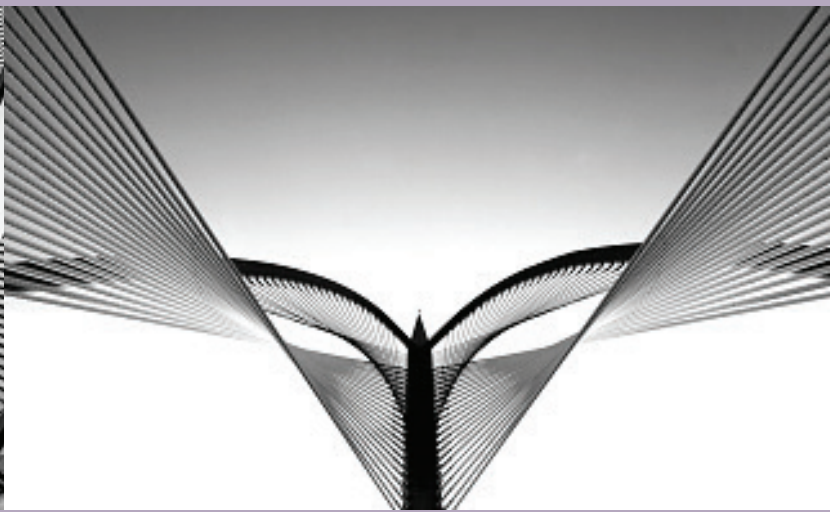


# Tomorrow's Technology

DAWN OF THE INTELLIGENCE REVOLUTION

AUGUST 2018





*“Change is the only constant in life.”*

*—Heraclitus*

## What's inside

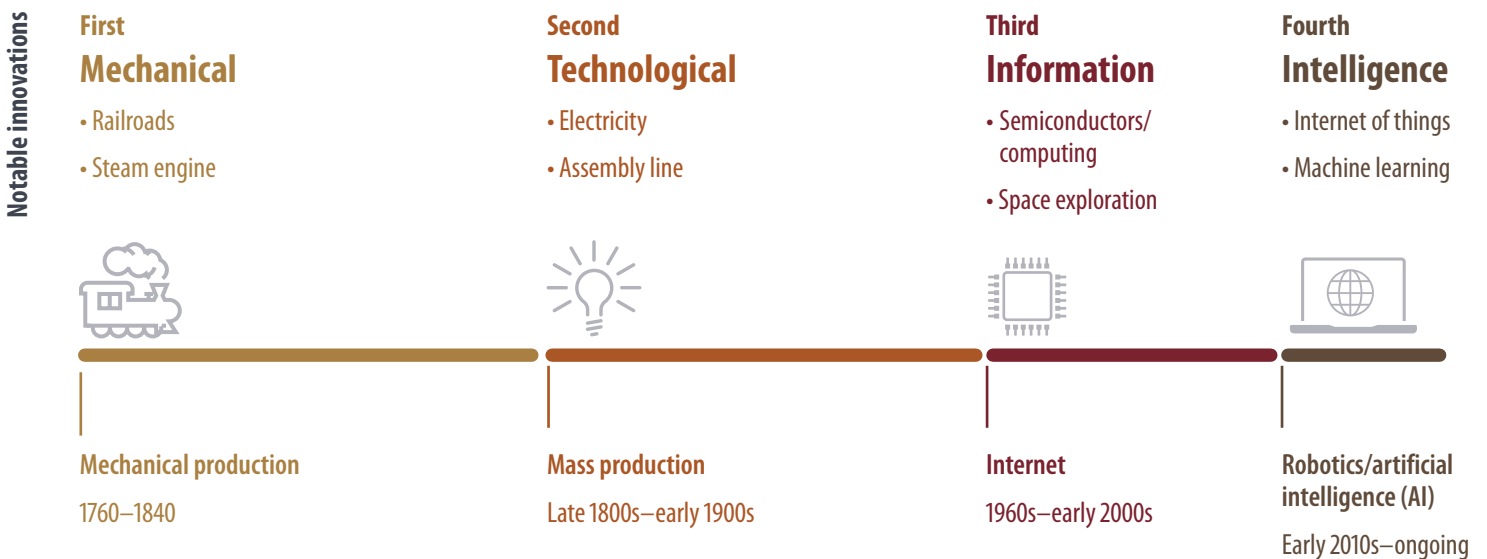
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# The shape of change

We believe that we are in a transition stage between the information and the intelligence revolutions. The beginning of a new revolution and the introduction of new technologies can provide tremendous growth opportunities for investors, but it can also bring great risks. In this report, we will explore the implications of the intelligence revolution for consumers and businesses. We also will outline four ways that investors can potentially benefit from these changes.

## Technical advancements across four industrial revolutions

The pace of technical advances ... quickens



**Sources:** Schwab, Klaus, *The Fourth Industrial Revolution*, New York, Crown Business, 2017, and Wells Fargo Investment Institute. In his book, Klaus Schwab identifies the fourth industrial revolution as being characterized by digital, physical, and biological systems. We are calling this the intelligence revolution.

## Key questions we answer in this report

What do we believe are the key drivers of the intelligence revolution?

How can transformative technology create value for investors?

How can the drivers of change create competitive advantages for businesses?

What do investors need to know about the opportunities and risks this transformation may bring?

# Welcome to the intelligence revolution

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## Data is currency

It is becoming increasingly important for companies to leverage digital data to build competitive advantages.

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## The scope of disruption

Today, we are likely on the cusp of an intelligence revolution that will be driven by technological advances such as AI, robotics, and machine learning. As with previous disruptions, changes likely will occur across several industries and potentially be so widespread that Klaus Schwab, founder and executive chairman of the World Economic Forum, calls it the “fourth industrial revolution.” We agree that we are at the dawn of a new revolution because it shares four important qualities with the three previous periods of U.S. industrial transformation: 1) innovative technology, 2) improved connectivity, 3) a responsive financial ecosystem, and 4) a better quality of life.

### 1 Innovative technology

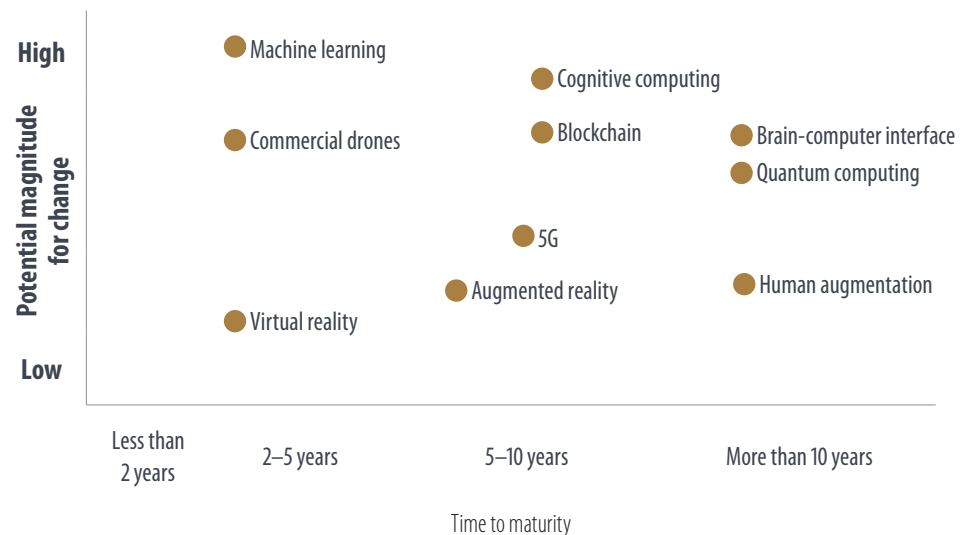
Inventions such as the railroad, the automobile, and the personal computer fundamentally changed the way people performed their daily activities. Inventions are often a product of the traditional research and development model that is followed by many organizations.

*Intelligence revolution disruption: Consumer technologies such as smart homes powered by AI and autonomous vehicles carry the promise of greater efficiency and reliability and improved user experiences.*

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## The timeline of potential disruption

We believe that a multitude of low- to high-impact technologies could significantly affect the market over the next decade or more.



Sources: Gartner, Inc., and Wells Fargo Investment Institute 2018. 5G = Fifth-generation wireless

## 2 Improved connectivity

Geographical distances were once a barrier to connectivity. That changed when the first communication satellite was launched into orbit in 1962, enabling the convenience of seamless communication. Today, people from all corners of the world communicate directly and immediately with a touch of their electronic devices.

*Intelligence revolution disruption: The explosion of digital data allows companies to build entirely new business models around communication platforms and gain competitive advantage by parsing real-time information about consumer behavior. For example, think of the growing gig economy, which was made possible by the location data and analytics in smartphone applications.*

## 3 Responsive financial ecosystem

Modern banking functions can be traced back to the 17th century, although the idea of lending capital in exchange for interest has existed since the beginning of human civilization. During the 20th century, developments in telecommunications and increased computing power brought major changes, such as the use of ATMs and round-the-clock access to online and mobile banking.

*Intelligence revolution disruption: The advent of blockchain and decentralized ledger technology has already resulted in cryptocurrencies, or digital currencies, such as bitcoin. Further disruptions likely lie ahead, such as the ability to verify real estate transactions without the use of a trusted intermediary.*

## 4 Better quality of life

Life expectancy continues to rise in many countries as technological advancements provide easier access to clean water, food, shelter, and health care.

*Intelligence revolution disruption: Advances in neurotechnology should aid in visualizing, improving, and repairing brain functionality. Cutting-edge technology is delivering high-frequency stimulation to sensory nerves in the peripheral nervous system to block chronic pain—including postsurgical pain and migraines. Scientists also are collecting and analyzing large data sets (big data) to determine an individual patient's prognosis and guide the use of prescription drug therapies and medical treatments.*

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### Gig economy

A labor market with a prevalence of short-term contracts or freelance work instead of permanent jobs.

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### Share of disposable income spent on food in the U.S.

|      |       |       |
|------|-------|-------|
| 1960 | ..... | 17.5% |
| 2016 | ..... | 6.3%  |

This decline was largely attributed to agricultural innovations such as advances in agricultural machinery and precision irrigation.

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Source: U.S. Department of Agriculture Economic Research Service, July 1, 2018

## The four main drivers of change

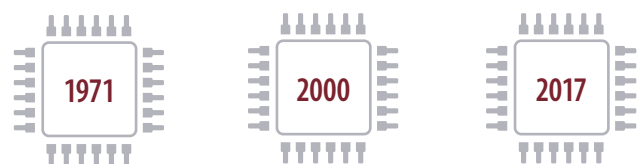
Technological advancements and innovations have disrupted long-standing businesses models, often allowing new businesses to gain competitive advantage over entrenched businesses. Entrepreneurs have employed the new technologies and inventions to create new businesses, effectively changing the composition of financial markets and sources of investor returns. Looking ahead at emerging technologies, we see several drivers of change. These include advances in: 1) computing power, 2) robotics, 3) decentralized ledgers, and 4) AI and machine learning.

### 1 Computing power

The density of an integrated circuit determines its computing power—the greater the number of transistors that can fit onto a chip, the greater its processing muscle. Moore’s law is the observation that the number of transistors in a dense integrated circuit doubles about every two years. Yet, Moore’s law is subject to physical limitations. Gordon Moore, who envisioned Moore’s law, theorizes that “we should soon reach truly fundamental limits.”<sup>1</sup>

### Reaching the limits of Moore’s law?

Innovation in production techniques shrunk the gap between transistors from 10,000 nanometers (billionths of a meter) in the 1970s to near 10 nanometers in late 2017. Given that the size of a silicon atom is around 0.3 nanometers, we appear to be approaching hard limits.



|                                |                   |                |               |
|--------------------------------|-------------------|----------------|---------------|
| <b>Transistors per chip</b>    | 2,200             | 37 million     | 10 billion    |
| <b>Gap between transistors</b> | 10,000 nanometers | 180 nanometers | 10 nanometers |

Sources: *Our World in Data*, Karl Rupp, GitHub, and Simonite, Tom, “Moore’s Law is Dead. Now What?,” *MIT Technology Review*

One centimeter = 10,000,000 nanometers

1. “Moore’s Law: The Life of Gordon Moore, Silicon Valley’s Quiet Revolutionary” - Arnold Thackray, David Brock, Rachel Jones

The demand for computing power will not ease. Improved processing speed can optimize automated-vehicle routes or allow biotechnology firms to analyze data stored in the world gene bank more quickly. Consumers also could benefit from more seamless connectivity on their mobile devices or more realistic simulated virtual reality and augmented reality experiences. As a result, industry practitioners are introducing new materials and 3D chips in an attempt to break the theoretical limits of computing speed.

### The future of computing power

| Optical   | Quantum   | Biological   |
|---|---|--|
| Uses photons produced by lasers or diodes as a basic unit for computation instead of electrons used in conventional computers | Uses basic units that do not have to be in definite binary states (0 or 1), unlike the current digital computing system | Uses systems of biologically derived molecules—such as DNA and proteins—to perform computations involving storing, retrieving, and processing data |
| Why it's a breakthrough   |   |  |
| Theoretical benefits include more bandwidth and less heat generation than traditional semiconductors                          | Significantly greater computing speed   | Provides a link between information technology and biotechnology   |

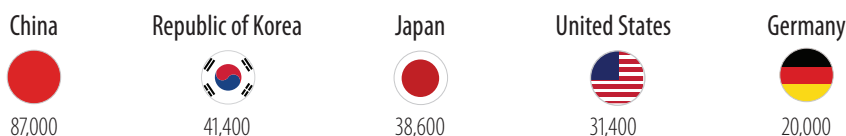
**Source:** DNA computing, retrieved from <https://cs.stanford.edu/people/eroberts/courses/soco/projects/dna-computing/index.htm>, and Wells Fargo Investment Institute

## 2 Robotics

The automatic machines of the 19th century were the first industrial robots. We have long had robots that could detect physical flaws by using elaborate statistical formulas. However, today's robots are so sophisticated that they can gather and understand visual data and then take action based on their observations. In manufacturing, robots enable increased production with fewer errors. In health care, robots help surgeons make smaller incisions with more precision and even allow them to operate on patients in distant parts of the world.

### Top five countries in industrial robotics adoption

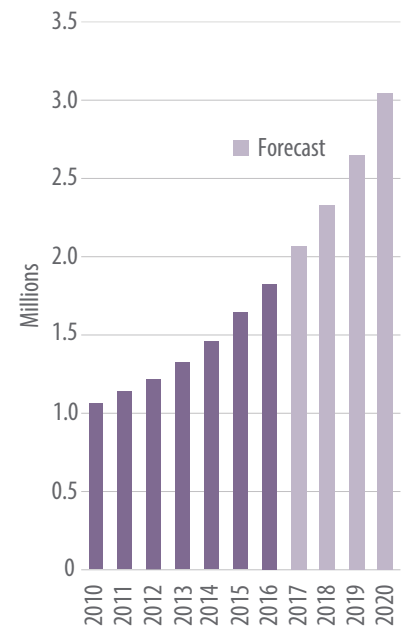
Based on 2016 unit sales of robots



**Source:** International Federation of Robotics, September 2017

### Use of industrial robots worldwide

The stock of industrial robots is forecast to increase from about 1.8 million units from the end of 2016 to 3.1 million units at the end of 2020, representing an average annual growth rate of 14% between 2018 and 2020.



**Source:** International Federation of Robotics, May 2018

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## What is the difference between a decentralized ledger and a centralized ledger?

### Decentralized ledger

Transactions are recorded on a common shared ledger and confirmed by participants in real time. This eliminates the need for an intermediary to reconcile transactions.

### Centralized ledger

Transactions are recorded by a central trusted authority on a centralized ledger that must be reconciled with each participant's copy of the ledger.

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## 3 Decentralized ledgers

Bitcoin. Blockchain. Cryptocurrencies. Everyone's talking about them, but what do these terms mean and how are they related?

A *decentralized ledger* combines peer-to-peer networking with algorithms to share, duplicate, and synchronize data. No central repository or administrator is needed. Relative to a centralized ledger, a decentralized ledger can offer speed, flexibility, and scale.

A *blockchain* is one type of decentralized ledger, in which transactions are chronologically grouped into blocks of data. Each block is cryptographically linked to a sequence of transactions down to the genesis block, thereby creating a chain of blocks. Because each block draws upon the data reference of the previous block in the chain, it is virtually impossible to add, remove, or change data without being detected by other members in the network. Bitcoin is a cryptocurrency created by using blockchains.

Although cryptocurrencies such as bitcoin have attracted the most press attention, blockchains have much broader uses. In the future, decentralized ledger technologies like blockchain could be used to reduce the cost and increase the speed of international monetary transfers because banks would no longer need to manually settle transactions. Blockchains can also be used to provide a quick, secure way to verify property transfers and help reduce fraud.

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## The benefits of decentralized ledgers

Decentralized ledgers offer the ability to deliver financial services with greater speed, accuracy, and security.



A decentralized ledger keeps a record of all transactions that take place on a peer-to-peer network



All information transferred via blockchain is encrypted and every occurrence is recorded, meaning it cannot be altered



The ledger is decentralized, so there's no need for any central, certifying authority



It can be used for much more than the transfer of currency; records and other kinds of data can be shared



Encrypted information can be shared across multiple providers without risk of a privacy breach

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Source: Wells Fargo Investment Institute, August 2018

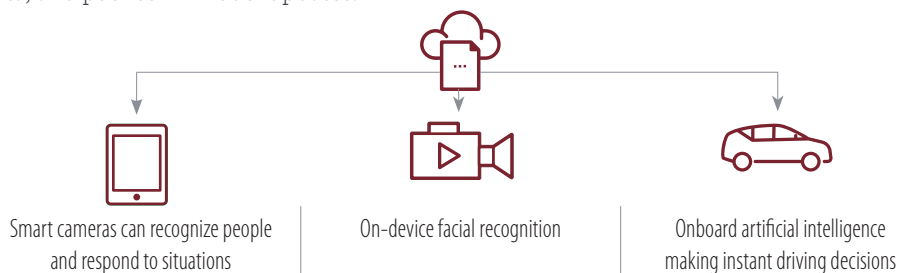


## 4 AI and machine learning

AI is a collection of technologies that allows a machine to learn and process language. AI and machine learning are projected to be as influential across industries and sectors as the internet was in prior decades. Today AI is used in the transportation industry to coordinate traffic lights in real time and pilot commercial airlines. It is used in the banking industry to enable mobile check deposits and make credit decisions, and in the medical field, it is used to diagnose diseases. AI also is enhancing data-gathering techniques at a time when gathering and analyzing data has become a key advantage for many businesses.

### Cutting-edge AI applications

Cloud-based technology stores large datasets, trains and improves algorithms, collects data, and pushes AI model updates.



Source: CB Insights, "State of AI 2018", January 2018

## Investor implications

- *Investors seeking to benefit from innovation should be aware that in past revolutions, there were periods of disruption after new technologies were introduced that made it unclear which large companies would adapt and which start-ups would become tomorrow's fast-growing companies.*
- *Companies' stock prices tend to increase when they issue patents for innovative technology.<sup>1</sup>*

1. See Hall, Jaffe, and Trajtenberg, "Market Value and Patent Citations", September 2003.

### Artificial intelligence

Intelligence exhibited by machines, as opposed to the natural intelligence exhibited by humans.

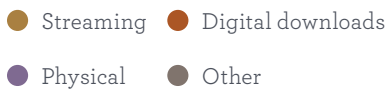
### Machine learning

A subset of artificial intelligence that uses statistical techniques to give computers the ability to improve performance on specific tasks (or *learn*).

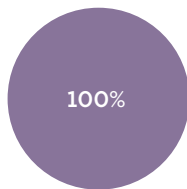
# The intelligence revolution's effect on businesses

## How technology disrupted the U.S. music industry

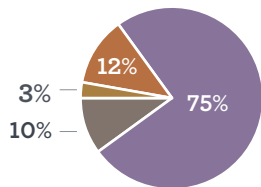
### Revenues by source



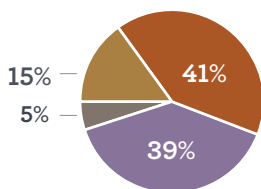
**2002:** All revenues come from physical sales.



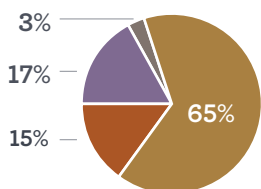
**2007:** Download sales gain while streaming emerges.



**2012:** Download sales peak and streaming gains momentum.



**2017:** Streaming dominates sales.



Source: Recording Industry Association of America, August 2018

## Updating business models

New technologies can be used to transform the way traditional firms conduct business. Early adopters might gain a competitive advantage over rivals. Alternatively, secondary movers might bypass crucial mistakes by waiting for snags in the technology to be resolved. Large, forward-thinking companies also may acquire innovation by purchasing smaller, more-nimble start-ups or may set up *incubators* to develop innovative processes and products. Companies that effectively harness the drivers of change can disrupt or even revolutionize traditional business models.

## The benefits of customization

Consumers increasingly demand products and services that are tailored to their unique needs and tastes. Innovations such as 3D printing are accelerating the development of new products and transforming consumer expectations of delivery time frames, product quality, and availability.

Looking ahead, we are on the cusp of developing 4D printing, in which printed objects have the ability to change their shape after exposure to an external trigger such as heat or light. Imagine printing artificial limbs that adjust to their owners' bodies to improve comfort, or a drug that changes shape as it is transported through the body and released. Further in the future, we might even be able to print artificial organs.

## Creating cost efficiencies

Many firms have eschewed traditional brick-and-mortar locations in favor of online stores. Companies also are selling digital products instead of physical ones using cloud infrastructure, the internet, and online sharing platforms. The digital format can create cost efficiencies for businesses and, in turn, can lead to lower prices for both businesses and consumers.

## Cloud-based software

Software as a service (SaaS—also known as web-based or on-demand software) is on the rise due to its low costs and ease of maintenance. SaaS companies typically provide third-party platforms and applications. For example, cloud-based data collection systems can use remote sensors to collect diagnostic information from telephone poles.

## Adapt or perish

Today, companies are using SMART (Self-Monitoring Analysis and Reporting Technology) tools to improve efficiency and the speed of doing business. Through cloud technology, companies can operate factory processes from a centralized location. Going forward, robots integrated into factorywide networks likely will control everything from the temperature of the factory to the volume of products manufactured each day.

## The workplace of tomorrow

With the intelligence revolution underway, robotics, machine learning, and AI likely will displace some human workers. These tools will allow businesses to automate some repetitive, low-skill tasks and incorporate AI and machine learning in areas such as performing calculations, working tirelessly without breaks, and recognizing patterns in the data.

According to a 2017 survey by the Pew Research Center, more than 70% of Americans are worried about the impact of automation on employment. However, it is very likely that human workers will continue to be necessary for more complex tasks. Providing situational context, understanding emotion, and creating new ideas and products are areas in which robots still struggle. So rather than taking over jobs, humans and robots will work together, each focusing on what they do best. Interestingly, a study from the World Economic Forum predicts that the technological drivers of change will ultimately lead to more net job creation.<sup>1</sup>

1. World Economic Forum, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," January 2016

## Share of U.S. jobs requiring AI skills

The share of jobs requiring AI skills in the U.S. has grown 4.5 times since 2013.



Sources: Artificial Intelligence Index, indeed.com. November 2017

## Investor implications

- *In the intelligence revolution, traditional companies will come under pressure to use technology to create better consumer outcomes or to improve efficiency. It will be increasingly important for investors to pay attention to how the companies they own are investing in and using technology.*
- *We expect the trend of advancing technology to place a premium on adaptability for both businesses and workers.*

## Created just for you

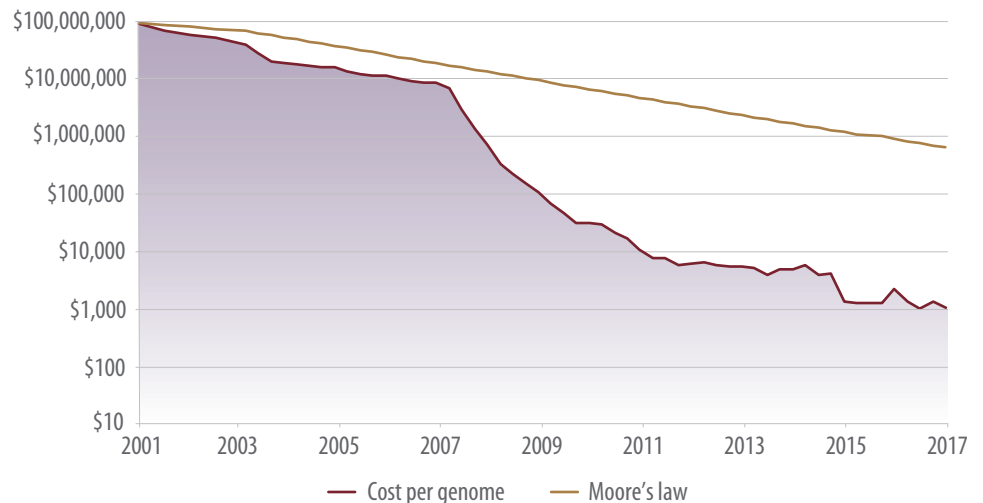
The world does not revolve around you—or does it? Many businesses now have the ability to customize and personalize products and services to a fine level of detail, something that not long ago seemed impossible to do in a profitable way. Today’s data-driven world allows consumers to gain more convenient and customized experiences, and businesses that effectively harness data are likely to gain consumers and grow profits.

## Customization down to our DNA

Human genome sequencing has major implications for individualized treatment of diseases. In August 2017, the U.S. Food and Drug Administration approved an immunotherapy treatment in which patients receive genetically modified immune cells derived from their own blood to target previously disguised cancer cells. The patient’s own customized immune cells theoretically are not subject to immune system resistance, and patients’ overall experience should resemble that of a flu shot versus conventional chemotherapy and radiation cancer therapies.

## Sequencing the human genome now is affordable and accessible

According to the National Human Genome Research Institute, sequencing the first human genome cost about \$1 billion and took 13 years to complete in 1999. The process now takes a few hours with a cost below \$1,000.



**Source:** Wetterstrand KA. DNA sequencing costs data from the NHGRI Genome Sequencing Program (GSP), [www.genome.gov/sequencingcostsdata](http://www.genome.gov/sequencingcostsdata), August 2018

For this example, data for Moore’s law is presented with a common reference (in U.S. dollar terms) to the price of sequencing the genome in 2001. Moore’s law describes a long-term trend in the computer hardware industry that involves the doubling of compute power every two years. Technology improvements that keep pace with Moore’s law are widely regarded to be doing well, making it useful for comparison.

## Algorithms all around us

Have you ever wondered how companies know so much about you? Let's say you browse online for a new pair of shoes, but after a few clicks, you move on. Soon, your personal email contains ads from shoe stores near you with some enticing discounts. Coincidence? Certainly not. An algorithm is keeping track of your searches and recommending solutions using AI.

Technologies such as wearable devices are beginning to capture data that is unique to each user, with the aim of providing medical services and treatments tailored to the individual. We believe the trend of using data to provide services, drive sales, and improve client satisfaction will continue as increasing computing power makes such outcomes more economically viable.

## Managing the risk of mishandling consumer data

Innovation tends to create new risks, and the intelligence revolution has brought new forms of identity theft. Many times, by agreeing to certain terms and services, consumers have provided access to data, including their contacts, images, audio, and location.

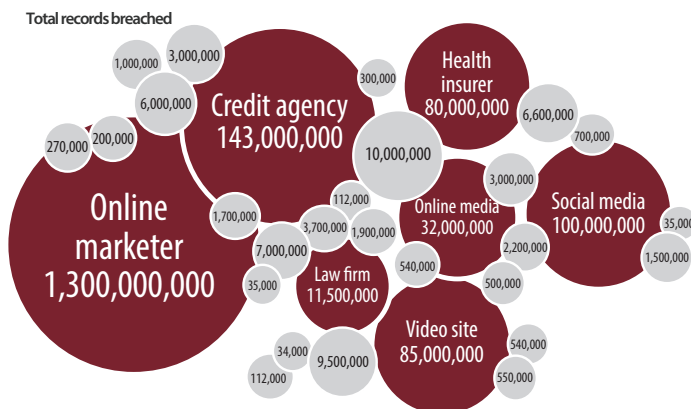
Privacy has taken the spotlight, given greater consumer concern about how data is managed and shared by companies. Such concerns may lead to more limited access to data in the future. The benefits of data analysis therefore may accrue to larger companies that have the resources to protect and effectively mine the consumer information they collect.

## Investor implications

- *The reduced cost of sequencing the human genome has opened the door to customized treatments of disease. Look for biotech companies that are using this technology.*
- *Data and analytic tools can help customize products and services, benefiting companies at the forefront of monetizing data-derived insights.*
- *Companies that develop digital security solutions should profit from increased capital expenditures from other businesses in their quest to stay ahead of cybercriminals.*

## Major data-security breaches worldwide, 2017

Cybersecurity is a significant and growing concern for businesses and consumers.



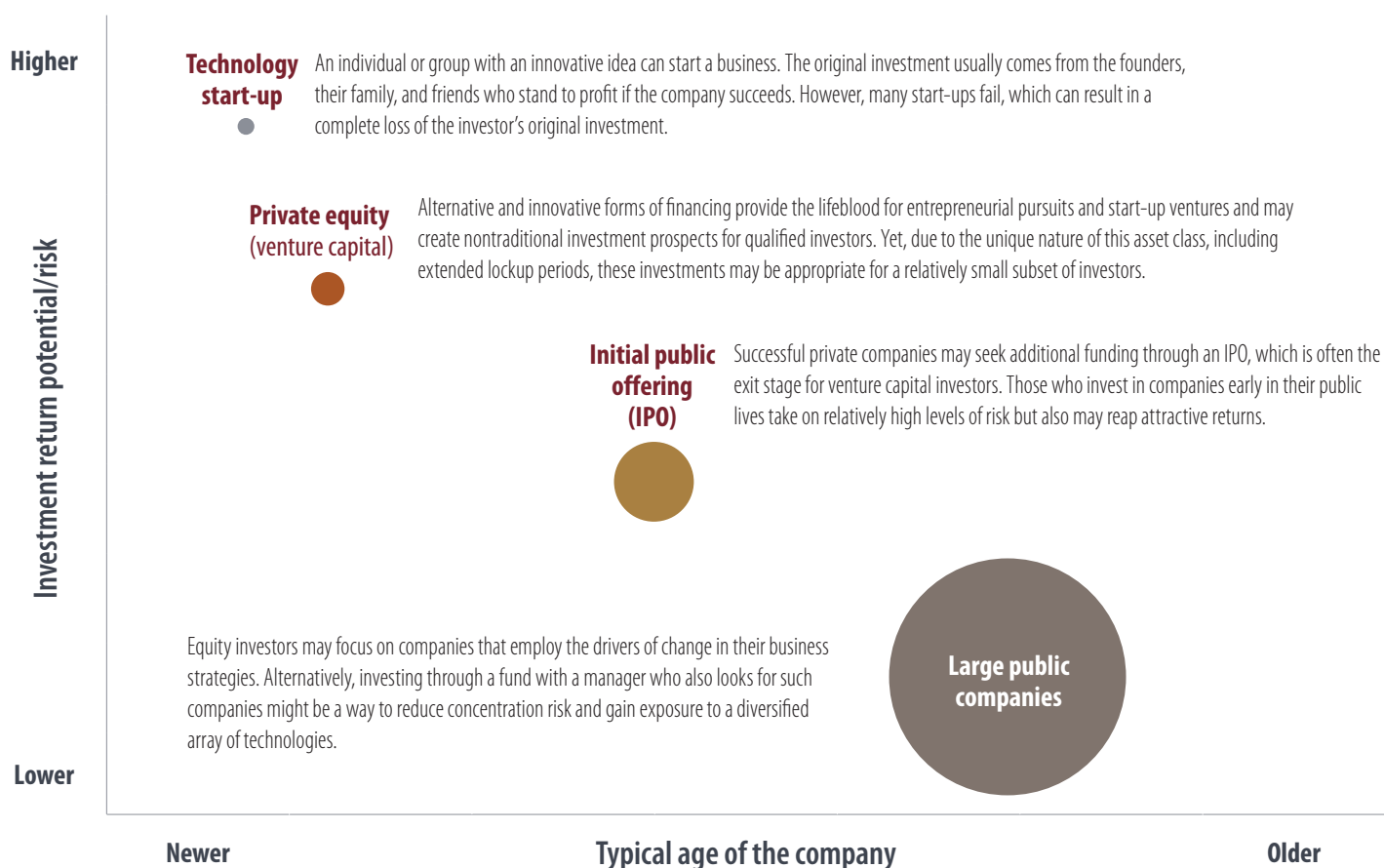
Source: Data from Information is Beautiful, Identity Theft Resource Center, "Data Breach Reports", 2016 and 2017, as of 12/31/2017

# Four ways to invest in tomorrow's technology

## Potential risk/reward trade-offs for investing in technology companies

Starting and growing a successful technology company typically requires financing at different stages of the startup's development. Although investing in younger, smaller companies can offer greater return potential, many investors do not meet the qualification requirements to do so. This chart illustrates the potential risk/reward trade-off for investing at certain stages of a company's development life cycle.

### Potential risk/return



● Circle's sizes represent the estimated percentage of investors who may find these opportunities appropriate for their investment needs.

Private equity funds are not suitable for all investors and are only available to persons who are "accredited investors" or "qualified purchasers" within the meaning of U.S. securities laws. It is important to remember that all investing involves risk, including the loss of the entire amount invested. The risks associated with each type of investment, security, or business should be carefully considered before any investment decision is made. We have highlighted some of these risks at the end of this report.






Source: Wells Fargo Investment Institute, June 2018

## Putting the drivers to work

Technology influences the way we work, consume, and interact with each other—and even how we invest. Looking ahead, we see potential opportunities for investors in sectors, industries, and businesses that incorporate the four technological drivers of change and create disruption. Often in combination with each other and with other technologies, the four key drivers—computing power, robotics, decentralized ledgers, and AI—are creating new and exciting opportunities for today’s investors.







## Where opportunities in tomorrow’s technology may emerge

Below, we look at equity market sectors and highlight the drivers and trends we expect to be prominent over the next several years.

| Sector   | Trends  | Drivers of change                            | Key industries   |
|--|---|--|--|
| <b>Consumer Discretionary</b><br> | <ul style="list-style-type: none"> <li>Self-driving vehicles transforming the transportation and automotive industries</li> <li>Expanding to create an on-demand model supported by a digital platform</li> <li>Virtual and augmented reality to visualize product placement ahead of purchase</li> </ul>                         | AI<br><br>Computing power<br><br>AI          | Automobile<br><br>Textiles, apparel, and luxury goods<br>Furniture and household goods |
| <b>Consumer Staples</b><br>     | <ul style="list-style-type: none"> <li>Personalizing loyalty programs, locating stolen products, and streamlining recall and service bulletins that benefit retailers and consumers</li> <li>Cutting-edge digital technology standardizing processes, improving operations, and helping optimize supply-chain planning</li> </ul> | Decentralized ledgers<br><br>Computing power | Food and staples retailing<br><br>Household products                                   |
| <b>Energy</b><br>               | <ul style="list-style-type: none"> <li>Seeking efficiencies and cost savings across the value chain</li> <li>Automating processes, redeploying workers to higher-value tasks and innovation</li> </ul>  | Computing power<br><br>Robotics              | Oil and gas, energy and equipment services<br><br>Oil and gas                          |
| <b>Financials</b><br>           | <ul style="list-style-type: none"> <li>Detecting and preventing insurance fraud, digitally tracking medical records, and creating efficiencies across the value chain</li> <li>Improving service through the vast amounts of data collected</li> </ul>  | Decentralized ledgers<br><br>Computing power | Insurance<br><br>Payment providers   |
| <b>Health Care</b><br>          | <ul style="list-style-type: none"> <li>Digitizing helping drive analytics and business insights that can improve revenues and margins</li> <li>Customization of treatments and therapies for diseases like cancer based on individual genetic codes</li> </ul>  | Computing power<br><br>AI                    | Pharmaceuticals<br><br>Biotechnology   |

Sources: Wells Fargo Investment Institute; Deloitte Insights, “Tech Trends 2018: The symphonic enterprise”, December 2017

## Where opportunities in tomorrow's technology may emerge (*continued*)

| Sector                            |   | Trends   | Drivers of change                 | Key industries  |
|-----------------------------------|---|--|-----------------------------------|---|
| <b>Industrials</b>                |    | <ul style="list-style-type: none"> <li>Filling shortages of unskilled and skilled workers</li> <li>Automating routine, monotonous, and dangerous tasks; exotic applications, from deep-sea missions and space exploration</li> </ul>   | AI/robotics<br>Robotics/AI        | Construction<br>Marine/aerospace  |
| <b>Information Technology</b>     |    | <ul style="list-style-type: none"> <li>Delivering powerful virtual experiences to improve consumer experience</li> <li>Protecting against cyberattacks and virtual threats; companies bolstering security operations with intelligence as well as segmenting, virtualizing, and automating networks to protect assets</li> </ul> | AI<br>Computing power/AI          | Internet software and services<br>Software                                    |
| <b>Materials</b>                  |    | <ul style="list-style-type: none"> <li>Robots replacing human workers engaged in high-risk industries, like mining and working with hazardous chemicals</li> <li>Process automation supporting mining and resource companies that require large volumes of data for decision-making</li> </ul>                                   | Robotics                          | Metals and mining chemicals<br>Mining   |
| <b>Real Estate</b>                |  | <ul style="list-style-type: none"> <li>Protecting property rights through enhancing security of title search and transfer processes</li> <li>Using computer-generated architectural designs to incorporate scenario analysis and safety testing</li> </ul>   | Decentralized ledgers<br>AI       | Real estate management<br>Real estate development                             |
| <b>Telecommunication Services</b> |  | <ul style="list-style-type: none"> <li>Satellites and rocket-launching technology enhancing communication and data-gathering techniques</li> <li>Developing improved consumer experiences and modernizing infrastructure by digitizing and migrating to cloud-based models to adjust to consumer behavior</li> </ul>             | Robotics<br>Computing power       | Wireless telecom services<br>Integrated telecom services                      |
| <b>Utilities</b>                  |  | <ul style="list-style-type: none"> <li>Process automation to drive efficiencies and cost savings</li> <li>Using blockchain to authenticate and manage billing processes</li> </ul>   | Robotics<br>Decentralized ledgers | Power generation, energy sales and transmission<br>Electric and gas utilities |

Sources: Wells Fargo Investment Institute; Deloitte Insights, "Tech Trends 2018: The symphonic enterprise", December 2017





# *Transformation*

Industrial revolutions bring widespread changes. We believe that investors can benefit from computing power, robotics, decentralized ledgers, and AI in a variety of sectors and industries.

Yet, while the intelligence revolution likely will disrupt many sectors of the financial markets, we believe that the core principles of investing will not change. We still see the benefits of following a diversified asset allocation plan that is consistent with an investor's risk/return profile and long-term goals.

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Ms. McMillion oversees the creation of strategic global asset allocation recommendations and writes economic and market commentary and analysis. Prior to her current role, she served as an asset allocation strategist and a senior investment research analyst for Wells Fargo and predecessor firms.

Ms. McMillion earned a bachelor's degree in economics and a master's degree in business administration from the College of William and Mary in Virginia. She is a CFA® charterholder and member of CFA Society North Carolina. Ms. McMillion is located in Winston-Salem, North Carolina.

## **Luis Alvarado**

### *Investment Strategy Analyst*

Mr. Alvarado researches and analyzes economic and market trends for the investment strategy team. He contributes to many Wells Fargo Investment Institute publications, including Global Investment Strategy reports, white papers, and special reports. In addition, he helps maintain the library of economic and market charts.

Prior to his current role, Mr. Alvarado served as a client service associate for Wells Fargo Advisors, supporting the sales and trading functions for brokerage clients. Mr. Alvarado earned a bachelor's degree in business administration from the Universidad de Costa Rica and a master's degree in financial analysis from the University of San Francisco. He is based in San Francisco.

## **Kenneth Johnson Jr., CFA**

### *Investment Strategy Analyst*

Mr. Johnson is responsible for analysis of the economy, financial markets, investment strategy, and asset allocation. Prior to his current role, he served as a wealth planner for the Mid-Atlantic region of Wells Fargo Private Bank, where he worked with clients to develop customized wealth plans.

Mr. Johnson earned a bachelor's degree in finance from Wayne State University in Detroit and is a CFA® charterholder. He is located in Charlotte, North Carolina.

## **Michael Taylor, CFA**

### *Investment Strategy Analyst*

Mr. Taylor focuses on global asset allocation strategy and economic and market analysis. He has more than 17 years of experience in financial services and has spent the past 13 years at Wells Fargo in various roles within wealth and brokerage.

Mr. Taylor earned a bachelor's degree in chemistry from the University of Minnesota Institute of Technology, bachelor's degrees in Chinese and Russian from the University of Minnesota College of Liberal Arts, and a master's degree in business administration from the University of Minnesota Carlson School of Management. Mr. Taylor is a CFA® charterholder and member of CFA Society Minnesota. He is based in Houston.

## **Bobby Zheng, CFA**

### *Investment Strategy Analyst*

Mr. Zheng is responsible for performing quantitative market, economic, and investment trend research support and assisting with the preparation of Wells Fargo Investment Institute strategy publications and presentations. Prior to his current role, he was an analytic consultant on the Wells Fargo Advisors product risk team.

Mr. Zheng earned a bachelor's degree in business from Chapman University and a master's degree in finance from the Olin Business School at Washington University in St. Louis. He is also a CFA® charterholder. Mr. Zheng is located in San Francisco.

# Investment risks/technology companies and drivers

**Start-up companies:** A start-up company is a privately held company that is not traded on a public exchange. Start-ups are often associated with a technology-oriented investment that has above-average growth potential. Investing in these companies is speculative and involves significant principal risk, including the risk of the entire loss of the amount invested. Returns are not guaranteed, may not be generated, and, if generated, may take several years to be realized.

**Venture capital:** Venture capital is equity financial capital often provided to early-stage or growth start-up companies. These investments often take on a substantially higher degree of risk in exchange for potentially higher returns. Although a company may receive the necessary capital to develop their business, the business can fail nonetheless due to a variety of factors, including entry into the market, competition from other firms with similar products, the development of new technology that requires rethinking or additional funding, and whether the company has a well-thought-out exit strategy or can manage rapid growth. These investments are suitable only for those investors who have the financial sophistication and expertise to evaluate the merits and risks of an investment and can bear a complete loss of capital.

**Initial public offering (IPO):** Investing in an IPO is considered speculative. The offering price for such securities may differ completely from the trading price, which could be well above or below the offering price. No guarantee can be given that the price performance of the company will meet expectations. In addition, these companies have limited operating histories, and information available about them may also be limited. There is no guarantee that the company will be able to complete an IPO.

**Technological drivers:** The technological drivers of change discussed in this report include advances in computing power, robotics, decentralized ledgers, and artificial intelligence. These drivers of change have the potential to create significant value for consumers; however, in some cases, that value may not be evenly distributed. The use of automation and robotics, for example, may create considerable opportunities for those with artificial intelligence skills while the labor of less-skilled workers may be replaced with machines. There is never any assurance that new technologies will create real value, and it is important that investors consider all aspects of technological advancement when considering potential investment opportunities, including which new technology may become commercially successful and make it possible to achieve excess investment returns. Allegations of data security breaches, infringement on intellectual property, and violation of privacy rights may engage companies in protracted legal proceedings and, even if a lawsuit is avoided, substantial costs, all of which can diminish the company's ability to operate successfully and produce negative consequences for its investors.

**Investment risks/sectors:** When considering investing in new technologies within equity sectors, it is important to consider the sector's particular risks and the risks associated with investing in new technologies. Keep in mind sector investing can be more volatile than investments that are broadly diversified over numerous sectors of the economy. This can increase a portfolio's vulnerability to any single economic, political, or regulatory development affecting the sector. The risks associated with equity sector investing include, among others, the following:

Consumer Discretionary risks include apparel price deflation due to low-cost entries, high inventory levels, and pressure from e-commerce players; reduction in traditional advertising dollars; increasing household debt levels that could limit consumer appetite for discretionary purchases; declining consumer acceptance of new product introductions; and geopolitical uncertainty that could affect consumer sentiment. Consumer Staples industries can be significantly affected by competitive pricing, particularly with respect to the growth of low-cost emerging market production, government regulation, the performance of overall economy, interest rates, and consumer confidence. Energy sector industries may be adversely affected by changes in worldwide energy prices, exploration, production spending, and government regulation and changes in exchange rates, depletion of natural resources, and risks that arise from extreme weather conditions. Financials companies are subject to adverse economic and market conditions, regulatory pressures, and the rapid evolution of innovative technologies and their ability to respond competitively to these changes. Health Care sector risks include competition on branded products, sales erosion due to cheaper alternatives, research and development risk, government regulations, and government approval of products anticipated to enter the market. Industrials industries within the sector can be significantly affected by general market and economic conditions, competition, technological innovation, legislation and government regulations, among other things, all of which can significantly affect a portfolio's performance. Information Technology sector risks include the risks associated with increased competition from domestic and international companies, rapidly changing technologies, unexpected changes in demand, regulatory actions, and technical problems with key products, short product life cycles, and the departure of key members of management. Materials industries can be significantly affected by the volatility of commodity prices, the exchange rate between foreign currency and the dollar, export/import concerns, worldwide competition, procurement and manufacturing, and cost containment issues. Real Estate investments have special risks, including possible illiquidity of the underlying properties, credit risk, interest rate fluctuations, and the impact of varied economic conditions. Telecommunication services are subject to the risks associated with rising interest rates, which could increase debt service costs, competition, and costs to providers due to potential for large equipment upgrades. Utilities are sensitive to changes in interest rates, and the securities within the sector can be volatile and may underperform in a slow economy.

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