

Thematic Investing at Hawthorn

Hawthorn has outlined the key elements of our thematic investment strategy, which attempts to identify themes we believe have the ability to break macro trends, creating an opportunity to produce returns that may look different from the overall market. Our thematic investing initiative encompasses lithium battery technology, financial technology (fintech), artificial intelligence (AI)/robotics, water resources, social media, and internet of things.

The Diffusion of Innovation Theory, developed by E.M. Rogers in 1962, has been widely adopted in describing how disruptive technologies often follow an adoption curve with five distinct stages (Chart 1).¹ We find this theory to be particularly useful in framing how we differentiate thematic and traditional asset allocations. For example, a mature company focused on producing consistent results and returning capital to its investors likely sits in the “late majority” or “laggards” stage. On the other hand, a social media company reinvesting all of its earnings into its business would likely be in the “early adopters” stage. Most traditional asset allocation methodologies are bound by typical index construction conventions related to factors such as market capitalization, sector, industry, region, and style.

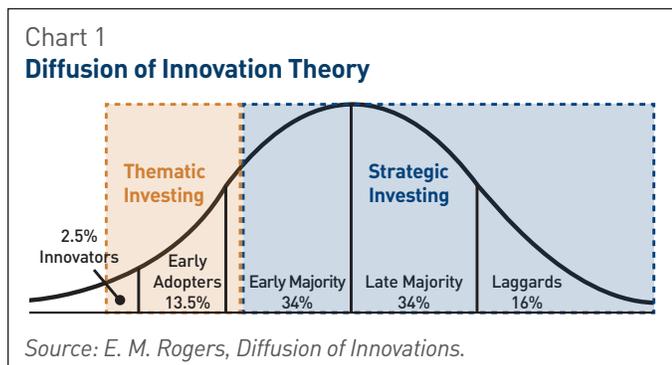
Market capitalization indexes are, by their nature, backward looking, assigning a higher weight to larger companies. This often results in a systematic underexposure to emerging trends that could disrupt the current market landscape for many years. We believe thematic investment strategies offer a solution

to this pervasive asset allocation shortcoming. Typically, thematic investment opportunities occur early in a new product’s or technology’s life cycle, where growth is at or close to its highest trajectory. However, these companies are often not included in market indexes in any meaningful size.

How We Think About Thematic Investing

Our thematic investment strategy attempts to identify themes we believe have the ability to break macro trends, creating an opportunity to produce returns that may look different from overall market returns. Thematic investments often originate from technological advancements, trends in populations, shifting consumer preferences, or changes to regional economies. However a theme emerges, it often represents a long-term and fundamental shift, powerful enough to affect market performance across multiple industries and geographies.

In our view, thematic investments are not bound by traditional geographic, style, or market capitalization classifications and typically do not fit neatly into a traditional box. Themes usually span multiple sectors, industries, and countries. The lack of a defined set of characteristics makes it difficult for thematic opportunities to fit conventional asset allocation and indexation frameworks. By allowing for such investment opportunities, our goal is to create a unique source of return within our overall asset allocation that relies on deep fundamental research, a multiyear view, and careful execution.



¹ E. M. Rogers, *Diffusion of Innovations*, 4th ed. (New York: The Free Press, 1995), <http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories4.html>.

We focus on identifying investable structural themes with the potential to disrupt existing market dynamics (for example, rise of social media) and/or create economic paradigm shifts (for example, impact of the internet). Ultimately, we hope to enhance portfolio diversification and boost future alpha generation and risk-adjusted returns.

Removing the Constraints: Thematic versus Relative Investing

The efficient market hypothesis postulates that current market prices reflect all knowable information; therefore, it is impossible to beat the market. This theory splits market efficiency into three forms:

- Weak: assumes all past market price and volume data are fully reflected in securities' prices; technical analysis would not be able to generate excess returns.
- Semi-strong: assumes all past and present information that is publicly available is fully reflected in securities' prices; neither fundamental nor technical analysis will generate excess returns.
- Strong: assumes all public and private information is fully reflected in securities' prices; technical, fundamental, or insider information will not generate excess returns.²

For years, investors have debated which form best represents actual market efficiency. We believe the truth lies somewhere in between, and the degree of market efficiency is not uniform across all investable markets. One source of market inefficiency, which we think thematic investing is able to capture, is the investment industry's need (real or perceived) to fit in a specific style box, fund category, sector, or market capitalization bucket relative to a predetermined benchmark. Simply put, thematic investing is not bound by these self-imposed constraints, which limit a portfolio's opportunity set and likely return potential. The most successful thematic investments frequently move laterally across value and supply chains, irrespective of sector, company size, or geographies.

For example, when allocating to AI and robotics we end up with a diverse set of sectors, industries, and countries when constructing a basket of such companies. These companies span the value chain from chip manufacturers to robot engineering. Because of this diverse set of holdings and lack of conformity with conventional asset allocation frameworks, it might be easy to miss this thematic opportunity if myopically focused on a relative investment process predisposed to sector or industry level of opportunities. For example, if we divide this basket of AI/robotics-exposed equities, we have a subset of holdings across four different sectors within the MSCI ACWI Index (Chart 2, page 3). In aggregate, our AI/robotics-exposed equities displayed stronger growth characteristics (here proxied using sales growth) and outperformed the index over the prevailing five years. Overall, we expect our thematic investment strategy to exhibit greater growth characteristics and subsequently outperform over the long term.

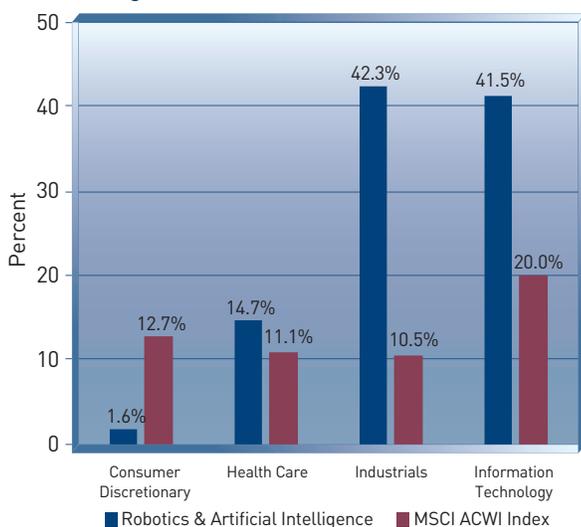
Thematic Investment Process

Throughout history, as major thematic shifts have occurred, there have been individual so-called "winners" and "losers"—think social media and the divergent paths of Facebook and Myspace. Our top-down approach strives to capture systematic exposure to targeted themes (that is, social media) and not take idiosyncratic risks by attempting to pick winners (Facebook versus Myspace) over the long term. Additionally, focusing on structural, long-term investment opportunities versus cyclical ones can significantly help limit a thematic investment's dependence on timing entry and exit points.

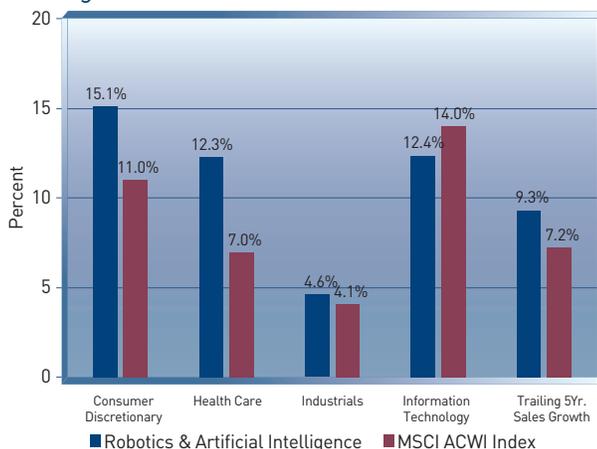
The primary challenge with any thematic investment process, in our view, is predicting which themes will ultimately be successful investments, especially since accurately identifying structural changes does not always correlate with profitable investment opportunities. We can mitigate some of this risk by pursuing themes that represent two critical elements: investability and multiple paths to success.

² Eugene F. Fama introduced the three forms of market efficiency in his research paper "Efficient Capital Markets: A Review of Theory and Empirical Work," *Journal of Finance*, 1970.

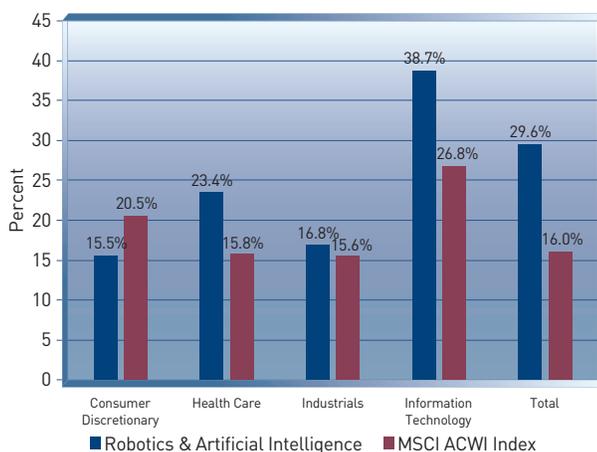
Chart 2
AI and Robotics Equities versus the MSCI ACWI Index
 As of 6/30/18
 Sector Weights



Trailing Five-Year Sales Growth



Five-Year Cumulative Performance



Source: FactSet Research Systems Inc.

Investability

We evaluate the investability of a theme based on two unique elements. First, does the opportunity have sufficient liquidity to absorb our expected allocation without causing market disruption? Thematic investment opportunities can often be less liquid than traditional assets. Our portfolio construction process includes a liquidity overlay analyzing secondary and primary (if available) market breadth.

Second, is the investable market able to grow with the anticipated capital flows associated with success of an individual theme? Simply put, our process is looking for investment opportunities in the early adopters phase, but ultimate investment success requires further market adoption over time. By identifying thematic opportunities with multiple paths to success, we strive to avoid investments with binary outcomes in an effort to limit the potential downside risk.

Thematic Investment Portfolio Construction

Our thematic portfolio construction process brings together the art and science of investing. Thematic investing is macro by nature, and the ultimate winners will be those investors who can anticipate the most powerful, multiyear trends that will help drive outperformance. We have identified several such trends, choosing to focus on a large/diversified set of companies rather than on individual companies that may win or lose. We believe it is more difficult to separate the winners from the losers in a rapidly evolving technology or nascent market theme. Therefore, Hawthorn uses broad-based exchange-traded funds, allowing for well-balanced and diversified exposure to our themes. The basket is equity based and growth oriented, with the thought that mighty oaks grow from tiny acorns.

What weaves the basket together is a carefully constructed set of metrics based on revenue growth. We have developed a statistical approach based on historical, current, and expected revenue growth to assist in identifying which themes merit a marginally higher weighting. There is also a valuation, momentum, liquidity, and volatility counterbalance to the growth drivers. The thematic basket is

not constrained in any other way. As mentioned, geography, sector, capitalization, and style are generally not considered. Ultimately, a tactical allocation to the final thematic basket is one that has little correlation to a typical Hawthorn portfolio, such as the Hawthorn Balanced Portfolio. The thematic portfolio is constructed to be a longer-term holding, potentially spanning multiple business cycles with identified themes developing over many years.

Hawthorn will monitor the thematic basket via returns-based and security deconstruction analysis on a monthly basis and quarterly for rebalancing purposes, if necessary. A risk model will dig deeper into factor exposures and predicted risk so there is a clear understanding of how the basket interacts with the overall portfolio's asset allocation.

The following sections describe our thematic investing themes.

Lithium Battery Technology

Lithium batteries are already the choice energy source for many products, such as smartphones and laptops. The global market for lithium consumption is expected to grow considerably over the coming decade. Lithium's light weight, high energy density, and rechargeable properties make it an attractive energy source. But until recently high production costs have limited its applications. Over the last decade, however, research and development dollars have made their way into the

lithium battery value chain, driving down production costs and improving battery efficiency (Chart 3).

Future growth drivers include the increase in electric vehicle (EV) usage, a supportive regulatory environment, and advancements in alternative/renewable energy sources (for example, solar and wind energy). These applications require more powerful batteries than traditional consumer electronic devices, helping to increase the demand for lithium. While we do not anticipate a maturing consumer electronics market to be the primary driver of lithium battery growth, with most people already owning a smartphone or laptop, we believe this market should serve as a stable floor for lithium battery demand.

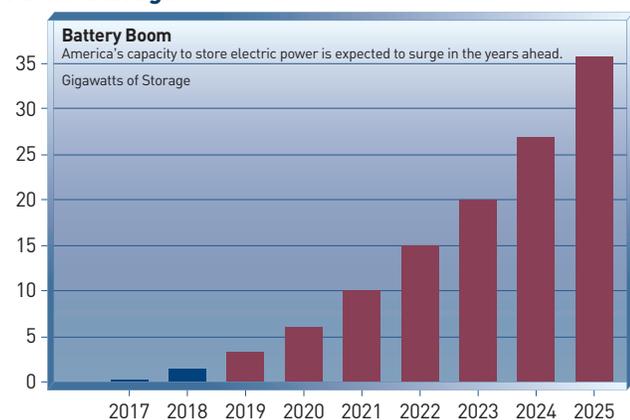
Ultimately, we believe both the economic and regulatory environments influencing lithium batteries and other associated technologies are becoming more favorable.

Sources of Future Lithium-Ion Battery Demand

Electric Vehicles

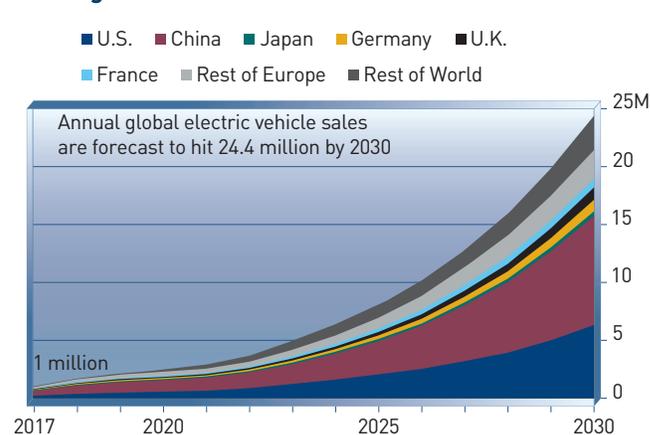
Advancements in EV technology and infrastructure coupled with tailwinds from supportive government policies are forecasted to drastically expand EV adoption over the coming decades (Chart 4). Declining costs of lithium-ion batteries are helping to make EVs more cost-competitive with traditional vehicles. The efficiency of some EVs has tripled since 2014, rising from an estimated 84 miles to about 240 miles.

Chart 3
Advances in Lithium-Ion Batteries Driving Electric Power Storage



Source: Navigant Research

Chart 4
EV Usage Forecast



Source: Bloomberg New Energy Finance

Additionally, larger and more efficient batteries are permitting lithium-ion battery usage beyond traditional consumer electric cars. Commercial vehicle manufacturers are beginning to develop “eTrucks,” foreshadowing a boom in EV adoption in the commercial trucking industry. According to McKinsey & Company, commercial bus and truck producers are ready to convert to electric commercial vehicles, or eTrucks.³ We believe the conversion of commercial vehicles to EVs will be more rapid than consumer decisions, which are often blurred by individual preferences. A company’s decision framework is more rigid and solely focused on economic and regulatory factors, both of which are favorable today. While there are technical and operational efficiencies still to be ironed out, the potential eTruck impact on lithium-ion battery demand could be robust, in our view.

Government Policy and Regulatory Intervention

Several governments have instituted policies that are favorable to the EV industry. Countries such as Norway, France, Germany, and the United Kingdom have introduced policies setting end dates on the future sales of internal combustion engine vehicles, some as soon as 2040. This transformation is already beginning to take place on a municipal scale. In the United Kingdom, an Ultra-Low Emission Zone will be instituted in London starting in 2018. Under this regulation, vehicles will need to meet new, more restrictive exhaust emission standards or pay a daily charge to travel within the designated area. Other European cities, including Rome, Paris, Madrid, and Athens, are following London’s lead and drafting policies to be in place by 2024–25.⁴ The European Union promised €800 million in EV charging infrastructure and another €200 million in battery production.⁵ The EU also has partnered with several

private companies to build “MEGA-E” charging hubs in metropolitan areas and along highways throughout 20 countries on a pan-European scale.⁶

This shift in zero emission/EV transportation guidance is also taking hold in the United States. Nine states have signed onto the U.S. Multi State Zero Emission Vehicle (ZEV) Plan, building on early success in some states and identifying clear objectives for reducing emissions through 2021 and beyond. This action plan recommends “high priority” actions for states, automakers, charging and fueling infrastructure companies, utilities, dealers, and other partners to guide coordination among stakeholders and encourage rapid adoption of EVs. These actions include consumer education and outreach, offering consumer purchase incentives, and building EV charging infrastructure.

Renewable Energy

Historically, high costs and inefficiencies in power storage of renewable energy sources (for example, solar and wind power) have acted as barriers to entry except for the most earth-conscious. The sun is most intense, generating the most solar energy in the middle of the day. Wind blows the hardest at night, that is, creates the most wind energy, so is most efficient as an energy source at that time. However, consumer electric demand is highest in the early evening. This mismatch often forces renewable energy users to pay peak energy prices to fill the gap. Lithium-ion batteries may offer a solution to this issue.

According to Lazard, 2017 was the first time in history it became profitable for the owner of an average coal plant to replace it with a wind farm.⁷ Two variables have led to this eye-opening dynamic. First, the cost of wind (and solar) energy production has fallen to less than nuclear, coal, and gas (Chart 5, page 6).

³ Excerpted from “What’s Sparking Electric-Vehicle Adoption in the Truck Industry?,” September 2017, McKinsey & Company, www.mckinsey.com. ©2018 McKinsey & Company. All rights reserved. Reprinted by permission.

⁴ P. Hockenos, “End of the Road: Are Diesel Cars on the Way Out in Europe?,” *Yale Environment 360* (April 12, 2018), <https://e360.yale.edu/features/end-of-the-road-are-diesel-cars-on-the-way-out-in-europe>.

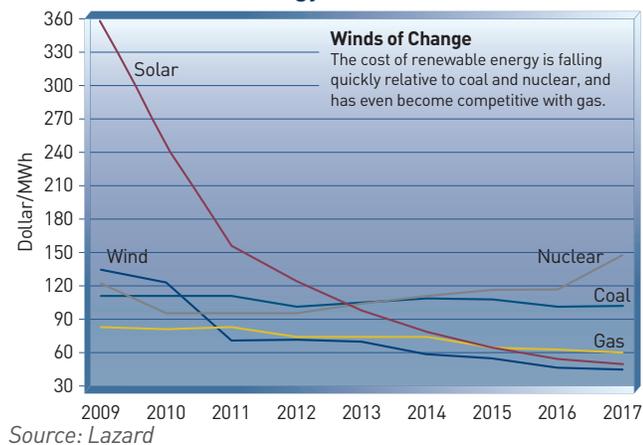
⁵ R. Toplensky, “New EU Vehicle Emission Rules Disappoint Climate Activists,” *Financial Times* (November 8, 2017), <https://www.ft.com/content/e075af19-e7b0-3da3-ac84-94bc916a5130>.

⁶ “Allego Project Mega-E Secures €29M in EU Funding,” <https://www.electrive.com/2018/04/25/allego-project-mega-e-secures-e29m-in-eu-funding/>.

⁷ J. Hough, “How Batteries Will Change the Power Business” (June 9, 2018), <https://www.barrons.com/articles/how-batteries-will-change-the-power-business-1528509035>.

Chart 5

Costs of Renewable Energy



Second, lithium-ion battery storage costs of surplus electricity production have fallen to levels where they are included in renewable power projects.

Tailwinds from economic and regulatory factors position lithium-ion batteries as an attractive alternative energy source. Given its potential cost-effectiveness and availability, it is clear to us that lithium-ion batteries could play a significant role in both future household consumption and commercial industries.

Evolution of Financial Technology

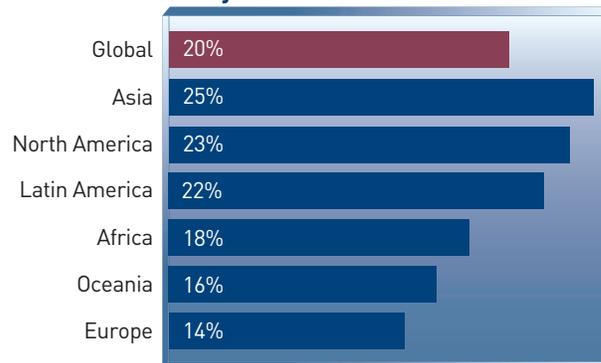
Financial technology (FinTech) is a broad term used to describe the integration of technological advancements within financial-related business processes. Many investors might think of the FinTech industry as something that has evolved over the last decade. The term FinTech has only been used over the last few years, but advances in financial technology are not new. It's clear to us FinTech is well-established, starting in the 1950s with credit cards and followed in the 1960s by automated teller machines (ATMs), the 1970s by electronic trading, the 1980s by mainframe computers, and the 1990s by e-commerce.⁸ Historically, most FinTech innovations have come from the financial services industry, but the impacts have been felt in other industries as well.

⁸ D. W. Arner, J. N. Barberis, and R. P. Buckley, "The Evolution of Fintech: A New Post-Crisis Paradigm?" (October 1, 2015), University of Hong Kong Faculty of Law Research Paper No. 2015/047; UNSW Law Research Paper No. 2016-62.

⁹ Excerpted from "Fintech Decoded: The Capital Markets Infrastructure Opportunity," February 2018, McKinsey & Company, www.mckinsey.com ©2018 McKinsey & Company. All rights reserved. Reprinted with permission.

Chart 6

Expected Return on Investment on FinTech-Related Projects



Source: PwC Global FinTech Survey 2017

No one can predict with certainty which areas of FinTech will lead to the next significant wave of disruption. However, we believe there are several growth catalysts for FinTech, including the rise and practical application of artificial intelligence (AI); distributed ledger technology, or DLT (that is, blockchain); and the wide adoption of mobile technology. A 2017 PwC Global FinTech survey projects annual returns on investment on FinTech-related projects will be 20% globally (Chart 6).

Here we highlight four areas where we anticipate FinTech will significantly shape growth:

- capital markets;
- the financial services value chain;
- developing economies; and
- e-payments.

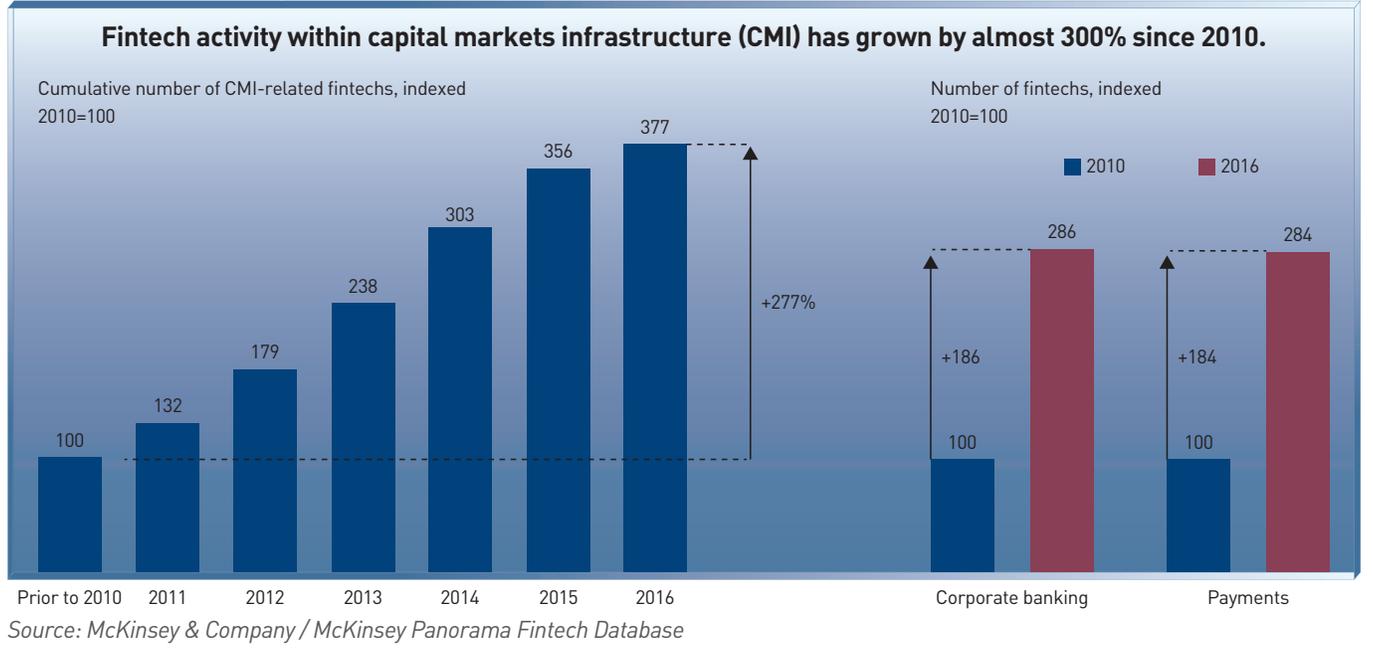
Sources of FinTech Growth

Partnerships Between Capital Markets Providers and FinTech Companies

According to a 2018 McKinsey study, many FinTech companies will look to partner with larger, more established capital markets companies and vice versa.⁹ These capital markets providers comprise a global network of organizations that securely carry out transactions, ranging from trade execution to

Chart 7

Growth of FinTech in Capital Markets



the custody of assets, across investment markets. Many of these partnership opportunities have proven to be mutually beneficial.

Corporations and capital markets providers view the integration of FinTech as a potential source of new revenue and an opportunity to leverage technological innovation to enhance productivity. While FinTech firms may be able to bypass some of the largest barriers to entry, particularly in developed economies, they often lack the resources or capital needed to compete directly with established capital markets providers.¹⁰ Consequently, FinTech activity within capital markets infrastructure has grown almost 300% since 2010 (Chart 7).

Innovation Across the Financial Services Value Chain

FinTech firms are designing new ways to enhance existing processes throughout the entire financial services value chain. For example, crowd-funding

platforms offer easier access to capital and simultaneously close any gap between issuers and investors. Fifty percent of consumers use FinTech money transfer and payments services, and 88% anticipate doing so in the future.¹¹ Additionally, the emergence of **robo-advisors** has driven fee compression across the investment management industry, making investments more accessible to a larger percentage of the population. Peer-to-peer lending offers relatively low interest rates and quicker access to funds than traditional bank loans.¹² FinTech is also helping to facilitate trade execution, with a focus on emerging asset classes such as cryptocurrencies.

Robo-advisors offer financial services digitally via the internet with limited human interaction.

¹⁰ V. Dhar and R. Stein, "FinTech Platforms and Strategy," MIT Sloan Research Paper No. 5183-16 (December 14, 2016), <https://ssrn.com/abstract=2892098>.

¹¹ *Emerging Markets: Driving the Payments Transformation*, PwC Global, <https://www.pwc.com/gx/en/industries/financial-services/publications/emerging-markets-driving-payments.html>. ©PwC. Not for further distribution without the prior written permission of PwC. PwC refers to the U.S. member firm or one of its subsidiaries or affiliates, and may sometimes refer to the PwC network. Each member firm is a separate legal entity. Please see www.pwc.com/structure for further details.

¹² A. Samitsu, "Structure of P2P Lending and Investor Protection: Analyses Based on an International Comparison of Legal Arrangements" (October 23, 2017), https://www.boj.or.jp/en/research/wps_rev/lab/lab17e06.htm/.

Today the use of blockchain/DLT has begun to help streamline clearing, custody, and settlement processes, resulting in significant cost savings for financial institutions. McKinsey estimates the use of DLT within the over-the-counter derivative markets alone, for example, is a \$4–7 billion value-generation opportunity. The use of DLT in posttrade services has already begun, with the Australian Securities Exchange (ASX) transitioning to a DLT system in March 2018 to help reduce posttrade reconciliation times and costs. Switzerland’s stock exchange recently announced it is building a fully integrated trading, settlement, and custody infrastructure for digital assets, mainly based on DLT.¹³ The Swiss exchange will then be able to trade assets that were previously not tradable.

Developing Economies

Developing economies are home to 85% of the global population and nearly 90% of people under the age of 30.¹⁴ As millions of **unbanked** or **underbanked** people in developing economies enter the digital era over the coming years, who will likely require a variety of financial services, there is \$380 billion in potential revenue, according to Accenture.¹⁵ FinTech providers are well positioned to lead in these markets, in our view. Digital offerings are more scalable than traditional banking and investment services, which require higher start-up costs relative to FinTech services. Today, most banking services are available online or through mobile applications. For example,

Underbanked means simply not having enough banking resources to meet the needs of a population. **Unbanked** people are not using banking resources to manage finances. This could be for a variety of reasons, including limited access to banks or a lack of education.

mobile payment services such as PayPal and Venmo along with online lenders such as LendingTree or Sofi bypass traditional banking infrastructure, including branches and ATMs.

E-Payments

Historically, digital payment services have served as a gateway technology introducing consumers to digital financial services. For example, PayPal introduced U.S. consumers to mobile payments and ushered in e-commerce in the early 2000s. Developing economies offer a significant growth opportunity for digital payment service providers, with momentum already building (Chart 8). Total digital payment transaction values in dollars continue to be dominated by the developed economies of the United States, United Kingdom, Germany, and Japan.

FinTech companies are leading this digital revolution, and we believe they may dictate the way unbanked and underbanked residents of developing economies enter

Chart 8
Emerging Markets and FinTech Adoption
Percent of Adoption in Each Category

Money Transfer and Payments	Financial Planning	Savings and Investments	Borrowing	Insurance
China 83%	China 22%	China 58%	China 46%	China 47%
India 72%	Brazil 21%	India 39%	India 20%	UK 43%
Brazil 60%	India 20%	Brazil 29%	Brazil 15%	China 38%
Australia 59%	U.S. 15%	U.S. 27%	U.S. 13%	South Africa 32%
UK 57%	Hong Kong 13%	Hong Kong 25%	Germany 12%	Germany 31%

Source: EY FinTech Adoption Index 2017, PNC

¹³ “SIX to Launch Full End-to-End and Fully Integrated Digital Asset Trading, Settlement and Custody Service” [Press Release] (July 6, 2018), <https://www.six-group.com/en/home/media/releases/2018/20180706-six-digitalexchange.html>.

¹⁴ *Emerging Markets: Driving the Payments Transformation*, PwC Global.

¹⁵ J. P. Moreno, M. Vazirani, and S. Lillis, “Billion Reasons to Bank Inclusively,” Accenture (2015), Accenture.com (accessed November 12, 2018), https://www.accenture.com/tr-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_22/Accenture-billion-reasons-bank-inclusively.pdf.

the marketplace. In our view, advances in financial technology are poised to lead future generations of growth across capital markets, the financial services value chain, and within developing economies.

Water Resources and Infrastructure

Water resources is a diverse and emerging investment theme. Broadly speaking, an investment in water consists of the pipes, pumps, and meters that form the infrastructure; the technology and software that manage the infrastructure; and the treatment technologies that make water drinkable. One of the most ubiquitous dilemmas for populations worldwide is inadequate access to fresh water — 97% of the world’s water is saltwater, with only 1% of the remaining water available for drinking, agriculture, and industrial uses. Economic growth, climate change, and rising populations are three of the factors affecting the availability of fresh water, and the issue is expected to intensify, even in regions currently considered water abundant. As the world’s population expands, maintaining an adequate supply of this limited and finite resource has become a priority of governments and business leaders.

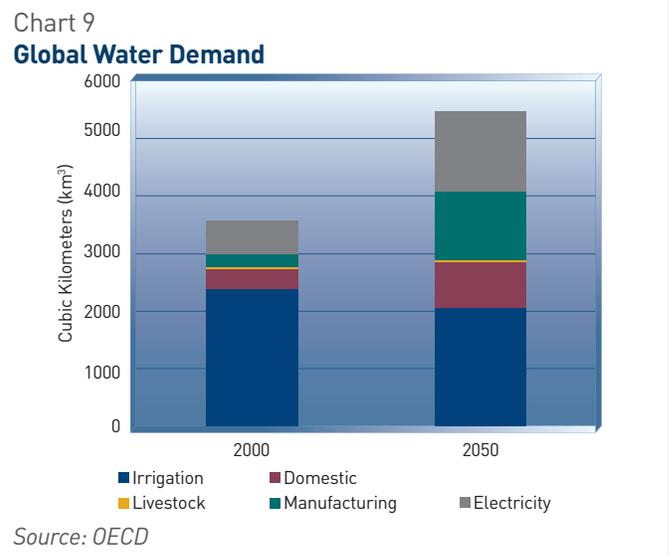
We believe the challenges confronting water resources and its associated infrastructure present a compelling thematic investment opportunity, since water shortages in the coming decades are expected to boost prices for this commodity. Companies actively involved in the water industry, particularly those with rights to water resources and distribution networks, may stand to benefit over the longer term. Our conclusion is based primarily on the following trends:

- the tightening water supply and demand gap, especially in developing economies;
- an uptick in government regulations to better manage the water supply; and
- more aggressive spending on infrastructure and innovative water technology.

Sources of Water Resources and Infrastructure Growth

Tightening Water Supply and Demand Gap

The demand for water has been climbing at a rate of about 1% per year, largely due to population growth and augmented water use in developing economies. The Organisation for Economic Co-operation and Development (OECD) projects water use will rise more than 50% between 2000 and 2050, with major upturns coming from manufacturing (400%), electricity (140%), and domestic (130%) (Chart 9).¹⁶ Currently, 3.6 billion people live in areas that suffer from water scarcity for at least one month a year, and it is anticipated this figure will rise to 5 billion by 2050.¹⁷ The water cycle has been shifting amid climate change, with drier regions becoming drier and the frequency and severity of droughts in places such as California and Brazil worsening. The situation is also becoming more acute from the effects of pollution amid an increase in industrialization, and water used for such purposes is expected to grow over time. In 2001, 54% of the world’s fresh water was consumed annually, primarily for agriculture (70%), industry (20%), and individuals



¹⁶ OECD, *Environmental Outlook to 2050. The Consequences of Inaction – Water* (Paris: OECD Publishing, 2012), <https://doi.org/10.1787/9789264122246-en>.

¹⁷ United Nations World Water Development Report, *Nature-based Solutions for Water* (March 19, 2018), <http://www.unwater.org/publications/world-water-development-report-2018/>.

(10%), and the International Monetary Fund (IMF) has concluded that number could jump to 70% by 2025.¹⁸

Government Regulation

Globally, many governments recognize water scarcity poses a threat to economic momentum and social development. Independently, some government officials are taking steps to rectify past missteps such as insufficient public spending on infrastructure, technology, and treatment processes, as well as a historically late response to shifting water demands and pollution. Most water services are delivered by the government, thus a mandate for higher water quality standards has considerable implications for future market growth and investment opportunities in the private sector as the pressure grows to address concerns around the water supply. The OECD has reported the global financing needs for water infrastructure are estimated to hit \$6.7 trillion by 2030 and \$22.6 trillion by 2050.¹⁹

In the United States, droughts and contaminated water are becoming more commonplace mainly due to aging infrastructure and faulty water treatment facilities, with the Flint, Michigan, crisis in 2014 a prime example of inefficient government oversight. The American Water Works Association reported in 2017 that about \$1 trillion will be necessary to restore the nation's underground pipes,²⁰ and the U.S. Environmental Protection Agency has projected \$472 billion will be required to modernize the water and waste water systems.²¹ Recognizing the problem, Congress passed the Water Resources Development Act of 2016 to address matters related to water security, lead contamination, sewer-overflow control, and drinking water conservation. It is estimated that more than \$3 trillion will be lost from U.S. GDP by 2025 if money is not invested in new infrastructure

and other water resources needs. The lack of a dependable water supply could also negatively affect some manufacturing industries, including steel, automotive, agriculture, and energy.²²

Global infrastructure projects are expected to rise 5–8% a year in the coming decades.²³ More than 50% of the world's population currently lives in urban areas and that number is expected to swell to 75% by 2050, with most of the growth in the developing countries.²⁴ Unsurprisingly, this has led to further strains on the water supply. The IMF anticipates developing economies will expand at an annual rate of at least 5% for the next four years, with the higher GDP growth tied to greater spending on water resources.²⁵

Water Technology Innovation

A rise in innovative technology to address global water resources and sustainability hurdles is changing the way water is delivered and used. This has led to a number of investment opportunities in the private sector in such areas as water treatment and conservation, desalination, groundwater extraction, water re-use, green energy solutions, and new processes to reduce water leaks caused by aging infrastructure.

Advancements in sensor technology and analytics in particular have helped the industry make more informed decisions around water management, for example:

- Smart meters have played a crucial role in improving the metering and pricing of water and have been key to detecting leaks and reducing overall water use. In the United States, utility companies lose nearly six billion gallons of treated water daily from leaking pipes, and as a result advanced metering solutions are selling at nearly twice the rate of traditional water meters.²⁶

¹⁸ *World Economic Outlook 2018: Brighter Prospects, Optimistic Markets, Challenges Ahead*, <https://www.imf.org/en/Publications/WEO/Issues/2018/01/11/world-economic-outlook-update-january-2018>.

¹⁹ <https://www.oecd.org/environment/resources/Water-Growth-and-Finance-policy-perspectives.pdf>.

²⁰ 2017 Infrastructure Report Card, <https://www.infrastructurereportcard.org/cat-item/drinking-water>.

²¹ <https://www.epa.gov>.

²² 2017 Infrastructure Report Card.

²³ "The SDG Investment Case" (2017), <https://www.calpers.ca.gov/docs/board-agendas/201801/full/day1/04-pri-blueprint-background.pdf>.

²⁴ <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/policybrief25.pdf>.

²⁵ <https://www.imf.org/en/Publications/WEO/Issues/2018/01/11/world-economic-outlook-update-january-2018>.

²⁶ "The Case for Fixing the Leaks: Protecting People and Saving Water While Supporting Economic Growth in the Great Lakes Region," Center for Neighborhood Technology (2013), http://www.cnt.org/sites/default/files/publications/CNT_CaseforFixingtheLeaks.pdf.

Fracking is a drilling technology established in 1947 used for extracting oil, natural gas, geothermal energy, and water from underground. The process involves drilling down deep into the earth before a mixture of water, sand, and chemicals is injected into the rock at high pressure, which allows the gas to flow out to the head of the well. More than 1.7 million U.S. wells have been completed using fracking, producing more than seven billion barrels of oil and 600 trillion cubic feet of natural gas.

- Smart pump technology is being developed, including the unveiling of waste water pumping systems with integrated intelligence. These systems can adapt performance in real time and give feedback to station operators, enhancing efficiency and making them simpler and less expensive to run than traditional methods.

Globally, desalination technology is playing a greater role in the water industry, largely in response to an urgent need for drinkable water in areas such as India, Israel, the Middle East, and Europe; currently, more than 100 countries rely on desalination for some of their fresh water consumption needs.²⁷ Demand is also coming from the hydraulic fracturing industry, which requires an immense amount of fresh water. While 20% of the water used by **fracking** can be re-used, 80% becomes saltier than seawater. The technology is still new and quite expensive, but we believe it has huge potential in the fight against water scarcity, which is a critical issue for governments faced with the challenge of providing an adequate water supply. This has led to stricter regulations in both developed and emerging markets around water quality standards, significant market growth in water analytics and treatment technology, and much-needed spending on essential infrastructure. There has been a marked upswing in investor interest in companies actively engaged in improving the delivery of water resources.

Convergence of Artificial Intelligence and Robotics

AI and robotics have been around for some time. But joining these disciplines can create intelligent robots with a range of implications, from preparing income taxes to farming. In fact, we have already seen the emergence of semi-autonomous vehicles, drones, and AI-driven facial recognition software.

The International Data Corporation (IDC) expects capital spending in robotics and AI to reach \$201.3 billion by 2022, with a compound annual growth rate of 19.6% over 2017–22.²⁸ IDC forecasts the majority of this capital will be invested in **AI and machine learning**.

As computers have become more powerful and data more readily available, advances in AI and machine learning have followed. We believe the combination of these disciplines with robotics can have a significant economic- and business-related benefit. According to a McKinsey study, AI could boost global economic activity by approximately \$13 trillion by 2030—a 16% increase in cumulative GDP versus today.²⁹

Outside of the traditional tech-heavy industries, AI and robotics are likely to affect diverse industries over the coming decades. From an investment perspective, we believe this is one of the most attractive attributes of these disciplines. Here we highlight two industries,

²⁷ "Saline Water: Desalination," U.S. Department of the Interior, U.S. Geological Survey, <https://water.usgs.gov/edu/drinkseawater.html>.

²⁸ "Worldwide Spending on Robotics and Drones Forecast to Accelerate Over the Next Five Years, Reaching \$201.3 Billion in 2022, According to New IDC Spending Guide" (July 18, 2018), <https://www.idc.com/getdoc.jsp?containerId=prUS44150218>.

²⁹ Excerpted from "Building Smarter Cars with Smarter Factories: How AI Will Change the Auto Business," October 2017, McKinsey & Company, www.mckinsey.com. ©2019 McKinsey & Company. All rights reserved. Reprinted by permission.

The terms **AI and machine learning** are often used interchangeably. For purposes of this analysis, we define AI as the broad concept of machines/robots performing tasks that require varying levels of intelligence for humans to perform. Machine learning is a form of AI that provides machines and robots with data so they can train themselves to use and apply data to specific tasks.

automotive and retail, and the potential impact of AI and robotics.

Lastly, beyond industry-specific applications, the convergence of AI and robotics will likely have a global impact. For example, advancements in AI/robotics will likely be instrumental in finding a solution to the declining global working-age population, a topic we touch on later.

Sources of Future AI/Robotics Demand *Impact on the Automotive Industry*

There are a number of technical, legal, and ethical challenges to autonomous vehicles (AVs), or self-driving cars, so they are likely years away from safely driving us to work or navigating an ambulance to the nearest hospital. While not all of the technologies needed for AVs have yet to be developed, there has been progress. We believe this sets up a so-called “long runway” for the growth of related AI and robotics companies. That is, an investment in AI/robotics today will benefit from the ongoing development of AV technologies.

We believe the path to fully autonomous vehicles is incremental, with many seemingly small innovations rather than a few large advancements. Automakers are already offering features such as forward collision warning, automatic emergency braking, lane departure warning, lane keeping assist, adaptive cruise control, and blind spot detection.³⁰ Each feature represents a small step to fully autonomous vehicles, and the underlying technologies enabling them are largely dependent on AI.

The automobile industry is a significant part of the global economy, so even small changes could have an effect on the growth trajectory of AI and robotic companies driving these advancements. McKinsey projects AVs could account for 10–15% of all new car sales by 2030.³¹ For context, 79 million cars were sold globally in 2017, with the United States accounting for 17 million of that total. Furthermore, we believe AI-enabled car components may have a greater near-term impact on global car markets.

Advances in AI/robotics are already affecting how cars are manufactured. Today, most of the production of traditional vehicles is automated. But as robots become smarter and able to process and analyze real-time data without human intervention, they will likely take on a greater share of the auto manufacturing business. Using AI-enabled robots will likely result in more efficient supply chains, less equipment failure, and better quality control. The evolution of cloud computing, sensor technology, and internet of things is converging to help drive innovation, which is enabling the ability to store and collect vast amounts of data, helping to fuel AI-enabled robots. In real time, machines could adjust raw material orders dynamically based on supply and demand and diagnose and correct manufacturing errors in a continual learning process. We believe AI-based machines will help lead to less production downtime, improved production equipment availability, lower maintenance costs, and ultimately greater productivity.

Beyond the underlying car technologies, components, and manufacturing process, how consumers think about and use cars will likely change as AVs become

³⁰ “Cars with Advanced Safety Systems” (last updated July 24, 2018), <https://www.consumerreports.org/car-safety/cars-with-advanced-safety-systems/>.

³¹ Excerpted from “Building Smarter Cars with Smarter Factories: How AI Will Change the Auto Business,” October 2017, McKinsey & Company, www.mckinsey.com. ©2019 McKinsey & Company. All rights reserved. Reprinted by permission.

a reality. For example, studies have estimated that, on average, cars are parked up to 95% of their lifespan.³² We think AVs and ride-sharing networks could flip this dynamic.

Today cars are considered all-purpose vehicles, whether a person is traveling alone to work or carpooling or vacationing with friends and family. The rise of AVs will likely change how we approach these two scenarios. For example, consumers may prefer to choose their transportation for a specific trip, similar to the on-demand services offered by Uber and Lyft. Car-sharing networks are the next step in the car ownership progression. In fact, many well-known companies such as Uber, Tesla, Inc., and Alphabet Inc. have begun to develop their own car-sharing networks. Once established, consumers could join a ride-sharing network and have access to an AV on demand. Network members could also have the option to share their own vehicles while not in use, potentially earning rental income. Car-sharing networks are one way consumers could amortize the anticipated higher costs of fully AVs, only paying for their actual usage.

Impact on the Retail Industry

Many sectors of the retail industry, from online sellers to big box stores, already have access to vast amounts of consumer data, including shoppers' previous transactions, when and how often consumers shop, social media data, online viewing histories, seasonality, weather patterns, and more. The depth of this data enhances the capabilities of applying AI to a retailer's business strategy. For example, using consumer data, retailers (with the help of AI) may be able to better anticipate consumer decisions, dynamically set up targeted promotions, optimize supply chains, and eliminate some manual processes that may be hindering getting goods to the market and the end consumer.

Recently, both Amazon.com, Inc. and Netflix, Inc. have made significant investments in this area. Amazon has automated its picking-and-packing processes, decreasing shipping times and operating costs. Netflix

has employed AI-supported algorithms to personalize customer recommendations, which has helped improve the customer experience and retention. Both Carrefour S.A. (France) and Target Corporation (United States) have deployed electronic tracking systems in their stores, allowing their mobile apps to know a consumer's geographic location and collect data about consumer behaviors and purchasing patterns. Harnessing AI, these data are then used to personalize promotions, in some cases while shoppers are in the store.

We believe AI/robotics could close the gap between the ease of online shopping and the higher overhead costs of physical locations by eliminating a store's check-out process. Today, Amazon.com is experimenting with a physical store in Seattle, Amazon Go, with no human employees. Shoppers entering the store are recognized by computer vision (like facial recognition available in iPhones today), which connects the shoppers with items they take from the store shelves and deducts the cost from their Amazon.com account once they leave the store.³³ The many technologies involved in this process are powered by AI and robotics. Collectively, they provide consumers with a more convenient shopping experience, help build customer loyalty, and lower a physical store retailer's costs. According to Focal Systems, Inc., a developer of AI-enabled/smart shopping cart technologies, a single Walmart store has monthly labor costs of approximately \$572,000. It is estimated that 57%, or \$326,000, of that cost is attributable to scanning, cashiers, and restocking shelves, all of which AI and robotics could eliminate.

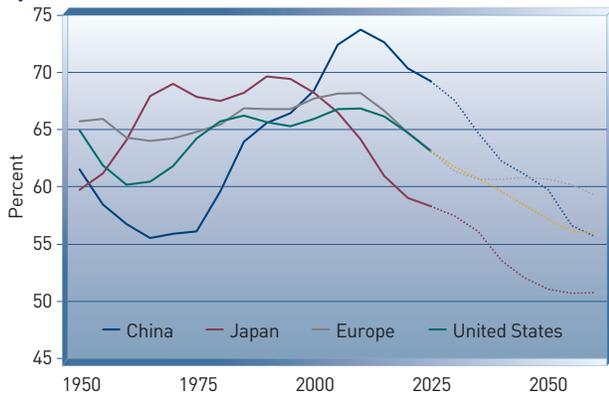
Solution to Declining Working Age Population

The integration of machine learning and AI could help improve the cognitive interactions of robots, allowing for wider adoption beyond just repetitive tasks. In our view, this combination makes AI-enabled robots a likely solution to the expected shortages in working-age populations across major global economies over the next few decades. Advanced economies with

³² P. Barter, "Cars Are Parked 95% of the Time. Let's check!" [Blog], Reinventing Parking, posted February 22, 2013, <https://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html>.

³³ Excerpted from "Artificial Intelligence: The Next Digital Frontier?", June 2017, McKinsey & Company, www.mckinsey.com. ©2019 McKinsey & Company. All rights reserved. Reprinted by permission.

Chart 10
AI/Robotics Possible Solution to Future Working Population Decline



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017)

declining working-age populations will likely need to rely more heavily on robotics and automation if they want to reach the necessary productivity levels to meet their GDP growth targets (Chart 10).

The objective of advancements in AI/robotics is to make the underlying technologies versatile enough to learn on their own without explicit programming (that is, machine learning). The machine-learning capabilities of robots would be nearly indistinguishable from human capabilities but with greater efficiencies. We are likely years or even decades away from this becoming a reality, and adoption of this technology will take time. However, momentum is building and there is the opportunity for virtually all industries to incorporate new AI/robotic technologies into their processes.

Taking a longer-term view, these incremental but simultaneous advances across many areas will have compounding effects over the coming decades. We believe that for patient investors, an investment in this area of technological evolution will allow them to get exposure to one of the most powerful trends in our world today.

The Monetization of Social Media

There has been a surge in the past decade in the number of people accessing the internet and social media platforms, driven in part by advancements in smartphone technology, an increasing millennial population (ages 18–34), and an emerging middle class in some countries. There are now about four billion active internet users (42% of the world’s population), which includes 98% of 18–29 and 97% of 30–49 year olds in the United States alone.³⁴ At the same time, there is a growing preference for smartphones, online shopping, and the launch of social networks such as Facebook, LinkedIn, and Instagram. These platforms were conceived as online vehicles to interact with friends and family, review news content, share personal information, and for entertainment purposes (for example, watching videos). Most social networks are now available as mobile apps, making it easier for people to connect online. The number of mobile phone users has expanded to five billion, with nine out of 10 global internet users accessing their social media platforms on these devices, and more than three billion people active on at least one social network.³⁵ Brands have taken note, with money spent on social media marketing hitting \$32 billion in 2017,³⁶ helping to fuel the revenue growth of social media market leaders such as Facebook in the United States and Tencent in China.

Many business leaders have looked to social media not just to market their products but also to gain a better understanding of how their brands resonate and connect with the target audience. The data collected and processed daily on social networks, also called “big data analytics,” have helped marketers analyze and predict consumer behavior and preferences, target key demographics, and engage customers. We believe those companies on the forefront of capturing and monetizing this information in an efficient and scalable manner have the potential to profit over the longer term as marketing strategies adapt with the times.

³⁴ Statista, “Share of Adults in the United States Who Use the Internet in 2018, by Age Group,” <https://www.statista.com/statistics/266587/percentage-of-internet-users-by-age-groups-in-the-us/>.

³⁵ S. Kemp, “11 New People Join Social Media Every Second (and Other Impressive Stats)” (January 29, 2018), <https://blog.hootsuite.com/11-people-join-social-every-second/>.

³⁶ Statista, “Social Media Marketing—Statistics & Facts,” <https://www.statista.com/topics/1538/social-media-marketing/>.

Many companies have turned their attention to the 1.8 billion millennials worldwide who are reaching their peak earning years, making this generation a very powerful consumer base. Millennials represent a significant part of most brands and are influential in the design and marketing of many products and services, especially given their dominant presence on social media. While there are 92 million U.S. millennials, China (415 million) and India (440 million) encompass another 47%, and their power to consume is climbing rapidly as incomes improve.

Sources of Social Media's Future Revenue Growth

Social Media's Global Presence

Despite recent concerns regarding the amount of user data collected, we view the social media industry as a powerful growth engine, with one million new users reported daily.³⁷ In the United States, 69% of adults are active on social media, a marked increase from 50% in 2011 and 5% in 2005. Much of the acceleration can be attributed to younger adults, with 88% of 18–29 year olds and 78% of 30–49 year olds on at least one platform. Millennials spend an average of 223 minutes per day on mobile devices, a jump from 107 daily minutes in 2014, and 85% are smartphone owners.³⁸ Facebook is currently the top network in the United States, with 214 million active users, and 82% of 18–29 year olds and 79% of 30–49 year olds have accounts. Facebook was the first network to reach one billion registered accounts globally, and it now has more than two billion as of July 2018, while photo-sharing app Instagram has one billion active accounts (116 million in the United States). These two platforms focus on exchanges between friends and family and on features such as posting photos and games. Other leading networks, for example, Twitter (336 million users), are used mainly for communication and are commonly called microblogs. Video-sharing site YouTube has 1.9 billion active users and is the second most preferred network in the world, while the messenger

app WhatsApp has 1.5 billion users globally.³⁹ Ultimately, these robust and growing user bases, particularly in developed markets, enable incremental revenue opportunities to have a significant impact on a social media company's revenues.

As wealth and education levels rise in the emerging markets (EMs) and as more people get access to the internet and smartphones, participation on social networks is expanding to levels previously seen only in the more advanced economies. In 2015, roughly 40% of adults in EM countries used social networking sites, rising to 53% in 2017. Social media development is particularly robust in China as a result of its strengthening economic influence and growing middle class. There are 634 million Chinese internet users (50% of the total Chinese population), with 400 million of them active on social media. The Chinese spend an average of 40% of their online time on a social network, with Weibo (similar to Twitter with 400 million users) and Tencent's WeChat (a mixture of Facebook and WhatsApp with one billion users) especially popular.⁴⁰ Douyin (video sharing app) is prevalent among young users in China, with 500 million users.⁴¹ India has the most number of Facebook users at 270 million.⁴² However, participation is centered with the millennials, so we expect overall activity to increase as the economy expands and incomes rise.

³⁷ S. Kemp, "11 New People Join Social Media Every Second."

³⁸ D. Chaffey, "Our Compilation of the Latest Social Media Statistics of Consumer Adoption and Usage," Smart® Insights (February 12, 2019), <https://www.smartinsights.com/social-media-marketing/social-media-strategy/new-global-social-media-research/>.

³⁹ Statista, "Most Popular Social Networks Worldwide as of January 2019, Ranked by Number of Active Users (in Millions)," <https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/>.

⁴⁰ B. Lamb, "5 Key Features of Chinese Social Media," <https://www.jeffbullas.com/5-key-features-chinese-social-media/>.

⁴¹ Statista, "Most Popular Social Networks Worldwide as of January 2019."

⁴² Statista, "Leading Countries Based on Number of Facebook Users as of January 2019 (in Millions)," <https://www.statista.com/statistics/268136/top-15-countries-based-on-number-of-facebook-users/>.

Marketing to Millennials

Embodying the largest generation in the United States, millennials consume more than \$600 billion in goods and services annually, and that is expected to jump to \$1.4 trillion (30% of all U.S. retail sales) by 2020 as the oldest millennials hit their peak earning years. Further, millennials control more than \$2 trillion in liquid assets, which is forecast to more than triple by 2020; by 2025 it is estimated they will generate 40% of all U.S. income.⁴³ Chinese millennials meanwhile are viewed as the most tech-savvy consumers in the world, preferring convenience and easy mobile access over brick and mortar; their income is expected to rise to more than \$3 trillion in the next decade.⁴⁴ U.S. brands in particular have dedicated resources to establishing online payment services, e-commerce sites, and social media accounts to break into a market with significant growth potential. The number of internet users who favor online shopping is projected to reach 453 million (65.5%) by 2020, and it is estimated those ages 18–34 will account for more than half of China’s online sales.⁴⁵

Brands recognize social media’s power to influence consumer behavior and are opening accounts on sites like Facebook and Instagram to advertise their products and services, engage and build brand loyalty with their targeted consumer base, and research what their customers are saying about their products. The 2017 *Social Media Marketing Report* found 71% of consumers who have had a positive experience with a brand on social media are more likely to recommend it to their friends and family, 49% of 18–29 year olds will purchase something after seeing an ad for it on social media, 77% of millennials will purchase something

either online or in-store after seeing it mentioned on Facebook, and customers will spend around 20–40% more on brands that have interacted with them on social media.⁴⁶

Part of the draw of social networks is that, for the most part, they are free to join, and many companies generate the bulk of their revenue from running advertisements. Results from the February 2018 Chief Marketing Officer Survey⁴⁷ show brands currently spend 12% of their marketing budgets on social media, an increase of more than 8% from 2009, and spending is expected to reach 20.5% of marketing budgets over the next five years. In the United States alone, \$26 billion was spent on social media advertising in 2018 and \$10.8 billion in China.⁴⁸ Facebook earned \$40 billion in 2017 from total advertising revenue, while Instagram earned almost \$4 billion and is expected to reach \$7 billion by year-end 2019.⁴⁹ In an online survey from Statista, the majority of brands stated social media marketing was necessary for business growth, with Facebook and Instagram found to be the most successful marketing platforms followed by Twitter and LinkedIn.⁵⁰

The Importance of Big Data

Historically, the primary focus of social media providers has been on growing and maintaining user subscriptions; typically their services are free and require little more than downloading an app. Today this dynamic is shifting, with the success of a given social network or brand increasingly hinging on its ability not only to innovate but also to adapt to the constantly evolving values, desires, and expectations of younger generations. “Big data” has played a role

⁴³ Accenture, *Who Are the Millennial Shoppers, and What Do They Really Want?*, <https://www.accenture.com/us-en/insight-outlook-who-are-millennial-shoppers-what-do-they-really-want-retail>.

⁴⁴ <https://www.brookings.edu/blog/future-development/2018/04/30/how-to-harness-the-spending-power-of-millennials-move-beyond-the-us/>.

⁴⁵ eShopWorld, “Chinese Millennials Are Shirking Traditional Roles and Demanding Brands that Reflect Interests and Ideals Online,” <https://www.eshopworld.com/chinese-millennials/>.

⁴⁶ Kayla, “30 Social Media Marketing Statistics that Will Change the Way You Think about Social Media” (March 5, 2018), <https://www.lyfemarketing.com/blog/social-media-marketing-statistics/>.

⁴⁷ *The CMO Survey. Highlights and Insights Report* (Duke University, 2018), https://cmosurvey.org/wp-content/uploads/sites/15/2018/02/The_CMO_Survey-Highlights_and_Insights_Report-Feb-2018.pdf.

⁴⁸ Statista, “Social Media Advertising,” <https://www.statista.com/outlook/220/109/social-media-advertising/united-states>.

⁴⁹ Statista, “Facebook’s Advertising Revenue Worldwide from 2009 to 2018 (in Million U.S. Dollars),” <https://www.statista.com/statistics/271258/facebooks-advertising-revenue-worldwide/>.

⁵⁰ Statista, “Social Media Marketing—Statistics & Facts.”

in powering personalization, increasing customer loyalty in a brand, and engaging the consumer through an analysis of personal data retrieved from social network users. Collectively, personalization via big data is expected to become a primary source of revenue growth across the social media industry. Facebook operates as one of the largest databases of personal information, and the company has invested heavily in technology to collect, store, and evaluate big data. Facebook can track information like purchase history, geography, demographics, and preferences to help brands proactively attract consumers via advertising and customized email offers. Big data analytics has made marketing more about future predictions and the potential impact of current strategies. By organizing large and complex data sets via machine learning algorithms, which was hard to do in the past in a scalable and usable form, Facebook has the ability to monetize valuable user information. Brands have used the data to more efficiently target consumers based on detailed factors that go beyond race, age, or gender. Researchers at Cambridge University and Microsoft Research conducted a study that found the patterns of “Facebook Likes” can forecast such data points as satisfaction with life, intelligence, sexual orientation, emotional stability, religion, drug use, and relationship status.⁵¹

Apart from simply examining user activity, Facebook has other ways of determining consumer behavior. For instance, if users are logged into Facebook and browse other websites, the company can track the sites they are visiting. Facebook also has invested in facial recognition and image processing tools to follow its users across the internet, with image data provided through user sharing. Topic Data is a new technology that incorporates sentiment algorithms to show marketers how Facebook networks feel about specific brands, events, activities, subjects, etc., while keeping sensitive data private. Brands have used this information to selectively adjust the way they market on the platform and on other social channels. In another example, Instagram introduced business accounts in May 2016, which has helped more than five million businesses market themselves on the

network. A business account allows a company to access analytics data, including insights on how posts are performing and what followers like, as well as to publish their address, phone number, and website and to create ads.

Social media has the potential to act as a disruptive force across many industries, driving technological innovation, helping to boost cost savings, and supporting brands through successful partnerships. We believe companies involved in the successful gathering and monetizing of important consumer data will provide another long-term growth opportunity for investors in the social media industry.

Internet of Things

The Internet of Things (IoT), a network of easily deployed sensors and smart devices, combined with advanced analytics platforms and cloud services, has the potential to disrupt and strengthen products and services across multiple industries. IoT is the convergence of more reliable and secure high-speed broadband networks, universal wireless internet, **cloud computing**, and sensor technologies that can collect and share data via the internet, and the emergence of big data analytics to store and dissect that data. Any standalone internet-connected device that can be monitored and/or controlled from a remote location is considered an IoT, or “smart,” device. With the development of cheaper and more powerful sensor chips, virtually any product can be transformed into a smart device. Advances in sensor technology have enabled data collection from everyday consumer products (for example, watches and cars) and industrial items (for example, factory equipment or utility grids). This information is centralized on networks which support platforms used to enhance productivity and support new business

Cloud computing is the delivery of elastic, on-demand computing power and data storage over the internet.

⁵¹ <https://www.bloomberg.com/news/articles/2018-03-21/understanding-the-facebook-cambridge-analytica-story-quicktake>.

services or applications to help secure health, safety, or environmental benefits for consumers and corporations.

This emerging technology is in the early stages of development, and the number of potential applications could be tremendous. However, measuring the technology's long-term impact has been a challenge. The International Data Corporation estimates IoT-related global spending will hit a growth rate of 15.6% by 2020, reaching \$1.29 trillion.⁵² Further, according to the NCTA—The Internet & Television Association, more than 50 billion smart devices will be linked to the internet by 2020, including such essentials as kitchen appliances, house security systems, and even subways (Chart 11).⁵³ Today, consumer applications like Garmin's fitness monitors and Amazon's Alexa smart speaker may attract the majority of the public's attention, but we believe industrial and commercial uses could be another powerful growth driver. Future consumer applications will likely focus on efficiency in everyday life and replace many of the more mundane tasks such as grocery shopping, prepapering

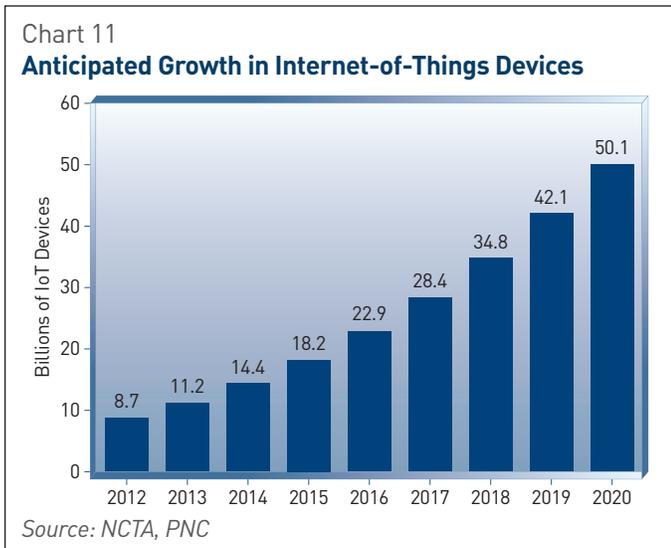
meals, landscaping, or automatically optimizing home heating and cooling based on current energy pricing. Together, consumer- and industrial IoT-related sales are forecast to reach \$1.6 trillion by 2025.⁵⁴

Sources of Internet of Things Growth

Evolution of IoT Consumer Applications

A few years ago, one would be hard pressed to predict how fast the consumer preference for smart speakers, one of the earlier innovations of sensor technology, would grow. But demand has skyrocketed, with consumers estimated to have purchased more than 56 million smart speakers from companies including Google and Amazon through 2018.⁵⁵ Smartphones increasing are becoming the personal gateway to IoT, serving as a remote control for the connected home, automobile, or even the fitness trackers popular among millennials. Finding keys, unlocking doors, turning the heat on, and other daily tasks can be automated with sensors and smart software. With wifi coverage available worldwide, wireless connectivity has become relatively inexpensive, helping to fuel the expanding usage in smart devices.

The ownership rate of smart devices is expected to climb, particularly in the realm of home automation to help reduce energy costs and improve security. The smart home market had sales of nearly 644 million devices in 2018, a 31% year-over-year growth rate, and as many as 1.3 billion units are expected to be sold in 2022.⁵⁶ Sensor-enabled products such as the Nest, which was bought by Google in 2014, allow



Smart speakers are basically “dumb” speakers connected with internet-linked sensors to better manage music listening preferences or function as home assistants.

⁵² “How 70% of Fortune 100 Companies Use the IoT,” Curator—Citi IO (October 3, 2017), <https://www.citi.io/2017/10/03/how-70-of-fortune-100-companies-use-the-iot/>.

⁵³ NCTA, Internet of Things, <https://www.ncta.com/positions/internet-of-things>.

⁵⁴ Priceonomics Data Studio, “The IoT Data Explosion: How Big Is the IoT Data Market?,” <https://priceonomics.com/the-iot-data-explosion-how-big-is-the-iot-data/>.

⁵⁵ canalys, “Smart Speakers Are the Fastest Growing Consumer Tech; Shipments to Surpass 50 Million in 2018,” <https://www.canalys.com/newsroom/smart-speakers-are-fastest-growing-consumer-tech-shipments-surpass-50-million-2018>.

⁵⁶ M. Hoffman, “The IoT Is at the Center of Disruptive Technologies” (February 8, 2019), <https://www.globalxfunds.com/iot-center-of-disruptive-technologies/>.

homeowners to manage their homes from a remote location via an app on their smartphones to prevent break-ins, theft, or any other home-related issue like a fire before it gets out of hand. IoT products related to home energy management aim to promote energy efficiency by automating the operation of lights, appliances, and heating and cooling systems.

In health care, smart medical devices have focused on improving patient outcomes and reducing costs by reducing the time spent in a hospital and by promoting preventive care. Technology designed to help the elderly live at home longer has become more relevant as the baby boom generation ages, for example, home medical dispensers that automatically upload data to the cloud if medication is not consumed. Smart technology has the potential to drastically reduce the workload and stress for health care providers by allowing them to remotely monitor a patient's health while he or she is recovering at home and take quick action in the event of any major changes in the patient's readings. The health care consumer trend is also being encouraged by millennial interest in staying healthy through the use of wearable fitness trackers, a market expected to double by 2022, hitting \$27 billion in revenue and an estimated 233 million units sold.⁵⁷ While these consumer products currently measure exercise, heart rate, diet, sleep patterns, and other factors, we believe they could eventually be used to relay information to health care providers, employers, or insurers.

Industrial/Commercial IoT Applications

Many people may think the internet's greatest impact is on consumer applications, entertainment, and social media networks. But multiple industries worldwide have been implementing smart technology into their manufacturing processes. Industrial/commercial applications, including customer engagement and performance tracking, comprise the largest percentage of global IoT-related spending.⁵⁸ Through the use of sensor technology and data analytics, there is potential to automate business and manufacturing

processes, remotely monitor and control operations, optimize supply chains, and conserve resources.

Consequently, we have seen a jump in fixed capital investment in software as opposed to traditional capital goods equipment, which has resulted in new business models that can integrate hardware and software offerings, strengthen revenue streams, and enhanced customer retention. Seven of 10 Fortune 100 companies currently use IoT-related products, services, or initiatives, while 38% of global manufacturers are producing such products and services and 48% are in the process of developing them.⁵⁹ We believe smart devices and the technologies supporting their application will help companies:

- prolong the life of assets;
- evaluate and enhance financial performance;
- boost operational efficiency; and
- act as a real-time data analytics platform to help steer long-term business strategies.

Big Data

Advancements in big data analytics have helped spur the rapid growth of IoT-related applications—database technology powered by specialized platforms and cloud software that can manage larger unstructured datasets more efficiently, quicker, and cheaper than traditional databases.⁶⁰ As the quantity of and accessibility to big data have grown in the past few years, more organizations are evaluating how they can better leverage this information to make more effective management decisions and improve their bottom lines. Big data analytics is the process of breaking down large and diverse datasets to reveal major market trends, unknown patterns, obscured correlations, customer penchants, and other valuable information to help organizations make “smarter” strategic moves. Predictive maintenance and analytics have already gained significant attention in manufacturing and telecommunications by using sensors to collect data that can then be analyzed by

⁵⁷ Hoffman, “The IoT Is at the Center of Disruptive Technologies.”

⁵⁸ <https://www.citi.io>.

⁵⁹ <https://www.citi.io>.

⁶⁰ *IoT Analytics, IoT Platforms: The Central Backbone for the Internet of Things* (November 2015), <http://iot-analytics.com/wp/wp-content/uploads/2016/01/White-paper-IoT-platforms-The-central-backbone-for-the-Internet-of-Things-Nov-2015-vfi5.pdf>.

algorithms. It is expected that by 2022 more than 80% of IoT capital projects will include an AI element, a leap from only 10% in 2017.⁶¹

Big data analytics has been especially constructive for corporations in highlighting such factors as new revenue streams, more effective marketing strategies, enhanced customer service, improved operational efficiency, and increased competitive advantages relative to industry peers.

Looking to the future, the amount of data produced by IoT usage is expected to hit 4.4 zettabytes by 2020, up from just 0.1 zettabytes in 2013.⁶² We expect further investments in powerful analytical technologies as more companies worldwide migrate toward implementing smart device sensor technology in their day-to-day operations and long-term strategic plans.

Conclusion

Our thematic investment strategy attempts to identify themes that we believe have the potential to drive structural change. Thematic investments typically originate from technological advancements, trends

in populations, shifting consumer preferences, or changes to regional economies that represent long-term, fundamental shifts powerful enough to affect market performance across multiple industries and geographies. In this paper, we have outlined our initial six thematic allocations. We will continue to explore emerging opportunities that align with our investment process.

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⁶¹ Hoffman, "The IoT Is at the Center of Disruptive Technologies."

⁶² PricewaterhouseCoopers Data Studio, "The IoT Data Explosion: How Big Is the IoT Data Market?"

For definitions of indexes used in this publication, please refer to pnc.com/indexdefinitions.

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