the younger generation look significantly worse in the absence of legal change. Older workers will also be more expensive, presenting a challenge for firms. The technological change that allows workers to work later in life may also require a change in ideas about the value of seniority.

Will technology finally let people work drastically fewer hours?

- For many, wages have not kept up with productivity gains.
- This means most workers won't be able to significantly shorten their hours.

In 1930, economist John Maynard Keynes speculated that "the standard of life in progressive countries one hundred years hence will be between four and eight times as high as it is today," high enough to solve the problem of meeting our basic needs. This turned out to be correct. However, Keynes thought that with productivity so high, people would choose to work a lot less, perhaps 15 hours a week – and even then just to fulfill the basic human desire to work, not because they needed the income.

One reason he got this wrong is that people want things beyond the basic essentials and are willing to work for them. For large segments of the population, wages have not kept up with productivity. More of the economic pie is going to owners of capital and to the upper fraction of the workforce, and wages for low-skilled workers have not increased much in recent decades. For most workers, it isn't clear that the productivity gains from AI and other emerging technologies will lift wages either.

In addition, companies are usually unwilling to hire people to work only 15 hours a week. Many highly paid jobs involve competition with other firms, and shorter working hours would serve as a disadvantage. Further, such jobs usually require highly educated workers. For employees who have invested many years in education, achieving a decent return on that investment requires long working hours.

For people who do want to work shorter hours, mobile apps have made it easier to connect businesses looking for temporary staff with people looking for only a few hours of work.

Similarly, ridesharing companies like Uber and Lyft can offer drivers flexible working hours. The ability to work remotely enables people to live in areas with lower housing costs while avoiding the time and expense of commuting. While there is little doubt that working arrangements will continue to become more flexible, without some sort of mechanism (or the corporate inclination) to broadly share productivity gains, it will remain difficult for people to make a living working only a few hours a week.

Can various types of technology serve to close the per capita income gap between emerging markets and developed markets?

- The manufacturing shift to cheaper markets is being unwound by technology, which allows for localization.
- To stay competitive, these countries may need to overhaul their education systems.

Emerging markets have some advantages in embracing economic change. For example, developed economies have built more legacy infrastructure – a sunk cost – that may have to be scrapped if technology is to be completely embraced. However, many emerging markets have benefitted from the local availability of cheap, low-skilled labor. That economic structure is likely to become increasingly obsolete as technology encourages localization.

The globalization model and the third industrial revolution have benefitted emerging markets. The technology of the fourth industrial revolution is a partial unwind of that model. It seems realistic to suggest that per capita incomes in emerging markets are more at risk in the years ahead. Emerging markets may therefore need to undertake more change than developed economies.

Given the importance of the labor force in implementing technology to achieve economic success, education is likely to play a significant role. But the "learning by rote" style of education will not fit the bill here, as that approach does not produce a flexible labor force. Instead, education needs to focus on adaptability and the ability to challenge the existing way of doing things. At the risk of generalizing, some emerging markets may struggle to achieve the necessary flexibility in education – fortunately, this is an area that can change quickly, especially if technology is applied.

EdTech for sustainable skills progression

- The focus on developing services sectors is putting more focus on education.
- EdTech is becoming a global phenomenon, as it could offer greater personalization, engagement, flexibility, efficiency, and productivity.
- We estimate global education spend will reach USD 6tr in the next decade, of which a sizable portion could be allocated to EdTech.

Economies worldwide are increasingly based on the services sector, requiring immense investment in human capital, advanced education, and specialized training to produce knowledgeable professionals. The physical convening of students has been the biggest impediment to scaling education to date.

Digital technology is already being used to make education delivery more productive and efficient. Although still in a nascent stage, the deployment of technology in the (physical and digital) classroom is becoming a disruptive trend in the global education market. We think that learning can migrate from a capital- and talent-intensive brick-and-mortar business model into one fit for the digital era. We anticipate that technology will make it easier and less capital-intensive to deliver more personalized education that will enable individuals to “reskill” over their lives. And, as parents well know, the coronavirus pandemic is only accelerating adoption globally.

The rise of education technology (EdTech) is becoming a global phenomenon, and as distribution and platforms scale internationally, it could offer greater personalization, engagement, flexibility, efficiency, and productivity. For example, increasing internet and smartphone penetration rates are expanding access to education, giving students the ability to study when-

ever and wherever they want. We also see scope for AI to further disrupt the space through employing its deep analysis of user behaviors to intelligently tailor learning programs to individuals with different modes of learning.

Technology can scale in a cost-efficient way, with relatively low incremental costs per additional student. Evolution in the format and delivery of education over the next decade is likely to change the allocation of global education spend, which we estimate at more than USD 6tr. While the EdTech industry is extremely fragmented, with start-ups scattered across every part of the education ecosystem, the larger internet platforms and technology companies are also clear players within the market. To date, the US has set the trend (and pace) for the global EdTech market, while Asia is now experiencing the world’s fastest growth in investment in the sector.

Education technology acts as an enabler of sustainable economic development. According to various studies by UNESCO (e.g., their Global Education Monitoring Report), an extra year of schooling raises earnings up to 10% a year and average annual GDP by 0.37%. EdTech also facilitates the re-skilling of workers and lifelong learning to bridge the gap between skills and jobs and, ultimately, increase economic productivity.

Private investors have shown a burgeoning interest in sustainable investments, and education companies represent a credible way to support the UN Sustainable Development Goals (SDGs) and economic welfare more generally. As public funding for education comes increasingly under pressure, the role of private enterprises and investments will be instrumental in ensuring we address the SDGs in support of sustainable and shared economic prosperity.

For more details, please refer to CIO’s Longer Term Investment publication on education services.

Summary

Automation and robotics are changing the way we work, while new ways of learning are becoming more scalable, personalized, and cost-effective.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled ‘Future of the Tech Economy – How to invest’ provides suggestions for investors who wish to pick single stocks.

How to invest

Consider the Automation and robotics Longer-term Investment theme. Seek exposure via education services and EdTech companies.

How will the retail real estate landscape change?

Can I work less hours in the future?

What is Edtech and why should it matter to me?

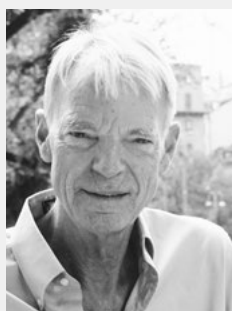
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Interview

Michael Spence

This interview contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the interview does not fully reflect the views of CIO GWM.



Michael Spence is the former Dean of the Stanford Graduate School of Business, a professor at NYU Stern, and chairman of the independent Commission on Growth and Development. His work demonstrating that markets are not always equipped with perfect information has changed the paradigm of microeconomics. He has shown how signaling and screening, major themes of his research, are part of modern people's daily routines. Spence received the Nobel Prize in 2011 for his contributions in microeconomics. Together with 50 other Nobel laureates in Economics, he is part of the UBS Nobel Perspectives initiative that explores the questions that shape our world. To read more about Spence's work, please see [here](#).

Some economists now see the world as past the peak in terms of global trade or globalization more generally, which may well lead to a lower potential growth level. To what extent – and how exactly – can technology help to stem this effect?

The data suggest that the period of trade in goods growing faster than global GDP has ended and is unlikely to resume. Trade in services (which is smaller, say about one-third of trade in goods, with lots of measurement problems) is still growing faster than global GDP, and that also is likely to continue.

Many of these observed patterns in recent (say post-GFC) years are structural. That means they have occurred independent of more recent trade frictions. The size of China's internal market alone reduces the fraction of GDP associated with trade.

Technology is another factor with multiple impacts. First, digital technology in the form of robotics (with vision, AI, etc.) will displace a fraction, probably a large fraction, of labor-intensive production and distribution over time – because it is lower cost. That will lead to some localization of production as the low-cost labor constraint is relaxed. This really means a very substantial reordering of supply chains (internal and external) that define the structure of the global economy.

On the other hand, technology will drive growth in services and perhaps also some trade. Studies of e-commerce, mobile payments, and other digitally enabled financial services have shown that the associated growth patterns are important and very inclusive. Thus far, these digital ecosystems are largely domestic. But they could become global with the right sort of international cooperation. It remains to be seen if that will happen, and there are headwinds. Digi-

tal technology has become both a risk (think cyber and data security) and a key element of national security and defense. The national security agenda runs counter to the global economic agenda. This agenda points in the direction of barriers to the globalization of the application of technology and some degree of fragmentation. At this point, the outcome is not clear and won't be for some time.

The application of technology will change the inner workings of societies. This process will result in winners and losers, in terms of both societal roles and business models for companies. How can we identify these? How should people and firms prepare for the future?

This is true. Step one is to recognize that economies are being built increasingly on digital foundations. These technologies are no longer just another sector with new services, markets, sources of information, and modes of communication. Businesses need adaptive digital strategies and a willingness to experiment. Hoping it won't happen is not going to work. But there are new technologies and capabilities coming forth all the time. So there is no static answer to this.

In the case of Europe, a digital strategy is needed. It has many parts, too many to try to cover them all. Controlling and democratizing access to and the use of data are really important. Competition policy is part of this, but not the whole story. Europe in particular should set in motion a policy agenda that results in major pieces of infrastructure like cloud computing being located domestically. It is not a good idea to outsource and offshore data and cloud computing. The same applies to other jurisdictions. China is already there. This gives one security and control over the way in which the digital economy and society develops.

It appears that in terms of major technology developments, the world is set to split between the US and China. Will there ultimately be a specialization of the two in particular areas where they have a comparative advantage leading to more progress globally, or should we expect everyone to go their own way, with regions outside the two giants bound to lose out?

Hard to say. It could go either way. China plans to achieve parity with the US in a number of areas of technology. They have taken advantage of the relatively globally open upstream research layer (where most of the research output is deliberately in the public domain – meaning not proprietary) to accelerate this process. The US is resisting and trying to slow that process down, leading to increasing frictions and some threat to the openness of scientific research. It is worth noting that this is not theft of proprietary intellectual property since there is little or no proprietary knowledge in this domain.

Based on your work regarding signaling, and considering that online education, for example, might lower the cost of acquiring skills, how do you see the roles of offline and online education developing? Do you anticipate additional technology-related ways of acquiring skills that may shape the way we learn and hence boost productivity and wages in the economy?

Digital technology is already being used to enhance and extend the range of education – in the education sector, in companies, and more broadly. It is a powerful tool. Companies are starting to deliver on this promise. For example, Byju's in India (an Indian edtech and online tutoring firm) is clearly adding to the quality and accessibility of K-12 education there, and doing it profitably. This is just one example.

The required skillset for workers is evolving rapidly. How can an aging workforce adapt to technological changes?

It is a challenge, and it isn't just digital technology. Any rapid evolution in the economy that produces structural change – the creation of new and altered jobs and the elimination of older ones – generates this kind of problem. You see it in developing countries in the course of high-speed growth. The transitions are easier for younger cohorts, and more challenging for the older ones. Part of the answer is social security. Another part is a multi-stakeholder commitment to the workforce and to training. A third element that has been observed in some companies that take this seriously is that the young can teach the old about digital technology and the old can teach the young about the legacy technologies which are still relevant.

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Quality education is one of the UN's Sustainable Development Goals, and, especially in emerging markets, access to good public education cannot always be taken for granted. Do you see a role for technology in achieving faster progress on the education side, both for basic education and for industry-specific skills?

Yes – and see the above example for India. But there are many more examples. AI makes it possible to intelligently tailor learning programs to individuals with different modes of learning and differing conceptual or skills blockages.

Will technology-based education and the learning of skills eventually be globally unified in the future, or will there be different flavors that suit different regions or economic systems?

Hard to see any kind of global unification in the near future. But one can expect innovations in this sphere in one country transferred and adapted to other societies. That seems certain and highly beneficial. I suppose that is some kind of partial unification.

How the economy is changing



The global economy is going through a period of great structural change. Jobs, inflation, money, and supply chains are just a few areas undergoing rapid and fundamental transformation.

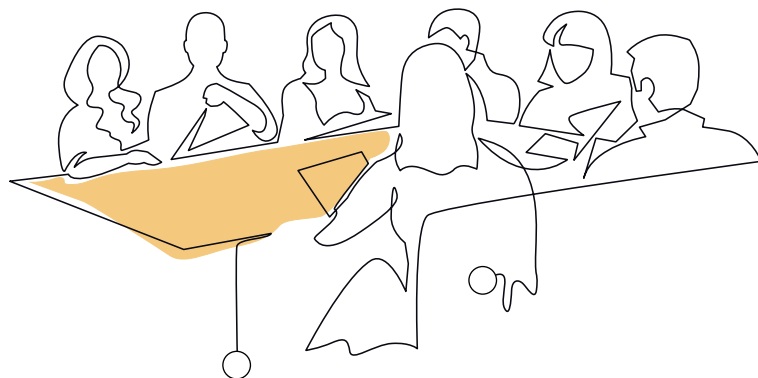
Technology and inflation – now it becomes personal

- In the fourth industrial revolution, existing jobs will change and new ones will be created.
- Wages may shift as a result, with those requiring new skills earning more.

With any period of structural change, the biggest concern is that people will lose their jobs when new technology is introduced. This fear has led to public protests in every era of significant structural change.

The worry is known in economics as the “lump of labor” fallacy – the idea that there are a limited number of jobs to go around. This has never been true, and will not be true in the fourth industrial revolution. Existing jobs will be changed, and new ones created. The problem is that there is likely to be a skills mismatch between the people losing jobs and the new jobs that are generated. Economists expect that between 10% and 15% of jobs will be lost as a result of technological change. However, around 50% of jobs will change, highlighting the importance of flexibility.

What is potentially more disruptive, socially and politically, is that the status of different jobs will shift. Jobs with superior social status requiring skills that were previously not valued may be created, which will be reflected in relative wages. Politically this is difficult to manage, as people tend to react badly to the loss of relative social status and relative income.



Does digital currency matter to central banks, and does technology really increase price transparency for consumers?

- Digital money issued by governments would neither alter fundamental monetary economics nor a central bank’s ability to adjust money supply.
- Technology allows for first-degree price discrimination, making inflation as an economy-wide metric less relevant.

A government issued digital currency does not change monetary economics, assuming that the digital and fiat currency have the same value. The digital currency should be accepted for tax payments, in which case the creation of a digital currency is simply another variation within money supply. Economists think of money as a broad range of things, including cash, bank accounts, electronic money, and some government securities. Digital money would fall into this definition.

China’s digital great leap forward

China is the first country to launch a national digital currency. Its Digital Currency/Electronic Payment (DCEP) is regarded as the digitalization of physical cash or, in other words, the substitution of money in circulation (M0). DCEP is legal tender fully backed by the credit of the People’s Bank of China, and is converted 1:1 to the Chinese renminbi. This makes it distinctive from existing cryptocurrencies such as Bitcoin. The major concern of the latter is the

lack of acknowledgment and oversight from sovereign countries, which leads to huge fluctuations in value. Furthermore, DCEP cannot be used for speculation.

DCEP integrates advantages of both physical cash and cryptocurrencies. It enjoys cryptocurrencies’ low issuance and storage costs, anonymity, and traceability, while maintaining the advantages of physical cash such as its legal status and relatively

stable face value. Unlike cryptocurrencies, DCEP is a centralized and sovereign-issued currency and cannot be mined.

We think DCEP has many advantages, including accelerated digital penetration, improved currency supervision, and reduced costs. For more, see “Understanding China’s digital currency and blockchain initiatives.”

Central banks can raise and lower the total money supply, be it fiat or digital currency, to match demand. This prevents the bouts of inflation and hyperinflation that have plagued the so-called cryptocurrencies.

Inflation is an average price measure, an aggregation of many different prices in an economy. Technology increases efficiency, and so should lower the price of a good or service. However, that tells us nothing about inflation. What technology will tend to do is to lower the relative price of one good against another.

The introduction of technology into one part of a supply chain will also change demand patterns in other parts of the supply chain. This will tend to raise prices – and potentially in areas relatively unrelated to the area of technology. As already discussed, brick prices rose because of improved methods of spinning wool during the first industrial revolution.

In theory, technology will increase price transparency – prices are more visible over the internet. One obstacle is that consumers do not tend to compare prices for regular purchases and, instead, often return to the same websites. This is partly a matter of convenience since there is a cost (in terms of time) to setting up an account on a different site. If consumers habitually visit a site with a “one-click purchase” option, then they may accept that they may pay a higher price than could be achieved with more diligent online searching.

Technology also allows for first-degree price discrimination, which occurs when a company charges each person a “personalized” price. Online consumption can drive this in two ways. First, consumers searching for products may not see all the options – search engines may bias results according to past spending habits. Second, the seller of a product can find out something about a person’s willingness to pay for that product through tracking past purchases and behavior. This means that people pay different prices for the same good or service, and so inflation as an economy-wide concept becomes less relevant.

Summary

Everything is going digital, even money. This shift has significant ramifications for the global economy, from retirement ages to productivity.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled ‘Future of the Tech Economy – How to invest’ provides suggestions for investors who wish to pick single stocks.

Does technology foster localization, and is this good or bad for global trend growth?

- Localization can have a positive impact on global growth.
- If localization is driven by technology, it will generate less waste and lead to greater productivity.

The drive toward localization of production is likely to be neutral or positive for global trend growth, as long as the main factor behind it is the advance of technology. Politically inspired localization is less certain to improve trend growth.

The “right” sort of localization is about technology changing the efficiency of producing close to home. The globalization trends from the mid-1990s onward were focused on the most efficient use of labor globally. Labor is the largest cost faced by most companies, so this was about efficiency. Thus, low-skilled, labor-intensive production shifted to countries where low-skilled labor was abundant.

The localization story does not need low-skilled labor. Instead, localization is about replacing large amounts of low-skilled labor with capital and a small amount of semi-skilled or high-skilled labor. This capital for labor substitution should not lower, and may increase, productivity.

In addition, localization is likely to reduce two forms of waste. First, the amount of transport required for localization is likely to fall, reducing energy consumption and increasing efficiency. Second, by producing closer to the consumer, the firm can come closer to producing on-demand, which cuts the waste of unsold inventory – around a third of all clothing in US stores is wasted, for example. So if localization of production is driven by technology, it will generate less waste and lead to greater productivity. The use of drones and 3D printing, for example, can also help boost localization. As a result, there is no reason to assume that the trend rate of growth will fall.

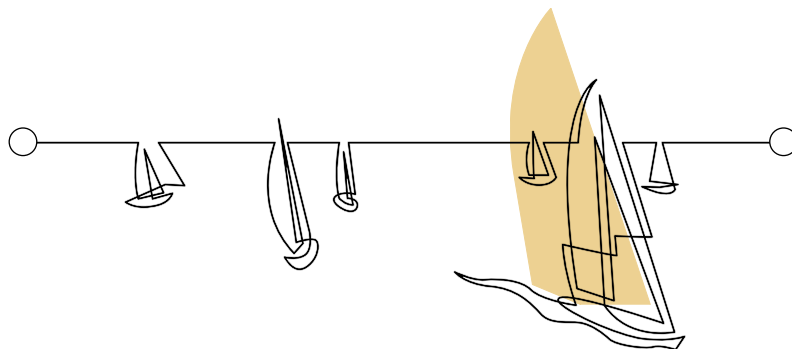
How to invest

The Fintech Longer-term Investment theme offers exposure to the transforming financial industry.

The race for tech leadership is on



The US, China, and Europe are sprinting to win the technology race. The US had a head start, but China is catching up and has even taken the lead in some areas. With neither side backing down, a bipolar technology world appears to be emerging, with the rest of the world caught in the middle.



Clash of the titans – what will determine the race’s outcome?

- China uses industrial policies to advance its homegrown industries and move up the value chain.
- The US focuses more on developing a competitive marketplace to allow the private sector to develop.
- Europe is a leader in setting the standards in a number of areas such as privacy and climate change.

The first steam engine was invented by Hero of Alexandria over 1,600 years before the UK’s James Watt reimaged the idea in the late 1700s. This fact underscores that where technology is created tends to be less consequential than where – and how effectively – it is ultimately used. Thus, technological rivalry between the US and China need not necessarily matter much to the economics of the rest of the world.

What *will* matter for the global economy is the extent to which technology is placed in “silos.” If users are free to switch between competing systems, then there is little economic problem. But if one system is chosen and the alternative is not compatible, the economics become a lot less efficient. One interesting possibility would be for the US and China to devise the technology and the European Union to design the global standards for the application of technology.

As the US has retreated from global leadership, in particular in trade, the EU has been looked to for guidance in designing global standards in a number of areas. Thus, regulations around climate or data protection are strongly influenced by views from Europe. The size and importance of the European consumer market, and the willingness of other countries (especially in Asia) to follow European leadership, supports this idea.

US, China, and EU industrial policies

Industrial policies can be designed to foster national champions. With its “Made in China 2025” initiative, China is seeking to move up the value chain by building up indigenous innovation, technological self-sufficiency, and sustainable environmental standards. However, the program has drawn heavy criticism from trading partners. And it has especially irked the US administration, which has levied tariffs on select products and placed restrictions on the supply of American high-end technology to China’s tech behemoths ZTE and Huawei. Beijing has since largely abandoned public promotion of the program, but China is still striving to lead in key technological areas like robotics, semiconductors (especially after US supply restrictions), AI, IoT, and renewable energy (including production and vehicles).

Even under the somewhat reduced catalog of target areas, these moves are likely to further fuel tensions with the US, especially if China meets with success. But for the world at large, breakthroughs are beneficial regardless of where they have been achieved.

In the EU, industrial policies are shaped by the national governments, and the focus is on advanced technologies, including cybersecurity, enabling technologies, 3D printing, and social and workplace innovation.

Since the EU is a union of diverse countries, the alignment of legal frameworks is key. It is no coincidence that the “Industrie 4.0” smart factory initiative came from Germany and that the concept has since found widespread promoters. A European battery alliance is seen as highly strategic for the car industry.



With just 20% of small and medium-sized enterprises considered to be sufficiently digitalized, transforming manufacturing sectors – which were once a traditional strength – via high degrees of automation and robotics is seen as another strategic imperative. Sustainable, low-carbon emitting, and circular plastic technologies are another focus point of the EU’s tech economy.

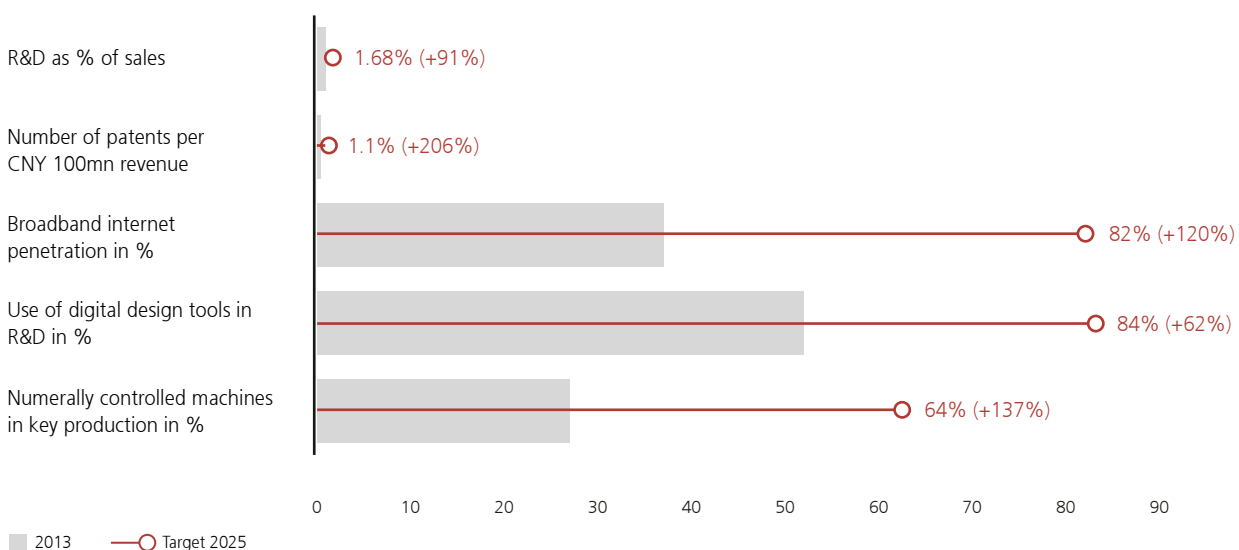
The US is taking a different approach to support its home-grown global technology champions. It has not issued extensive industry-specific policies. Instead, the idea is to create a competitive environment and let market forces play to find the winning technologies. The measures used to safeguard interests of technology providers have, in recent years, focused on intellectual property rights (IP) protection – a key motivation for imposing tariffs on China. Similarly, when France proposed a

digital tax that the US viewed as discriminatory toward US internet platforms, countermeasures were announced. The primary aim of the US is not to protect domestic technology leaders, as they currently have limited need to fear foreign competitors in most cases. Rather, the objective is to use them as bargaining chips for changing trade partners’ behaviors. In China’s case, the goal is for the country to tighten its IP rules and address the perceived mingling of civil and military entities.

Export restrictions on high-end semiconductors are seen by China as an attempt to hinder its technological advances, leading to accelerated efforts to increase self-sustainability over time. Our assumption is that the technological rivalry between the US and China is strategic in nature, and therefore unlikely to ebb with different administrations.

China’s ambitions to close technological gaps

Selected 2025 targets



Source: MIC 2025, UBS

Interview

John Savercool

This interview contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the interview does not fully reflect the views of CIO GWM.

It is often claimed that the US aims to curb China's rise as an emerging technological power. Being close to the action in Washington, is this an over-simplification? How do you read the strategic objective of the US?

I believe the strategic objective of the US is straightforward: to preserve its status as the world's leading economic and military power. China's rapid economic rise has challenged the US in a number of ways and generated significant debate among policymakers about an appropriate US response. Technology is a big part of the equation given its contribution to both the US and Chinese economies, military and global competitiveness. China's economic rise has been dramatic and far-reaching, and the US has to decide what role it wants to play in the world over the next decade and what resources it is willing to commit toward that end. I sense that debate in the US is undecided on these questions and will determine to a large degree future US policy toward China. Many of these observed patterns in recent (say post-GFC) years are structural. That means they have occurred independent of more recent trade frictions. The size of China's internal market alone reduces the fraction of GDP associated with trade.

We are moving ever closer to US presidential elections. To what extent do you see the two parties' objectives differing with regards to the US-China relationship?

Many US voters now believe that China poses the biggest economic and national security threat to the US, a perspective

that probably did not exist just three years ago. US-China trade disagreements have focused US voter attention on China in ways that far exceed trading policies and are increasingly negative. As such, politicians from both sides of the political divide will focus on US-China relations as a top priority. Regardless of who is elected president come November, I expect US-China relations to remain strained. The focus may change a bit as a President Biden would focus more on human rights in China, while a re-elected President Trump would focus more on the economic competition issues that have lately defined the relationship.

Compared to China and the European Union the US appears to have no comparable industrial policy and to rely more on market mechanisms. Could this change in the future and if so, what could such a policy plan for the US look like?

Yes, the US has historically shied away from establishing a broad industrial policy to guide its economy. Occasionally, there have been events that have led to greater government control, oversight or incentives in some sectors, especially when they are financially-stressed. We are seeing that now, temporarily, with the US economic response to the coronavirus, as the government has asserted itself on certain distressed sectors and has reassessed some disadvantageous trade, manufacturing and supply chain practices. In the near term, there will be more serious conversations between lawmakers and the White House about businesses in the critical infrastructure and defense sectors. These businesses will be subject to both more scrutiny and potential government support. How more government support may evolve is unclear at this time, but clearly this is a topic of far more importance now than it was five or ten years ago.



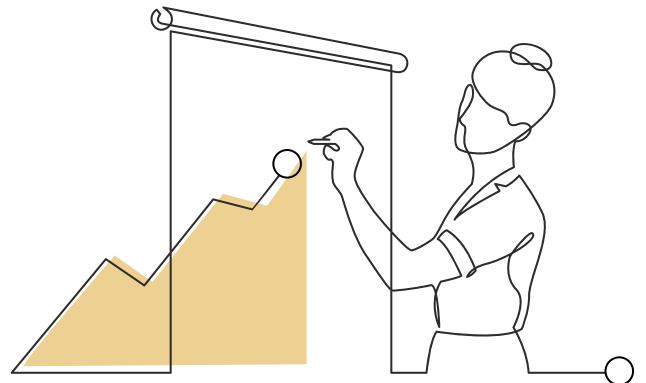
John Savercool, Managing Director and Head of the US Office of Public Policy

It could be argued that limiting China's access to high-end IT software pushes the country toward greater self-sufficiency. Should China achieve a greater degree of self-sufficiency it may not only curb US firms' growth potential but even foster new competition. What type of strategies are you seeing from technology businesses in term of lobbying work on Capitol Hill?

Chinese self-sufficiency and the development of its own broad technology industry are viewed as inevitable in the US. There is a view among current US technology suppliers that the Chinese market will change, and Chinese buyers will eventually have a mandate or be encouraged to buy from Chinese suppliers. Nonetheless, US suppliers are apprehensive about recent US rules to restrict US technology sales to Chinese companies and do not want to lose this important market in the short term. The US industry has taken notice of the Chinese government's growing investment in its technology sector and would like to see the US Government make a similar commitment. I believe the industry will push this initiative more than fight the recent federal export restriction rules.

US and China in a race to dominate the bipolar technology world

- The US currently has a significant lead over China – and any other country – in terms of core and upstream technologies.
- But China is closing the gap and has even taken the lead in certain areas.
- The growing rivalry between the two could create a bipolar tech world, with both battling it out for tech supremacy.



While the US holds a comfortable lead in the technology race, China is quickly closing the gap. China ranked 15th globally in Bloomberg's latest innovation index, a leap from 22nd in 2015, whereas the US remained firmly in the top 10. China's patent activity has exploded in the past few years, with the country now ranked second behind the US.

The competition is most intense in the technology space. This clash boiled over in 2019, resulting in punitive measures and ongoing jockeying for supremacy over 5G, semiconductor manufacturing, and supply chains. Both countries – and their leading firms – continue to spend billions of dollars in R&D.

The US currently has a significant lead over China – and any other country – in terms of core and upstream technologies. It dominates the software and semiconductor markets, including operating systems, databases, and microprocessors, which the entire world depends on for its computing needs.

It will take many years for China to make deep inroads in these areas. Thanks to its solid manufacturing base, China should find it much easier to focus on downstream technologies.

US and China's global innovation ranking across segments

	US	China
Consolidated	9	15
R&D Intensity	9	15
Manufacturing Value-added	27	14
Productivity	12	47
High-tech Density	1	11
Tertiary Efficiency	47	5
Researcher Concentration	29	39
Patent Activity	1	2

Source: Bloomberg, UBS, as of 2020

While these technologies may not be critical, the rising importance of wireless technologies and emerging products like robots and drones put the country in a good position.

As a result, we think China will continue to strengthen its presence in the downstream area and increasingly focus its efforts on building up competence in core or upstream technologies. Chinese technology giant Huawei, for instance, has built its own mobile operating system ecosystem because of the US's technology transfer restrictions. Meanwhile, the US is seeking to bolster its prowess in downstream fields, particularly in wireless and emerging technologies.

Beyond traditional IT, the jury is still out on other innovative areas. While the US benefited from an enviable head start on internet business models, China has rapidly caught up over the last decade thanks to the limited presence of foreign internet companies in the country. In fact, Chinese companies have been more successful than their US peers in monetizing some of the most commonly used consumer internet applications like instant messaging. For example, unlike WhatsApp, Tencent has successfully used "super app" features to monetize WeChat.

There are many such examples of China's growing might in other verticals like video sharing and AI-based internet models, including autonomous driving initiatives in which China's innovation output matches or exceeds the US's. Besides the US and China, other (albeit smaller) tech titans include Korea, Taiwan, Japan, Germany, and India. Nonetheless, over the next decade technology and innovation will largely be shaped by the US and China, with both battling it out to reign supreme in an increasingly bipolar tech world.

The US will continue to be a force in an increasingly global technology world

- Asia (ex-Japan) accounts for 63% of global semiconductor industry revenues, from 53% a decade ago.
- But the profit pool remains largely in the US, and most of the biggest software companies are US-based.
- In time, some spheres of influence globally may center on a Chinese technology ecosystem while others may be intertwined in a Western ecosystem dominated by the US.

The US currently dominates the technology landscape across profit pools and the main enabling technologies, continuing a trend that has been firmly in place for the past 50 years. Industry analyst Gartner estimates IT and communication services (ICT) spending will reach nearly USD 4tr in 2020, or roughly 5% of the global economy. Semiconductors are the key technology that underpins the IT industry and, in some ways, all economic growth. Yet this industry only accounts for about 10% of global ICT industry revenues.

While Intel remains the world's largest semiconductor company by revenue, global competition is on the rise, with companies such as Samsung, SK Hynix, and Taiwan Semiconductor growing rapidly over the past decade. The Asia Pacific region (excluding Japan) now accounts for 63% of global industry revenues compared to 53% a decade ago.

That said, the profit pool remains largely in the US when looking at the leading companies. Gartner data shows that six out of the top 10 semiconductor companies are US corporations, accounting for over 60% of the collective revenue of the top 10 global semiconductor companies' revenue. Data from FactSet and company reports suggest that US companies currently capture 75% of the operating profit pool. We think the data would look much the same if expanded to the global industry, given the US industry's move away from low-margin commodity components.

Summary

The world's major regions have developed unique strengths in technology and labor. In the race to secure technological leadership, governments are looking to enhance their competitive advantages.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled 'Future of the Tech Economy – How to invest' provides suggestions for investors who wish to pick single stocks.

While third-party foundry suppliers such as Taiwan Semiconductor have undoubtedly found success, it should be noted that their largest customers are often US semiconductor companies that have outsourced manufacturing to allow them to concentrate on the higher-margin design of semiconductors. And it should not be overlooked that much of the intellectual capital in semiconductor capital equipment (SCE) manufacturing is domiciled in the US. The USD 60bn SCE industry doesn't make chips, but rather provides the machines and much of the consumable materials to semiconductor companies.

The software industry is characterized by extremely high gross margins, strong secular growth, and increasing recurring revenues that garner above-market valuations. According to data from Forbes, eight out of the 10 largest software companies are US-based. Infrastructure and application software companies alike have been able to build wide competitive moats by taking advantage of the "stickiness" of infrastructure software and generating very high margins that are then reinvested into growth areas and shareholder returns.

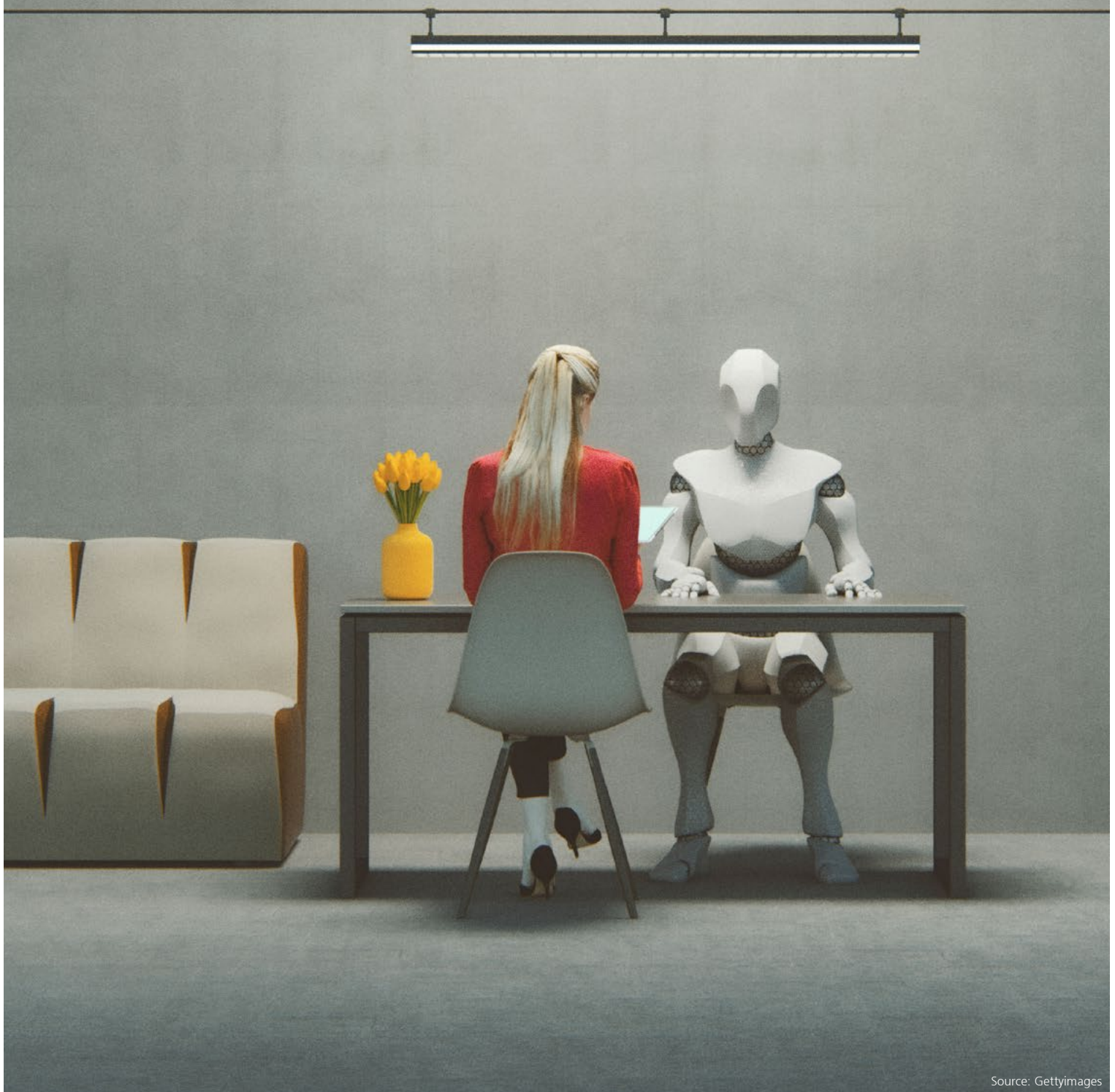
The IT services industry is more globally balanced, with the US represented by only four of the 10 largest IT services companies. The balance is rounded out by India (four), followed by France and Japan. The industry has shifted its focus away from traditional outsourcing to higher-value consulting and digital transformation projects, a move that has driven a bifurcation in terms of growth trajectories and margin profiles that cuts across regions.

The US technology industry will certainly face competition from a rising China. Some spheres of influence globally may center on a Chinese technology ecosystem while others may be intertwined in a Western ecosystem dominated by the US, but we think that this will take a generation to play out and that, during this time, the US will maintain its leading role in developing and monetizing new technology products.

How to invest

Investors should diversify across regions to combine these diverse strengths in their portfolios.

What are
the next
moonshots?



Moonshots are innovations that, conceptually, have tremendous disruptive potential. The possibility of such moonshots is attracting significant attention from investors, entrepreneurs, policy-makers, and corporations. We examine a few of the moonshots that, though commercially unviable today, hold significant long-term promise.

Moonshots are defined as ambitious, exploratory, and groundbreaking projects undertaken without any expectation of near-term profitability. Google has characterized moonshot projects as those that 1) address a huge problem; 2) propose a radical solution; and 3) use breakthrough technology. Many moonshots never take off, but if successful, they can be of significant societal and economic value.

In this section, we focus on moonshots that, though commercially unviable today, hold significant long-term promise.

Quantum computing – early days of the quantum era

- The long-term potential of quantum computing is vast, but we are only in the early days of the quantum era.
- Quantum computing has the potential to transform the high-end computing market.
- We see use cases across sectors like financials, healthcare, industrials, materials, and energy.

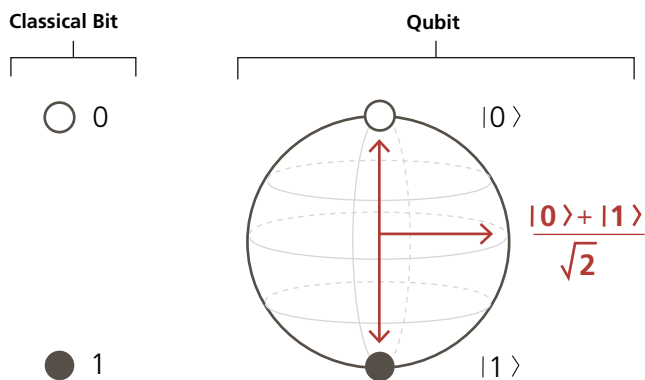
Moore's Law, which postulates that the number of transistors doubles every two years while costs halve, is approaching its limit. While recent progress in extreme ultraviolet lithography technology has helped to maintain that rate, costs are going to soar due to the increased complexity of design and manufacturing. Also, the binary nature of traditional computing limits its ability to solve the more complex tasks around simulations.

Enter quantum computing, a groundbreaking technology with the potential to overcome these limitations. Unlike traditional computing, which is developed around the laws of mathematics, quantum computing is built on physics. With traditional computing, information is stored in bits with two states: 0 or 1. With quantum computing, information is stored in qubits (or quantum bits) that can be in any state between 0 and 1.

In other words, rather than just being either 0 or 1, qubits can be in what's called "superposition" – when they're both 0 and 1 at the same time, or somewhere on a spectrum between the two. Here's an easy way to think about it: When you flip a coin, it will either land on heads or tails. But if you spin it, the coin can be both heads and tails while it's moving. Binary computing is the flipping coin, and superposition the spinning coin; the latter is particularly useful for simulations.

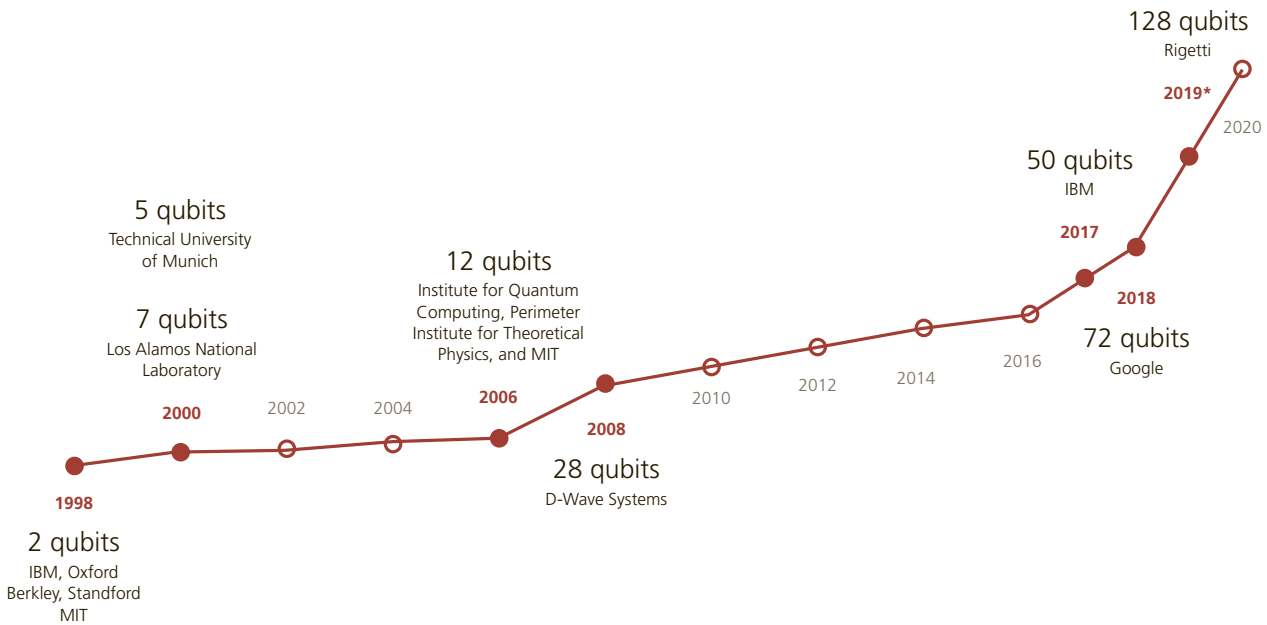
At the core of quantum computing are superconductors, where electrons move without any resistance because of the extremely low temperatures being maintained. In such an environment there are no impediments to the flow of information, so the computers can process highly complex algorithms at incredible speeds. Other materials and methods are also being explored, like trapping ions using lasers or using compound semiconductors.

Bits vs. qubits



Source: UBS

The rise of quantum computers

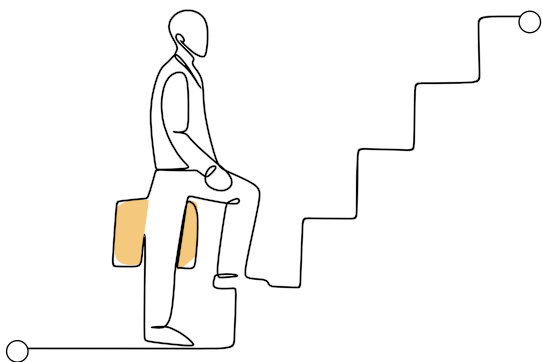


* Rigetti announced its plan in 2019
 Source: MIT, Qubit Counter, CB Insights, UBS

Traditional computing vs. quantum computing

Traditional computing	Quantum computing
Use electric circuits which are in a single state at any given point in time: on or off	Uses quantum circuits that can be in more than one state at any given point of time
Runs at normal temperatures	Runs at extremely low temperatures
Information storage is based on voltage	Information storage is based on direction of electron spin
Processing of information is carried out by logic gates in a sequential basis	Processing of information is carried out by quantum logic gates in a parallel basis
Conventional bits store limited amount of information and consume more energy	Quantum bits can store an enormous amount of information and use less energy
Circuits interface condition is stable	Circuits are incredibly sensitive to interface
Results are specifically defined, limited by algorithm design	Due to superposition and entanglement, answers are probabilistic in nature
No restriction on copying or measuring signals	Encryption has high degree of restrictions on copying and measuring signals

Source: UBS



Quantum computing won't replace traditional computing anytime soon. The latter has many critical advantages for the mass market, such as miniaturization (quantum computers are massive) and affordability. Instead, quantum computing can really make an impact in high-end computing.

Today, the size of global computing, including consumer and enterprise computing, is close to USD 1tr. High-end computing (which includes supercomputers) accounts for close to 2–3% of the overall market. Quantum computing has the potential to transform the high-end computing market, with consumers leveraging the technology through cloud-based business models. We anticipate multiple use cases for quantum computing across sectors like financials (portfolio optimizations using simulations and cryptography), healthcare (drug discovery), industrials (design and predictive maintenance), materials (molecule design), and energy (real-time data analytics).

The long-term potential of quantum computing is vast, but we are only in the early days of the quantum era. Most of the research is still being done in labs with limited commercialization so far; few companies have built quantum computers with more than 50 qubits. Along with qubits, the performance of quantum computing is measured by the amount of interconnections (the more the better) and the noise level (the lower the better).

The challenge is scaling up the qubits with reduced noise levels and additional interconnections. And since qubits are fragile, quantum computers operate at very low temperatures to slow qubit movements, and they are much larger in size than traditional computers. Both features are supposed to help maintain qubit stability so that the information stored on the qubits can be read, but doing so requires dedicated and large premises to run operations.

The good news is that many big technology companies are spearheading the research efforts on quantum computing. The industry is working on two primary models: Gate and Ising machines. The Gate model targets more general use cases, whereas the Ising model targets specific use cases. Today's quantum computing supply chain is still largely located in the US and Europe, and it is based on IBM's Q System hardware. But we expect many emerging companies, including those in China, to lead development over the coming decade.

Neural interfaces – the next step in human evolution

- Neural interfaces are capable of improving brain access for impaired individuals and connecting brains to a computer.
- Recent developments are driving the industry toward an inflection point for commercialization.
- We are hopeful that by the end of this decade neural interfaces will become a mainstream technology.

Neural interfaces are systems designed to provide stable mapping and modulation of activity within neural networks of the central nervous system. The topic has been attracting significant attention thanks to keen interest both from leading entrepreneurs like Elon Musk and Mark Zuckerberg, and from government institutions like the BRAIN initiative in the US.


Neural interfaces are also widely known as brain computer interfaces (BCI), with current research focusing on both noninvasive and invasive technologies. Broadly speaking, neural interfaces fulfill two important purposes: improving brain access for people with neurological damage like paralysis, and augmenting the natural human brain function by connecting directly to a computer. Today, there are a few technologies that can help people who have suffered paralysis or a stroke to "type with their mind" and control external machines. Neural interfaces take this interaction to next level.

Research is being done today to develop 1) systems that can analyze brain waves and use AI to predict epileptic seizures; 2) parallel neural interfaces that can decode brain information in real time; and 3) chips that can "mimic, repair, and improve" human cognition using AI. If commercialized, some of these applications will have a long-lasting impact across industries like healthcare (where surgeons can get real-time feedback as they operate), as well as education, gaming, and market research (where engagement can be measured in real time).

Years of research have led to treatments like cochlear implants for hearing loss and retinal implants to restore eyesight. Recent advances in AI and new technological developments in chronic neural recording devices have enabled willful control of robotic prosthetic limbs used by people with paralysis. These developments are driving the industry toward an inflection point for commercialization, in our view.

Despite the huge potential, neural interfaces face many limitations. Besides the challenges posed by implanting electronic devices, other ethical, computational, and engineering-related issues need to be addressed. While noninvasive technologies

Neural interfaces should be a reality soon

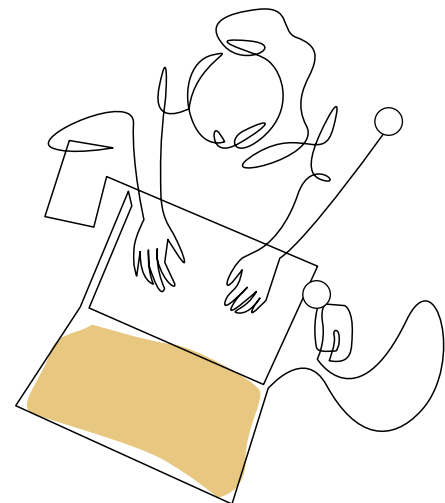


Yesterday	Today	Tomorrow
Poor understanding of neurological anatomy	Mastery of general neurological anatomy, limited understanding of details	Two-way communication between brain and machine becomes routine
Lack of neuromonitoring tools with which to record brain activity	Able to geo-locate diseased areas of the brain and repair with implanted devices	Software replaces drugs in the treatment of neurological diseases such as epilepsy
No ability to associate disease with specific parts of the brain	Beginning to extend the nervous system's reach beyond the body	Computers become extension of the mind

Source: CB Insights, UBS

provide some basic details, they lack the spatial resolution required to record truly detailed activity and are mostly restricted to low-bandwidth interfaces. While progress is being made with regard to surgeries and implanting devices, the longevity of devices is an issue.

As with any other technological development, these challenges can (and will, in our view) be overcome with time. We are still a long way from the Defense Advanced Research Projects Agency's ambitious target of simultaneously recording 106 neurons (or one million; for comparison, the human brain has 86 billion neurons). But with governments and companies investing heavily, and with significant progress being made in technologies like AI, we are hopeful that by end of this decade neural interfaces will become a mainstream technology.



The batteries powering the future

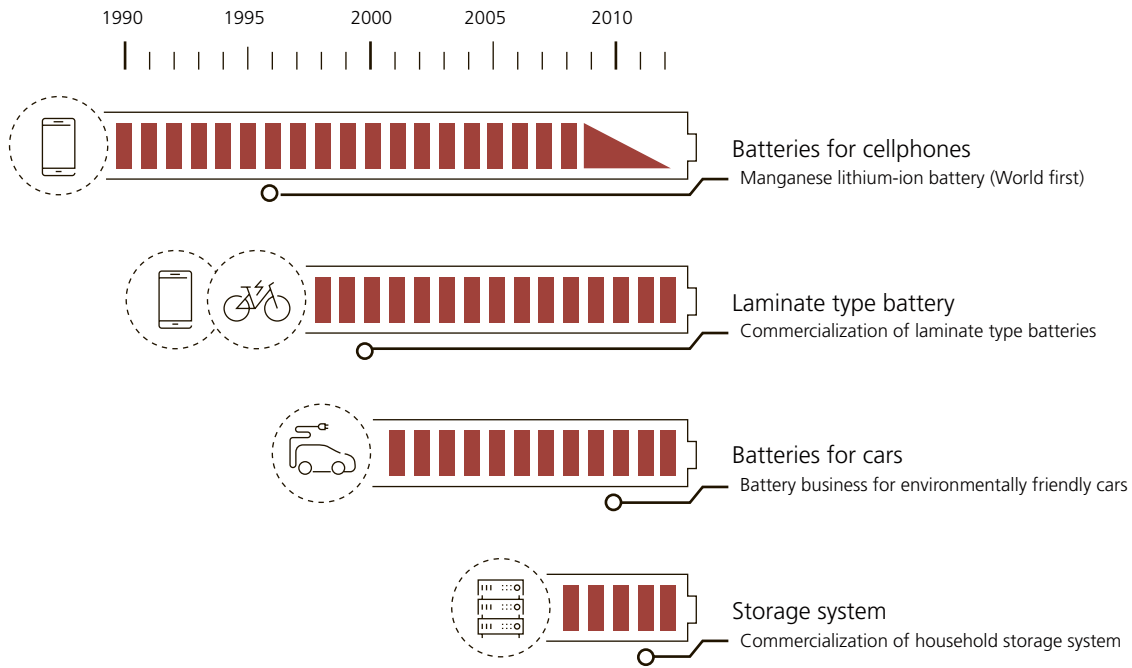
- Solid-state batteries can pack up to 50%–60% more energy into the same volume than lithium batteries.
- They can revolutionize the way electric vehicles, smartphones storage systems, and other consumer electronics are powered.
- While they are expensive and complicated to make, we think these obstacles will be overcome in the years ahead.

Significant progress has been made in battery technology over the past few decades. Yet lithium-based batteries still power the bulk of end applications today. Mirroring the discussion

above on traditional versus quantum computing, while lithium-based batteries will remain dominant in the near term, the future may belong to solid-state batteries.

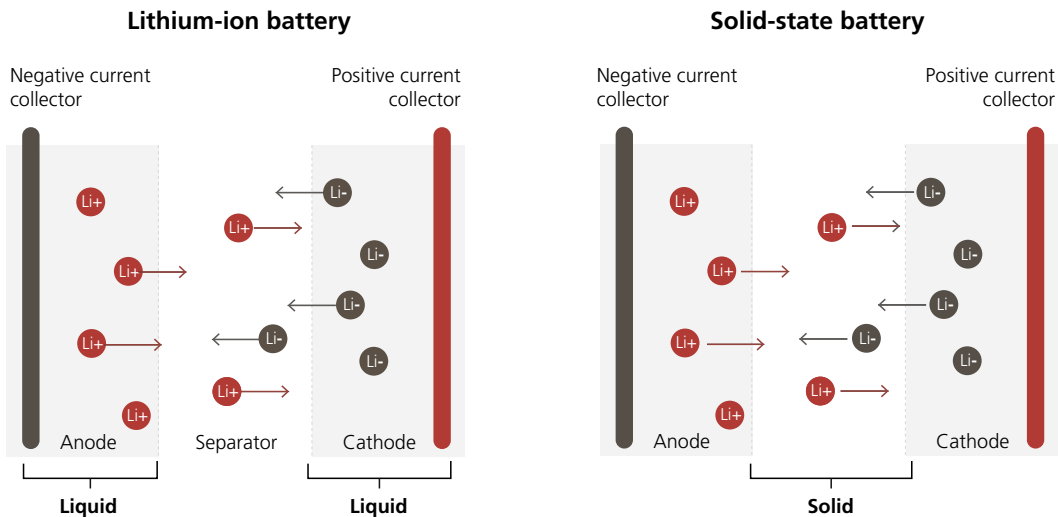
The “solid” in solid-state refers to the electrolyte – i.e., the substance between the terminals of a battery through which charged ions flow. In standard lithium-ion batteries, the electrolyte is a liquid, whereas in solid-state batteries, it's replaced with solid materials like lithium metal. Liquid-based batteries can leak or catch fire, but solid-state batteries are less likely to do so because they don't require separators, which eliminate the risk of damaged separators causing short circuits – a distinct advantage.

Evolution of lithium-ion battery applications during the past few decades



Source: NEC, Bloomberg Intelligence, UBS

Comparison between traditional and solid state batteries



Source: UBS

The concept of solid-state batteries is not new – they’ve been used in devices like pacemakers since the 1970s – but the idea of using these batteries in larger applications like electric vehicles and other consumer electronics is gaining traction. Japanese and European auto companies are currently leading the efforts, with Korean and other electronics makers jumping on the bandwagon.

In addition to reducing fire risk, solid electrolytes allow the anode, one of the battery’s two terminals, to be made of lithium metal instead of the graphite that is widely used today. Since lithium metal can hold more electrons than graphite, solid-state batteries can pack up to 50%–60% more energy into the same volume. Based on both gravimetric (watt hours/kg or Wh/kg) and volumetric (watt hours/liter or Wh/L) data, solid-state batteries promise superior energy density. Sulfide-based solid electrolytes can also significantly reduce charging times.

Despite their long-term promise, solid-state batteries have some limitations. They are expensive to manufacture today because the production process is relatively new and very complex. That said, we expect initial teething problems to be resolved in time,

Energy density by battery chemistry

Battery chemistry	Wh/kg	Wh/L
Lead Acid	50	100
Nickel	100–150	200–300
Lithium (ion/sulphur)	250–350	400–800
Solid-state	400–500	1,000–1,200

Source: Company reports, UBS

While solid-state batteries may be the future, we should not ignore the advances being made in current battery technology. Substantial investment in battery capacity will more than double global battery capacity by 2021 from 2017 levels. And with upcoming battery-electric vehicle launches scheduled from all the major global automotive players, more investment in capacity is on the way. Moreover, improvement in battery cell chemistry should help increase the energy density of batteries and reduce their size and cost. The combination of better and cheaper batteries should support the auto industry’s electrification trend and, therefore, the battery value chain. The extended life of batteries and technological advances should also make recycling less problematic for the industry.

and companies are working to address other challenges like the chemical reactions of solid-state batteries. Assuming most hurdles are cleared over the next 5–10 years, solid-state batteries can revolutionize the way electric vehicles, smartphones storage systems, and other consumer electronics are powered.

Fuel cells – a new kind of gas in the tank

- Fuel cells produce the cleanest emission – pure water – and can be recharged in a few minutes.
- But they are expensive to produce and infrastructure is lacking.
- Fuel cells hold promise, and will likely achieve cost parity with BEVs in commercial applications and passenger vehicles by 2030.

Although fuel cells have often been praised for their many advantages, predictions of major breakthroughs in their mass application have so far proven broadly premature. But we think that the search for sustainable sources of energy should give fuel cells a new lease on life.

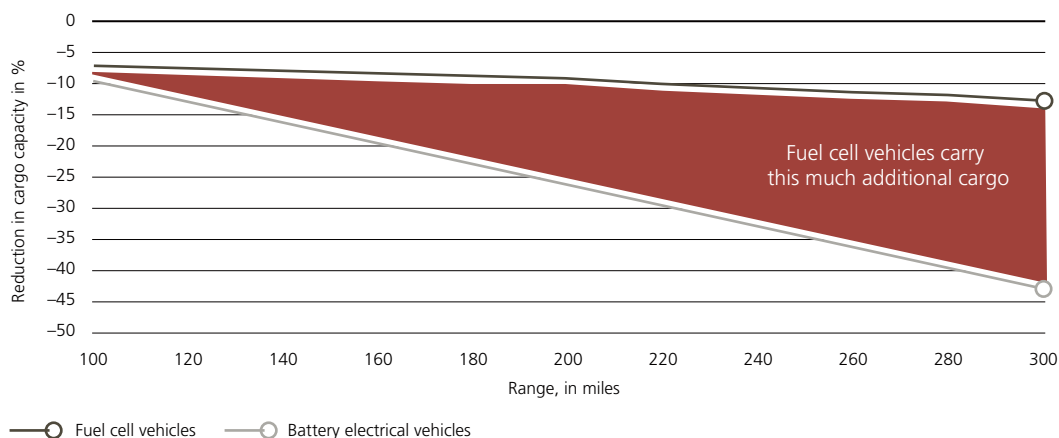
Fuel cells provide electric energy just like a battery does. But unlike a battery, which needs to be charged externally, a fuel cell requires an ongoing external supply of “fuel” to function. This fuel would typically be hydrogen and oxygen, which via their chemical reaction releases a current.

As in the case of battery technology, environmental considerations are an issue. Hydrogen cells produce the cleanest emission – pure water. However, the currently substantial use of fossil fuels to produce the hydrogen still stands in the way of fuel cells being a truly clean technology. But if renewable energy is used, fuel cells can operate at virtually zero carbon emissions.

The use of fuel cells can be both stationary (e.g., for power generation and backup purposes) and mobile. Smaller movable applications include mobile phones and laptops. In recent years there have been trial runs in many areas such as small airplanes, ships, trains, and passenger and commercial vehicles. As we expect fuel cell technology to become competitive the soonest in road vehicles, we will focus on this area.

An advantage that fuel cells have over battery electric vehicles (BEVs) is refueling time, which is similar to combustion engines. Consumer giants Amazon and Walmart, as well as BMW, for example, are using fuel cell fork lifters, a source of huge savings since lead batteries take around 10 times longer to recharge (fuel cells take two minutes).

Fuel cell vehicles offer more cargo capacity than battery electric vehicles as the range increases



Source: Company presentation Plug Power

Nevertheless, fuel cell electric vehicles (FCEVs) are unlikely to take over as the primary choice for residential vehicle use for many years. Their benefits generally come into play for fleet operations, especially when longer ranges are required (typically north of 150km per day) and the payload is high. Batteries for trucks, for instance, have the drawback that they can easily weigh tons and occupy a large amount of space.

Refueling infrastructure is another challenge. At this stage no extended network of stations is available. Due to the high pressure required to handle hydrogen, the safety requirements and costs to fuel up are higher than those associated with gasoline stations. Higher pressure also means the (carbon fiber) tank and pipes of a car are currently more expensive to build, particularly with volumes still low.

Cost competitiveness remains another obstacle. Fuel cells do not scale as well as batteries, partly because the commodities used to make them are expensive and not produced at scale. For example, until 2010, car fuel cells used to have 200 grams

of white gold built in, which made it impossible to produce in large numbers. That amount has since fallen to 6–8 grams per vehicle, which is about on par with combustion-engine cars, but batteries do not use any, making them easier to produce. To boost volumes and enable commercial feasibility, government support is crucial in the early stages. China, for instance, initially subsidized both BEVs and FCEVs. It has since lowered BEV subsidies by up to 70%, but Beijing still wants to help FCEVs to take off, since it continues to believe in the technology.

The governments of South Korea and Japan are also banking on a fuel cell future. The EU’s focus is less clear at this stage, but, given its CO₂ neutrality objective, it will likely consider several support measures as well. More broadly, 18 countries (including the US) that account for 70% of global GDP have signed up to develop hydrogen strategies.

Fuel cell technology holds promise, and will likely cost parity with BEVs in commercial applications (including busses) and with passenger vehicles by 2025–2030 and 2030, respectively.

Summary

Still nascent but potentially groundbreaking technologies offer glimpses into the future tech economy. Some of the more promising moonshots include quantum computing, neural interfaces, solid-state batteries, and fuel cells.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled ‘Future of the Tech Economy – How to invest’ provides suggestions for investors who wish to pick single stocks.

How to invest

Plant some seeds now to get in early on possibly transformative technologies.

Will the future bring alternative fuel sources?

Read more www.ubs.com/cio



The pros and cons of combustion engines, battery and fuel cell vehicles now and in 10 years

Selected parameters that determine cost and convenience

	ICE		BEV		FCE	
	2020	2030	2020	2030	2020	2030
Cost of fuel	~1.20 (gasoline: EUR/liter)	Relatively sticky due to taxation of gasoline end-price; potentially downward on declining demand	~EUR 0.30 per kWh private charging	Higher than today possible from mounting demand	USD ~10 per kg incl. distribution	USD 4.5–6 per kg
Energy density	~13KWh/kg	Unchanged	Energy density of Tesla Model 3 cell at ~17 watt hours; or 246 watt hours/kg; +4% improvement vs. Chevy Bolt EV	Growing energy density of battery cells significant contributor to range / performance	~34KWh/kg, i.e. higher than ICE and battery of a BEV	Unchanged but can be compressed further to hold in smaller tanks or more in a similar-sized tank (see below)
Cost of vehicle	GOLF (1.5TSI "Life", the cheapest version so far): Sticker price EUR 27,510	Mounting discounts for legacy technology: ~EUR 25,000	ID3 (low range version): Sticker price EUR 29,900	Large-scale EV production to significantly reduce prices: ~EUR 25,000	70–100% above BEV due to limited scale effects currently. E.g. Toyota Mirai at ~EUR 50,000	Potential 55% reduction if >600,000 volumes can be produced; up to 65% for CVs if >150,000 are produced
Range	700–850km on average	750–950km average on further ICE optimization and weight efficiencies	300–450km in budget segment; 450–550km in premium; >550km luxury	>600km range on average across segments a realistic scenario	400–600km on 4–6 kg of hydrogen in a tank	Hydrogen compressed to 700 bar can yield 70% higher density, and if liquefied another 90%; i.e. range could potentially multiply
Time to refuel	5 min	5 min	Tesla Model Y 50 mins (4–500km) or 80% in 30 mins on super charge	<10 mins for 80% of charging	Hyundai Nexo 8 mins for 6kg / 600km	Unlikely to decrease dramatically since it is already low
Refueling station cost and density	To build 100,000 stations; large countries like the US and China have close to 100,000 stations	Declining from 2020, in DMs the trend has been falling since a number of years	~5mn charging points today (50% in the US, 25% in the EU and 25% China)	~42mn charging points globally expected fairly distributed among top 3 regions	>USD 2mn to build stations, estimates vary but global number likely close to 1,000	At least 10,000 stations globally targeted by leading global governments, likely to be exceeded
Driveability / other considerations	Last rounds of ICE powertrain investments leading to efficiency to improvements	Absence of ICE investments, i.e. no significant efficiency improvements likely	Initial ramp-up of large-scale production of new EVs successful, further improvements expected with EV adoption growing	Significant technology improvements through high-scale EV investments	Low noise driving but lacks comparable power and torque, especially at higher speeds; limited industry investments at scale to limit efficiency improvements	As fuel cell stacks get smaller, performance parameters can be improved

Source: Industry data, Hydrogen Council, UBS

Interview with BMW

This statement contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the statement does not fully reflect the views of CIO GWM.

The internal combustion engine has been declared dead more than once in the past. What is your sense? When will we really see this type of power train disappear for passenger and heavy commercial vehicles?

E-mobility continues to gain ground. However, the conventional engine remains the best drive-train choice for a lot of people's mobility needs in many regions of the world. That is why it makes a lot of sense to continue improving combustion engines' efficiency.

What will lead to the discontinuation of the combustion engine? Will it be regulation, cost or consumer demand?

We are convinced that different drive technologies will coexist alongside one another into the long term. Customers will always decide for themselves what is right for their needs, naturally based within a given political framework. The new targets set by legislators in Europe mean that the share of electrified vehicles must increase significantly in the coming years.

Some pundits argue battery-powered electric vehicles are the future, while others believe fuel cell technology could be even bigger. You engage in both. What is your strategic rationale?

Although we have no doubt as to the long-term potential of fuel cell powertrain systems, it will be some time before we produce a car in series production powered by hydrogen fuel cell technology. In our view, hydrogen as an energy carrier must first be produced in sufficient quantities at a competitive price using green electricity. Hydrogen will then be used primarily in applications that cannot be directly electrified, such as long-distance heavy duty transport. The requisite infrastructure, such as an

extensive, Europe-wide network of hydrogen filling stations, is also lacking at present. We are using the time until the infrastructure and sustainably produced hydrogen supply are in place to substantially reduce the cost of manufacturing the powertrain system.

What are the nuances when distinguishing between passenger cars and commercial and heavy vehicles? Could the mainstream and luxury passenger car segments take different powertrain approaches?

Fuel cell technology might be used in a first step primarily in long-distance heavy duty transport. It could become the fourth pillar of our powertrain portfolio in the long term (next to PHEVs, BEVs and ICEs). As mentioned above, the technology is still very expensive and the infrastructure for (green) hydrogen is still not developed. Both factors might limit an early adoption of this technology in the mainstream passenger car segment.

Being a Europe-based global brand, do you need to consider different levels of readiness and government support in different regions?

Customers' mobility demands vary increasingly between different regions of the world and different countries, and between urban and rural areas. Furthermore, politicians worldwide go in different directions regarding climate change, CO2 emissions targets, and support for emission-free vehicles and infrastructure.

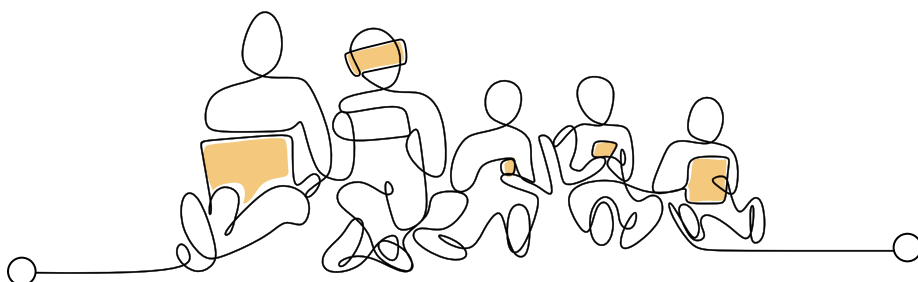
Do you believe that the two technologies could even co-exist in the future, or can only one prevail?

We are convinced that various alternative powertrain systems will exist alongside one another in the future, as there is no single solution that addresses the full spectrum of customers' mobility requirements worldwide.

The technologies shaping society



Artificial intelligence, 3D printing, drones, and other high-tech fields are gaining momentum and starting to make their way into our everyday lives. These technologies offer us a glimpse into the future, and how our society may look a decade from now.



Artificial intelligence is arriving

- After a long wait, AI is about to realize its potential.
- Its initial beneficiaries will be the companies that provide the technologies and products that underpin it.

Widely regarded as one of the fathers of theoretical computer science and artificial intelligence, the UK's Alan Turing first described AI in his 1951 paper "Computing Machinery and Intelligence" as "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." More practically, we think of AI as a set of tools and programs that makes software "smart" enough that an outside observer would think its output is generated by a human.

Almost seven decades after Turing's paper was published, AI is finally about to realize its potential thanks to the huge strides made in computing power, storage, networking, and software platforms. In the longer term, AI will likely function as a broad horizontal technology platform with the capacity to fundamentally change how many industries operate. Its initial beneficiaries will be the companies that provide the technologies and products that underpin it.

AI is typically used as a blanket term to describe what are actually three very different forms of the technology: narrow AI, artificial general intelligence (AGI), and artificial super intelligence (ASI). Each form has very different applications, effects, and adoption timelines. Similarly, many equate machine learning, neural nets, and deep learning with AI, while they are actually individual technologies and techniques among other AI components. Finally, AI is not a panacea that solves problems autonomously, but instead requires significant human guidance in terms of designing, implementing, and directing component systems.

The AI effect – the world is changing (but we don't realize it)

- The "AI effect" describes a phenomenon whereby the public fails to perceive the influence of AI in applications once they become commonplace.
- While there is some anxiety about AI today, it will likely become more accepted as it becomes more integrated in society.

Unlike the printing press, the steam engine, and the automobile, today's most disruptive technologies – AI, automation, robotics, and machine learning – are, for the most part, invisible to the human eye. The enigmatic nature of these advances makes them difficult for the public to fully fathom or embrace. In fact, in a recent survey by the Center for the Governance of AI, less than half of Americans (41%) somewhat or strongly supported the development of AI. The rest were neutral (28%), opposed to it (22%), or weren't sure (10%).¹

Fearing the unfamiliar is nothing new. Consider the mass hysteria that ensued when the first motor vehicles were introduced. A look at old newspaper clippings traces the gradual evolution from the initial terror at the sight of the first horseless carriages in 1894, to ethical considerations around the displacement of the horse and the military usage of automobiles, to public enthusiasm and acceptance in the 1920s as the motor vehicle industry created jobs and transformed daily life. Given the unprecedented disruptive power of these new technologies, we can expect that the ethical considerations and potential societal ramifications will be only amplified.

¹ Zhang, Baobao, Dafoe, Allan. Artificial Intelligence: American Attitudes and Trends. Center for Governance of AI at University of Oxford. January 2019.

Over time, greater familiarity with and understanding of these technologies will likely reshape public attitudes. The “AI effect” describes a phenomenon whereby the public fails to perceive the influence of AI in applications once they become commonplace.² For example, 85% of Americans use AI-powered devices like smartphones every day, but, given the frequency and familiarity of these interactions, they don’t realize that their device usage involves an abundance of AI (e.g., social media apps, maps navigation, web search). Instead, consumers are more cognizant of the influence of these technologies in more futuristic applications like social robots and driverless cars.¹ As these technologies become more integrated into daily life, we will likely see greater acceptance of a larger number of applications.

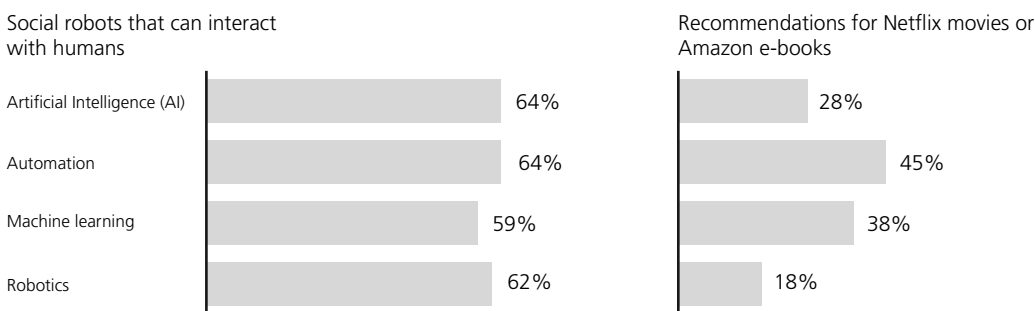
While familiarity is likely to gradually increase over time, comprehension will be a greater hurdle. This is the first time in history that we have emerging technologies that are not always fully understood by their creators, sparking fears that run the gamut from job losses to robot dominion. But these worries are outweighed by the numerous potential positive effects these technologies offer, ranging from greater energy efficiency to improved access to affordable healthcare. However,

our anxiety reflects the inherent risks associated with relying on technologies whose potential powers and repercussions are not yet fully grasped. Within the healthcare field, for example, until we get to the point where we understand exactly how AI-based software arrives at its conclusion for diagnosing and treating an illness, we still need to depend on the opinion and expertise of medical professionals. A similar line of thought applies to a vast range of applications, from driverless cars to financial transactions.

While the transition to autonomous vehicles is well underway, the most advanced applications of AI that tend to garner skepticism – otherwise known as artificial super intelligence – have not yet been realized. Reaping the fruits of AGI has already taken several decades, and achieving ASI is an even more difficult feat. According to a report by the Center for Governance of AI, 54% of survey respondents (American adults age 18+) predicted high-level machine intelligence would likely arrive within the next decade.¹ While estimates vary, this result seemingly contradicts the view of most experts. Several studies show those in the computer science field expect the transformation to take much longer. In our view, the transition to ASI will likely begin closer to 2050.

The influence of technology often goes unnoticed in very familiar tasks vs. “futuristic” applications

Percentage of respondents who selected the term



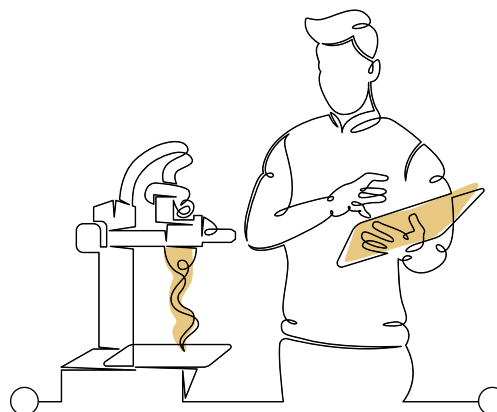
Source: Center of Governance of AI at University of Oxford, Artificial Intelligence: American Attitudes and Trends, as of January 2019

1 Zhang, Baobao, Dafoe, Allan. Artificial Intelligence: American Attitudes and Trends. Center for Governance of AI at University of Oxford. January 2019.

2 McCorduck, Pamela. Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence. 2004.

Will 3D printing and drones take flight?

- Over the coming years, we expect the 3D printing industry to grow by a low-teen annual rate and the drone market to grow by a high-teen rate.
- Further upside for drones may come once safety and other regulatory issues are addressed.



3D printing remains a niche opportunity...

The COVID-19 pandemic and the subsequent increased emphasis on local manufacturing are putting the focus back on 3D printing. Industry pundits had great hopes for 3D printing, or additive manufacturing, over the past decade, but adoption has been slow. Costs and the inability to scale up have been the reasons most often cited to account for the technology’s lukewarm reception. Other factors include increased complexity and the lack of standardization given the multitude (almost seven) of different 3D printing techniques available. In the near term, we anticipate opportunities for 3D printers in businesses requiring rapid prototyping and high customization with small production quantities, rather than in mass production applications. We expect the industry’s revenues to grow by a low-teen annual rate in the coming years, from around USD 10.9bn in 2019.

...whereas drones can fly higher for longer

Drones, which were initially restricted to military applications, have slowly expanded to personal use and are now literally taking off for commercial purposes. Drones are operated remotely or autonomously and generally carry a video camera to monitor flight. Although drone development is still in its infancy, the devices are already being used across industries such as manufacturing, utilities, agriculture, movies, and gov-

ernment organizations – and at a fraction of the cost of a manned aircraft.

E-commerce and logistics companies are also beginning to experiment with drone technology, with Amazon anticipating a future in which unmanned aircraft will eclipse general air traffic. Throughout the pandemic, drones have proven critical to the delivery of essential goods in key urban centers globally. Thanks to their autonomous features, drones could be a new tool for industrial automation. Among other applications, they can be used for aerial inspection surveying, particularly in the oil, gas, and mineral exploration and production industries, or for short cargo transport within the factory line, resulting in significant cost savings.

Agriculture is another promising industry where drones can be widely used to survey crops and spot irrigation problems, for example. With adoption increasing both for several industries and for personal use, we expect the global drone market to grow by 15%–20% over the coming years. To realize further upside, safety and other regulatory issues first need to be addressed given the rise in use cases. Many governments across the world are in the process of setting up regulations on safety and privacy.

Multiple 3D printing techniques in the market today

Process name	Description
Binder jetting	A liquid bonding agent is selectively deposited to join powder materials
Directed energy deposition	Focused thermal energy, such as a laser, is used to fuse materials to form an object by melting as the materials are being deposited
Material extrusion	Materials are heated and selectively dispensed through a nozzle or orifice
Material jetting	Materials, such as photopolymers or wax are selectively deposited
Powder bed fusion	Thermal energy selectively fuses regions of a powder bed
Vat photopolymerization	Certain types of light, such as lasers, are used to selectively solidify liquid photopolymers
Sheet lamination	Sheets of materials are bonded to form an object

Source: U.S. Government Accountability Office, Bloomberg Intelligence, UBS

Life beyond the big platforms

- Big tech platforms dominate tech, but we see potential opportunities in the mid-cap space.
- Cloud-based mid-cap software companies can offer strong margin upside over the long run.
- We think investors will be best rewarded with a core-satellite investment approach between big and mid-cap tech.

Technology has rewarded investors handsomely over the past decade, with the tech sector significantly outperforming the broader equity market. A few big platform companies, in particular, have generated outsized returns. The question is whether investors should pay attention only to the dominant tech platforms in the decade ahead, or if a new world order will emerge.

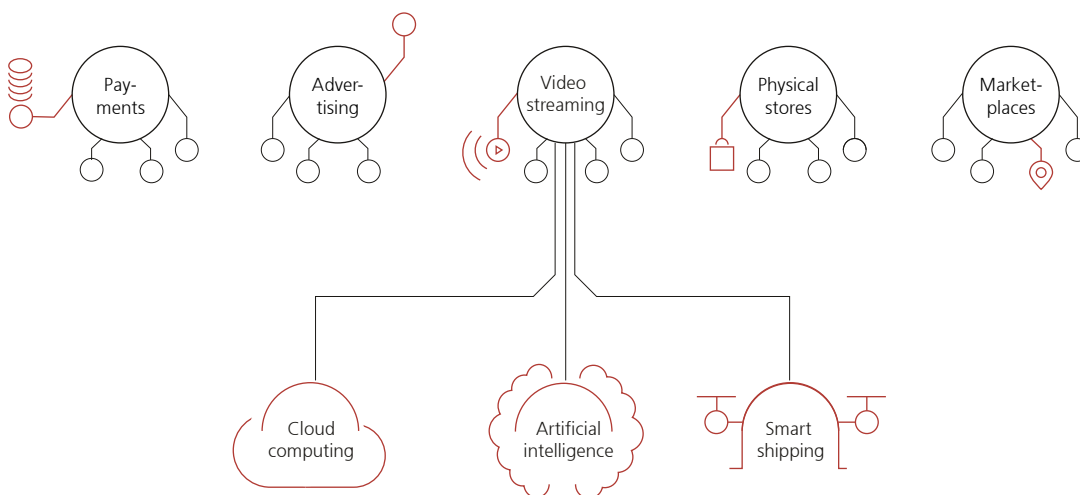
For consumers, it's difficult to imagine life beyond the big tech platforms – Amazon, Alibaba, Alphabet, Apple, Microsoft, Facebook – as they touch nearly every aspect of our lives. Thanks to their millions, and in some cases billions, of users around the world, platform companies are able to capitalize on network effects by launching successful businesses in various industries.



Tech platform companies are riding the waves of surging network effects to generate solid growth, and investors are rewarding them accordingly. These leviathans of tech have become benchmark heavyweights, and their share prices often drive the overall performance of the market, with the top five platforms constituting more than 20% of the S&P 500 (as of April 2020). In addition to replacing the older giants at the top of the (benchmark index) totem pole, these platforms have also significantly outperformed their smaller peers in the technology space.

The top two companies in the six tech industries (i.e., tech hardware, software, IT services, semiconductors, e-commerce, digital media) currently have a market cap weight of around 56% on average; the rest is shared among hundreds of other companies. This means most investors are concentrating on the leading tech platforms and largely ignoring the hundreds of other innovative companies in the mid-cap space.

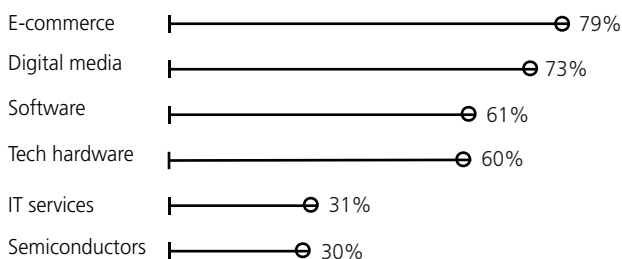
With multiple businesses, big tech platforms are capitalizing on the benefits of network effects



Source: UBS

Top two firms in each tech industry have disproportionate weights in market indices

In % of market cap



Source: Bloomberg, UBS, as of April 2020

These mid-cap tech companies (mostly in the software and digital media industries) often have revenue growth and cash flow generation in line with the big platform companies, but with greater potential earnings growth due to margin expansion. In particular, thanks to their recurring revenue base and expanding cross-selling opportunities, cloud-based mid-cap software companies can offer strong margin upside over the long run.

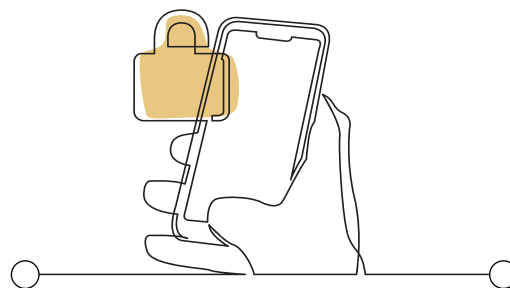
But this doesn't mean that we are cautious on the leading platform companies. On the contrary, we expect them to continue generating double-digit earnings growth rates in the decade ahead. Their swelling scale should boost margins, as well. Our confidence is based on our view that, unlike the industry leaders of the 1980s and 1990s, today's platform leaders will keep their top spots in the future thanks to high recurring revenue models and growing network effects.

The latter is especially integral for long-term success in tech given the industry's rapidly changing nature, and leading firms are already spending big on expansion. For instance, in 2018, the top American tech companies spent USD 104bn in R&D, significantly more than those in other sectors and their smaller tech peers. Stricter governmental regulations are an increasing risk we need to monitor, but they shouldn't materially alter these companies' monetization models.

That said, there's plenty of opportunity to go around, and investing in technology is not only about the leading tech platforms – such a myopic approach would ignore the many interesting companies in the mid-cap space. And the unlisted seg-

ment is worthy of consideration, too. Worldwide there are almost 400 unicorns, or privately held companies with a valuation of more than USD 1bn, with promising disruption potential, according to CB Insights.

We think investors will be best rewarded with a core-satellite investment approach in technology: Leading tech platforms form the core, and prospective opportunities in mid-cap software or digital media companies, both listed and unlisted, the satellite.



Mind the cybersecurity risks

- Globally, cybersecurity incidents are rising by 20%–30% every year.
- Security is no longer merely a concern of IT managers, but a key boardroom topic.
- Investment in cybersecurity should continue to be robust in the years ahead, growing by high single digits over the next few years.

As more and more things become connected to the internet, from shoes to refrigerators, the number of internet users and the amount of sheer data generated are growing exponentially. Ericsson expects the number of IoT devices to rise from 10.8 billion units in 2019 to 24.9 billion in 2025. The downside is that this ubiquity of connectedness makes us more vulnerable to cybersecurity attacks.

In a recent global UBS Investor Survey, cybersecurity ranked as one of the top three concerns for investors and business owners. Globally, we believe cybersecurity incidents are rising by 20%–30% every year. And cybercrime has broader consequences than merely exposing the vulnerabilities of the affected party – it also damages trade, competitiveness, and innovation at the macro level.

UBS Y future research guest commentary by Markus Iofcea

Transitioning into the post-platform age

This statement contains views which originate from outside Chief Investment Office Global Wealth Management (CIO GWM). It is therefore possible that the statement does not fully reflect the views of CIO GWM.

Today's platforms make use of centralized intelligence to connect a potential buyer or interested party with a non-smart product (car, book, DVD, etc.) or service (banking offerings, insurance, movies -, music subscription, etc.).

A person voices their need on a platform, and that platform then facilitates the exchange by making use of the buyer's and seller's information so that the need can be satisfied.

Here's an example from today:

Joe is looking for a specific DVD but doesn't know who is offering it. A platform like eBay or Amazon can help by connecting Joe with potential sellers. Therefore, a great deal of power resides in the platform principle, and an abundance of smart computing is needed to optimize this ecosystem.

Tomorrow's game

With the advent of the fully connected world (through IoT, 5G, and the like), literally everything could be sensor enabled and therefore connected. There is no reason to believe that today's sensor-enabled goods (smartphones, home appliances, cars, etc.) will be the only things connected to the internet in the future. We can easily imagine that we will find sensors in our clothing, furniture, coffee cups, pens, floors, walls, etc. Everything can be connected to everything – and everyone – else. Welcome to the Trillion Sensor Economy!

This can ultimately lead to a scenario where we humans will be part of the net ourselves. Our needs and wishes will be legible to the network and accessible, potentially to everyone.

In addition to the trillions of sensors in the world, we could also observe an increase in the smartness of products and services themselves, independent of platforms. AI, cloud computing, and big data could combine to power this new generation of products and services. In this scenario, trillions of intelligent (and potentially autonomous) devices or participants in the network can now sense our needs and wishes directly. Intermediaries become wholly unnecessary. These products and services will not resemble the DVD that Joe was looking for or the banking offering of 2020, but rather will roam the global network and become fundamental pillars of the new economy. Our needs can now be sensed by the products and services directly, and it will be they who will serve the client of the future directly. Tomorrow's products and services will no longer just be smart (like smartphones or smart fridges), but something that includes those ideas and goes beyond – maybe one day becoming truly intelligent.

We are also starting to see a paradigm shift with regard to data ownership and data privacy (the General Data Protection Regulation in Europe and similar regulations worldwide are only the beginning). This does not necessarily pose a threat to heavily data-driven businesses, as many (maybe most of them) can transition and adhere to the concept of data translucency instead of transparency. This will solve a lot of the privacy issues we are facing today.

Bringing all of these trends together, it is not hard to imagine that many of the central platforms as we know them today could lose their relevance or positions of power in their current state of operations, and that many could potentially pivot to other offerings since they already hold such large amounts of data and economic clout.



Markus Iofcea joined UBS in 2007 and is a Future Archeologist and the founder of UBS Y Think Tank. The mandate of UBS Y Think Tank is to envision and develop future scenarios which cast a new light on decisions that need to be taken today. With a time horizon of 20–30 years from now, UBS Y Think Tank is exploring new challenges and opportunities in the 21st century.

Data will still stay relevant – not in the sense of who owns it, but rather who can access it barrier-free. The paradigm shift here would be access over ownership, with access ruling over most interactions of the future.

So what is the next big thing in the post-platform economy if platforms are no longer relevant in the form we know them in today? Intelligent autonomous products. Just-in-time, on-demand sensing products and services that match post-platform supply and user (consumer) demand like a lock and key. Let's return to the DVD example from the beginning. Future Joe is not used to searching for movies to watch anymore. In fact, searching for things generally is foreign to him. We need to imagine that the movie of the future will be an intelligent participant within the network itself. When Joe wants to watch a movie, the ideal movie for him in that moment will simply present itself in the most seamless, optimal way. The search is over. Simply perfect!

According to the Ponemon Institute, an organization dedicated to researching privacy and data security (among other topics), the average cost of a security breach remains high, with the average cost of breaches in the US as steep as USD 8.2mn. Cybercrime also has serious implications for employment; it can jeopardize new investment and, in turn, job creation. Cyber breaches are costing the global economy billions of dollars, with the total expense rising every year.

Despite the broad-based implications of these risks, many businesses are ill prepared to deal with them, as the rising number of threats indicates. Security is no longer merely a concern of IT managers, but a key boardroom topic. Businesses must recognize its strategic importance and beef up their security infrastructure to prevent breaches. Regulations like the US's National Institute of Standards and Technology framework and the EU Cybersecurity Act mandate minimum cybersecurity standards. Financial institutions, for example, face hefty fines if they do not comply. Interestingly, regulators themselves are increasing cybersecurity spending. Given the greater regulations on internet platforms, including the implementation of General Data Regulation Protection (GDPR) in Europe, spending on security is likely to remain a focus.

As a result, investment in cybersecurity should continue to be robust in the years ahead. Cybersecurity is also one of the most defensive segments within IT; spending on it has limited downside due to its strategic importance, and it should continue to grow at a high-single-digit rate in the next few years. With cloud penetration increasing, so have cloud-based security offerings as more organizations embrace hybrid cloud data storage solutions. While legacy cloud spending constitutes the bulk of today's cybersecurity expenditures, software-as-a-service and cloud offerings are gaining share within the security market.

Summary

Promising new tech areas like AI, 3D printing, drones, and cybersecurity are in the midst of becoming mainstream. Even the big IT platforms will need to adapt in the decade ahead.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled 'Future of the Tech Economy – How to invest' provides suggestions for investors who wish to pick single stocks.

Cybersecurity spending breakdown is increasingly moving to cloud

	2016	2019	2022E
Software as a service	12%	15%	17%
Traditional software	49%	47%	45%
Others (hardware and services)	39%	38%	38%

Source: IDC, Bloomberg Intelligence, UBS estimates

Average cost of security breaches

In USD million

Country	Cost
US	8.2
Germany	4.8
Canada	4.4
France	4.3
UK	3.9
Japan	3.8
South Korea	3.3
Turkey	1.9
India	1.8
Brazil	1.4

Source: Ponemon Institute (Cost of a Data Breach Report 2019)

How to invest

Select leaders in each of these spaces. Attractive opportunities can be found among mid-cap and big platform companies alike.

The tech economy and sustainable investing



Sustainability is a key tenet of the tech economy, whether the focus is on education, agriculture, automation, or energy. Investors can support this trend through sustainable investing strategies, which aim to achieve a positive environmental or social impact while delivering market-rate returns.

The tech economy and sustainable investing

- Technology enables the efficient use of resources, and that promotes transparency, education, and well-being.
- Private investors can channel capital toward achieving these goals, all while earning comparable returns.

Sustainable development has become a rising priority around the world. Until the onset of the coronavirus pandemic we had enjoyed a decade of largely uninterrupted economic growth, but some argue that it has enabled humanity to raise its standard of living only at the expense of future generations. Since 1971, the Global Footprint Network has marked the annual Earth Overshoot Day (the day when global demand for natural resources in a given year exceeds what Earth can regenerate in that year), and every year this day moves to an earlier date. Society is also increasingly concerned about human rights within globalized supply chains, universal access to affordable healthcare and education, and many other social issues.

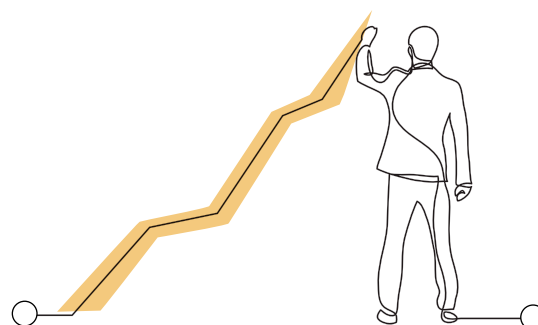
While technology has driven much of the global economic growth, it can also offer solutions for growing sustainably. Technology holds the power to transform industries, adapt business models, and ultimately further the prosperity of communities and regions. The key is the development of technologies that enable the efficient use of resources, and that promote transparency, education, and well-being. And companies and consumers must be encouraged to use these technologies responsibly.

Entrepreneurs, investors, researchers, and policymakers are all trying to identify the pivotal technologies. For instance, the Institute for Transformative Technologies, a leading international think tank, is working to identify the 50 breakthrough technologies that are essential to sustainable development.

Summary

Promising new tech areas like AI, 3D printing, drones, and cybersecurity are in the midst of becoming mainstream. Even the big IT platforms will need to adapt in the decade ahead.

For technology investments, investors should consider solutions across a variety of different technologies and trends, as well as countries and regions. In addition, our separate research document titled 'Future of the Tech Economy – How to invest' provides suggestions for investors who wish to pick single stocks.



They are assessing the ease of implementation, and also the potential investment attractiveness. Electricity storage technologies, renewable energy infrastructure, education technologies, digital agriculture, food technologies, and wearable healthcare devices are just a few examples of investments that deliver strong profits and bolster sustainable development.

Investors who channel capital toward such enabling technologies can benefit from economic growth and support sustainable development at the same time. Their portfolios can incorporate a number of investment strategies across asset classes including, for example, lending capital to a private company that captures carbon from soil or improves agricultural distribution via digital marketplaces for farmers, investing in renewable energy infrastructure as part of a diversified impact private equity fund, or buying stocks and bonds of public enterprises that develop the next generation of batteries and energy distribution networks.

In 2015, the United Nations launched the 2030 Agenda for Sustainable Development along with the 17 SDGs, each with an elaborate set of targets. While in the past the expectation was that financing development was the job of governments, it has quickly become apparent that if we want to achieve the SDGs, private capital has to be involved. Private investors, with their long-term horizon and personal values, are well positioned to bridge the financing gap that must be closed to achieve these goals – all while earning comparable returns.

How to invest

Select leaders in each of these spaces. Attractive opportunities can be found among mid-cap and big platform companies alike.

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