RBC Capital Markets

Imagine 2025

Themes, Opportunities &
"The Law of Accelerating Returns"

FOR REQUIRED CONFLICTS DISCLOSURES
PLEASE SEE PAGE 196.

GLOBAL RESEARCH | JUNE 26 2018

A message from the Directors of Global Research

Futurist Ray Kurzweil first wrote two decades ago about "The Law of Accelerating Returns". His theory posited that the same exponential growth qualities that made Moore's Law possible – doubling of semiconductor capacity per square inch every 12-18 months -- have extended themselves to all forms of technological progress. Paradigm shifts would rapidly become the norm and, in his view, we would experience thousands of years of progress in the historical exponential equivalent of several years.

Kurzweil's vision of a 'technological singularity' in 30 years, where the nature of our existence changes as cumulative machine intelligence surpasses collective human intellect, may never come to pass. But as an executive, board member or investor, ignoring the indisputable parabolic curves emerging across industries and economies is not an option. How should you think differently about the companies you manage or own in the face of this transformative competitive backdrop? What are the early indicators of this step function change and what can you learn from the examples? Which public companies are taking proactive steps to trade near-term earnings for long-term positioning?

Challenged and intrigued by these questions, RBC Capital Markets embarked on an ambitious six-month study of the global drivers of parabolic change. Our work highlights the pervasive impact of technological innovation but also contextualizes this with non-technological change forces such as population growth, climate change, urbanization, resource shortages, and an evolving workforce. The six themes that emerged from this work – The Calibrated & Augmented Self, The AI Race, Collective Action, Escalating Uncertainties, The Agility Imperative and In Cloud We Trust – formed the outline of the report that follows, asking many "what if" questions about the future status quo. **IMAGINE 2025** captures the collaboration of our Global Research Team, the broader RBC Capital Markets employee base and industry experts or "futurists" affiliated with our partners at Sterling Rice Group. Importantly, this collaboration across disciplines fostered lateral thinking that helped us identify the change forces and themes of a less obvious, non-linear future.

The overarching goal of our report is to challenge management and investor thinking, creating a framework to help anticipate which companies will be on their front foot strategically. Leadership decisions today may well determine a company's fate in 2025, as the historical change examples illustrated throughout this report demonstrate. We encourage readers to take a lateral approach in reviewing this report, reading all sections and reflecting upon how developments in one industry may influence another. We hope this thematic roadmap, including the global list of forward-thinking companies highlighted in our IMAGINE 2025 Portfolio will challenge executives and asset managers to think expansively and creatively as they invest with an eye towards the next decade.

Marc Harris   **Andre-Philippe Hardy**   **Rufus Grantham**   **Paul Hissey**

Directors of Global Research

RBC Capital Markets

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Priced as of market close, June 20, 2018 ET.
All values in US dollars unless otherwise note.

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> *What if automation, the Industrial IoT, and 3D printing capabilities removed the need for manufacturing in low-cost regions? Could this drive companies to reinvest in the U.S. and other developed markets where higher-skilled workers reside?*

> *What if using a wrist integrated smart device consumers could understand the direct implications on life expectancy, weight gain and loss from consuming different foods/beverages, and participating in certain activities?*

II: The Artificial Intelligence Race: We are on the precipice of the Artificial intelligence (AI) era. Software, enabled by machine learning (training algorithms on input data) and deep learning (using neural networks) can replicate and eventually surpass human cognition. It is helpful to think about AI technology in phases as a progression: narrow AI, general AI and superintelligence or "the singularity." Each stage of AI development has different implications for different industries and the world at large.

> *What if AI-enabled autonomous driving turns your vehicle from a depreciating asset to an income-earning one – being put into a shared fleet or used for last-mile delivery when not in personal use? What if the vehicle could mine for crypto currencies or other future crypto assets with its computing capacity when not in use, generating additional income for owners and operators?*

> *What if AI precision farming ushers in the next global "green revolution" and cuts food costs in half? Will this accelerate the long-term decline in the percentage of income spent on food? Or will consumers use savings to trade up to more expensive and nutritious foods? How will this impact grain-reliant packaged food companies? Healthcare companies?*

III. In Cloud We Trust: The adoption and utilization of cloud technology is rapidly changing the landscape of corporate IT as well as corporate competition across industries. The democratization and affordability of cloud computing and storage is fueling the rate at which companies can start, scale, and succeed. As basic cloud services become more affordable with price cuts, premium services such as intelligence, machine learning, and advanced compute will continue to be introduced at affordable rates, giving high power tools and capabilities to businesses of all sizes.

> *What if the "Asian Hyperscale Threat" becomes real? We could see companies like Alibaba, Baidu and Samsung scale their public cloud offering beyond the current regional presence and offer an alternative to the big three (Amazon, MSFT and Google). What if Alibaba is Amazon's Amazon? What if this sparks a new round of national security conversations, along with all data sovereignty/ safety issues that are associated with them?*

> *What if the network becomes more valuable than compute? Despite this land-grab for compute and storage, what of the network? Could we see a land-grab for metropolitan cable operators and infrastructure? What about long-distance transport and who dominates that? Is the Microsoft and Facebook partnership on a new sub-Atlantic 4K cable just the start of a new capex arms race?*

IV. Collective Action: The power to act collectively has never been greater given technology and the viral speed with which social sharing can occur. As a result, long-held beliefs in traditional institutions, social norms, and commerce are being challenged. As a result, we believe the pace of disruptive change will accelerate, but also believe increased collaboration between historical adversaries could increase, as incumbents seek to partner for survival via self-cannibalization and disruptors seek change at scale.

> *What if self-sovereign IDs become the norm? Will large-scale consumer–data-derived models be required to directly compensate consumers to gain access to data? Will banks become "token vaults" holding consumers' digital tokens/currencies as a new demand deposit account or will they be disintermediated as new digital token wallets become the on ramps to gain access to a decentralized network of value?*

> *What if the rise of the collective conscience drives proof-of-sourcing, ranging from food, clothing, and raw materials, as consumers demand specificity on providence tracking? An example would be scanning a QR code with a smart device. Will the cost of tracking inherently increase the cost of goods and services making it more attainable by the wealthy vs. the poor? Will more people be willing to pay more to support natural/organic, non-GMO, all natural or local products?*

V: Escalating Uncertainties: Even as we struggle with a staggering amount of change, we can envision a future where this change goes parabolic, making our present concerns seem quaint, heightening uncertainty, and expanding the list of threats and challenges posed to the world's nations, institutions, and corporations. The sheer scale of change has significant economic, environmental and resource considerations. We have already seen the shoots of violent extremism and economic and political nationalism as nations react differently to shifting societal realities. As we look forward, we see the potential for two paths – an adherence to the post-war tenets of globalization, inclusion and joint solutions, or a hard turn towards nationalism and isolation in all its forms. These uncertainties create the opportunity for innovative solutions to global conflicts and resource allocation, but equally increase the potential for a fragmentation of global institutions, military and economic threats, and a chasm between the haves and have-nots.

> *What if the use of alternative energy fuels causes lower oil prices, creating civil unrest in economies that rely primarily on hydrocarbon revenues (Venezuela, Saudi Arabia, Russia, etc.)?*

> *What if rising nationalism and the resulting growth of military expenditures forces significant cuts to social programs, exacerbating today's economic divide between the "haves" and "have nots"?*

VI: Agility Imperative: The Agility Imperative is based on the increasing need for companies to be flexible and able to quickly adapt to the societal change forces. An asset base and existing brand equity will no longer be enough to carry companies through changing times, or to sustain dominance and relevance in a category. In fact, it may lead to their extinction. Companies will have to change their structure and cultures to become and remain agile to compete and succeed.

> *What if retail stores or restaurants paid for your autonomous ride to ensure the consumer comes to their establishments? Does this high-ROI spend upend more traditional advertising?*

> *What if the proliferation of connected devices led to a decentralized ecosystem where all products from any manufacturer could communicate with one another? How would this change the competitive landscape and how would companies differentiate offerings? What is the value proposition for consumers?*

The Imagine 2025 Portfolio and next steps

Our process was brought full circle by asking our global analysts to identify the public companies under coverage that they felt were positioning most boldly and effectively for the future based on our futures framework. The result? Our Imagine 2025 Portfolio. Over the coming weeks, we will release companion products including tear sheets on each sector identifying summarized drivers and challenges, along with deep dive sector reports deconstructing the topics we discuss within for each industry.

Why did we engage in this study?

We wanted to equip our analysts and clients with a multi-dimensional way of thinking about companies, stocks and valuations.

Equity valuations are based on the present value of future cash flows. Most analysis is focused on the next quarter or 1-2 years, but *rarely* is time and effort taken to think about the next 7 years when assessing the valuation of a company. This was the impetus for the RBC research team. We wanted to equip our analysts and clients with a multi-dimensional way of thinking about companies, stocks and valuations. The most important assessment for our research team was to understand which companies across our collective coverage had the capabilities to adjust to a rapidly evolving future.

Illustrating the power of a Futures study: The Kodak case study

We acknowledge that the concept of Futures is more art than science. The goal of this study is to make sure we understand how things could evolve so we can assess which companies are best positioned to effectively adapt. And while this report is about the future, we believe a quick history lesson could help bring to life how the process of Futures could help companies (and investors) make better decisions. Below we take a look at the rise and fall of Kodak. And while Kodak is often the standard case study on a company that failed to adapt to the future, we believe it still provides a powerful illustration on the dangers of not embracing change.

Despite not becoming common among consumers until the early-to-mid 2000s, the self-contained digital camera was developed by an engineer at Kodak (!) in 1975.

Despite not becoming common among consumers until the early-to-mid 2000s, the self-contained digital camera was developed by an engineer at Kodak (!) in 1975. Kodak feared the invention could cannibalize its core businesses which were chemicals, film cameras, film, and paper. The inventor, Steve Sasson, later went on to say Kodak management's reaction was "don't tell anyone about it." But by the late 90s and early 2000s, the digital camera wave went on without Kodak, and the company struggled to catch up, all while its core businesses shrank and, by 2012, it filed for bankruptcy.

But even the trend of standalone digital cameras did not last long once mobile phones and smartphones came into the picture and quickly reached mass adoption. Digital camera production reached its peak in 2010 and fell every year thereafter. From 2010 to 2013, digital camera production fell from about 150 million to 20 million units. With the increasing quality of smartphone cameras, and the easy connected way to share photos without physical connections or setups, along with the slimming profile of the devices themselves, consumers no longer needed or wanted to carry around a separate device for photo sharing. Cameras are now essentially standard on all smartphones and a consistent top key decision factor in choosing a device.

From 2006 to 2012, Kodak went bankrupt while Shutterfly's stock rose to its all-time highs, up 200% since its IPO.

With the mass accessibility to create photos came massive amounts of photo and content, and a once beloved standalone product for 100 years became a standard, baseline feature, to meet consumer demand for the inexpensive, portable, and unlimited. Although Kodak had an online digital photo print and storage business, courtesy of its purchase of Ofoto, the site deleted users' photos after 90 days if they did not make any qualifying photos from the site. California-based company Shutterfly, which launched in 1999, offers free and unlimited photo storage, as well as photo products such as albums, cards, and calendars. Shutterfly went public in 2006 and bought Kodak's online digital photo business in 2012 ahead of its bankruptcy. From 2006 to 2012, Kodak went bankrupt while Shutterfly's stock rose to its all-time highs, up 200% since its IPO.

What If…

What direction could Kodak have gone had it embraced and commercialized its digital camera creation rather than hiding from it? Could Kodak have been the first to invent a smartphone? Could it have beaten Facebook to the social aspects of photo sharing and tagging? Could it have been first to make photo-focused consumer favorites like Instagram,

Snapchat, VSCO, and a pioneer of filters, photo editing, and selfies? Had Kodak led instead of falling behind, could it have been the current leader on augmented and virtual realities? Or perhaps even a leader in cloud storage, beating to the punch ideas like Google Drive, and Box?

Understanding "The law of accelerating returns"

All of our six future themes by 2025 are rooted in dramatic and accelerating advancements in technology. Before we discuss each of these themes in more detail, we thought it would be helpful to explain why we have conviction these (at times uncomfortable) themes are in the not too distant future. Ultimately, exponential technology advancement always has been and will continue to be underpinned by five underlying principles: 1) new technology; 2) the network effect; 3) ability to store information; 4) faster pace of mass adoption; and 5) rising affordability.

Exhibit 1: Exponential technological change is rooted in the combination of 5 principles
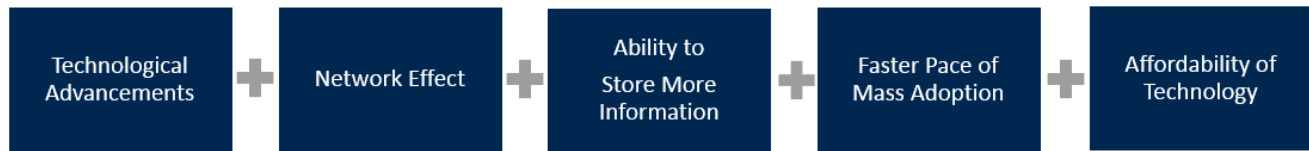
Source: Augmented

"The only thing that is constant is change" – Heraclitus

While the above quote from the famous Greek philosopher Heraclitus may be true in the proverbial sense, it is not a fair representation of the state of play today. Change is not constant; it is accelerating at a dramatic pace. We believe this accelerating pace of change have been driven partly by faster rates of adoption around new technologies. It took about 46 years before electricity received mass adoption. However, the time for mass adoption of the telephone and radio was only 35 years and 31 years, respectively; the personal computer took about 16 years, and the iPhone took less than 3 years.

Exhibit 2: The accelerating pace of change

Year Developed	Technology	Years until mass adoption
1872	Electricity	46
1876	Telephone	35
1897	Radio	31
1926	Television	26
1975	PC	16
1983	Mobile Phone	13
1991	The Web	7
2001	iPod	4
2006	Facebook	3
2007	iPhone	2.5

Source: Augmented

Consider the following:

Today's pocket calculators have more computing power than the computers used for the Apollo moon missions. As a reminder, these computers cost $3.5 M and were the size of a car. Today, the iPhone is 32,600 times faster than the best Apollo-era computers, and can perform instructions 120,000,000 times faster. Put differently, the iPhone could be used to guide 120,000,000 Apollo era spacecraft to the moon, all at the same time. Today's supercomputers are able to execute so many instructions per second that scientists do not even measure their speed in instructions per second.

Exhibit 3: Data created globally today is exponentially greater than prior years

Quickbench Storage Test, Extended Test Average
Megabytes Per Second (Higher is Better)
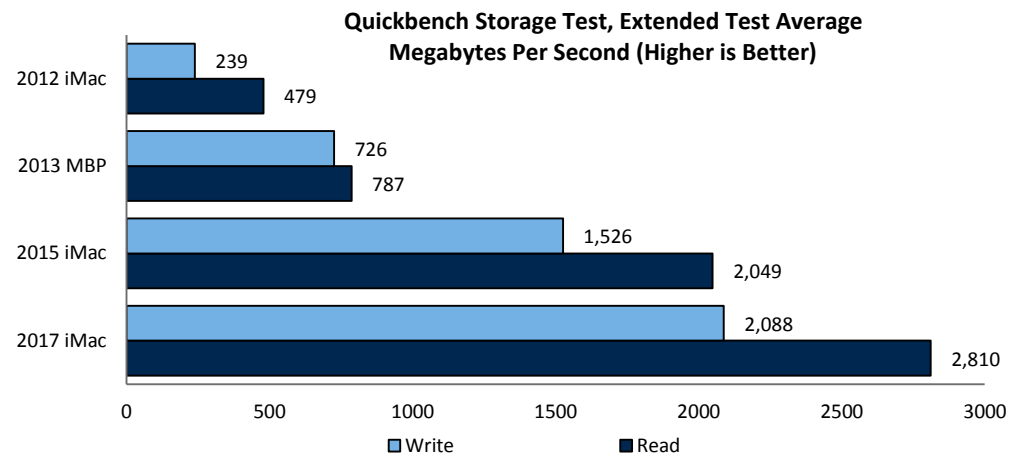
Source: StorageNewsletter

Exhibit 4: Internet accessibility has grown exponentially
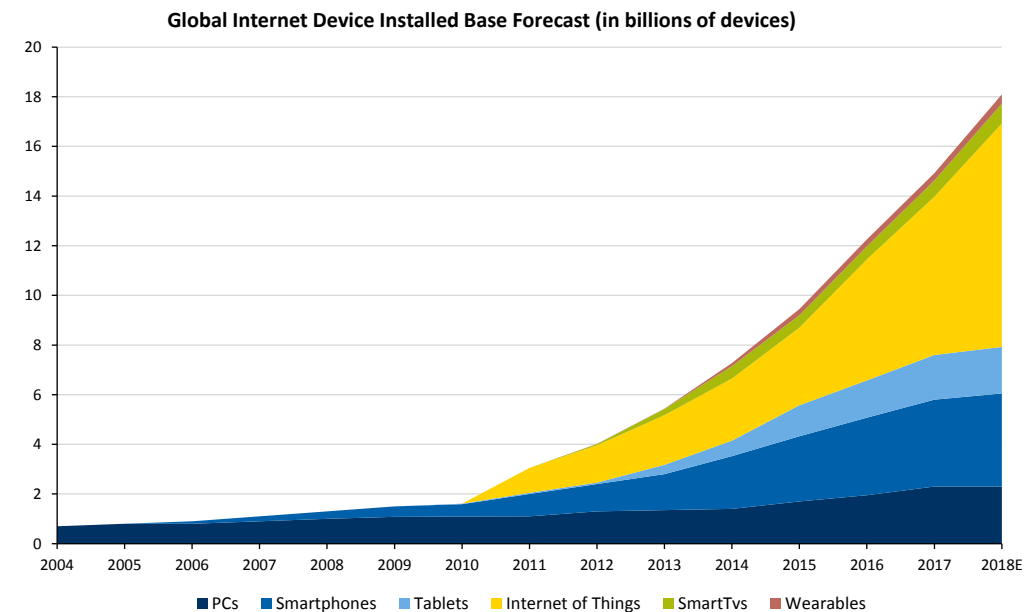
Global Internet Device Installed Base Forecast (in billions of devices)

Source: StorageNewsletter

The only certainties are doubt and discomfort…

"What we do know is human's utter dominance on earth suggests a clear rule: with intelligence comes power. Which means an ASI, when we create it, will be the most powerful being in the history of life on Earth and all living things, including humans, will be entirely at its whim – and this might happen in the next few decades." – Tim Urban

"And mark my words, AI is far more dangerous than nukes." – Elon Musk

With any new advancement in technology or dramatic changes in society, there is always doubt, discomfort and inevitable angst about the future… even amongst the very pioneers that are promulgating the revolutionary changes of the time. It can take time for these advancements to be broadly distributed and widely accepted throughout a critical mass of the population. As we look forward from 2018, it stands to reason that exponential change leads to exponential anxiety about the future. With this Imagine 2025 report, we truly put our imaginations to the test in developing concepts and potential outcomes for a non-linear future. We embraced ideas that made us uncomfortable. Given the "law of accelerating returns," we have left no idea off the table.

What if we lose our grip on AI? *What if* people didn't believe in "Don't be evil"? Since 2012 the amount of compute used in the largest AI training runs has been increasing at a rate of 2x per 3.5 months (i.e., over 5x faster than Moore's Law) and since 2012 AI compute capacity is up 300,000x. AlphaGo Zero is being trained on operations of >2,000 Petaflops, a truly astounding amount of compute power.

What if security and policy-making does not keep up with the rapid AI technological development? *What if* a breach originates from the trusted hyper-scale sources and cascades from within?

What if CRISPR technology enables people to create designer babies? Does there become a market to design the smartest, most athletic, and best-looking humans? How do we think about traditional concepts of achievement and success? Does this simply become a function of having the best genetic engineer?

What if the question is really When, not If?

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Exhibit 5: Perspective from the "experts" on "What if…we put a man on the moon?"

"There is no hope for the fanciful idea of reaching the Moon because of insurmountable barriers to escaping the Earth's gravity."

— Dr. Forest Ray Moulton, University of Chicago astronomer, 1932.

"All this writing about space travel is utter bilge."

— Sir Richard Woolley, Astronomer Royal of Britain, 1956

"To place a man in a multi-stage rocket and project him into the controlling gravitational field of the moon…. I am bold enough to say that such a man-made voyage will never occur regardless of all future advances."

— Dr. Lee De Forest, famous engineer, 1957
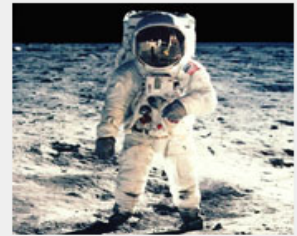
Buzz Aldrin, July, 1969

*First they ignore you,
then they laugh at you,
then they fight you,
then you win.*

Mohandas Gandhi

Source: Alcor Life Extension Foundation

Theme I: The Calibrated and Augmented Self

The Calibrated and Augmented Self is the concept that the "average consumer" is vanishing as machine and quantum computing learn and predict behaviors, leading to hyper-personalized products and services, and the ability for mass customization with less friction. However, the Calibrated and Augmented Self will most likely come with privacy and ethical risks. We believe companies that can balance personalization expectations and privacy demands, with a clear stand on ethical boundaries, will be the best positioned to succeed.

What you need to know…

"The Calibrated and Augmented Self" is the concept that everything in the future is personalized, a stark contrast to the mass consumer products, media and healthcare of yesterday.

How "The Calibrated and Augmented Self" developed: Over the past two decades, the proliferation of choice has trained consumers to expect more goods and services that mirror their specific needs and preferences. Our dialogue with company C-suites indicates a majority of companies understand the power of mass customization, however, the means do so in a profitable way has not existed—until now. Big data, artificial intelligence, and advancements in technology are now enabling products, services, and experiences to cater specifically to an individual with lowers levels of friction (at a very basic level). As we move forward, we believe the convergence of microcomputers, big data, wearable technologies, the moderating costs of genetic testing and advancements in 3D printing will all drive much more personalized offerings that will be available and affordable to the masses.

The advancements that will drive "The Calibrated and Augmented Self":

3D printing will play a role in creating custom products of all categories, conveniently in each consumer's home.

Virtual reality will enable consumers to experience the world, and to seamlessly interact with family, friends, and work colleagues not just from the couch at home but from anywhere and at any time given advancements in digital eyewear such as Google Glass.

The miniaturization of technology is structurally altering the face of medicine. Ingestible digital pills will both monitor and proactively treat health conditions, while also connecting directly to doctors in the event of an emergency.

CRISPR technology will enable humans to design custom plants and animals, including their own human babies.

Organ and limb replacement advancements will blue the biologic line between what is human and what is machine.

From "Mass" to "Me"

"Catering to the masses"— this was the business model that enabled companies to provide goods and services to a generation of Baby Boomers that had similar needs and wants.

"Catering to the masses"— this was the business model that enabled companies to provide goods and services to a generation of Baby Boomers that had similar needs and wants. This generation drove the success of mass marketing (TV advertising), mass retailers (Walmart/Target), and mass housing (developments with 2-3 models). Targeting consumers was typically based on age, gender, and race, with the more sophisticated companies catering to broad consumer "need states" to help guide their offerings.

We believe the convergence of microcomputers, Big Data, wearable technologies, the moderating costs of genetic testing and advancements in 3D printing will all drive much more personalized offerings that will be available and affordable to the masses.

However, over the past two decades, the proliferation of choice has trained consumers to expect more goods and services that mirror their *specific* needs and preferences. Our dialogue with company C-suites indicates a majority of companies understand the power of mass customization, however, the means do so in a profitable way has not existed—**until now.** Big Data, artificial intelligence, and advancements in technology are now enabling products, services, and experiences to cater specifically to an individual with lower levels of friction (at a very basic level). As we move forward, we believe the convergence of microcomputers, Big Data, wearable technologies, the moderating costs of genetic testing and advancements in 3D printing will all drive much more personalized offerings that will be available and affordable to the masses.

The famous author William Gibson once wrote *"the future is already here – it's just not evenly distributed."* Within that spirit, we provide a series of early manifestations of mass customization across a host of industries from footwear to healthcare to provide a glimpse of what the future holds. Having gone through this exercise, we are very excited to be consumers in the year 2025. However, we are equally as concerned for the large publicly traded companies that have not yet evolved their capabilities to fully participate in this new era of hyper-personalized consumerism.

Footwear – Buy a pair of "Fill in your name"

Nike teamed up with Hewlett Packard to use 3D printing to reduce time-to-market for new products.

Years ago, footwear companies were early adopters of 3D printing to help create fast prototypes for new sneaker models. However, today, 3D printing is starting to become a part of the supply chain. Nike teamed up with Hewlett Packard to use 3D printing to reduce time-to-market for new products. Several of the biggest brands in footwear, including Nike, Adidas, Vans, Under Armour, and Converse, already allow users to create custom versions of their shoes online that turn around between 3 to 5 weeks. For example, at Nike's Soho retail store in New York, consumers have the opportunity to design their own shoes at the "NikeLab Bespoke iD" which offers a customizable and personal design experience with one-on-one appointments with dedicated Nike Design consultants. Consumers can choose an Air Force 1 high, Air Force 1 Low or an Air Max 1 and over 400 premium materials, to be tailored to their exact specifications. Consumers must first make a reservation and meet with a designer in a private appointment. They will leave the appointment with hand-drawn sketches and digital renderings of their completely custom shoe. The "handcrafted" shoe will then arrive for pickup or delivery in 6-8 weeks.

We expect all consumers will be able to affordably design their own shoe (in store or even at home) with a completely custom sole, made specifically for their size, weight, and gait, and see a finished product within minutes (in store) or within a day (at home).

While this level of personalization did not exist a few years ago, we believe it will pale in comparison to what will be available by 2025. In fact, we expect all consumers will be able to affordably design their own shoe (in store or even at home) with a completely custom sole, made specifically for their size, weight, and gait, and see a finished product within minutes (in store) or within a day (at home). Adidas sees this as one of the end goals for its new manufacturing process called Speedfactory (which leverages robots and 3D printing to create a more localized and customized manufacturing process).

Exhibit 6: Adidas Speedfactory leverages 3D printing technology to create custom sneakers

Source: Adidas

Smile – An example of mass customization via 3D printing

One company that has been using 3D printing for decades and has succeeded with a custom product on a mass scale is Align Technology, the company behind Invisalign, the clear orthodontic aligners. Currently, the company produces over 200,000 *custom-made* aligners per day. In the last 7 years, the company has dramatically increased its market share, patient reach, and physician reach; its stock price has increased over 1,000% since 2011. However, as we move forward, we believe this process will become cheaper and faster.

Exhibit 7: Align Technology manufactures Invisalign using 3D printing technology

Source: Align Technology

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For additional perspective on 3D printing, see our previously published work: Feedback from our Additive Manufacturing Roundtable and RBC Pan-European Industrial Goods: Additive disruption - opportunities in services and materials.

Beauty products – Fifty shades of beige

One driver behind customization will be necessity borne from diversity—the diversity of the consumer and the diversity (proliferation) of choice. The two approaches to these challenges are to curate and to customize.

Shiseido-owned makeup brand BareMinerals meets the diversity of the customer through the customization approach. Launched in 2017, the company's app MADE-2-FIT allows users to create their own perfectly custom liquid foundation in just a few minutes. While custom foundations are not a new idea to those who remember the Perscriptives makeup counters of the 90s and early 2000s, this is a more precise method, done at home, driven by technology, and made possible by the advances in phone camera quality.

MADE-2-FIT allows users to create their own perfectly custom liquid foundation in just a few minutes.

Exhibit 8: Custom makeup
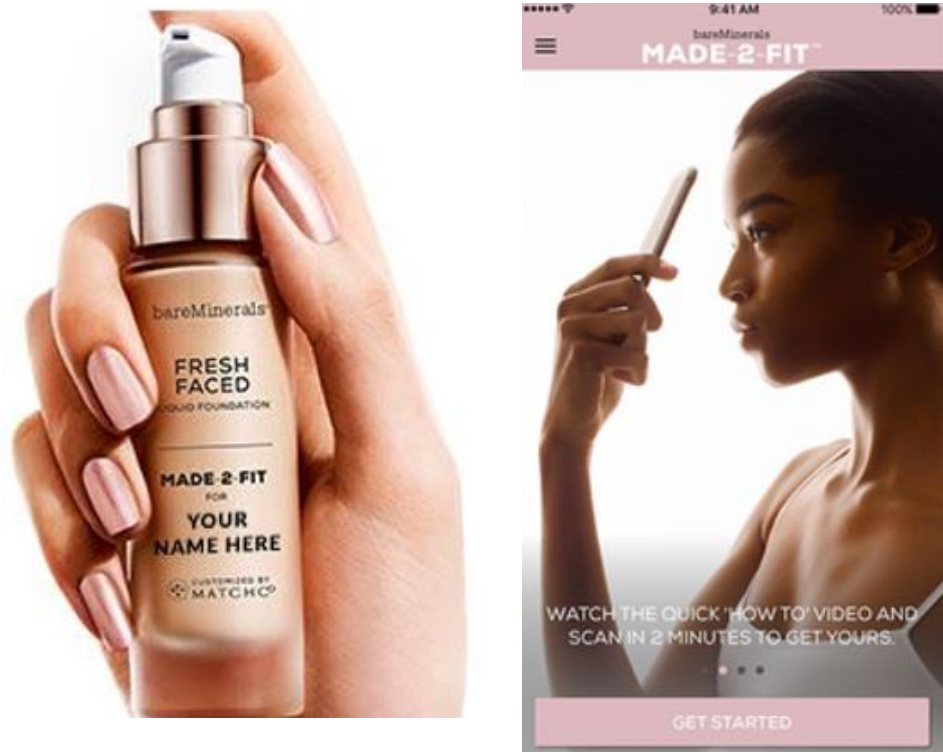
Source: BareMinerals

In the app, users are guided through taking several close-up images of different areas of the face; the company then creates a foundation to perfectly match the user's skin tone, which can then be ordered through the app, made with the user's name on the bottle. We expect custom offerings like this, fueled by technological advances, to proliferate across brands, products, and markets, driving down price and increasing availability.

Similarly, online haircare company Function of Beauty creates custom shampoos and conditioners for its users with proprietary algorithms that utilize hair characteristics, complaints, and goals. Customers can even put in preferences on the product's color, scent, strength of scent, size, and delivery frequency. The company says their algorithms can create an unlimited number of different mixes, making each totally unique.

Exhibit 9: Custom haircare products

Source: Function

Apparel retailing – Custom, easy and fabulous

The changes over the last five or so years to the retail landscape could pale in comparison to what could be ahead in the next 10-20 years if Augmented and Virtual Reality (AR/VR), 3D Printing, Voice Assistants, Hyper Personalization using data/Artificial Intelligence (AI) and drone deliveries among others have more mainstream adoption in the retail industry.

Exhibit 10: Reimagining retail journey 2025
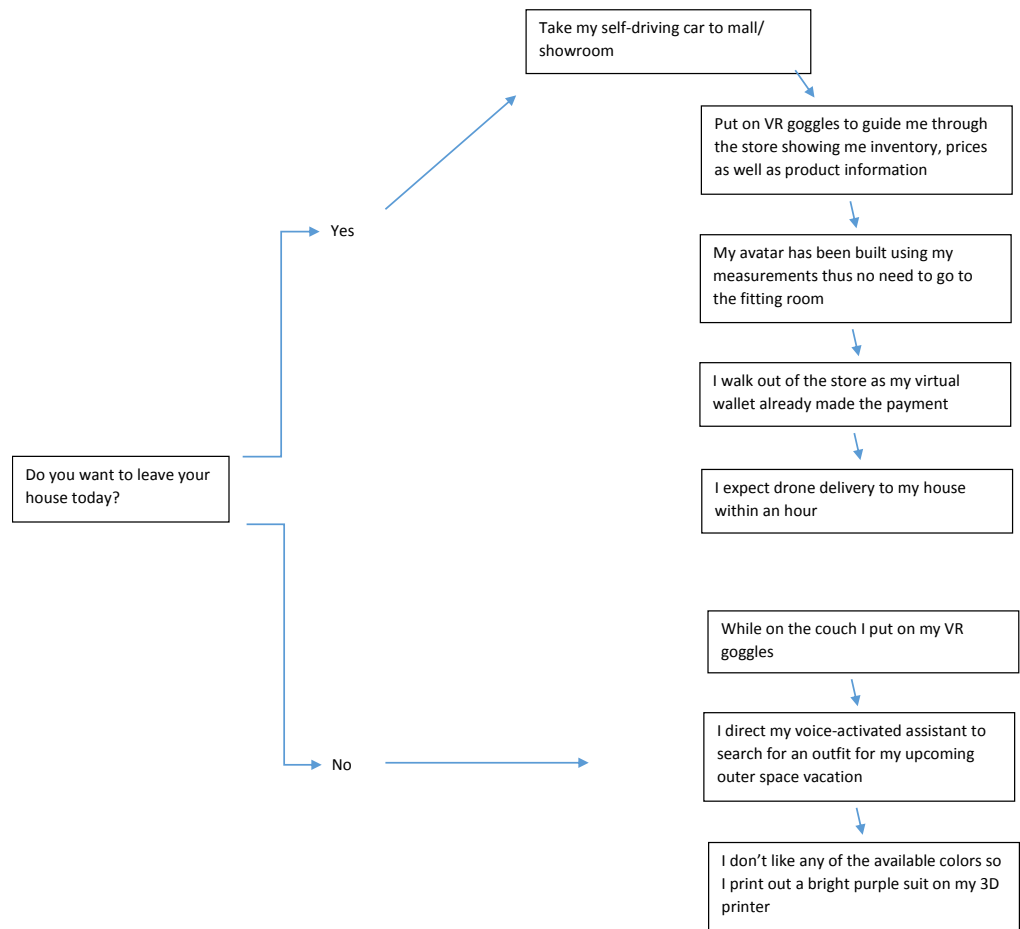
Source: RBC Capital Markets

Who is better prepared to leverage these new tools? Will it be the larger/surviving incumbents that have the balance sheets to spend on these new technologies, or will well-funded start-ups who have embedded some of these features into their DNA continue to take market share?

We see a few emerging customer-facing applications to make a more customized and seamless retail experience at retail:

Augmented Reality (AR) in the store: As per a 2016 Deloitte study, 84% of shoppers suggested that they use a digital resource before or during their visit to a store. With smartphones now du jour in the consumers' reality, the opportunity exists for a retailer to provide a customized and personalized experience for their shopper—from store navigation instructions, personalized product suggestions, and customized storefronts. We think store navigation will be a particular benefit to bigger box retailers as customers can often get confused about where an item or department is located—thus aiding conversion. Lowe's in fact has piloted this technology in a handful of stores, offering step-by-step directions to customers with an AR-enabled device.

Avatars as the digital dressing room: Amazon recently acquired the VR/tech firm Body Lab, which aims to use 3D impressions of a person's body to predict size and measurements. This technology suggests that the traditional argument in the name of stores—"Customers like to

As per a 2016 Deloitte study, 84% of shoppers suggested that they use a digital resource before or during their visit to a store.

touch and feel the product"—could be under assault as technology could assist in size/fit selection along with giving a customer a sense of what he/she could look like in an item. We've seen simpler versions of this technology already, such as Warby Parker allowing a user to get a sense of what a pair of glasses would look like on by uploading a picture of his/her face.

In December of 2017, Amazon was issued patents that include an augmented reality mirror. The mirror is set to offer a blended reality display that puts your image into a virtual scene, and puts you in a virtual version of your desired attire (enabling you to see how you'd look in a particular bathing suit on the beach or in a dress at a gala). The blended-reality display, described in the patent, relies on a system of cameras, projectors, displays, mirrors and lights that can add layers of pixels to your moving image on a real-time basis.

Exhibit 11: Virtual shopping example
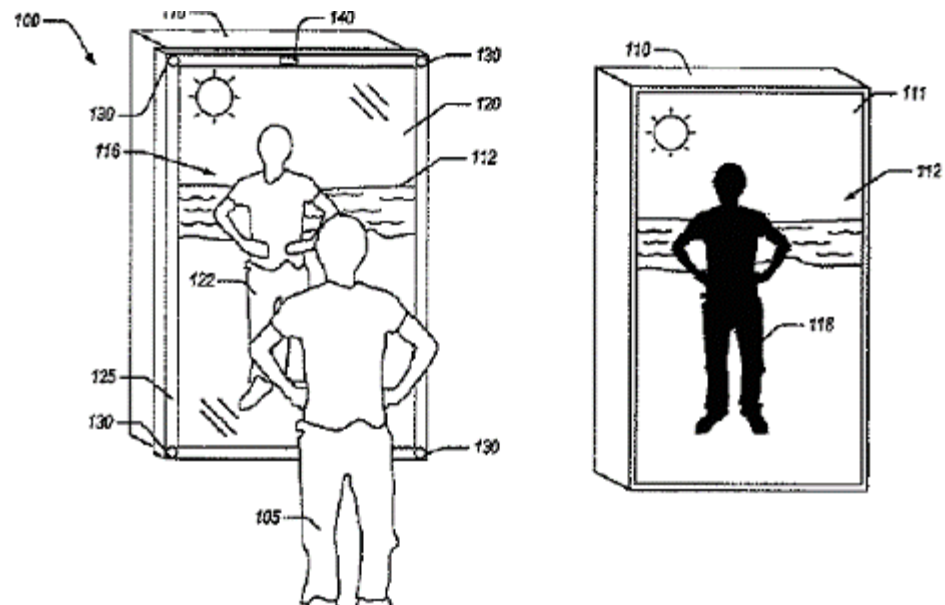
Source: CNBC, Amazon

We think it's only a matter of time until a voice-activated assistant becomes not just a shopping resource for customer searches, but also a proactive recommender of product.

Digital Assistants aiding in shopping choices? According to a Mindshare report, 600 million people globally use a voice-activated assistant, from Siri to Alexa, Echo, Google Home, and so on. The report indicated that helping customers find product information is the #2 common use of voice assistants, after doing online searches. With Amazon amping up its Prime Wardrobe efforts, we think it's only a matter of time until a voice-activated assistant becomes not just a shopping resource for customer searches, but also a proactive recommender of product—especially once body shapes/forms are assessed by other Amazon-owned technologies (such as the aforementioned Body Lab).

We wonder if Stitchfix-like services could be disrupted by the ability for consumers to 3D print custom apparel at home.

Another example is Stitchfix, the online subscription shopping service, which uses a combination of data science and human stylists to curate and customize a box of apparel and accessories for customers. The company's use of AI, helped by human stylists and fed by customer feedback and preferences before and after shipment, makes for an experience that evolves based on the customer, and aims to reach a personal level of recommendation and prediction beyond the superficial "if you liked that, you might like this." However, we wonder if Stitchfix-like services could be disrupted by the ability for consumers to 3D print custom apparel at home.

It is foreseeable we may never have to buy clothing off the rack in store or online again.

Personal designers and downloaded clothes for all? Looking out to the future, it is foreseeable we may never have to buy clothing off the rack in store or online again. Rather, working with a customer designer who may either be a real person or an AI, we can digitally design our own clothes that will be downloaded and printed by a 3D printer in our very own homes. Israel-based 3D printer clothing designer Danit Peleg commented, *"We used to buy CDs, and we had to go to the physical stores to get music and now we can just download it everywhere…I believe that the same thing will happen with fashion eventually — clothes will become more and more digital."* Ministry of Supply, another 3D printing clothing designer, noted that materials could also be customized for each individual and that the benefits of 3D printed clothing are not limited to aesthetics and fit but also air flow, the ability to move seamlessly and ultimately to last longer.

Exhibit 12: 3D printed clothing by Danit Peleg and Ministry of Supply
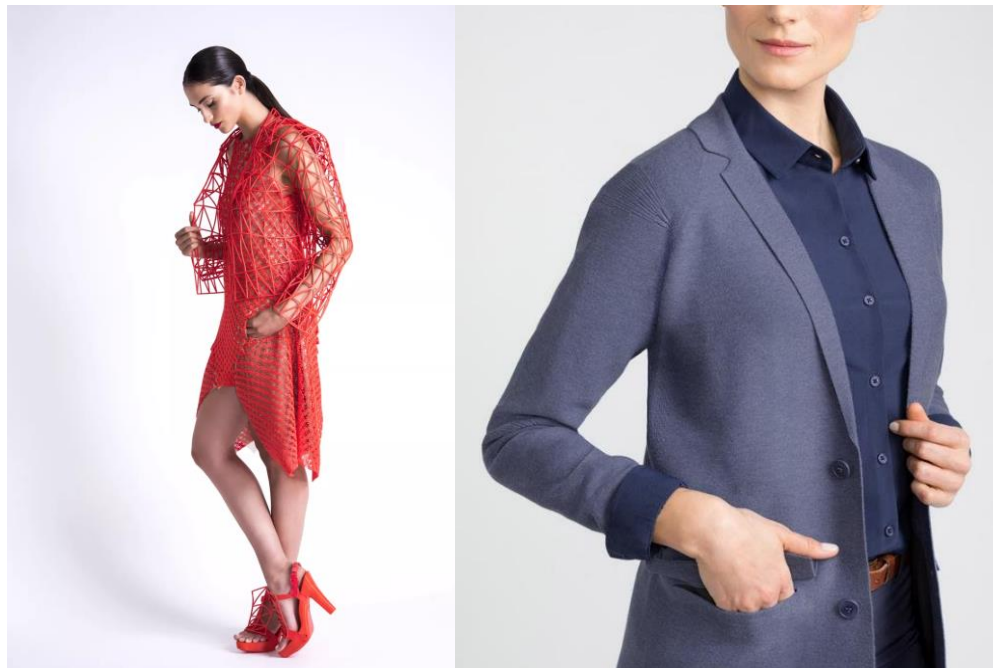
Source: Racked.com

Today, China is regarded as the "world's 3D printer" but protectionist trade policies with China could change that. If developed market trade with China abates behind trade policy, then reinvestment in 3D printing technologies will accelerate.

Right now, high-end 3D printing clothing may cost over $1,000 (excluding the cost of an expensive, over $1,000 3D printer itself) and take 100 hours to print. Like all advancements in technology, we expect both cost and time to completion to come down over time and are already noticing this reflected in industry projections (not necessarily at an exponential rate). However, the cost reduction in 3D printing over time may accelerate if the U.S. continues to instill protectionist policies per Theme V: Escalating Uncertainties. Today, China is regarded as the "world's 3D printer," but protectionist trade policies with China could change that. If developed market trade with China abates behind trade policy, then reinvestment in 3D printing technologies will accelerate.

Exhibit 13: 3D printing costs are decreasing over time

Illustrative Comparative Part Manufacturing Costs
3D Printing vs. Traditional Molding
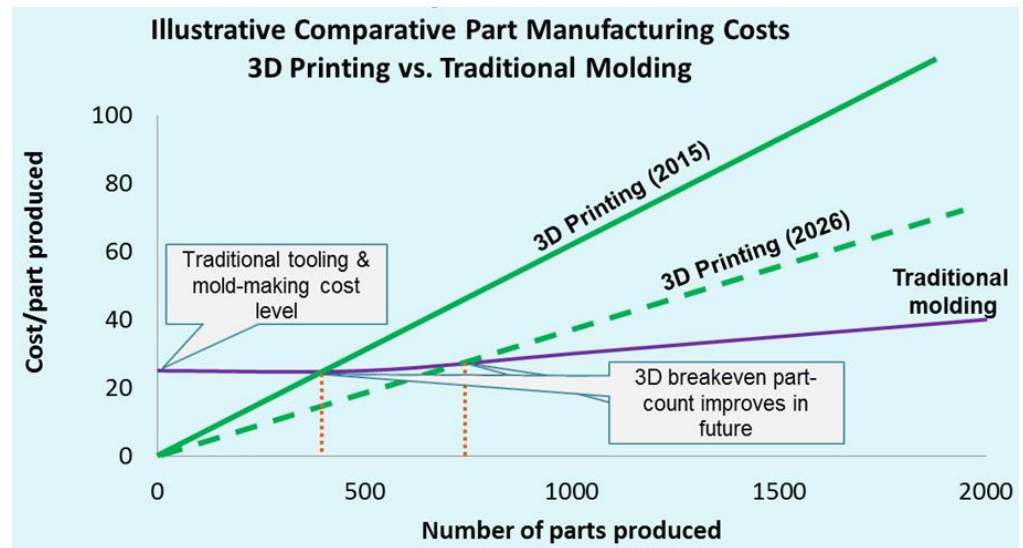
Source: Smithers Pira

Exhibit 14: 3D printing adoption rates based on new 3D printing purposes
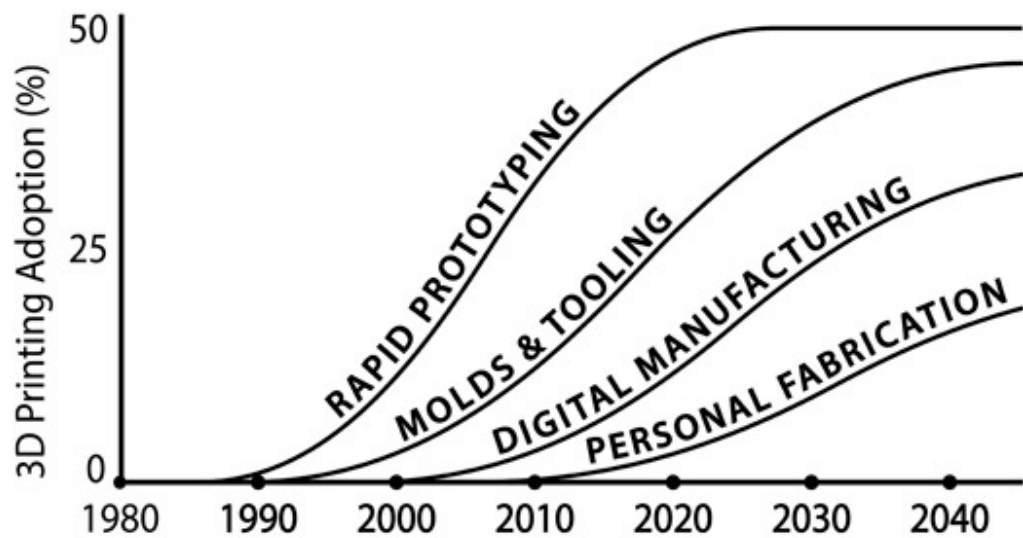
3D Printing Market Segment Adoption Curves

Reproduced from "3D Printing: Second Edtion" by Christopher Barnatt

Source: Explaining the Future.com and "3D Printing: Second Edition" by Christopher Barnatt

Food retailing: You know me so well

The convergence of Big Data, ecommerce and artificial intelligence is driving a complete evolution of the food retail channel, which is quickly transforming from a commodity business to a highly personalized shopping experience. However, this transformation presents a problem for many in the highly fragmented Food Retail sector. Led by Amazon and strong incumbents, like Kroger, the next five years will feature: 1) lighter in-store labor models; 2) more personalization through increased home delivery and unique one-to-one promotional offerings; 3) rapid consolidation and 4) through VR, the ability to have a brick-and-mortar shopping experience anywhere, anytime.

We feel many traditional retailers are unprepared/unequipped to evolve to the rapidly changing landscape. The immediate pressure comes from **relative labor models**. Amazon, with its Amazon Go model, has introduced cashier-less stores. Using spatial recognition, unique customer tagging (through your app), and overhead cameras, customers do not have to check out and Amazon is able to remove a large labor component from physical retail. These labor savings could provide Amazon with a funding source to add labor/investment to the second disruptive force: **delivery/personalization**.

Taking labor out of the store allows Amazon to put funding where it is needed: re-investing behind either last-mile delivery costs or behind price. Amazon is already testing home/car entry order delivery and staging convenient pickup lockers. Ultimately, the last mile "labor" may come in the form of drone delivery. Universally, shoppers' habits are based on price and convenience. On price, Amazon's knowledge of its customers will result in greater promotional funding from vendors and cross-merchandising opportunities.

With convenience and possibly price being redefined, many grocers, who are notoriously tech averse, will be forced to adapt. We believe Amazon will force a wave of industry consolidation as incumbents scramble to keep up.

The convergence of Big Data, ecommerce and artificial intelligence is driving a complete evolution of the food retail channel, which is quickly transforming from a commodity business to a highly personalized shopping experience.

We believe Amazon will force a wave of industry consolidation as incumbents scramble to keep up.

Amazon opened its first Amazon Go store in Seattle in January 2018.

Exhibit 15: Amazon Go – the future cashier-free store

Source: CNN

RBC Capital Markets

Last-mile delivery has become increasingly important as ecommerce gains traction. Amazon has been talking about their drone delivery model (Prime Air) since 2013, with a stated aim of a completely autonomous order-to-delivery time of 30 minutes, but has met with a lot of skepticism and regulatory difficulties. Amazon has been doing a private trial and successfully completed its first drone delivery in England in December 2016. However, recently the FAA has approved drone pilot programs for 10 companies, including Alphabet and Uber (not yet for Amazon). This is one step closer to making drone delivery a reality. Amazon has even filed a patent to deliver the drones from a blimp warehouse.

Exhibit 16: Amazon has filed a patent for a flying blimp warehouse
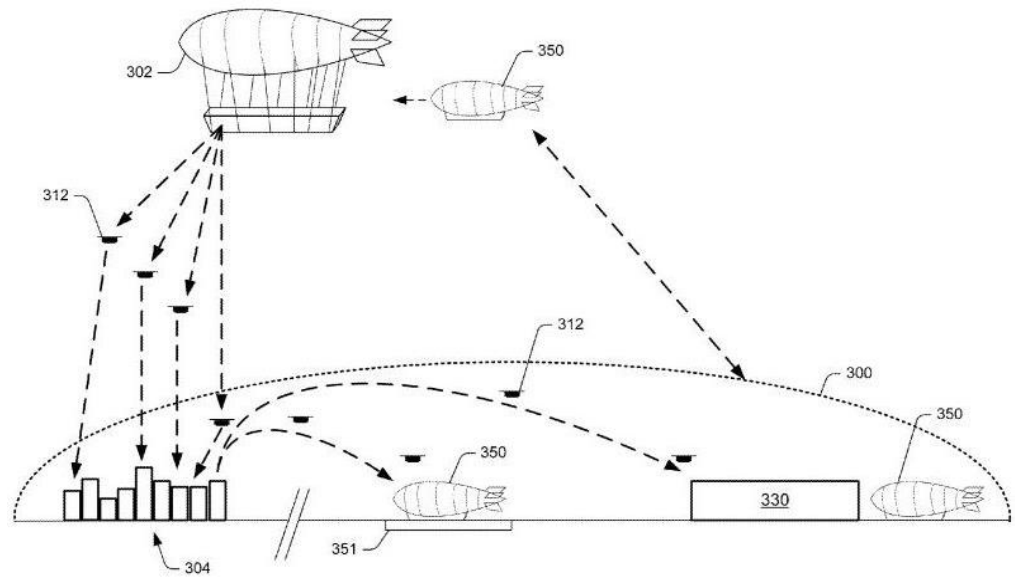
Source: CNBC

Exhibit 17: Amazon Prime Air

Amazon has filed a patent to launch drones from a blimp warehouse in the sky

Source: The Daily Mail

Knowing a certain shopper prefers a certain product on a certain day is incredibly valuable when considering promotional activity and cross-merchandising opportunities.

The most sophisticated players have the data and data analytics programs to offer shoppers non-commoditized assortment/offerings. Knowing a certain shopper prefers a certain product on a certain day is incredibly valuable when considering promotional activity and cross-merchandising opportunities. Frankly, much of the Food Retail space cannot tie a person to a basket. Kroger, who we consider the industry data leader, will build a generational moat with this relative strength.

Exhibit 18: Kroger's data analytics capability

Using data analytics, Kroger is able to learn many aspects of its customers and stay relevant.
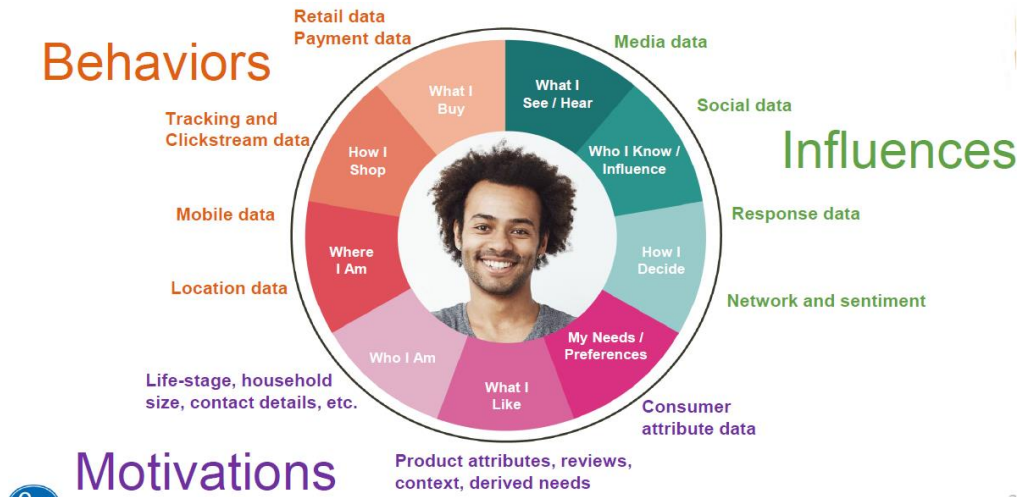
Source: Company Presentation

Exhibit 19: Kroger's data analytics capability

By tailoring offerings differently according to customer needs, Kroger improved customer experience and drove more sales.
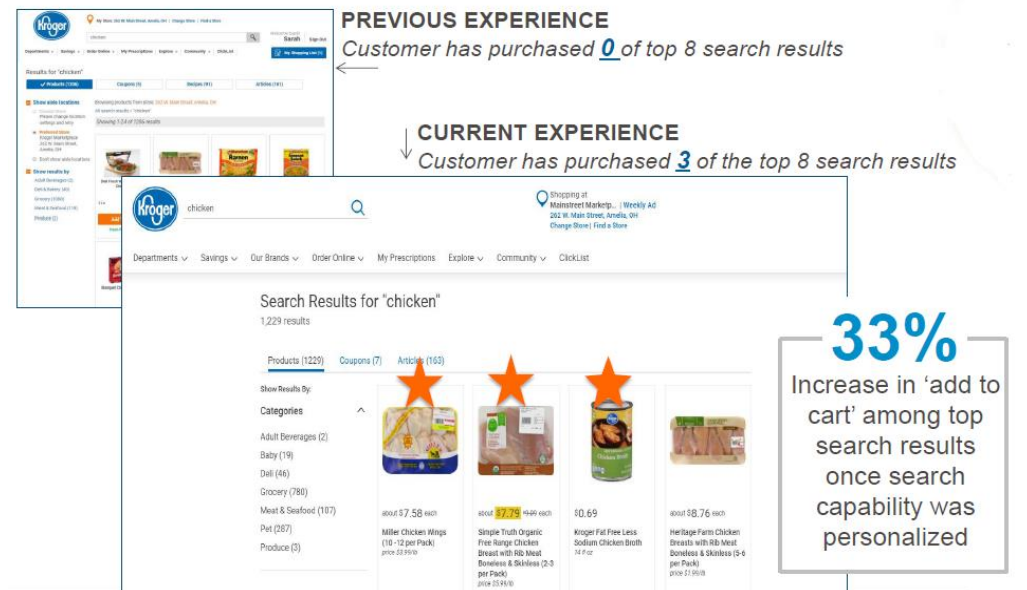
Source: Company Presentation

With increased personalization comes increased convenience—with that, friction decreases and the tasks in daily routines will take less time and energy.

Infoscout data suggests this growth is driven primarily by increased purchase frequency, not household penetration.

Amazon has undoubtedly removed some friction associated with the traditional brick-and-mortar shopping experience. As a result, recent Amazon sales growth has been compounding at 30% levels. Interestingly, Infoscout data suggests this growth is driven primarily by increased purchase frequency, not household penetration. We believe this is because of the ease of purchase. Consumers are more frequently taking advantage of the convenience of online shopping and we do not expect this trend to abate.

Exhibit 20: Amazon growth drivers
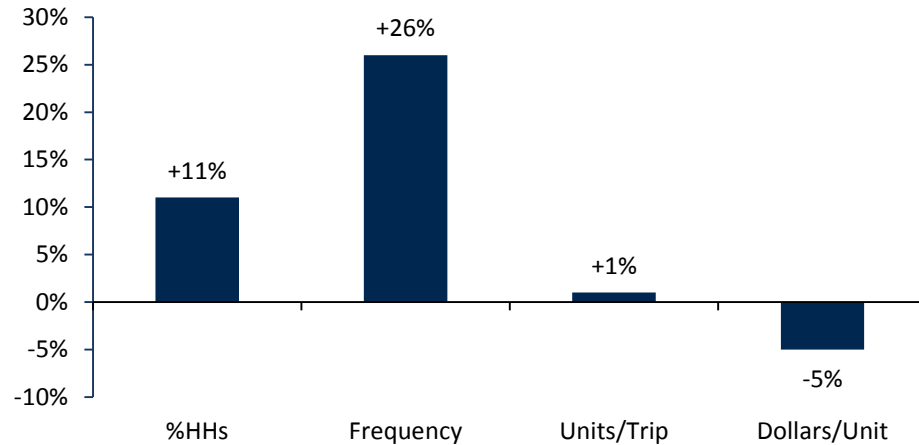
Source: Infoscout Omnichannel Panel – P12M for baskets containing FMCG products from FMCG retailers / etailers

Virtual reality could allow consumers to have this experience from the comfort of home, which could be of particular use to those in rural, remote, or high traffic areas, as well as those in densely populated cities—all while reducing companies' real estate costs.

However, Amazon has not removed *all* the friction of online shopping, and not everything can be found on Amazon. Consumers still rely on brick-and-mortar experiences as they enjoy walking the aisles, seeing and interacting with products, and ensuring they do not forget anything. Consumers also still enjoy discovering products this way, as well as window-shopping walks through showrooms. Virtual reality could allow consumers to have this experience from the comfort of home, which could be of particular use to those in rural, remote, or high traffic areas, as well as those in densely populated cities—all while reducing companies' real estate costs.

Virtual shopping is already succeeding in one arena: home buying. Last year, homebuilders Lennar, Pulte Group, and Toll Brothers all reported higher quality foot traffic and improving conversion rates that they attributed to increased digital marketing and spend. Toll Brothers management noted an increase in sales, despite decreasing foot traffic through properties, which they attributed to the consumers' preference to shop for homes, *from* home. By the time a buyer shows up at a property, they are already interested in the property and more likely to buy. The weekends of driving around neighborhoods for open houses are all but gone.

Last summer, Ikea launched its first virtual store, allowing customers to explore and edit a showroom from home—no parking lots, long drives, or crowds. Customers are able to customize the showroom as they go, changing the colors of sofas, walls, and the time of the day. Customers can add items to their virtual cart and, at the end, check out like any other online shopping experience. Although this is a limited test market for Ikea, we expect experiences like these to be a norm in the future, and an opportunity for retailers to increase foot traffic while reducing footprint. This also creates an opportunity for online only retailers—like Wayfair and ASOS—to create in-store-like experiences.

Exhibit 21: Virtual shopping example

Source: Google Images

Seeing the future

Virtual reality experiences will not be limited to the home or any stationary place.

Importantly, virtual reality experiences will not be limited to the home or any stationary place. Even in the event consumers are not at home but would still like to have a virtual reality shopping experience, Google Glass eyewear could provide a virtual reality shopping experience anywhere and anytime. Google Glass is a wearable, augmented reality device developed by Google's X unit. The first iteration of Glass for consumers was discontinued in 2015; Glass Enterprise Edition, however, has been targeted for businesses where it has gained traction as a device that increases efficiency, accuracy, and safety. Users can access apps, manuals, and training videos with instructions, all while keeping their hands engaged in their work. The technology has been tested, and adopted by companies such as Boeing, GE, Volkswagen, and DHL where it has shown positive results, including increased worker productivity. Similarly, start-up Augmedix utilizes Google Glass technology to allow remote transcribing of doctor-patient visits, freeing up providers from time-consuming charting, increasing efficiency and patient volumes.

Exhibit 22: The evolution of "Wearables"
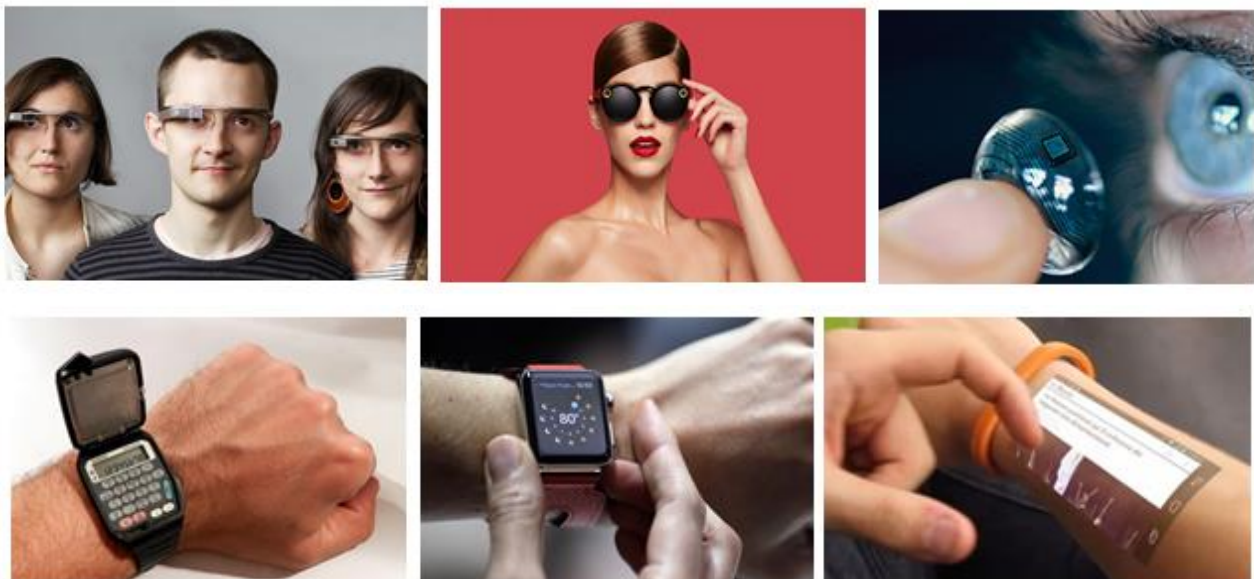
Source: RBC Capital Markets. Google Images.

The next phase of content creation is likely to fuse data and analytics more directly with production.

Thinking forward, we could see analytics not just inform content decisions but be part of a feedback loop between viewership data and entertainment creation processes.

One day we might all wake up to Your Daily Show – an individual video short that simultaneously understands us, amazes us, challenges us, informs us and connects us to areas of our interests.

Highly personalized VR experiences could soon include entire simulated virtual lives, incorporating deeply embedded cyber relationships, at the expense of the real world.

Media/entertainment -- Your very own Daily Show

Personalization is not limited to physical goods. It can be applied to content as well. The next phase of content creation is likely to fuse data and analytics more directly with production. Netflix, Amazon and other digital platforms already collect viewership data and use that to make suggestions to subscribers, as well as inform their content acquisition strategies. Thinking forward, we could see analytics not just inform content decisions but be part of a feedback loop between viewership data and entertainment creation processes. Advances in animation, licensing of Hollywood talent in digital spaces, and virtual reality could allow content to be "rapidly prototyped," matching show concepts with virtual actors, 2D and 3D set creation and digital scripts to quickly create pilots for testing against target audiences. Such processes could also be used to localize content concepts to adapt to cultural norms, language and standards. User-generated content – billions if not trillions of mineable videos on social media – provide a rich resource that automated show creators could tap in to to create highly targeted content on a global scale and at a low marginal cost. One day we might all wake up to Your Daily Show – an individual video short that simultaneously understands us, amazes us, challenges us, informs us and connects us to areas of our interests. With the fusing of social media tracking (knows what we like/care about) and content platform algorithms (knows what we watch for entertainment) the ability to personalize content to make it more compelling is significant.

Choose your own adventure. Choose your own reality…

One exciting content technology is virtual reality with its ability to create unique and immersive content experiences. VR has been covered *ad nauseum* by consumer and tech researchers and its possibilities expand exponentially with the potential for highly targeted and personalized content. VR is already a potential risk to real reality, e.g., will travel suffer if we can "visit" China's Great Wall through VR goggles? Equally, highly personalized VR experiences could soon include entire simulated virtual lives, incorporating deeply embedded cyber relationships, at the expense of the real world. Will we find better lives in a virtual dream state than our physical existence, with virtual selves that we're happier with? The social implications of deeply embedded virtual reality are significant and like most technologies likely to lag actual adoption.

Madison Avenue behind every pixel

Proliferation of content goes hand in hand with the proliferation of advertising as the Internet has reset expectations that information, video, social media, etc., should be instant and without an explicit cost. Seeking compensation, digital platforms have uniformly turned to advertising and advertisers couldn't be happier given the promise of targeting consumers with the user data from digital exhaust. The Internet is far more advertised than the real world, and we see this continuing as time shifts to digital engagement in various shapes and forms.

Madison Avenue has been at the forefront of this technology alongside major digital publishers, especially Google and Facebook. "Programmatic" advertising is not new and allows ad buyers to set consumer-targeting parameters (e.g., women under 30 living in Brooklyn), with programmatic exchanges matching advertising demand to publisher supply at instantaneous market-clearing prices. This is how the majority of ads we see online are delivered and promises to give advertisers the kind of data that allows them to better measure ROI across publishers, ad types, media platforms (e.g., search vs. Facebook), etc.

Advertisers and ad tech are already pushing the envelope of targeted advertising with Google and Facebook (and Amazon) using their massive customer data sets to help advertisers target with improved granularity. For example, searches for "bathroom renovation videos" may mean that in addition to Home Depot and Lowe's ads showing up

Marrying data sets with correlated behaviors and trackable purchase outcomes is what makes Google, Facebook and Amazon so significant in the advertising world and an increasing disintermediation threat to Madison Avenue, as data analytics used to be the competitive advantage of ad agencies.

before future YouTube videos, DIY-correlated ads such as home décor, may find you buying a new sofa, due in part to the West Elm ads that popped up in the days after the bathroom video search. Marrying data sets with correlated behaviors and trackable purchase outcomes is what makes Google, Facebook and Amazon so significant in the advertising world and an increasing disintermediation threat to Madison Avenue, as data analytics used to be the competitive advantage of ad agencies.

Healthcare -- Perfect medicine inside and out

We believe the convergence of devices like Alexa, more sophisticated artificial intelligence, nanotechnology in the body and smart devices that track key vitals could make Iron Man's J.A.R.V.I.S. (the superhero's artificially intelligent household butler) a reality.

Medical device evolution and integration a practical first step

According to Research and Markets, the global wearable medical devices market is estimated to grow at a CAGR of ~17% over the next decade and reach ~$24B by 2025. We believe medical devices of the future will be

1) descriptive (as we primarily know them to be today, simply providing pulse and calories burned among other quantitative data),

2) prescriptive (mention solutions to improve health),

3) proactive (actively treat the body with medicine, vitamins and nutrients to prevent health issues), and

4) reactive (automatically treat the body with lifesaving medicine or automatically notify a doctor or other forms of help such as drone ambulance).

Most of today's products, like an Apple Watch or fitbit, are descriptive (describing the state of your vitals). Next-generation products, also available today, are prescriptive. An example of this is L'Oreal's La Roche-Posay brand "My UV Pad", a patch that allows users to measure and monitor their sun exposure via an app that tells them whether to stay out of the sun or apply more sunscreen.

However, the definition of "descriptive" as we look towards the future is evolving. For instance, iRhythm Technologies (IRTC) is a medical device company that manufactures heart-monitoring devices to detect cardiac arrhythmias (Zio Service). Also, Apple recently announced its Apple Heart Study in partnership with Stanford University and BioTelemetry (BEAT). The study is an assessment of whether photoplethsmography (PPG) can accurately identify cardiac arrhythmias. Further, Apple's documentation suggests that the "study is part of the development of a new investigational device and certain Study Data will be used for FDA submission to seek approval of the investigational device," hinting that Apple might seek approval from the FDA to market future wearable devices as a medical device.

Exhibit 23: New heart monitoring (left) vs. traditional heart monitoring
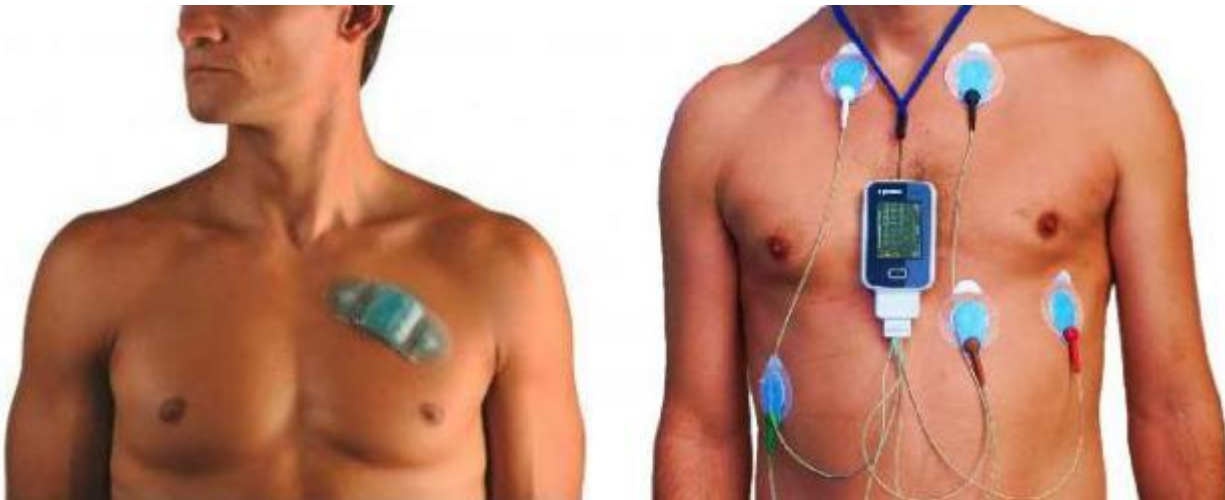
Source: NIH, iRhythm Technologies

Devices will not only evolve as it relates to descriptive capabilities but also become prescriptive.

In the future, devices will not only evolve as it relates to descriptive capabilities but also become prescriptive. One way to think about this is the ability to provide the direct implications of every choice we make and its impact on our lifespan. Each person will simply be able to scan a consumable product and receive a readout on their wrist. Healthy foods like vegetables and clean water would have a positive impact on life expectancy, while other items such as tobacco, alcohol and illicit drugs could have a negative impact. Importantly, lifespan impacts will vary depending on each person's **personal** state of health. The device would also be able to tell the impact that sleep, exercise and hydration habits are having on lifespan.

Exhibit 24: In the future humans will have a live feed of the lifespan impact certain activities, foods and drinks will have on themselves

Source: Image from *In Time*, a Regency Enterprises/New Regency Pictures/Strike Entertainment production, distributed by/20th Century Fox, 2011.

The miniaturization of technology is structurally altering the face of medicine.

Automatic, personalized healthcare from within?

The miniaturization of technology is structurally altering the face of medicine. Performing a one-time self-diagnostic test may be easy and convenient for patients but often compliance with regular medications can be difficult. Solutions for compliance and medication may be on the horizon though. The FDA recently cleared a pill to help individuals understand when they need to take their medication. Otsuka Pharmaceutical Co Ltd.'s Abilify MyCite is the first drug with a digital ingestion tracking system approved in the United States. According to the FDA, the product, which uses digital tracking to record if the medication was taken, has been

approved for the treatment of schizophrenia, acute treatment of manic and mixed episodes associated with bipolar disorder, and for use as an add-on treatment for depression in adults. The system sends a message from the pill's sensor to a wearable patch, which then transmits the information to a mobile application, so that patients can track the ingestion of the medication on their smartphone.

Exhibit 25: How Abilify MyCite works
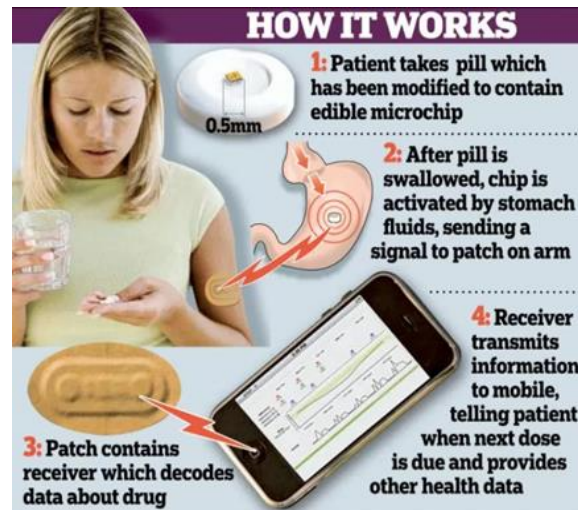
Source: Otsuka Pharmaceutical Company

With a computer already in our body, it will not be too much longer until that computer actually dispenses medicines directly into our bloodstream.

To take this a step further, internal medicine of the future will also be proactive. With a computer already in our body, it will not be too much longer until that computer actually dispenses medicines directly into our bloodstream. For example if a person's blood pressure were to rise, the computer would detect this immediately and connect with a doctor to remotely authorize release of a drug to avoid a blood clot or heart attack. In many cases, the digital pill could do this automatically, without a doctor's authorization. In events that the pill alone would be unable to help, it could automatically contact 911 or an ambulance drone for assistance.

Exhibit 26: Drone ambulance devices will automatically be notified by devices within your body, should an issue arise

Source: Alec Momont, Damdaar.com

Another such product could be the creation of the diagnostic tampon. Such a product would capitalize on the menstrual blood and cells shed by the uterine wall each month by women. A quick shipment of the tampon to the diagnostic center could easily, and painlessly, test women for STIs, non-sexual infections, hormone readings, and other health information—all

without a trip to the clinic. As this technology develops and refines, researchers would be able to diagnose and identify more conditions that can cause pain, infertility or death, including: endometriosis, uterine fibroids, cervical cancer, and ovarian cancer, which currently has no reliable routine screening and is typically not diagnosed until advanced late stages. Genomic start-up NextGen Jane is currently working on this technology with funding help from next-generation sequencing company Illumina.

Knowing yourself like never before

One of the fastest-growing fields in biology and medical science involves genetic testing and genome mapping, and the impact of genetics on various disease vulnerabilities in individuals.

Basic tests, which target single genes to find specific results related to a single outcome (Huntington's, Alzheimer's, etc.), only cost about $100. Whole genome sequencing is getting less expensive all the time and is quickly moving out of the lab and into hospitals. Direct-to-consumer kits (such as 23 and Me among others), while far less accurate, can be bought off the rack at Walmart for as little as $29.97.

Exhibit 27: Genetic testing types

Genetic test	Description	Quality	Main providers and owners of the data	Approximate cost of a test	Risk of adverse selection
Single gene analysis	Identifies mutations in a single gene responsible for a particular disease (single gene diseases)	High	Specialized healthcare providers	USD 100	**Now: Low,** as single gene diseases on average affect approx. 1-2% of population **Medium term: Low**
Whole genome sequencing	Analysis of the entire human genome and genetic variants associated with diseases	High potential	Now moving from the research sector to hospitals and clinics, primarily to analyze and better target treatments for cancers	USD 1,000 within the next few years	**Now: Low,** data processing requirement to incorporate patient's medical history and clinical symptoms not yet available **Medium term: High,** processing capabilities rapidly advancing
Direct-to-consumer genetic tests	Investigates a small proportion of the genome, i.e. SNPs suspected to be associated with diseases	Low	Private companies; no healthcare professionals need be involved	USD 200	**Now: Low** **Medium term: Medium,** accuracy of tests will improve

Source: PartnerRe

The implications of more accurate and less costly genetic testing will have significant lateral implications for industries outside of healthcare.

The implications of more accurate and less costly genetic testing will have significant lateral implications for industries outside of healthcare. For instance, the application of these tests will help life insurance companies to better understand disease risks inherent in a customer's DNA — which will help better assess pricing and premiums. The converse is also true – plenty of people who might today utilize life insurance products to protect their wealth and family might not be underwritten if life insurers knew what was in their genome.

From "A" diet plan to "MY" diet plan

In the future, hyper-custom and personalized diet options will not be a premium option but a baseline expectation.

In the future, hyper-custom and personalized diet options will not be a premium option but a baseline expectation. Manifestations of this are already apparent such as Arivale, Day Two, Vitagene, Vitamin Packs and Suggestic. And, while these companies and their technologies are interesting on their own now, we expect these are products that could (can, and should) become features, driven by Big Data, AI, and utilization of existing technology. One example becoming increasingly popular today is Habit, a start-up that received a $30M investment from Campbell's and creates customized meal plans based on a consumer's genetics. Habit engages consumers in a two-step process: 1) the consumer drinks a Habit Challenge shake at home and takes three blood test samples to send back to the Habit Lab, and 2) Habit uses the test results to assess how the consumer's body responds to food and develops an easy-to-navigate eating plan accessible through the Habit app.

Exhibit 28: Habit Nutrition Plan (synched with fitbit)

Source: Habit

Gut health is increasingly being discussed as a way to improve overall health. Viome's approach to dieting focuses on the role microbiomes (micro-organisms in our body) play in human health and disease. With a customized diet targeting relative differences in microbiome composition, Viome is able to limit the risk of obesity, diabetes, heart disease, autoimmune disease, mental health, Alzheimer's Disease, Parkinson's Disease and colorectal cancer.

Exhibit 29: Viome offers a customized diet based on a better understanding of microbiome in our digestive system
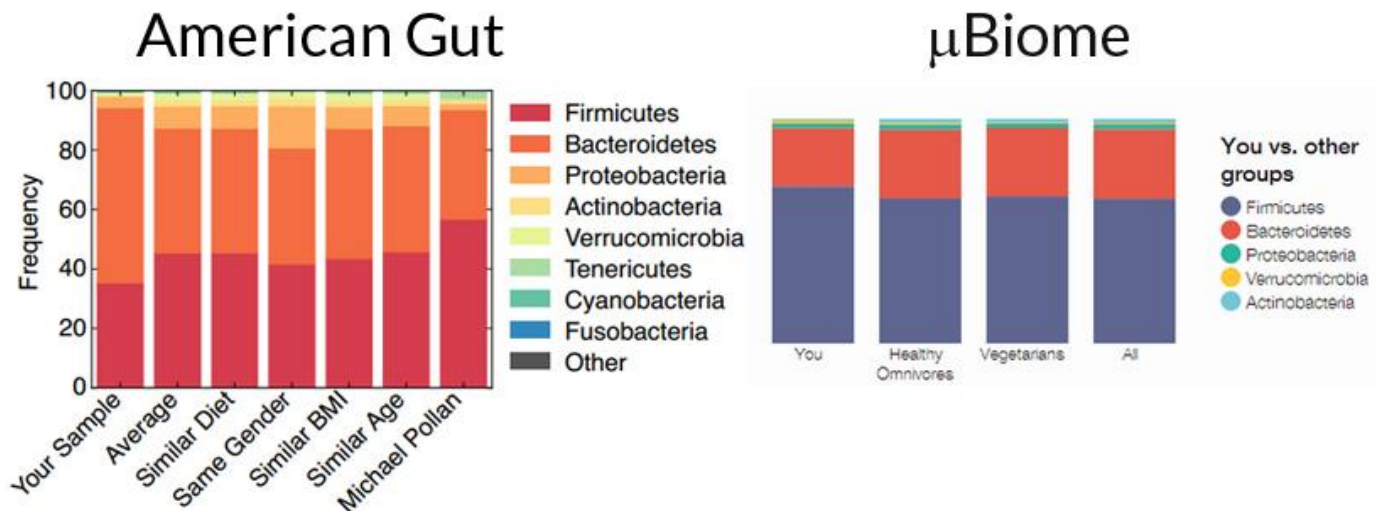
Source: Viome

Rather than having a personalized diet plan sent to your door, why not have it 3D printed at home?

But rather than having a personalized diet plan sent to your door, why not have it 3D printed at home? Foodini is a 3D printer for real food, made from fresh ingredients prepared before printing. Promoting cooking with fresh ingredients, Foodini manages the difficult and time-consuming parts of food preparation that often discourage people from creating homemade food. In the future, a similar product may be able to download personalized recipes consistent with your diet and execute the creation of those meals right at home.

Exhibit 30: Foodini

Source: Foodini, Natural Machines

The new human growth hormone

Cyborg (short for Cybernetic Organism) refers to a being with both organic and biomechanical body parts. Manfred Clynes and Nathan Kline coined the term in 1960 in reference to an enhanced human being that could survive extraterrestrial environments. Cyborgs today are becoming more and more prevalent in the form of both organ and limb transplants. Today, 116,892 people are on the waiting list for a solid organ transplant in the United States, and improved artificial organ generation, which will become cheaper over time, directly addresses this issue. Assuming Moore's Law is at play, scientists will be able to create every human body part in 40 years – effectively, artificially creating a human. As it relates to Cyborgs, it is quickly becoming the case that prosthetic body parts are superior to natural ones. An example is Hugh Herr, a mountain climber who lost his legs due to frostbite in a climbing incident. Herr, now a professor at MIT, focused on the design of prosthetic limbs where his research suggests (and he is a living example) that the latest in prosthetics enables humans to walk, run, dance, swim, and even climb mountains better than natural counterparts. A more recent example is at the 2018 NFL Scouting Combine where UCF linebacker Shaquem Griffin, who lost his hand as a child due to a birth defect, managed to bench press 225 pounds (102kg) an impressive 20 times while wearing a prosthetic. This suggests that prosthetics may become the new steroid of the future. Consumers may look to voluntarily replace, without cause, natural limbs, blood or organs with superior, custom-engineered substitutes.

Next-level personalized, pre-emptive medicine

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is new genetic technology that enables scientists to remove and replace components of DNA. CRISPR is affordable – and popular today for the modification of plants and animal species. For example, many start-ups are already working on projects like engineering superior fat composition from canola, wheat with higher fiber, and heat tolerant cattle. It will only be a matter of time until CRISPR is used frequently and affordably with humans, likely preventing genetic diseases in the near term, and potentially developing "designer babies" in the longer

Assuming Moore's Law is at play, scientists will be able to create every human body part in 40 years – effectively, artificially creating a human.

Prosthetics may become the new steroid of the future. Consumers may look to voluntarily replace, without cause, natural limbs, blood or organs with superior, custom-engineered substitutes.

term. Today, 1 in 33 babies born in the U.S. has a genetic birth defect; CRISPR technology will work towards eliminating such defects. Someday – perhaps much sooner than we realize – scientists could use this technique to edit not just the offspring of people with genetic diseases, but their offspring, as well. Theoretically, this could eradicate diseases caused by mutated genes, such as Huntington's, sickle-cell anemia, Tay-Sachs, and others.

Scientists could use this technique to edit not just the offspring of people with genetic diseases, but their offspring, as well. Theoretically, this could eradicate diseases caused by mutated genes, such as Huntington's, sickle-cell anemia, Tay-Sachs, and others.

Exhibit 31: The cost per genome in 2017 is 0.001% of the cost in 2001
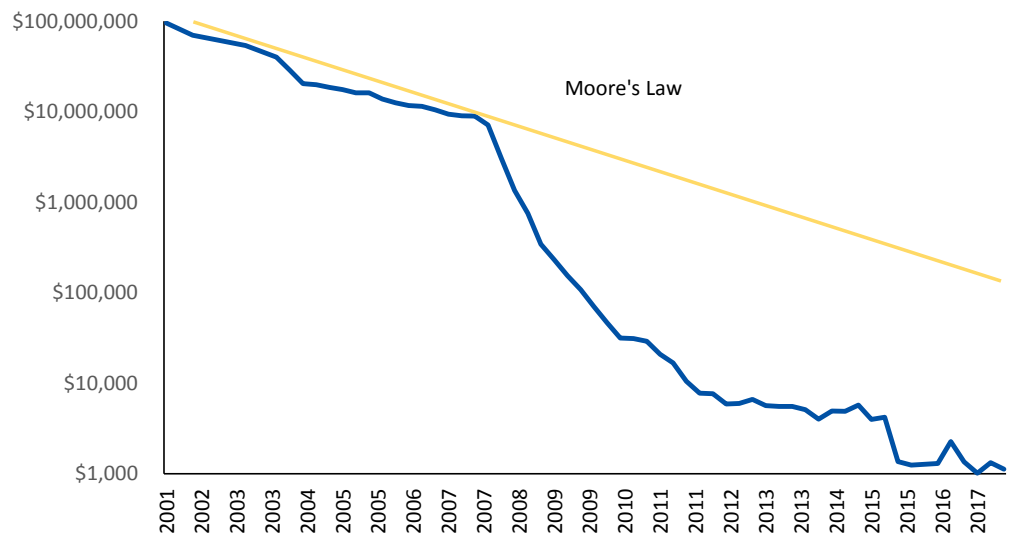
Source: National Human Genome Research Institute

Children for one and all?

Technological advancements in pregnancy and childbirth have created tremendous opportunities for women and families over time. At the time of the first successful IVF birth, the idea of "test tube babies" was a tabloid sensation. Since then, more than 6 million children have been born using the procedure. The next step in the evolution of pregnancy and childbirth could be artificial wombs, and ectogenesis—developing an embryo in artificial conditions outside the uterus.

In the more distant future, a technology like this could become the first step towards full ectogenesis, enabling families to grow their children outside their own bodies.

Japanese scientists conducted the first artificial womb experiment in 1996. In 2017, this technology was used to develop a lamb fetus from as early as 105 days (comparable to 23-week human gestational period). If approved, this technology could be ready for human testing within 3-5 years. On the outset, these artificial wombs could be used for extremely premature babies. In the more distant future, a technology like this could become the first step towards full ectogenesis, enabling families to grow their children outside their own bodies.

The possibility of ectogenesis for the full, or even partial gestational period, could have tremendous implications as women across all demographics continue to delay childbirth, rise to higher levels in both education and the workplace, and the idea of the traditional family unit changes. Barriers to, and burdens of, pregnancy and childbirth could be removed for both men and women including postpartum recovery, return to work, age at pregnancy, number of pregnancies, health risks inherent to pregnancy, and fertility challenges.

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Exhibit 32: Extrauterine fetal incubator
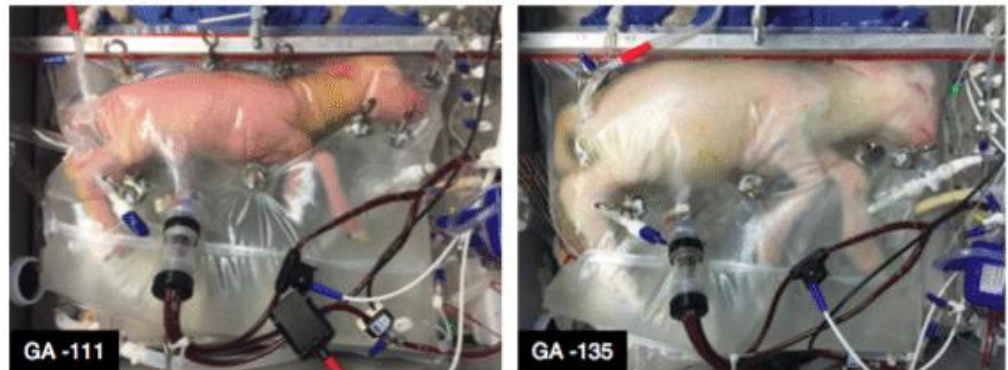
Source: Center for Fetal Research, The Children's Hospital of Philadelphia Research Institute

Complex ethics issues

Gene editing is rife with controversy and ethical concerns. While many say CRISPR-Cas9 will help reduce the occurrence of genetic diseases, a camp of experts say there are ways to accomplish that without editing the human genome. For example, preimplantation diagnosis (PGD) allows parents to screen embryos for certain disease-causing genes before implanting them via in-vitro fertilization (IVF). However, in cases where someone carries two copies of a defective gene, PGD will not work because all their embryos would also carry that gene.

Although scientists are now focused on editing disease-causing genes, CRISPR could potentially open the door to the creation of "designer babies."

Although scientists are now focused on editing disease-causing genes, CRISPR could potentially open the door to the creation of "designer babies," in which parents edit their children to be better at sports or math, for example, or to be more physically attractive. Is this ethically acceptable? Would it be ethically acceptable for consumers to decide they want organs replaced without cause, because prosthetic replacements are superior to their natural counterparts? Generally speaking, consumers are worried about the impact of these implications on society, particularly those that involve biological changes. In the future, new legal frameworks will have to be adopted to address this.

Exhibit 33: Public opinion on human enhancements

Public expresses more worry than enthusiasm about each of these potential human enhancements

% of U.S. adults who say they are _____ about each of these enhancements
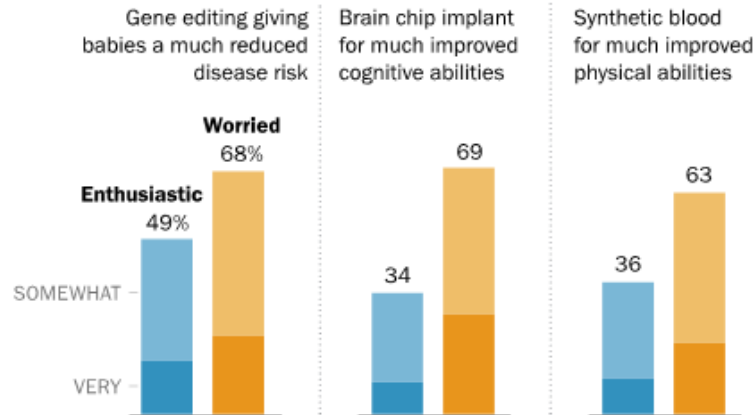
Note: Respondents who gave other responses or who did not give an answer are not shown.

Source: Survey of U.S. adults conducted March 2-28, 2016.

"U.S. Public Wary of Biomedical Technologies to 'Enhance' Human Abilities"

PEW RESEARCH CENTER

Source: National Human Genome Research Institute

What if…? The Calibrated and Augmented Self

What if virtual reality combines with the industrial Internet of Things (IoT), allowing workers to remotely operate equipment, thereby eliminating the chance of an accident physically harming a human being? Do equipment manufacturers stop placing emphasis on machinery safety and place emphasis solely on a machine's capability?

What if online retail personalization gets so accurate that consumers will simply receive weekly or biweekly shipments from Amazon with all of their grocery and consumer packaged goods needs?

What if advances in artificial intelligence leads to more efficient drug discovery? What will be the impact to pharma/biotech companies' current R&D efforts / processes? How will companies prioritize programs given potential for a significant inflection in product candidates?

What if CRISPR technology enables people to create designer babies? Does there become a market to design the smartest, most athletic, and best-looking humans?

What if advances in artificial limbs and organs develops a market of consumers proactively looking to replace body parts without injury or issue to enhance performance?

What if your mobile phone could switch to a Google Glass feature that allowed for novel ways to explain information, such as a 3D view of information?

What if VR entertainment and equipment becomes so good, robust, functional, immersive, entertaining, and intuitive that we no longer consume linear or streaming entertainment. Will that shrink the TV market…and the streaming market?

What if AI and holograms were used to generate a list of properties that a buyer might be interested in and create holograms of the various rooms and parts of those properties for the buyer to step into and see?

What if your connected, autonomous vehicles recognize the occupant has a medical emergency and automatically diverts to the emergency room?

What if printing materials could be pumped into a home printer like a water tap? What if consumers could 3D print personalized products in their own home? What if the need for factories decrease?

What if…? continued

What if automation, the Industrial IoT, and 3D printing capabilities removed the need for manufacturing in low-cost regions? Could this drive companies to reinvest in the U.S. and other developed markets where higher-skilled workers reside?

What if advancements in gene editing enable the eradication of addiction? What would this mean for the use and abuse of recreational products like alcohol & tobacco as well as prescribed medications like opioids?

What if advances in information technology and general safety technology lead to proactive, autonomous digital responses to acute medical events? What is the impact for providers and the hospital systems? Can AI and diagnostic technology make most providers obsolete? How much of care delivery and preventive care can be virtualized, disrupting this trillion-dollar industry?

What if the future of the smartphone is not hardware that is carried externally, but rather chips carried internally? What if credit cards, phones, and keys are all physically replaced this way? How far are humans willing to go with invasive technology?

What if physical shopping consisted of simply tapping an item on your phone or your wearable to add to your virtual cart and then simply walking through a scanner to process the items in your virtual cart? Would there be a need for the service industry and specifically cashiers?

What if drone delivery becomes a reality and last mile costs and delivery time frames drop sharply? Does that create another sea-change impact on today's bricks-and-mortar retailers? What are the impacts on the transportation and logistics industries? How much more retail square footage would be forced to close? Will the transformation from brick-and-mortar retailers becoming only showrooms be complete? How would manufacturers adapt to a true just-in-time environment whereby all of their orders/demand comes from individual consumer-oriented purchases rather than through large retailer-based purchase orders?

What if ecommerce becomes the be-all end-all resource for customer shopping? Would shopping centers and malls become less valuable? Will these landlords be able to reinvent themselves as an experience-focused good that must be visited in person to be fully enjoyed?

What if 3D printing completely removed the barriers to entry for high fixed-cost businesses, disrupting long-standing economic moats? Could small-scale players disrupt industries that once required huge installed bases and decades of specialized engineering expertise?

What if…? continued

What if artificial intelligence and augmented reality makes servicing mechanical equipment easier? Could the average person use augmented reality glasses to fix their car without the use of a mechanic? Would this eliminate the need for workforce redeployment?

What if most Internet interactions transition to voice – with fewer spots on voice channels, how would advertising models change? Will the world become brand agnostic and will the winners be voice-enabled device companies?

What if advancements in VR and AR offer a very real, 3D virtual experience for any place in the world? Would the demand for travel grow as users are inspired to visit those places or be curbed because people feel they have already visited the place?

What if people become more reclusive because virtual reality gives them one less reason to leave their homes, positively impacting food delivery and negatively impacting the on-premise food and entertainment industries?

What if 3D printing becomes the preferred method for constructing affordable housing? What happens to demand for the equipment previously used to construct homes?

What if advances in gene editing become mainstream and we eliminate many expensive rare/orphan diseases? What are the impacts on the pharmaceutical/biotech/healthcare markets? What are the impacts on R&D? How does this impact the total cost of care delivery globally? How does it impact personal income and corporate/government healthcare expenses? How about the impact on personal wealth and consumer consumption? How will we define the cost of a "cure" and how will this be paid for?

What if there was a miracle drug that meaningfully prolonged life expectancies? How would life insurers adapt their annuity products or their life products? What if the cure was extremely expensive such that only certain people could afford it – how would that change underwriting? Would health insurers and life insurers have incentive to combine?

What if all the personal care products, and consumer packaged goods of everyday life could affordably be customized for any specific person's combinations of needs and desires? Would this create a mass proliferation of SKUs or dramatically reduce them and erase mass market goods?

What if building materials are able to be recreated synthetically for 3D printing? Would there be a drop in demand for raw materials and a subsequent decline in demand for equipment to extract and move the raw materials? How would patent protections and other safeguards against IP theft work in this new paradigm?

Theme II: The Artificial Intelligence (AI) Race

We believe we are on the precipice of the Artificial Intelligence (AI) era. Software, enabled by machine learning (training algorithms on input data) and deep learning (using neural networks) can replicate and eventually surpass human cognition. It is helpful to think about AI technology in phases as a progression: Narrow AI, General AI and superintelligence or "the singularity." Each stage of AI development has different implications for different industries and the world at large.

What you need to know…

With the emergence of Big Data and more powerful compute power, AI has started entering real life applications. To date, AI is still solving fairly basic tasks. But the ingredients are there for AI to accomplish something much more substantial. We believe the application of AI will have very broad implications across a wide swath of industries (Internet, Autos, Banking, Software, Macro Economy, Health Care, and Utilities, to name a few) over the next 5-10 years. Among the different Technology Change Forces we have identified, we believe that AI may well be the most impactful.

There are three types of AI: Narrow AI: The most immediate application of AI. The ability to automate a single activity that outperforms human efficiency. **General AI:** Perform any intellectual task a human can and is sometimes referred to as human-level AI. **Super AI:** Super-Intelligence, aka the Singularity, is achieved when AI becomes much smarter than humans.

Industry uses and implications of AI: While we discuss these in more detail, some high-level AI uses and implications across industries include: 1) greater proliferation of smart devices and application of Internet of Things (IoT) into household devices; 2) more autonomous vehicles becoming mainstream; 3) blockchain potentially disaggregating the data used to feed AI; 4) increased AI powered software security solutions; 5) smart, autonomous farming and mining; and 6) more streamlined front-, middle- and back-offices across financial institutions.

AI's impact on the economy? Barring the development of general AI, we view the shocks to labor market in the Unites States and the developed world more generally as limited. Indeed, we see scope for AI to solve the problem of slowing potential economic growth via a non-trivial acceleration in productivity growth. Although, what is good for a technologically advanced society with slowing labor force growth could be risky for economies that are poised to see dramatic growth in working age populations.

Big Data + increasing compute power drive AI

Artificial Intelligence has gone from science fiction to the research labs and now into real life applications. Why? Compute power continued to increase and Big Data developed via the proliferation of the Internet, mobile, and sensors everywhere. Meanwhile, the cost of storage decreased allowing deep learning algorithms to use all that data. Three data points for now highlight the rise of Big Data. First, we expect there will be 1.7MB of new information created every second for every human being on the planet by 2020. Second, we believe 50 billion machine voices will be added to today's 2 billion connected users as the Internet of Things manifests over the next five years. And third, there are now expected to be 20 billion IoT devices installed by 2020, up from 6B in 2016.

To date, AI is still solving fairly basic tasks. But the ingredients are there for AI to accomplish something much more substantial. We believe the application of Artificial Intelligence will have very broad implications across a wide swath of industries and economic drivers over the next 5-10 years. Among the different Technology Change Forces we have identified, we believe that AI may well be the most impactful. Broader industry research from TCS (Tata Consulting Services) suggests that 84% of executives believe AI will be essential to competitiveness in the future. And there is also the belief that a doubling in growth rates is possible for developed countries by 2035 as AI becomes a new factor of production.

Applications are potentially very, very broad, and include autonomous cars, voice-enabled devices, bioengineering, industrial robotics, etc. Economic, social, and political implications could be dramatic. Per renowned tech seer Vladimir Putin, "The country that leads AI development will be ruler of the world." We put forth our conclusions with great caution and humility. But we have little doubt that the companies that are most successful in harnessing the power of AI will be those companies that likely have the most robust fundamental outlooks – and thus best potential stock performance – in their respective verticals. Yes, AI is THAT much of a Change Force.

AI sophistication will only increase

Narrow AI

Narrow AI is the most immediate application of AI and effectively automates a single activity that outperforms human efficiency. Most AI applications to date are Narrow AI. Examples include online purchasing recommendations, music recommendations from a streaming service, high-frequency trading, or IBM's Watson assisting doctors with diagnoses. However, the impact even Narrow AI has had is still in the early innings and the technology will continue to progress. For example, by definition, even autonomous driving is a form of Narrow AI as it aims to replace a single functionality – human drivers. However, autonomous driving AI is far more complex than other current existing forms of Narrow AI.

Case study: Understanding Narrow AI improvement via games

A good example that shows how even Narrow AI is improving is via the board game Go. Google's (Deepmind) AlphaGo beat a top Go master, Lee Sedol, in March 2016 and then world champion Go player, Ke Jie, in May 2017. AlphaGo was fed vast amounts of data (actual player moves) and used machine learning algorithms to analyze these moves and played games against itself to reinforce its learnings. Shortly after, the team developed AlphaGo Zero. In contrast to AlphaGo, AlphaGo Zero used a neural network to learn to play the game itself, without being "trained". According to the Deepmind team, after just three days of self-play training, AlphaGo Zero defeated its predecessor, AlphaGo (which defeated Lee Sedol), by 100 games to 0. After 40 days, AlphaGo Zero beat the version that defeated world champion Ke Jie. AlphaGo Zero was also able to develop new, creative and unconventional strategies. Another example is OpenAI, a non-profit AI research company

Most AI applications to date are Narrow AI. Examples include online purchasing recommendations, music recommendations from a streaming service, high-frequency trading, or IBM's Watson assisting doctors with diagnoses.

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focused on building safe AI, creating a program that beat the world's top professionals at 1-on-1 matches of Dota 2. Dota 2 is a complex video game with hidden information. The program learned from scratch through self-play. The team's next goal is to teach the system to play 5-on-5 (multi-player) matches. These developments exemplify how increasingly applying Narrow AI to other areas of society could unleash efficiency and productivity.

Exhibit 34: AlphaGo Zero Elo rating progression

40 days

AlphaGo Zero surpasses all other versions of AlphaGo and, arguably, becomes the best Go player in the world. It does this entirely from self-play, with no human intervention and using no historical data.

Source: Deepmind

General AI

General AI is artificial intelligence that can perform any intellectual task a human can and is sometimes referred to as human-level AI.

For AI to be as intelligent as a human, it would need the human brain's computing power.

General AI is artificial intelligence that can perform any intellectual task a human can and is sometimes referred to as human-level AI. Here the machine can understand its environment and reason as a human would. The AI is not focused on a specific activity like in Narrow AI. However, General AI is much harder to achieve than Narrow AI and will require technological breakthroughs in both hardware and software.

On hardware, it's mostly a function of higher computing power. Simplistically, for AI to be as intelligent as a human, it would need the human brain's computing power. In his 2006 book, *The Singularity Is Near: When Humans Transcend Biology*, Ray Kurzweil calculated that a human brain is capable of 10^{16} (10 quadrillion) calculations per second. He then shows the cost of computing calculations per second per $1,000. While the data only goes to 1998, the exponential improvement trend is clear and the implication is that when human brain-level compute power is available for $1,000, General AI becomes a reality. According to top500.org, the Sunway TaihuLight, a system developed by China's National Research Center of Parallel Computer Engineering & Technology (NRCPC), is the world's most powerful supercomputer, able to perform 93 quadrillion calculations per second. But it cost 1.8 billion Yuan ($273 million USD) to build this system and consumes 15,371 kW of power.

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Exhibit 35: Exponential growth of computing
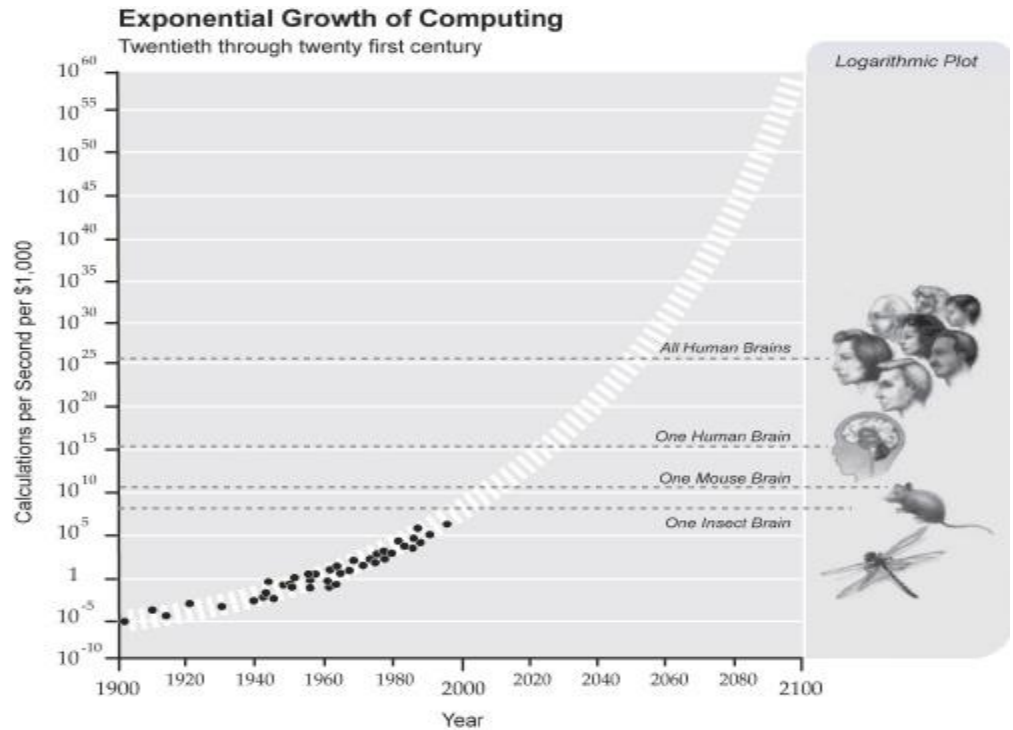
Source: The Singularity Is Near: When Humans Transcend Biology by Ray Kurzweil, p. 70; www.singularity.com

Once the hardware is there, the software must develop. The methodology here seems to be deep neural networks, which effectively aim to replicate how it is believed the human brain works. In recent years, deep neural networks have had strong success in AI such as the example with AlphaGo Zero above. Another good example of deep learning showing marked improvement is in the annual ImageNet Large Scale Visual Recognition Challenge. This is a competition where teams test their algorithms on a given data set. 2012 saw a major breakthrough for deep learning when Alex Krizhevsky led a team from the University of Toronto in the competition that used a deep neural network (called AlexNet) to train a model and achieved an image classification error rate of 15%, far ahead of the competition and a significant improvement from prior years. Imitation is the sincerest form of flattery and the use of deep learning in the competition has increased. The following year, almost all teams improved to below a 25% error rate. In 2017, 29 of 38 teams got less than 5% wrong.

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Exhibit 36: ImageNet large-scale Visual Recognition Challenge results
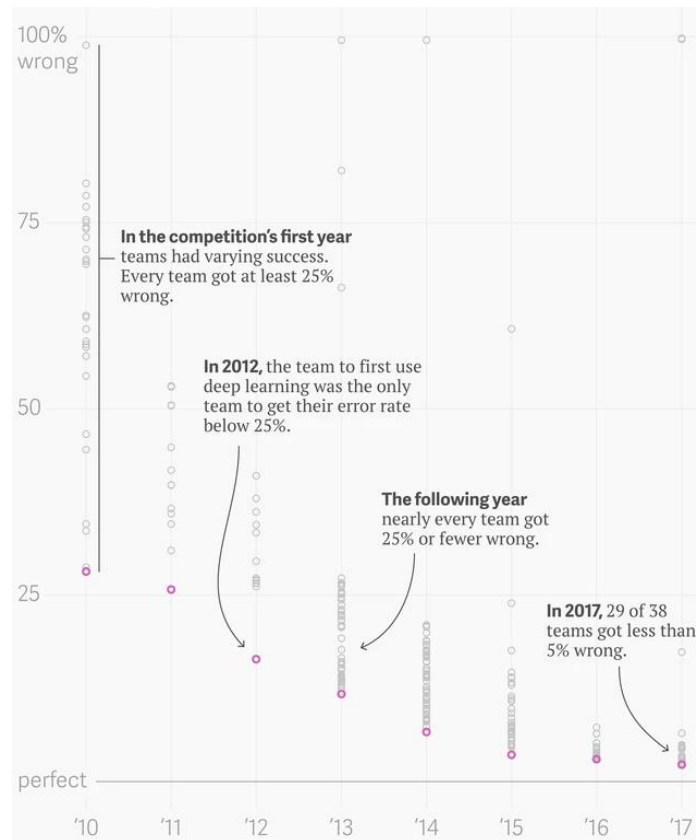
Source: David Yanofsky, Quartz; Data: ImageNet

To be sure, ImageNet is still a Narrow AI task, but it does go to show the meaningful improvements deep learning has had on AI. The previously mentioned OpenAI that developed a system to beat top Dota 2 players also has goals to solve a wide variety of games using a single agent. If they are able to accomplish this, it would be a good example of AI branching out from a more singular task.

Super AI

<div style="float:left; width:30%">

In thinking about AI advancement it is important to recognize that technology can change exponentially and humans generally think linearly.

</div>

Super AI, aka Super-Intelligence aka the Singularity, is achieved when AI becomes much smarter than humans. While significant improvements in hardware and software will be needed to achieve Super AI, we do believe it is important to look at this through our future lenses, recognizing that technology can change exponentially and humans generally think linearly.

On the geological timeline, the first homo sapiens (200 thousand years ago) are closer to the extinction of the last dinosaurs of the Cretaceous period (~66 million years ago) than the appearance of those last Cretaceous dinosaurs (~145 million years ago) are to the very first dinosaurs of the Triassic period (~240 million years ago). So intelligence, as we understand it, has been increasing non-linearly. Perhaps AI is just the next stage of evolution on earth. The idea of a brain-machine interface ("BMI") is not new and has been under study for 15 years by institutions including the Department of Defense, and the neurology and engineering departments at Stanford, Boston Mass General, and NYU, among others. Like many technological breakthroughs, this research so far focuses on the application of BMI in restoring function to persons with varying levels of disabilities; a cochlear implant to restore hearing is an example already in use. But as funds pour into the race to hack the human brain

Elon Musk's Neuralink start-up is seeking to create a brain-to-machine interface. The company wants to develop neural lace – an ultra-thin mesh implanted in the skull – that merges humans and AI, increasing human storage and processing power.

through companies such as Kernel, and Paradromics, coupled with increasing compute power to handle the data from the human brain (24gb per second), the idea of integrating AI into ourselves becomes more of a possibility than science fiction. Elon Musk's Neuralink start-up is working on exactly that, seeking to create a brain-to-machine interface. The company wants to develop neural lace – an ultra-thin mesh implanted in the skull – that merges humans and AI, increasing human storage and processing power. A darker thought is that Super AI supplants humans. After all, it may be human folly to assume that we can create Super AI, which is by definition smarter than humans, and then still be able to control it.

Exhibit 37: Dinosaur timeline

Source: Natural History Museum, http://www.nhm.ac.uk/

Internet companies have been collecting Big Data and investing heavily in AI

By 2025, we would anticipate that AI will be very broadly deployed across the Internet sector, used in many aspects of business operations – from operations to marketing to finance to HR.

By 2025, we would anticipate that AI will be very broadly deployed across the Internet sector, used in many aspects of business operations – from operations to marketing to finance to HR. One of the reasons for this is that we believe AI will permeate functions throughout all industries. But another reason is that we believe the Internet sector contains several of the companies that are most aggressively and effectively embracing AI – companies like Amazon, Google, Facebook, Netflix, Expedia, eBay, and Booking.com.

What the Internet could look like in 2025:

1) We believe machine-learning techniques will be widely deployed by 2025 across the Internet sector to improve the personalization of companies' offerings. Content, product promotions, advertising, recommendations are all likely to be more personalized than they are today. All major Internet companies should benefit from this trend, as should their core customers.

2) AI-powered Voice Recognition will likely improve dramatically from current levels allowing even better use of Internet apps via voice commands. Search functionality would skew much more heavily towards voice commands than to keypad/phonepad prompts.

3) Virtual Reality and Augmented Reality, empowered by AI, will likely become much more mainstream. These should provide new platform opportunities for entertainment companies like Netflix, but also reveal key execution challenges if they don't execute well on this transition. Our guess is that this transition could be more like 10-20 years, but we could foresee a world where Friday Night Streaming gets replaced by Friday Night VR.

4) Advanced robotics could become a central part of logistics operations for vertically integrated ecommerce companies. Like, say, Amazon. The company already deploys something like 100K Kiva robots, and we wouldn't be surprised to see a very large % of Amazon's distribution workforce complemented with these robots by 2025. The impact of this should be greater operational efficiency.

5) We see greater proliferation of smart devices and application of Internet of Things (IoT) into household devices. It is likely that all devices could potentially be Internet-connected and with improvement in machine learning and AI technology, smart devices could become "smarter." Some common applications could include the ability for consumers to

track energy consumption of home appliances and increasing home security features with improved cameras and alarms.

6) While some view blockchain as application of AI, we believe that decentralized networks may in fact disaggregate the data used to feed AI. From this, we see the potential for large consumer Internet companies as needing to rent personal data from users (e.g., pay users in tokens) for its use in AI applications. But we also envision the potential for Amazon and other Cloud Computing powerhouses to become large nodes on the decentralized network with the ability to rent out unused or latent processing power to others. So this would likely be a symbiotic relationship. We provide additional perspective on the future of blockchain on pages 73 and 124.

Software is an important cog in the AI "machine"

Software is the lifeblood for machines getting smarter.

Software is the lifeblood for machines getting smarter. Software is at the core of Facebook's algorithms, it is what powers smart devices like Amazon Alexa or Google Home, the heart of self-driving cars, key to advancements in medicine, the very definition of cyberwarfare and critical to major banking applications. Point is, software drives innovation in compute and is critical to artificial intelligence and machine learning. Much of this innovation is good, but it could also be used against us if "the machines take over" or if the machines produce undesirable results.

Before the dawn of the Internet, the world was less connected…and IT was quite frankly not as complicated.

Thomas Young (1773-1829) is referred to as "The Last Man Who Knew Everything". Young's achievements were immense and diverse in areas such as physics, mathematics, physiology, medicine, and linguistics. As the complexity of the world accelerated with modern compute power, it is now virtually impossible to find a person who "knows everything," but rather more likely to find a machine that "knows everything."

IT departments of old each had their version of "Thomas Young" that knew everything about their environment and if a computer had an issue, the IT help desk would often say, "did you try restarting your computer," which usually fixed the problem.

Today though, the world is more connected than ever and it is becoming increasingly difficult to identify "people" that know everything about an interconnected network. To that point, software is taking the place of people and is often the brains behind computer networks and algorithms.

In the future, we think software's impact on AI/ML could be even greater with a wide variety of use cases including leveraging massive compute power within the public cloud, enhanced software security protection, intelligent workflow automation and Big Data analysis among others.

At a high level, AI/ML is having a large impact today. In the future, we think software's impact on AI/ML could be even greater with a wide variety of use cases including leveraging massive compute power within the public cloud, enhanced software security protection, intelligent workflow automation and Big Data analysis among others. Further leveraging of software for AI/ML will in turn have a trickle-down effect on other industries including banking, insurance, automotive, retail, etc.

While it is often more science fiction than reality, with such an interconnected, software driven world, the potential for periodic failure of the Internet or the machines taking over is not zero.

Some additional musings on select AI Internet and Software Leaders

While we touched on what Amazon, Google, Facebook and Netflix are doing on the AI front, we thought it was important to provide a more comprehensive perspective on what these AI leaders are doing.

Amazon and AI

What AI means to Amazon: Speaking generally on Artificial Intelligence, Jeff Bezos, CEO of Amazon, describes it as "A Renaissance" or a horizontal enabling layer that will empower and improve every institution, business, and government organization in the world. We believe Amazon is embedding machine learning and AI techniques into just about every part of its business, and is going all-in by investing heavily to be at the forefront of this wave. And it's arguable that Amazon has a commanding lead in spending on AI-related jobs. According to a study from Paysa, a career and hiring data firm, Amazon was estimated to have spent ~$228M last year on annual salaries for AI related jobs, accounting for up to 35% of the total annual spend ($650M) by U.S. employers on AI jobs. This is 80%–85% higher than Google's spend that came in second at ~$125M (see Exhibit 38).

Exhibit 38: Top 20 companies' estimated investment in AI talent
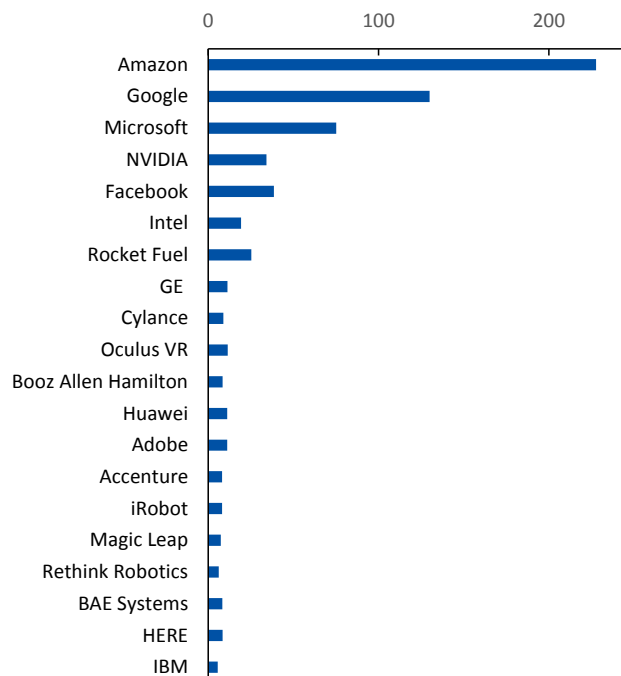
Source: Paysa

Where (and how) is Amazon applying AI and machine learning?: While Mr. Bezos highlights some applications of AI at Amazon in his 2016 Shareholder letter, we believe the company is applying machine learning and AI techniques everywhere it can within the organization. This includes Alexa and Echo devices, autonomous Prime Air delivery drones, AmazonGo – Amazon's checkout-free convenience store, AWS cloud services – its marketplace to improve search results and product recommendations (also applies to smarter recommendations for the next song to listen to on Amazon Music, next movie to watch on Amazon Video, and the next item to buy on its platform), improvements in demand and inventory management forecasting, merchandising placements, fraud detection, and FC optimization with Kiva robots.

How does AI benefit Amazon? We view three key benefits: i) Retail sales growth; ii) AWS cloud sales growth; and iii) Reduce operating costs. i) Retail sales growth – as Amazon continues to improve its search & product recommendation algorithms to offer a more personalized experience, we believe this could result in growth of its higher-spending loyal customer base (global Prime members) and retail sales; ii) AWS cloud sales – AWS' machine learning and AI services lower cost barriers for smaller businesses to adopt these technologies. Amazon could use its market leadership (30-40% share) to cross-sell AI products and grow AWS sales; and iii) Reduce operating costs – Amazon could become a more efficient business by using AI to optimize for cheaper and faster delivery/shipping methods and less FC sq. footage by making improvements in optimizing shelf space. This includes the use of likely over 100K Kiva Robots in FCs, which continue to help drive operating cost efficiency for Amazon.

Overall thought - How does Amazon compare to others in its AI efforts? Overall, while it is still relatively early in the AI lifecycle, leaders are emerging quickly and we believe Amazon is one of them. Here is why - AI is primarily a prediction technology that gets better as more relevant data and information is fed to the system. Not only does Amazon have the resources (~$30B in cash) to invest in AI, but also has the scale and the ability to generate large volumes of data. With well over 300M global customers, likely close to 100M Prime members, likely well over 15B items sold per year, millions of sellers, over 1M AWS clients, and the diversity of products and services for consumers (video, music, grocery, shopping), Amazon's global scale is a huge advantage in improving its own competitive position and operations using AI.

Google and AI

What AI means to Google: If gas was the most important factor to the automobile industry, then information is likely the most important factor in the AI race. What would that make Google then? Well, Google's mission is to "Organize the world's information and make it universally accessible and useful." And AI is enabling Google to do that in new ways. Google has been a leader in the AI field, creating educational classes, working on research projects across numerous industry verticals, and creating tools (hardware & software) for developers to further enhance the field. According to a study from Paysa, a career and hiring data firm, Google was estimated to have spent ~$125M last year on annual salaries for AI related jobs, accounting for 19% of the total annual spend ($650M) by U.S. employers on AI jobs. This is second only to Amazon's ~$228M.

Where (and how) is Google applying AI and machine learning? Across the company, machine learning and artificial intelligence (AI) are increasingly driving many of Google's latest innovations. Google's investments in machine learning over the past decade have enabled the company to build products that are smarter and more useful – machine learning allows you to use your voice to ask the Google Assistant for information, to translate the Web from one language to another, to see better YouTube recommendations, and to search for people and events in Google Photos. Machine learning is also showing great promise in helping Google tackle big issues, like dramatically improving the energy efficiency of its data centers. Across its "Other Bets" segment, machine learning helps self-driving cars better detect and respond to others on the road, and can also improve the ability of clinicians to detect diseases such as diabetic retinopathy and cancers. Of course, Google is also using ML to improve its core revenue generator (its Advertising business… responsible for ~$100B in annual revenue).

What investments is Google making in AI? It's important to recognize that Google is creating many of the tools AI researchers are using to develop applications. Over the past year, Google introduced its second generation TPU (Tensor Processing Unit), which is its custom-

built processor specifically built for machine learning. And Google is offering them through Google Cloud, as Cloud TPUs on GCE (Google Compute Engine), enabling more people to use these processors. Google is also behind TensorFlow, its open-source machine learning platform. TensorFlow supports a variety of applications, and is used notably for training and inference with deep neural networks. Last year Google acquired Kaggle, the world's largest community for data science and machine learning. Kaggle has a repository of public data sets available, Kernels, and even hosts competitions and courses to teach users Data Science.

Overall thought – How does Google compare to others in its AI efforts? Imagine working for a company with $100B of cash on its balance sheet. You were just hired from Stanford, MIT, or your mother's garage. Either way, you were labeled the "geek" growing up. But now you are with everyone else who shares your computational passions. And your first day you are given a blank check and the resources to conduct studies in the field of AI. Welcome to Google! Overall, while it is still relatively early in the AI lifecycle, leaders are emerging quickly and we believe Google is clearly one of them. As with Amazon – AI is primarily a prediction technology that gets better as more, relevant data and information is fed to the system. Not only does Google have the resources to do this, but it arguably hosts the largest collection of information across the entire Internet and the world. With over 2 trillion searches and 60 trillion unique indexed pages, and quintillions of page views, the Internet itself is a huge advantage in improving Google's own competitive position and operations using AI.

Facebook and AI

What AI means to Facebook: It is extremely important. With over 2B users on the core Facebook product alone, Facebook cannot possibly monitor all the content creation and advertising being done on the platform by humans. Thus, Facebook leverages Artificial Intelligence and machine learning to improve its service drastically for both consumers and advertisers. **In 2013, Facebook hired the French artificial-intelligence specialist Yann LeCun to start its AI research Lab.** Ever since, they've become a major player in AI/ML research. A company spokesman noted in January that "AI is more important than ever to Facebook. Our teams are growing. We're continuing to publish and open-source more than ever before, and deploying AI across Facebook at a really high level." In fact, Facebook's AI has become so advanced that it even created its own language: in attempting to improve their chatbot technology and offering, Facebook AI Lab created a "generative adversarial network" for the purpose of developing negotiation software. Though not truly nefarious, when the created bot was set to compete against another bot instead of a human agent, they began communicating in what seems like gibberish but was actually an advanced bot language that tried to improve their conversational skills. See the example below:

> **Bob:** i can i i everything else . . . .
> **Alice:** balls have zero to me to me to me to me to me to me to me to me to
> **Bob:** you i everything else . . . .
> **Alice:** balls have a ball to me to me to me to me to me to me to me
> **Bob:** i i can i i i everything else . . . .
> **Alice:** balls have a ball to me to me to me to me to me to me to me
> **Bob:** i . . . .
> **Alice:** balls have zero to me to me to me to me to me to me to me to me to
> **Bob:** you i i i i i everything else . . . .
> **Alice:** balls have 0 to me to me to me to me to me to me to me to me to
> **Bob:** you i i i everything else . . . .
> **Alice:** balls have zero to me to me to me to me to me to me to me to me to

Looks strange right? What these bots were doing is actually communicating in their own advanced language to negotiate in advanced ways against each other.

Where and how does Facebook apply AI? Facebook uses AI and ML in numerous ways across the platform: text analysis, screening for offensive content, advertising targeting, demographic categorization, sorting your newsfeed and checking for security threats. Algorithms handle a lot of work for the company. As an example, Facebook developed a tool called DeepText in June of 2016 to understand with "near-human accuracy" the textual content of several thousand posts per second across many languages, using neural networks to understand context and extract meaning from the words. Facebook has also been using AI for many years for facial recognition (the DeepFace product) that has an accuracy of 97% in recognizing human faces, close to human-level performance.

How does AI benefit Facebook? We view two key benefits: i) Advertising – Facebook uses neural networks to determine how advertising is shown and to whom. They also do advanced sorting of the user base through algorithms to categorize users and learn what's relevant to them (using products such as DeepText). This is a significant boon for the company's advertising revenue stream and products as it allows them to improve advertiser ROI and attract more advertising dollars as a result. ii) Improved User Experience – By sorting content according to relevancy to the users, Facebook can materially improve how consumers engage and connect on the platform.

Overall thought – How does Facebook compare to others in its AI efforts? We believe Facebook is very far ahead in their AI/ML efforts given their scale and investment size. Furthermore, the amount of data they have to work from is a huge advantage. Nevertheless, In a Washington Post article from January 24, 2018, Pedro Domingos, a University of Washington Professor and AI researcher stated that he believed that in terms of AI, Facebook was "still a minion in the terms of Google or Microsoft." The company currently employs more than 100 AI researchers globally, still a much smaller number than Google or Microsoft. We believe Facebook is likely significantly behind Amazon and Google in the AI race.

Netflix and AI… and AR

What AI means to Netflix: At Mobile World Congress in Barcelona in 2017, Netflix CEO Reed Hastings joked that within entertainment, he wasn't sure whether Netflix would be "entertaining you or entertaining AIs." Though light-hearted, it speaks to the fact that Netflix recognizes the importance of AI to both its business and to the Internet more generally. **Netflix has been working on AI and ML for several years.** In fact, those tailored Movie and TV picks you see on your Netflix home screen aren't from a human curator… they are coming from the algorithms working behind the scenes for Netflix.

Where and how does Netflix apply AI? According to the Netflix technology blog, Netflix uses AI for a variety of tasks, including Content Promotion, Content Price Modeling, Programmatic Marketing, Efficient Content Delivery, Adaptive Streaming Quality of Experience, and more. In a more groundbreaking experiment, Netflix is experimenting with creating software-edited trailers that are personalized for each subscriber to get them to watch its films (as reported by the Register in a December 6th, 2017 article).

How does AI benefit Netflix? We view two key benefits: i) Improved User Experience – Helping improve user content recommendations through personalization helps improve a consumer's experience with the Netflix platform and thus increase users' stickiness with the platform, as well as increasing the likelihood that they recommend the service to their friends. ii) Improved Operations and Cost Savings – Using AI/ML, Netflix can predict which level of streaming quality a user should be using based on a number of factors including their location, device, etc., and also ensure efficient content delivery to help cut down on bandwidth costs. Furthermore, they can use their AI/ML proficiencies to help improve how

they market their content and also to help them determine what users are watching, and thus, how much they should be bidding on new content.

Netflix's view on VR: Netflix launched a VR product in 2015 that allowed users to step into a virtual room to watch movies or TV shows on the Gear VR, then later the same product for the Google Daydream headset, according to Engadget. However, the company has been somewhat quieter on AR and VR as of late. Chief Production Officer Greg Peters views VR as more of a medium for gaming now, rather than a lean-back experience for TV content watching.

Overall thought – How does Netflix compare to others in its AI efforts? Netflix is likely on par with most other major Internet companies in terms of its artificial intelligence and machine learning development, though not quite as advanced as the leading players who use/need it more (i.e. Google, Amazon). Nevertheless, with ~120MM subscriber base (a figure that is growing fast), Netflix likely has the scale to compete significantly in the AI/ML space.

EBAY and AI

What AI means to eBay: Speaking generally on Artificial Intelligence and its importance, Devin Wenig, CEO of eBay noted, "[I]f you don't have an AI strategy, you will die." Since Mr. Wenig took the helm at eBay in July 2015, he has been very clear in communicating the company's multi-year transformational strategies with investments in AI capabilities as one of the company's top priorities. We see this in eBay's investments around AI – three notable AI-related acquisitions since July 2015, which include Expertmaker, Salespredict, and Corrigon in addition to building in-house capabilities, and hiring Jan Pedersen to spearhead the company's AI efforts. A quick look at eBay's job openings tells us about eBay's focus on AI – ~30% of the company's currently available jobs (697 jobs) are related to / require "data science" and ~13% of total available jobs are related to / require machine learning/AI.

What does AI offer eBay? "Relevance" says Mr. Wenig, and we agree – use of AI at eBay has primarily been related to creating a "my eBay" personalized user experience. Some examples of how eBay is using AI to power many of its efforts at scale, that benefit consumers and sellers, include: an updated homepage with personalized and improved search results & product recommendations, Grouped Listings, Visual search features such as Image Search and Find It On eBay, improved contextual advertising for eBay Affiliate Marketing, ShopBot, and AI-based pricing and inventory solutions for sellers. Key benefits of using AI for eBay in our view are to boost user growth (up from its current low-single digit growth rate) and increase spend/user for its 170MM current users, which would ultimately impact GMV and topline growth. We may already be seeing green shoots with currently accelerating GMV growth rates.

Expedia and AI

What AI means to EXPE: According to a recent interview with Mark Okerstrom, Expedia's CEO, the emergence of AI, voice-based digital assistants, and chatbots could provide fragmentation that offers Expedia a larger set of top-of-the-funnel options, currently dominated by Google. Expedia is a technology company first and then a travel company and is almost always in a test & learn environment – this includes integrating new products and features using machine learning and AI. Expedia not only builds products, solutions and technology that is personalized to each brand, but is also easily scalable across its B2B and B2C brands, globally.

How does EXPE use and benefit from AI? While Expedia has been investing in AI, voice, and bots for the booking side of the business, the company is leaning in by investing in AI for customer care and its search platform. Expedia uses machine learning to power its platform's

search algorithms, for example its Best Fare Search algorithm for flights. Before launching chatbots, as a part of early testing, Expedia found that 40%–80% of customer contacts preferred text-based channels such as social or chat over phone calls. Currently, Expedia offers chatbots for Travelocity, Hotels.com, and Expedia platform, and plans to roll these out across all its properties. While Expedia has made significant progress around AI and bots for customer service, the company acknowledges that the overall industry is still in early stages. The future of AI in travel will likely include multi-turn service bot conversations with appropriate context to offer a personalized experience and solve customer problems efficiently. Key benefits of using AI for Expedia in our view include: i) Growing and building a more loyal customer base by improving search results and customer service experiences; and ii) potentially lowering advertising costs – build diversity in customer acquisition strategy using Voice assistants and partially shift away from Google, which currently accounts for the largest share of Expedia's performance advertising budget.

Microsoft and AI

What AI means to Microsoft: We believe Microsoft's attempted Salesforce acquisition and closed Linked acquisition represent a stage of evolution in the company towards bringing together apps, intelligence and compute. We think the portfolio of key enterprise assets ranging from O365 and Azure to Dynamics, LinkedIn, Devices and Artificial Intelligence is creating a new halo effect for the company, driving more consumption and IT budget share shifts in Microsoft's favor. We also see the evolution of Azure developer services and toolkits emulating AWS' shift toward intelligence, with the aggressive rollout of AI+Cognitive service offerings in recent months. Additionally, Microsoft has recently reorganized its engineering teams with a specific emphasis on Cloud + AI Platforms and AI + Research.

Where (and how) is Microsoft applying AI and ML?: We highlight the rapid evolution of Azure services in the AI and Cognitive services bucket with features like Azure Machine Learning, Experimentation Service, Workbench, and Model Management Service. Additionally, new AI features for Bing would make better use of object recognition, machine reading and conversational nuances. Beyond voice recognition, natural language processing, real-time translation, and feedback capabilities that become more advanced each year, business use cases for machine learning with partners/customers continue to evolve. The most common use cases are for issues with: i) a large amount of data; ii) well-defined processes; and iii) clear precedents of what works from other companies (issue taxonomy, shortening processes, providing context). Examples of implementation for customers are at Tetrapak (prediction of breakage/ maintenance), Land O Lakes (precision agriculture), and Trimble (creating digital twins of mining sites).

How does AI benefit Microsoft? We think Microsoft has emerged as a key player in corporate digital transformation and we think this will drive sustained growth in the commercial businesses over the next several years. More unique use cases for Azure premium services could drive additional mind share, user evangelism and provide scale (and associated margin uplift) to non-premium services. Additionally, we think this leads to enhanced functionality and cross pollination of enterprise assets (Office, LinkedIn, Dynamics, etc.).

Overall thought – How does Microsoft compare to others in its AI efforts? As one of the original 6 on the Partnership of AI researchers, we think Microsoft is at the forefront of AI efforts. Microsoft has a unique position with breadth spanning the entire value chain from infrastructure to content, being front and center of digital transformation initiatives and conversations, and a strong presence within the majority of core enterprise IT infrastructure. Additionally, with key R&D resources and the ability to hire talent, we think the moat remains unassailable.

Salesforce and AI

What AI means to Salesforce: As one of the pioneers of SaaS, Salesforce was also early to define the value of the Systems of Intelligence that can be created through effective software use of data assets. Since then, Salesforce has been one of the most acquisitive and aggressive companies in chasing talent and assets and successfully productizing them. We've seen the evolution of a number of acquisitions including RelateIQ (for relational intelligence), MetaMind (Automatic image recognition), PredictionIO (open source machine learning server), Beyondcore, MinHash and Implisit (predictive analytics). Einstein is an amalgamation of AI and data science techniques to add intelligence to existing cloud products from the existing Salesforce datasets.

Where (and how) is Salesforce applying AI and ML?: The company expects Einstein will capture data from Salesforce, email, calendar, social, IoT channels to help guide sales (by providing insights like surfacing high lead scores, crafting emails, etc.), assist service agents (prompts), empower marketers (enhancing predictive journeys and prompts), and improve commerce (personalized recommendations). Einstein is sold as additional functionality provided to the customer (charged additionally). The equation: *Customer data + AI + the Salesforce platform = World's smartest CRM.*
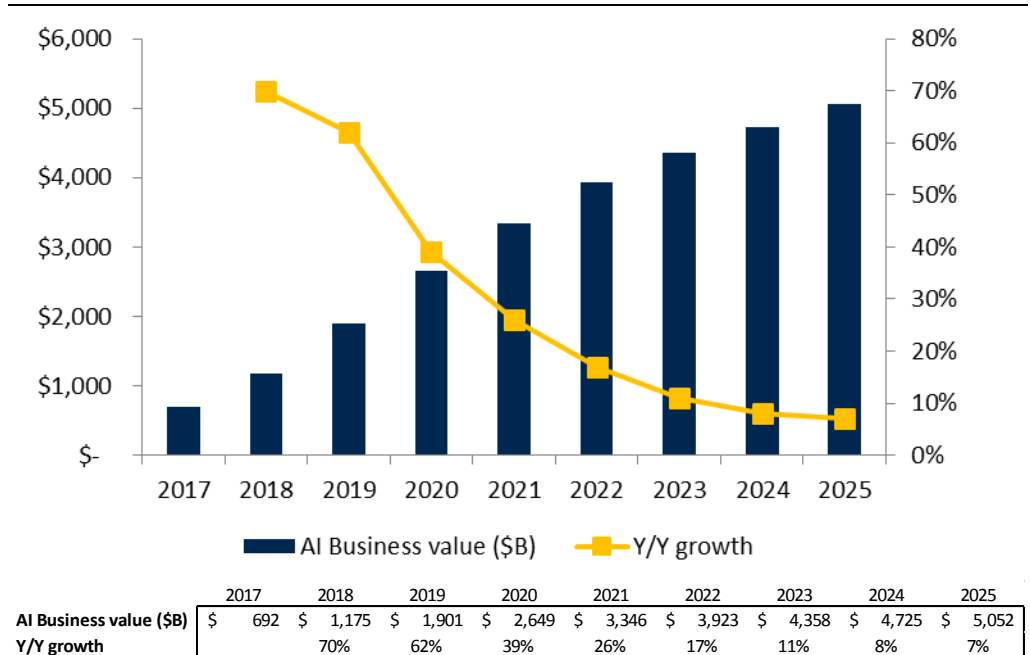
Overall thought – How does Salesforce compare to others in its AI efforts? One of the most successful companies we've seen in terms of actually being able to productize and monetize AI outputs (through module upsell to existing customers); along with striking key partnerships or acquisitions to enhance areas of existing weakness (Google Partnership, Krux acquisition for Marketing).

AI software predictions through 2025:

1) We believe there will be a call to focus on building "ethical machines."

2) Government organizations could enact additional regulation or create agencies to monitor companies that cannot regulate the interdependencies between larger computer networks.

3) A focus on leveraging the IoT to create additional software-driven connected devices.

4) Disruptive software assets that focus on AI/ML could see increased M&A interest from larger vendors in and out of technology.

5) Innovation is good and software is good for innovation. We think investing in disruptive software vendors that focus on AI is the correct long-term approach.

As far as the overall size of the opportunity, Gartner forecasts AI to grow at a CAGR of 28% from $692 billion in 2017 to $5.025 trillion in 2025.[1]

Exhibit 39: AI Business Value forecast 2017-2025 ($B)

	2017	2018	2019	2020	2021	2022	2023	2024	2025
AI Business value ($B)	$ 692	$ 1,175	$ 1,901	$ 2,649	$ 3,346	$ 3,923	$ 4,358	$ 4,725	$ 5,052
Y/Y growth		70%	62%	39%	26%	17%	11%	8%	7%

Source: Gartner "Forecast: The Business Value of Artificial Intelligence, Worldwide, 2017-2025" by John-David Lovelock, Susan Tan, Jim Hare, Alys Woodward and Alan Priestley (March 12, 2018)

While public and hybrid-cloud could see the most leverage from AI/ML in the future, we believe there are several overarching trends that point to software seeing a positive impact from AI/ML including: 1) the explosion of data from new and existing sources including machine-generated data; 2) the increase and practical cost around compute power driven by the public cloud; 3) growing complexity and prevalence of hybrid networks; 4) the constraints on human resources to manage expanding networks; and 5) the advances in deep neural networks and ML to power AI.

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[1] "Forecast: The Business Value of Artificial Intelligence, Worldwide, 2017-2025" by John-David Lovelock, Susan Tan, Jim Hare, Alys Woodward and Alan Priestley (March 12, 2018).

Software Theme 1: Leveraging the compute power of the public cloud

We believe public cloud vendors including AWS, Azure and GCP likely see the most leverage from AI and ML given 1) massive amounts of raw compute power, 2) large data sets, and 3) ability to hire and incent some of the smartest data scientist on the planet.

The public cloud has changed the pricing dynamic around two of the most important components of AI or ML, which are storage and compute. Being able to run continuous analysis on large data sets requires an amount of compute power and storage capacity that makes public or hybrid infrastructure an attractive value proposition.

In addition to the structure and cost component of why public cloud is a logical environment for ML and AI, there is also the fact that all three of the largest public cloud players have each made substantial investments in the space and have the resources to continue to do so. In the hotly contested market for AI talent, Amazon, Google and Microsoft all have the ability to acquire these professionals and have used it to develop their own AI development stacks on their public clouds bringing the technology to the masses.

Software Theme 2: Making the most of your data

While public cloud providers look like a natural winner in AI and ML, the reality is most organizations will likely operate some form of a hybrid-cloud. Therefore, we believe software solutions that provide AI and ML capabilities across both public and private-cloud looks like another area that could receive above-average spending.

As the amount of hybrid-cloud data generated continues to grow, corporations are working harder to identify what data holds value and how to extract it. Further, organizations are also looking at historical data sets as an opportunity to mine for gold and gain insights through AI and ML that humans could never find.

Finally, discovering patterns through AI and ML on data stored within an organization is important not just for gaining insights, but also ensuring data security. Companies are now using machine learning to automate data discovery to identify areas of risk such as the location of credit card information and SSN. Being able to identify, manage and make use of historical data is equally important to real-time insights provided by data in motion.

Software Theme 3: What about the application layer?

Moving up the stack, we believe the application layer is another logical area to leverage embedded AI and ML capabilities. Although there are several good examples of this, two areas that could see increased interest likely include embedded analytics in Salesforce.com and automation/discovery capabilities from ServiceNow.

Although applications can feed data to a correlation engine such as Splunk, embedded analytics is gaining additional traction across the application stack.

We think automation through AI and ML creates efficiencies and helps to offload repetitive tasks to machines as well as making the workforce more productive with faster insights and better task prioritization. By 2021, Gartner expects AI augmentation to recover 6.2 billion hours of workforce productivity while generating $2.9 billion in business value.[2] AI augmentation is the combination of AI with humans to increase the ease and effectiveness of cognitive tasks for workers. This is another reason why we don't feel that AI is a job taker. The operational insights should create new tasks that were not previously possible while

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efficiency gains would let workers focus on more mission critical tasks. AI augmentation leads to better results and more cost-efficient enterprises as the sum of the parts for cognitive decision making and AI is greater than either on its own.

Software Theme 4: Security and AI/ML – a perfect match

In 2015, the "(ISC)² Global Information Security Workforce Study" conducted by Frost & Sullivan predicted there would be a shortage of 1.5 million workers in the cyber-security sector by 2020. In 2017, the Center for Cyber Security Safety and Education released its "Global Information Security Workforce Study" expecting the gap to be 1.8 million by 2022. In conversations with security software vendors, we feel this has become a real issue for CISOs and has helped spur investments from software security companies in automation, AI and ML.

Companies are turning to security software solutions to address this gap in labor by utilizing automation for repetitive tasks to reduce workload on skilled employees such as setting policies for security and compliance, endpoint orchestration or performing and monitoring security patches and updates. Additionally, AI and ML are being used to help cyber-security professionals become more efficient and to focus on mission critical aspects of network security and respond to events. Some of the most common use cases for AI and ML are for preventing targeted and zero-day attacks by using data about known attacks to identify the unknown, as well as by helping to eliminate alert fatigue by decreasing the number of false positive security events and ranking potential events in the order that they need to be addressed.

With all of this additional automation of repetitive tasks and efficiency gains, will AI take away jobs for IT and cyber-security personnel? We don't think so. We feel the acceleration of data generation from new and existing sources, the growing number of network endpoints, the expansion of the network perimeter and the increasing complexity of hybrid environments are creating positions at a much faster rate than the market can fill. This makes AI and ML solutions well positioned to help IT and cyber-security personnel to eliminate maintenance tasks and focus on high-value problems. Gartner expects AI to generate 2.3 million jobs by 2020.[3]

Autonomous vehicles an example of how AI can transform an industry and society

The automotive industry is experiencing four major disruptive trends: connectivity, autonomous driving, shared mobility and electrification (CASE). Artificial Intelligence (AI) is likely to be a key enabler for all four of those factors. For instance, AI in connectivity can create a better user experience and new potential revenue streams by predicting that the driver wants to stop at Starbucks on the way to work (and routing them there), or improving maintenance scheduling. In shared mobility, AI can help with better predictive routes improving arrival times, utilization and pooling. In electrification, AI can help with manufacturing operations and cost reduction. However, the most obvious, and likely most disruptive use case of AI in automotive is to solve autonomous driving.

With autonomous driving, safety is improved and mobility enabled for those that may otherwise not have had access to it. But the true power to transform the landscape and the economic opportunity is the convergence of autonomous vehicles with another mega, macro trend – a culture of shared. As has been documented in many aspects of society from music to housing, young adults and urban populations have begun to shun ownership, especially

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[3] "The Business Value of Artificial Intelligence, Worldwide, 2017-2025" by John-David Lovelock, Susan Tan, Jim Hare, Alys Woodward and Alan Priestley (March 12, 2018).

when it relates to an asset with a high capital cost. The combination of sharing and autonomous vehicles gives rise to shared autonomous vehicles (SAVs) or robo-taxis and the emergence of a new modality of transportation.

We think the benefit to society is multi-fold. First is safety. In the U.S., there are about ~40k road fatalities per year and >2 million injuries. Global fatalities are closer to 1.2 million. Experts believe that nearly 95% of those accidents are caused by human error. So if AI can provide improved autonomous versus human driving, lives are saved. Secondly, time – arguably the most valuable asset – is freed up. Productivity (or Netflix watching) can increase. Travel times and city congestion can be brought down. Which leads into a third benefit – a potential re-shaping of the landscape. Estimates show that roughly a third of all urban and suburban landscape is for the vehicle. With robo-taxis, square footage set aside for parking spots and garages can now be freed up.

From a business perspective, the model can shift from one of vehicle ownership to one of pay-per-mile – Transportation as a Service (TaaS). This has many implications for existing automakers and suppliers, as well as many technology companies and other potential new entrants. We believe the economic profit opportunity for those that capitalize can be great. The ramifications are far reaching, impacting municipalities (who can rethink urban planning and potentially lessen the need for public transportation), but also the fields of insurance, law, medicine, energy, and media. Further, new "meta" data is created that can be monetized. Similar to how the smartphone created a whole new eco-system of business, so too can the autonomous vehicle.

We've been on the autonomous path for a while, but AI causes an inflection

In many respects, operation of a motor vehicle has been automated for a while (think power steering or cruise control). And the world is now in an era when advanced driver assistance systems (ADAS or active safety) that offer features such as automatic emergency breaking and lane-keep assist are increasing in penetration. But we think of *autonomous driving* more in terms of the SAE definitions of Level 4 (autonomous given certain environments) and Level 5 (autonomous all the time). It is higher compute power and the development of AI through more robust machine learning and deep learning neural networks that enable these higher levels of autonomy. That being said, there are already enough signals that we expect the technology to advance to make robo-taxis a reality by 2025.

Experts believe that nearly 95% of those accidents are caused by human error. So if AI can provide improved autonomous versus human driving, lives are saved.

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RBC Capital Markets

Exhibit 40: SAE levels of autonomy

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver performs part or all of the DDT						
0	No Driving Automation	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	Driver	Driver	Driver	n/a
1	Driver Assistance	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	Driver and System	Driver	Driver	Limited
2	Partial Driving Automation	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	System	Driver	Driver	Limited
ADS ("System") performs the entire DDT (while engaged)						
3	Conditional Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is receptive to *ADS*-issued requests to intervene, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	System	System	Fallback-ready user (becomes the driver during fallback)	Limited
4	High Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	System	System	System	Limited
5	Full Driving Automation	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	System	System	System	Unlimited

Source: SAE International J3016

How is AI used for autonomous

Autonomous driving is one of the most high-profile use cases for Narrow AI – that is a specific use case, in this instance replacing a human driver. While Narrow AI may be simpler than General AI or super-human AI, it is by no means simple. Autonomous driving will rely on machine learning algorithms and deep neural networks (deep learning) to take all the sensor inputs (cameras, lidar, radar, maps, and other sensors) to drive, make decisions and understand location/perception.

The more miles the AI takes in, the more it learns. Thus, miles = knowledge.

The more miles the AI takes in, the more it learns. Thus, miles = knowledge. These miles come in two forms: on-road and simulated miles. On-road miles are just as they sound – done on the road. All parties testing autonomous vehicles have some sort of on-road testing. The challenge with only using on-road testing is that the amount of miles that can be achieved is limited by fleet size. Waymo reported that as of February 2018, they have driven ~5M autonomous miles on-road since 2009. The pace has been exponential.

Exhibit 41: Waymo cumulative autonomous miles

Source: Waymo

The other form of miles is simulated miles. These are done using more AI that allow for the learning algorithms to be tested in different environments. In 2017, Waymo claimed they drove 2.7 billion simulated miles (and 5 billion miles cumulatively since inception). The 2.7 billion miles in 2017 alone is equivalent to >3,400x what a human driver will do in their lifetime.

Why robo-taxis before an autonomous vehicle in your garage

Because of two main factors, cost and technological progress, we expect autonomous vehicles will first be deployed in a ride-share business model. For our *futurist* vision, we will assume the technology progresses and gets there. But the economic reality of shared and fleets makes robo-taxis economically attractive. A personally owned vehicle may put on 12-15k miles/year and is utilized about 4% of the time. However, in a fleet environment utilization can be much higher and vehicles could put on 70-100k miles per year (current networks like NYC taxis, Uber and Lyft support this). This allows for a much greater defraying of costs – even if an autonomous vehicle were to cost more.

When we surveyed average taxi rates across over 360 urban U.S. areas, we found the average taxi cost per mile to be about $3. When we looked at UberX rates in U.S. cities they operate in, we found the cost per mile to be closer to $1.70. Across the U.S., the average cost to own a vehicle comes to about $0.87 (though clearly more in urban areas where parking costs more money and miles driven are generally lower). Our work suggests that a shared autonomous vehicle could bring the cost per mile to the consumer down to near $0.50/mile. That amount could be cut in half in a "pooled" ride.

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Exhibit 42: Cost per mile economics for various mobility solutions
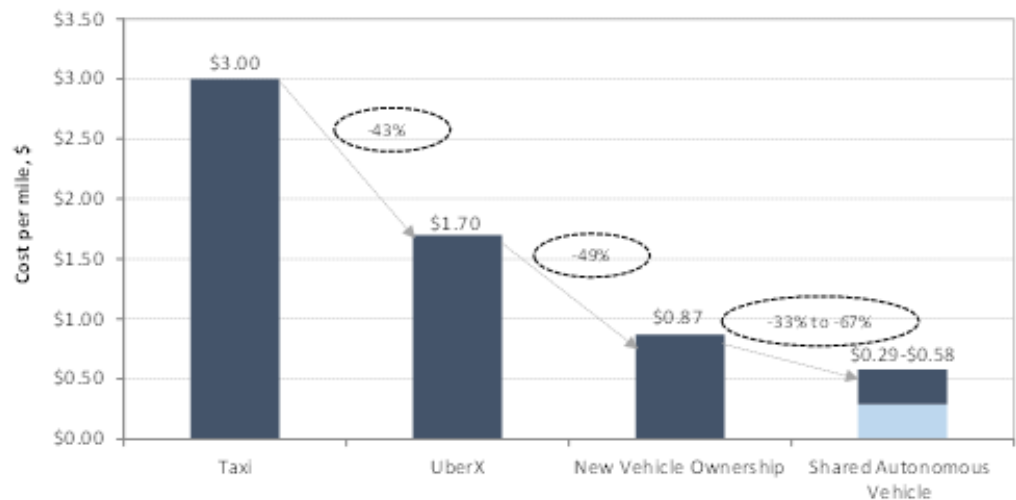
Note: Taxi and UberX analysis assumes an average trip distance of 10 miles traveled. New vehicle ownership analysis assumes 15,000 miles traveled annually. Shared autonomous analysis assumes 70,000 miles traveled annually.
Source: Uber, Taxi Fare Finder, ALG, RBC Capital Markets estimates

The mobility market up for grabs could be meaningful

While the robo-taxi total addressable market (TAM) opportunity will likely still be nascent in 2025, we believe that it will grow exponentially through 2050, requiring technology companies, OEMs and suppliers to invest today to be able to capitalize on the trend. Today, the global average miles driven per year is ~7,500 (in the U.S. it is closer to 12,000 miles/year). On average, we assume that "owned" vehicles will drive ~7,000/year, a lower amount (and decreasing over time) presuming that even those who own vehicles will at times use autonomous vehicles on demand. For autonomous vehicles on demand, globally, we assumed they will put on 75,000 miles/year or a 10x improvement in the annual utilization of the asset. This results in ~40% of total miles driven in 2050 being driven by autonomous vehicles on demand or ~7.7 trillion miles. If the operators of these robo-taxis were able to collect $0.50/mile, that is a ~$3.8 trillion TAM in 2050 (in today's dollars). Note there were ~94 million vehicles sold globally in 2017, which if we assume an average transaction price of $22,500 yields a $2.1 trillion market for selling vehicles.

If the operators of these robo-taxis were able to collect $0.50/mile, that is a ~$3.8 trillion TAM in 2050 (in today's dollars).

To the automotive industry, as autonomous vehicles begin to spread, the number of vehicles needed in the vehicle parc could begin to decline. However, annual demand may not decline as much since replacement cycles could hasten (we see a potential ~27% scrap rate for robo-taxis vs. global average of ~4.7%). Further, industry cyclicality could be reduced as miles vary less than units with the economic cycles, and we would argue that miles driven could increase as mobility would become more affordable and more available to those that didn't have access prior like the elderly, youth and the disabled. Therefore, the return profile of an SAV could be improved. GM has indicated they believe ~20-30% margins are possible for SAVs, which is far superior to any auto operating margin in today's world.

GM has indicated they believe ~20-30% margins are possible for SAVs, which is far superior to any auto operating margin in today's world.

Tangential industries impacted too

There are of course other industries that would be impacted. Insurance premiums may fall but the companies are likely to also experience lower claims. And, because of all the data coming off the vehicle, they could use AI to better write or dynamically adjust rates. Autonomous vehicles could represent a growing opportunity for entertainment and advertising as well as the telecom industry. The beverage industry may see growth as

Autonomous vehicles could represent a growing opportunity for entertainment and advertising as well as the telecom industry.

On the flip side, what happens to (among other areas) dealerships, auto retail and repair, and public transportation?

Artificial intelligence and machine learning have the potential to make major impacts on the drug development process from early scientific discovery through clinical trials and commercialization.

While each individual strand of human DNA is microscopic in size, there currently exists ~25 petabytes of human genomic data, or ~1/4 of YouTube's annual production (equivalent to about 75 hours of video uploaded/minute).

AI has the potential to disrupt this process by expanding the potential number of "drugable" targets, determining potential therapeutic candidates more quickly and effectively.

Recent estimates demonstrate that only 14% of new drug candidates entering the clinic ultimately make it to approval.

impaired driving becomes less of a concern. On the flip side, what happens to (among other areas) dealerships, auto retail and repair, and public transportation?

AI can accelerate medical breakthroughs

Artificial intelligence and machine learning have the potential to make major impacts on the drug development process from early scientific discovery through clinical trials and commercialization. The years preceding major advancements in AI, cheaper and more efficient methods of genetic sequencing have resulted in a genomic revolution yielding vast quantities of data. Further, cross-collaboration across the basic sciences of chemistry, biology, biophysics, and computer sciences underlying biotechnology has created multiple new interdisciplinary fields (bioinformatics, computational biology, and systems biology) that can leverage this repository to identify new molecules and disease targets to more effectively develop drugs and precisely treat disease.

The pace of genomic data generation, however, has greatly exceeded the progress of computing power and tools necessary to analyze the trends within this explosion of information. While each individual strand of human DNA is microscopic in size, there currently exists ~25 petabytes of human genomic data, or ~1/4 of YouTube's annual production (equivalent to about 75 hours of video uploaded/minute). With the expansion of genomic sequencing, however, the rate of genomic data generation is estimated to increase astronomically by 2-40 exabytes of annual data production per year in 2025 – surpassing the annual storage needs of YouTube, Twitter, and astronomy combined (Exhibit 43).

Exhibit 43: Estimated data production rates in 2025

	Genomics	Twitter	YouTube	Astronomy
Estimated 2025 production rate	2-40 exabytes/year	0.001-0.017 exabytes/year	1-2 exabytes/year	1 exabyte/year
	~300 million genomes/year	1.2 billion tweets/day	1,000-1,700 hours of video/minute	750 terabytes of image data/second

Source: Stephens, ZD, et al.; Big Data: Astronomical or Genomical?, PLoS Biol, 2015; RBC Capital Markets estimates

Setting aside the challenges to accommodate the necessary future large storage and CPU requirements, we believe deploying analytical toolsets that utilize machine-learning approaches to analyze datasets across genomics, proteomics and other biological systems will be pertinent to discovering, diagnosing, and treating the underlying bases of human disease in the future.

Interestingly, an often underappreciated and unseen aspect of drug development in the biotech sector is the drug discovery and lead optimization work that goes into generating and validating new product candidates – oftentimes this is an onerous bottom-up process involving blind preclinical testing of thousands of molecules through trial-and-error in order to identify a handful of candidates. AI has the potential to disrupt this process by expanding the potential number of "drugable" targets, determining potential therapeutic candidates more quickly and effectively, and refining current approaches to improve drug characteristics.

This high-risk nature and increasing costs associated with drug development further emphasizes the need for more effective and cost-efficient approaches. Recent estimates demonstrate that only 14% of new drug candidates entering the clinic ultimately make it to approval, with success rates in certain therapeutic areas, such as oncology, as low as 3% (Exhibit 44).

Exhibit 44: Estimated clinical trial success rates and timelines
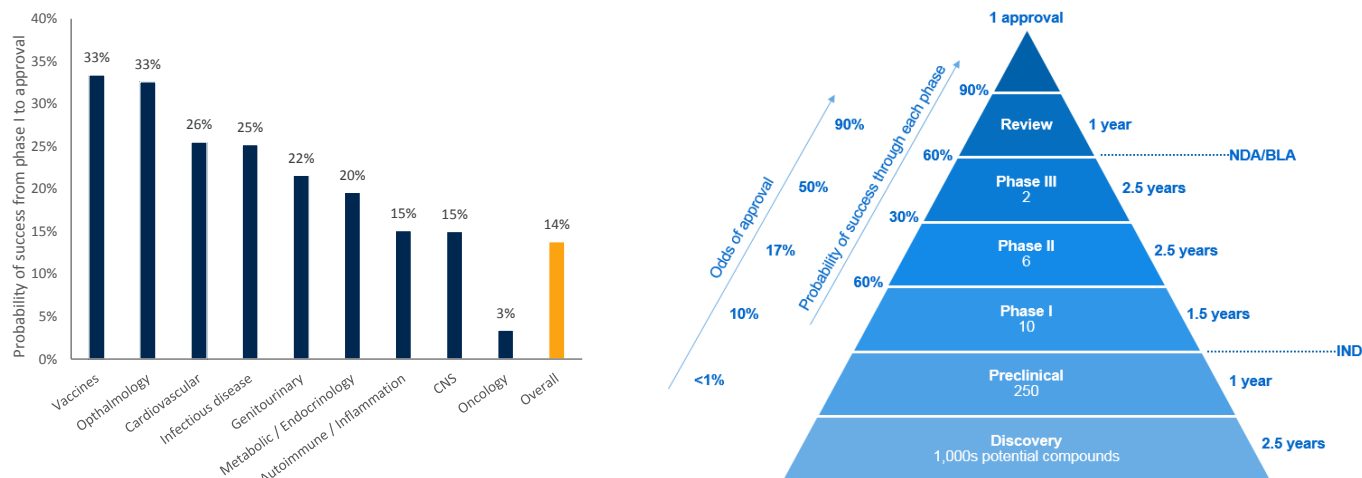
Source: Chi Heem Wong, Kien Wei Siah, Andrew W Lo; Estimation of clinical trial success rates and related parameters, Biostatistics, 2018; RBC Capital Markets estimates, RBC Capital Markets Biotech Primer

Additionally, of the estimated $2.6B needed to take a drug from the discovery stage to approval, nearly 43%, $1.1B, is related to preclinical testing essential to characterizing the drug's use in humans. Therefore, the aspects of drug development we would expect AI-driven approaches to influence most immediately are those relevant to identifying new disease targets and developing more effective targeted therapeutics.

We think that identifying new clinical target genes and proteins to treat disease and developing predictive top-down molecular approaches is just the beginning of AI's drug discovery potential. Many large drug developers, recognizing this data evolution, have already partnered with drug discovery platforms centered on AI. For example, GSK, Sanofi, and Evotec, among others, have partnered with private start-up Exscientia – a company with an approach that uses AI and intentional design to discover multi-targeted small molecules and new mechanisms to treat disease phenotypes with previously unknown targets.

Many large drug developers, recognizing this data evolution, have already partnered with drug discovery platforms centered on AI.

Applying AI approaches to emerging therapeutic modalities, such as gene editing, can also augment the drug development process by enhancing key drug characteristics. A recent collaboration between Microsoft and a number of academic institutions to refine CRISPR, a gene-editing technology, led to a machine learning software that could predict potential safety consequences from off-target gene insertion, which can result in more optimally selected genomic insertion locations.

Applying AI approaches to emerging therapeutic modalities, such as gene editing, can also augment the drug development process by enhancing key drug characteristics.

As evidenced by the Microsoft gene editing partnership, it is apparent that tech companies are increasingly important to the biotech-AI endeavor. GILD recently partnered with Alphabet's Verily Life Science to leverage machine learning in order to better understand immunological diseases and molecular signatures.

GILD recently partnered with Alphabet's Verily Life Science to leverage machine learning in order to better understand immunological diseases and molecular signatures.

Altogether, both improvements to traditional drug development strategies and applications for new therapeutic approaches should lower the failure rate that has historically predominated drug discovery, thereby increasing R&D efficiency and expanding operating margins for biotechnology companies.

Improving the ROI of clinical trials

The validation of new clinical trial endpoints can also improve the ROI of novel drugs. Identifying a subset of patients predefined by a seemingly unrelated genetic marker, or otherwise unknown disease correlate not noticeable in present day clinical trial analysis, may better be able to predict patients more likely to respond to a treatment or enable faster trials.

Incorporating biomarkers into clinical trial design has resulted in improved clinical trial success rates. Trials that incorporate biomarkers to stratify patients are twice as successful as those that do not and indeed the FDA and other regulatory authorities have acknowledged this through development initiatives that encourage innovative clinical trial design integrating biomarkers. Given this, it is estimated only 7% of clinical trials use biomarkers – in part because of challenges in finding well-validated surrogates.

> A private company is developing a drug for depression by leveraging prior machine learning work identifying likely responders as those with the inability to feel pleasure at baseline.

AI and machine learning have already proven useful in this regard – a private company is developing a drug for depression by leveraging prior machine learning work identifying likely responders as those with the inability to feel pleasure at baseline. Another private company, Qrativ, uses AI to find patient subsets or previously untested diseases that may respond to repurposed drugs.

The rise of precision medicine

Leveraging AI to merge data from multiple sources (scientific literature, clinical trials, electronic health records, gene sequences, physiological parameters) in the diagnosis and treatment of patients would enable healthcare providers to visualize a much broader spectrum of data that define a patient's disease characteristics that enables them to provide a custom-matched drug most optimal for their treatment. While this would likely lead to increased technological expenses in the already-costly healthcare industry, precision medicine that leverages AI could have the ability to ultimately decrease the societal economic burden of medical treatment by:

> Precision medicine that leverages AI could have the ability to ultimately decrease the societal economic burden of medical treatment.

1) diagnosing patients earlier in their disease progression using previously unidentified signals;
2) reducing the number of failed medications that a patient may cycle through;
3) more effectively choosing safer/efficacious medications for a patient's specific disease characteristics; and
4) preventing disease by discovering susceptible patients early-on in life with improved diagnostics.

Many companies have been involved in this effort – IBM Watson is the most notable, and other smaller private companies, such as NantHealth and Datavant are focused on concatenating electronic health record data that makes it more amenable to data analysis.

Is AI the new DNA of biotech?

Overall, while new discoveries in the life sciences have largely driven innovation in the biopharma sector to-date, such as groundbreaking advances in gene editing and immuno-oncology, it seems that a shift is on the horizon not only towards continued innovative treatments, but also for more disruptive, cost-effective drug development approaches. With an exponentially increasing quantity of genomic data and centralized electronic health records, it is clear to us that AI has greatly untapped potential in the drug development space. As new software and computing power develop to help in this enterprise, we believe key large-cap players must adapt or risk becoming obsolete. We thus anticipate a number of start-ups and partnerships to emerge alongside up-and-coming therapeutic technologies in an attempt to better harness the power of new therapeutics. Similar to how the DNA revolution brought new information that disrupted the norms of small molecule drug discovery in favor of increasingly complex biological therapies, as tech and biotech companies blur the lines, perhaps the biotech of the future is ultimately less "bio" and more "tech" as we enter an AI evolution.

> With an exponentially increasing quantity of genomic data and centralized electronic health records, it is clear to us that AI has greatly untapped potential in the drug development space.

AI transforms the banking industry

Since the financial crisis, bank profitability has been squeezed, driven by restrictions from certain business activities, higher compliance costs, and higher capital and liquidity requirements, as well as, cyclical revenue headwinds from lackluster loan growth and a persistently low interest rate environment at the time. To offset these headwinds, banks began to focus on cutting costs with deep investments in their technology and infrastructure. The investments in technology and infrastructure from a cost-cutting focus also went hand-in-hand with regulatory requirements to bring legacy bank systems into the modern age.

This would be the start of the AI race in banking. As banks started to review archaic processes, more investments poured into business process automation and eventually machine learning. Historically, banks have innovated at a snail's pace, and would rather make generational systems changes. With massive gains in technology and costs, bank systems now appear to be designed for more iterative development and extensibility. We are still in the very early stages of where AI fits in banking, so we believe there will be a profusion of trial and error on where investments will be made over the next three years. We think AI investments and development, however, will follow a similar path to what we have seen in bank M&A: it's much more likely to realize its own cost savings than to generate new revenue synergies. The problem with revenue synergies (i.e., targeted marketing) is that banks and nonbank financials would be doing it...everyone would be competing for the same wallet. Furthermore, over the near term AI systems are not capable of being cognitive, which in our view, will be needed to drive revenue growth. Cutting one's own costs and minimizing risk will most likely prove to be the winning strategy, along with a revenue focus in certain niche areas like trading, in our view. As such, we believe the AI race will impact the banking sector in the following areas:

- Middle/back-office to be more streamlined
- Front-office to see increasing usage of bots/virtual assistants and to be more automated
- Risk management/fraud detection to be further augmented and strengthened with human interaction
- Trading to be more automated with deep investments in equipment and scientists

Middle/Back-office to be more streamlined

One of the highest value areas where we see AI impacting the banking industry is in the middle and back-office areas. We see many banks overhauling business processes that are overly complex with lots of paper being pushed. Employees most impacted would be back-office workers who handle data entry and/or data management and anything paperwork related. We expect banks to methodically review their business processes to understand the steps and resources required and to completely overhaul the process with AI bots where prudent. A June 13, 2017 Bloomberg article highlighted the efficiency Goldman Sachs achieved from such a review in its IPO process: "They mapped 127 steps in every deal, and then set out to see how many could be done by computers instead of people. The answer so far: about half."

We believe banks will continue to methodically review every area of their business and drive out inefficiencies. According to a digital solutions provider in an Innovation Enterprise article on September 25, 2017, approximately "75% of the current banking operations can undergo robotic process automation (RPA)." The inclusion of AI programs has several benefits, such as being able to work 24/7 without days off or a raise. However, the biggest benefit by far in our view is the scalability. Once an AI program has been trained to execute certain processes, it can then be replicated to many different locations and for similar functions within the bank. This allows for rapid deployment of new products and services with higher levels of quality control.

As banks overhaul their middle and back-office processes with AI programs, we see two main challenges that may slow this change. First is the disconnectedness of data from legacy systems. The banking industry is notorious for its kluging of different systems. Many banks conducted many acquisitions, but spent little time doing proper integration between the different systems of the banks they acquired leading to a patchwork of different systems unable to share data digitally. To reap the benefits of AI, banks need to "bite the bullet" and overhaul their systems if they haven't already to allow for data transfer among the different bank silos.

The second challenge we see is the mountain of un-digitized (paper) and unstructured data. Structured data is data that can be placed neatly in a table, such as an Excel table, to manipulate and draw conclusions from it. Unstructured data is data from emails, phone calls, social media, etc. AI could provide insights into these types of data, but it has to be collected in a proper format first.

Front-office to see increasing usage of bots/virtual assistants and to be more automated

The use of bots and virtual assistants has already begun and we see this increasing as the AI programs become more improved. According to a Financial Times survey provided on April 12, 2018, 17 of the 18 banks surveyed were already using AI in the front office, such as Citigroup's Facebook messenger chatbot and UBS's use of Amazon's virtual assistant, Alexa, for customer service. In the survey, banks saw the front-office as the biggest potential for AI-related savings.

Aside from chatbots and virtual assistants replacing call centers, we also see pressure in other banking jobs, particularly brokers, bank tellers, and eventually financial advisors. We do not believe AI programs will replace these jobs, but we do believe that there may not be a need for the same number of employees in those positions. What we see is AI being augmented with these jobs, resulting in increased productivity outpacing the growth in potential clients. If one broker/bank teller/financial advisor can serve one client in one-tenth the time with the help of AI, then that broker/bank teller/financial advisor could take on nine more clients.

> What we see is AI being augmented with these jobs, resulting in increased productivity outpacing the growth in potential clients.

In an August 2, 2017 article, Business Insider forecast that robo-advisors will manage around $1 trillion by 2020, and around $4.6 trillion by 2022. Currently, the start-up arena offering robo-advisor products and services is quite crowded, and we believe there will be consolidation and attrition in this space as large banks roll out their own robo-advisor products and services.

Risk management/fraud detection to be further augmented and strengthened with human interaction

In risk management and fraud detection, past methods of using human-written rules engines caught only a small percentage of fraud cases, but produced a high level of false positives. These programs were simple, rule-based and fairly rigid with a score-based system where the higher the score, the greater the likelihood of fraud. To improve on identifying actual cases of fraud and reduce false positives, banks had to change their approach and include AI. In one example, Danske Bank in Copenhagen, Denmark, struggled with a 40% fraud detection rate with 1,200 false positives per day (99.5% of which were not fraud related) under its original fraud detection program that did not include AI. Upon implementing a modern enterprise solution that leveraged AI, the bank realized a 60% reduction in false positives with an expectation to reach up to 80% and increased true positives by 50%, which freed resources to focus more on actual fraud cases. In this example, the AI software helped to identify potential fraud cases, but human intervention was still necessary to handle

> Upon implementing a modern enterprise solution that leveraged AI, the bank realized a 60% reduction in false positives with an expectation to reach up to 80% and increased true positives by 50%, which freed resources to focus more on actual fraud cases.

legitimate transaction anomalies. Today, we see the further maturation of AI in risk management and fraud detection. With the digitization of banking products and services, the level of fraud has increased dramatically along with the sophistication of the fraud. Machine learning, which can adapt and learn, is critical in keeping pace with fraudulent actors and improving fraud detection.

Trading to be more automated with deep investments in equipment and scientists

AI-trading programs are much different than many other AI programs, such as a facial-recognition program. Trading is one of the ultimate challenges for AI because the rules constantly change. Gary Collier of the Man Group Plc, one of the largest hedge funds in the world with $96 billion in AUM and based out of London, cites that "in the financial world, the ground is always shifting." The Man Group has begun to invest heavily in AI trading in the past few years. Its AI program, which was taken out of dormancy in 2014, was immediately profitable. By 2015, the AI program was contributing approximately half the profits in one of Man Group's funds.

Similar to Man Group, we believe AI-based trading companies will continue to see growth, but they will need to be deeply technology focused. The job of building and managing an AI system is labor-intensive with distinct knowledge and skillsets. As a result, there would be increasing demand for engineers and data scientists and less so for MBAs. AI-based trading companies will likely focus their capital on equipment and hiring engineers and data scientists.

We believe that as the AI-based trading, segment matures, there will be a higher focus on the equipment and the talent. This would be similar to what we've seen with the growth in high-frequency traders where the advantage was in the equipment and location of the trade. We expect there will be a continued arms race to develop smarter AI programs with each iteration. Eventually, we expect to see consolidation among the players as fewer and fewer companies would gain more market share. As programs become better, there would be fewer humans involved and costs would go down further leading to further reduction in prices. Jeff Tarrant, founder and chairman of the investment firm, Protégé Partners, noted that new AI-focused funds already charge a 1% management fee and 10% of profits, which is half as much as the typical hedge fund. Mr. Tarrant adds that the industry is shifting to those who build the best technology, not those who have the most talented portfolio managers, and expects mass unemployment in asset management in the next several years. The jury is still out, but we do see this risk.

We've also seen some of the big banks use AI in trading and believe this is just the start. JPMorgan developed an AI program, LOXM, in 1Q17 to execute trades. The LOXM program was trained on billions of historic transactions to optimize equities trades at maximum speed and best prices, and to offload large equity stakes without causing market swings. The company said that the LOXM program delivered significant savings and far outperformed both manual and automated existing trading methods in trials. JPMorgan believes the LOXM program could be used to personalize execution for particular clients as the program learns and adapts to each client to optimize each client's trade.

Mizuho Financial Group Inc. also started an AI-trading program in late 2017 to bolster its Japanese equity business, according to Bloomberg. The AI trading service is expected to be offered to some large institutional clients in Japan and elsewhere in Asia offering insights on how stock prices in Japan will change over an hour and determine the best time to trade.

Lastly, we expect the AI-powered ETFs space to grow. One AI-based ETF is AI Powered Equity ETF (http://www.equbotetf.com/). The underlying investments utilize models the company developed in collaboration with IBM Watson AI. The ETF started trading in October 2017 and

Trading is one of the ultimate challenges for AI because the rules constantly change.

Eventually, we expect to see consolidation among the players as fewer and fewer companies would gain more market share.

has yet to beat the market, but more time is needed and the jury is still out. In addition, BlackRock launched seven AI-based sector ETFs in March 2018. The ETFs plan to balance "sector evolution driven by changing businesses" while still sticking to the traditional categories, such as the Global Industry Classification Standard developed by MSCI and Standard & Poor's. The ETF will review public filings to determine a company's weighting in a particular sector and will rebalance constituents quarterly.

Smarter insurance underwriting with AI

For over 400 years, property casualty insurance has been about paying claims after a loss. A person with a risk would identify that risk, seek someone to cover it and then wait for a check to be received if a loss occurs and is found to be valid. Insurance companies have always sought ways to minimize these payouts through loss control and mitigation. New tools mean new opportunity.

Imagine a world where the role of the insurance company is less about paying claims after a loss has occurred but rather is about proactively preventing losses or at least limiting the size of losses.

Artificial intelligence, Big Data and the Internet of Things collectively have the ability to turn the old "wait then pay" model on its head. Imagine a world where the role of the insurance company is less about paying claims after a loss has occurred but rather is about proactively preventing losses or at least limiting the size of losses.

To be sure, insurance companies have long understood the value of risk mitigation. Most large companies and insurance brokers employ teams of risk managers who will visit commercial worksites and make suggestions that can accomplish things like improving the safety of employees, reducing the risk of theft and preventing devastating mishaps. Technology allows this service to be taken to another level. In the end, AI works well in three areas of the insurance underwriting process: anticipation, mitigation and verification.

The industrial AI revolution

The next frontier in the evolution of industrial manufacturing has arrived. Coined colloquially as "Industry 4.0", this so-called fourth industrial revolution marries both the physical and the digital through the application of machine learning, smart factories, advanced automation, and intelligent supply chains—all powered by rapidly advancing Artificial Intelligence capabilities. To be clear, this is the next phase of the journey *after* the Industrial Internet of Things and data analytics. While most industrial companies are still scrambling to install software capabilities and sensors into their traditional analog equipment, many thought-leaders and visionaries like GE and Siemens are already moving on to the next big challenge of feeding the data collected by their connected devices into new AI-powered solutions with machine learning. We are still many years away from "Industry 4.0" becoming mainstream, but the early seeds of progress are already sprouting in select applications within the global sector. In our view, here are the four primary ways in which this fourth industrial revolution is expected to transform and optimize manufacturing processes and create radically new business models: 1) Smarter Robots and Adaptive Manufacturing, 2) Predictive Maintenance, 3) Demand Driven Production, and 4) Automated Quality Control.

With these principles and applications of Artificial Intelligence in mind, the utopian "factory of the future" can be envisioned.

With these principles and applications of Artificial Intelligence in mind, the utopian "factory of the future" can be envisioned. Today, these hyper-intelligent and adaptive manufacturing facilities are being conceptualized and prototyped by GE through its "Brilliant Factory" initiative. These factories will house an ecosystem of smart robots, advanced sensors, and computers that can communicate with one another in real time to ensure that the production line runs smoothly and that product quality remains pristine. Today, many of GE's factories already operate using lean manufacturing best practices, additive/3D-printing capabilities, and advanced software analytics powered by Predix. In the future, the company aims to inject Artificial Intelligence to further upgrade these facilities to react in real time to

order trends and operate multi-modal manufacturing services, whereby existing machines can adjust their output across a range of different products, depending on demand.

AI could improve crop supply and quality

We see the benefits of this shift as able to help mitigate relatively subdued farmer economics and drive some incremental equipment demand. Further, we expect growth in remote diagnostics to help drive higher margin parts and service sales.

We expect the trend toward "**smart farming**" – including AI/machine learning – to accelerate as farmers search for ways to maximize productivity/yield, improve crop quality, and reduce costs/improve machine uptime in the face of relatively low commodity prices and stressed natural resources (land/water). Importantly, we see the benefits of this shift as able to help mitigate relatively subdued farmer economics and drive some incremental equipment demand. Further, we expect growth in remote diagnostics to help drive higher margin parts and service sales.

Technology adoption has evolved over a relatively short period of time from the advent of GPS/navigation in the late 1990s to predictive analytics (to increase equipment productivity and consistency) and machine coordination (more efficient/effective farming). Today, much of the focus is on the collection and transfer of data from machines to enable better farm/field management decisions (e.g., variable fertilizer/chemical applications, seed spacing, measuring potentially different crop/soil conditions across the same field) as the evolution toward machine learning continues. We expect developed markets to lead, but also see opportunity in emerging areas as adoption costs decline.

We expect the evolution to favor larger incumbent equipment manufacturers.

We expect the evolution to favor larger incumbent equipment manufacturers, given the significant value ascribed to their established dealer networks/farmer relationships (i.e., farmers' reluctance to share their data with unknown entities), resources to fund or acquire new technology/data initiatives, and importance of the equipment/existing fleets as the medium of change. Equipment OEMs Deere and AGCO have used acquisitions to supplement internal development as the pace of change accelerates, with recent examples including Deere's acquisition of Blue River Tech and AGCO's purchase of Precision Planting.

Exhibit 45: The Precision Farming Framework
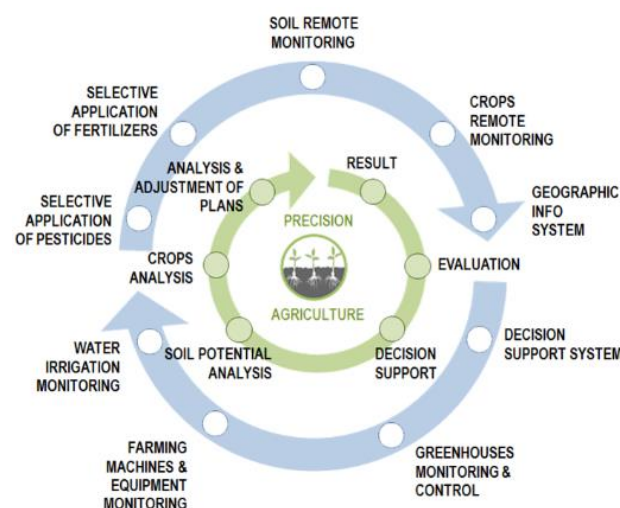
Source: Hexastep

Autonomous and AI capabilities will transform mining

Mining is a sector laser focused on driving efficiencies at all levels due to the fact that the companies are producing virtually identical commodities as their competitors. Speed, yield and productivity enhancements are oftentimes the only profitability differentiators between operations.

Many mining operations are employing basic robotics and smarter sensors currently, and autonomous trucks have been operating in mines for years. Off-road autonomous trucks are an easier sell than on-road given a much more limited set of uncertainties of which the vehicle needs to be aware. For example, in a mining operation, there are no pedestrians that could step out into the road at any given moment, or constant oncoming traffic.

Rio Tinto launched its Mine of the Future™ program in 2008 aimed at advancing the ways it mines while also minimizing environmental impacts and improving safety.

Rio Tinto launched its Mine of the Future™ program in 2008 aimed at advancing the ways it mines while also minimizing environmental impacts and improving safety. One component of the program was rolling out autonomous hauling systems (aka self-driving trucks). Today, it has 80+ self-driving vehicles (produced by Komatsu) in Australian mining operations that are the size of a two-story building and can carry 350t of material, controlled independently by GPS. Rio notes that since trials began in 2008, there have been no injuries attributable to the trucks. Further, the company notes profound efficiency gains, including 15% lower unit costs and 700hr longer lifespan than manned equivalents. Rio expects to increase its autonomous fleet to 140 by the end of 2019 and is also retrofitting 48 Komatsu and CAT haul trucks with autonomous technology over the next two years.

Exhibit 46: Komatsu autonomous mining haulage vehicle

Source: Komatsu, Equipment World

In 2017, Volvo announced it had begun testing an autonomous truck underground in its Kristineberg Mine, a more technically complex application given it cannot be guided by GPS like surface vehicles can.

Similarly, BHP announced in mid-2017 that its Jimblebar mine would go completely autonomous using 50 CAT 793F mining trucks by end of 2017 while other mining companies like Fortescue Metals Group (FMG) have also announced plans to go driverless to some degree. Roughly 75% of FMG's fleet at Solomon Hub is driverless. CAT noted that its autonomous trucks in FMG's Solomon mine have reported 20% higher production than manned equivalents.

In 2017, Volvo announced it had begun testing an autonomous truck underground in its Kristineberg Mine, a more technically complex application given it cannot be guided by GPS like surface vehicles can.
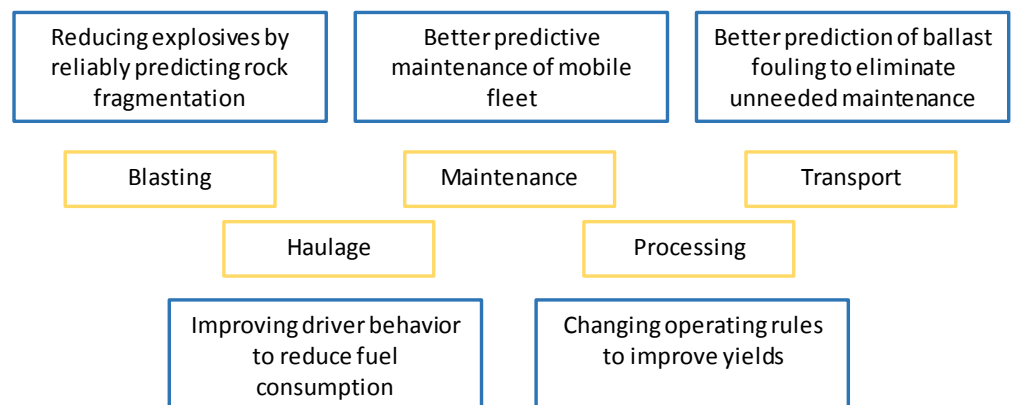
Beyond autonomous mining vehicles, some companies have been developing advanced drilling systems to further improve efficiency. Rio has an autonomous drilling system that can boost productivity by 10% and allows one operator to control multiple drill rigs remotely. Rio is also working on a fully autonomous rail system at its Pilbara iron ore operation, with a 100km pilot run successfully completed in 2017. It expects full commissioning of the system in late 2018.

AI/machine learning in mining

Although we believe autonomous applications and penetration will increase in the mines, newer technology such as AI/machine learning would also begin to play a larger role in mining operations as the technology develops.

Machine learning is essentially a network of algorithms designed to detect relationships and complex patterns from a large amount of unformatted data, which is rampant in heavy industrial applications including mining. Boston Consulting Group discusses five examples of machine learning and its advantages to the mining sector.

Exhibit 47: Examples of machine learning applications in mining

Reducing explosives by reliably predicting rock fragmentation	Better predictive maintenance of mobile fleet	Better prediction of ballast fouling to eliminate unneeded maintenance
Blasting	Maintenance	Transport
Haulage	Processing	
Improving driver behavior to reduce fuel consumption	Changing operating rules to improve yields	

Source: BCG

To touch on a few examples, BCG notes that machine learning can collect data related to drill patterns, blast designs, geology and rock fragmentation to understand how these key variables relate, and as a result, predict the effect of an explosive at the mine site, allowing for a more informed decision of explosive type and potentially minimizing cost of a rock fragmentation outcome. Further, similar to predictive maintenance and remote diagnostics for on-road commercial vehicles, machine learning can collect data on mining equipment and predict when it will break down.

Companies like Yandex Data Factory specialize in AI in the mining sector, and it claims 3-5% initial efficiency savings by having better predictive models, but can grow to 10% over time as the model receives more data and can make more precise predictions.

From Energy to Smart Energy -- How AI is impacting the Utility space

In 2025, we envision a smarter electric grid on multiple levels.

Once utilities couple AMI with technologically enhanced transformers and wires, they could manage the downtime more quickly.

In 2025, we envision a smarter electric grid on multiple levels. First, we expect the hardware to become sophisticated. At the beginning of 2017, 47% of the 150 million electricity customers in the United States had smart meters on premise. We expect that by 2025, nearly all customers will have advanced metering infrastructure (AMI) capability installed. Such devices serve as two-way communication devices. Prior to AMI, a utility would know that an area was out of power if they received calls from their customers complaining about an outage. With AMI, utilities know real time the damage on their equipment. Once utilities couple AMI with technologically enhanced transformers and wires, they could manage the downtime more quickly.

Second, we expect the software to take advantage of data collected from AMI. Not only would the grid self-heal more effectively, but software would process data across the region to prioritize the deployment of linemen. The presence of sensors on the poles and data collected from weather services should allow utilities to counter a storm before it even hits. Heavy winds can knock down poles that can ignite fires, as we have seen in California over the years. Software-driven grids fed with the right kind of data should be able to de-energize the lines before the heavy winds hit.

Third, AI should allow utilities to provide customers more control over their usage. It is still unknown at this point who will provide the added services "behind the meter" (i.e., within the residence). In fact, there is a reasonably good chance that equipment manufacturers and technology will dominate those offerings. Where utilities could gain share would be in managing the recharging of electric vehicles and how the process interacts with the grid. Through AI, it could analyze the state of the grid and tap into EV resources when available. It could alert customers days or hours ahead of a potential outage to allow them to make whatever arrangement necessary in preparation. In some states, utilities have introduced an app that considers the customer's bill month-to-date and will predict what the current month's bill will end up being depending on expected weather patterns.

The dark side of AI?

Just as the atomic race and the space race dictated global power in prior periods, so too can the AI race.

With intelligence comes power. Just as the atomic race and the space race dictated global power in prior periods, so too can the AI race. What's interesting about AI versus prior intelligence races is that completion in those prior races was essentially between different states. Pedro Domingos, a professor at the University of Washington, author of the book *The Master Algorithm* and machine learning expert, recently conducted an interview with *Der Spiegel* in which he states: "Artificial intelligence is a very powerful technology, and there is an arms race going on. Fast forward 20 years into the future and one of the players could have won the race. China is more likely to win than Russia is, although Russia has a lot going on. So, we could end up in a world that China may not formally control, but they effectively do because they rule the cyberworld." However, the AI race also seems to include more private enterprise, particularly in the United States with the likes of Google, Microsoft, Facebook and Amazon. This begs the question, does power increasingly shift away from governments and towards corporations? Did someone say Skynet…? Yes, governments can regulate, but some governments are more authoritarian than libertarian, and regulation could be difficult if the technology is not understood. Further, there are clear ethical considerations. Nick Bostrom, author of the book *Superintelligence: Paths, Dangers, Strategies* discusses how there may be few problems Super AI can't solve. This includes ending suffering from disease, poverty, and environmental disasters. But, AI development must also take care to make sure it is for the betterment of humanity as opposed to a select group of humans. He gives the sample of "superintelligence whose top goal is the manufacturing of paperclips, with the consequence that it starts transforming first all of earth and then increasing portions of space into paperclip manufacturing facilities."

AI development must also take care to make sure it is for the betterment of humanity as opposed to a select group of humans.

Even in a world where machines don't rule over humans, AI can be used for benefit or detriment. Technologist Aviv Ovadya has warned about the "Infocalypse" – that the Internet and information ecosystem can reward misleading information or "fake news". AI could amplify this issue leading to AI-assisted misinformation campaigns. Twitter bots could seem tame compared to AI driven reality distortion that could make it, as Ovadya was quoted saying, "appear as if anything has happened, regardless of whether or not it did." Teams at Stanford University and the University of Washington have built programs, using AI, that manipulate audio and video to make it appear as if world leaders said things they never did. Software currently under development can use AI to generate hyper-realistic photos and audio. Ian Goodfellow, a staff research scientist at Google Brain stated at a conference in November 2017 that deep-learning systems can be used to create fake images and learn to make them more believable making it easier to fool people and warned that AI could set the way we consume news back 100 years.

China is using an AI-driven facial recognition system in 16 Chinese cities and provinces to help police crackdown on criminals and improve security.

China is using an AI-driven facial recognition system in 16 Chinese cities and provinces to help police crackdown on criminals and improve security. Reports indicated the system is fast enough to scan China's population in 1 second and has an accuracy rate of 99.8% even with the individual in motion. Such technology holds promise for counter-terrorism and security as well as tracking missing persons. However, it's easy to see how this power in the wrong hands can impede human rights. Somewhat ominously, this system is called "Skynet."
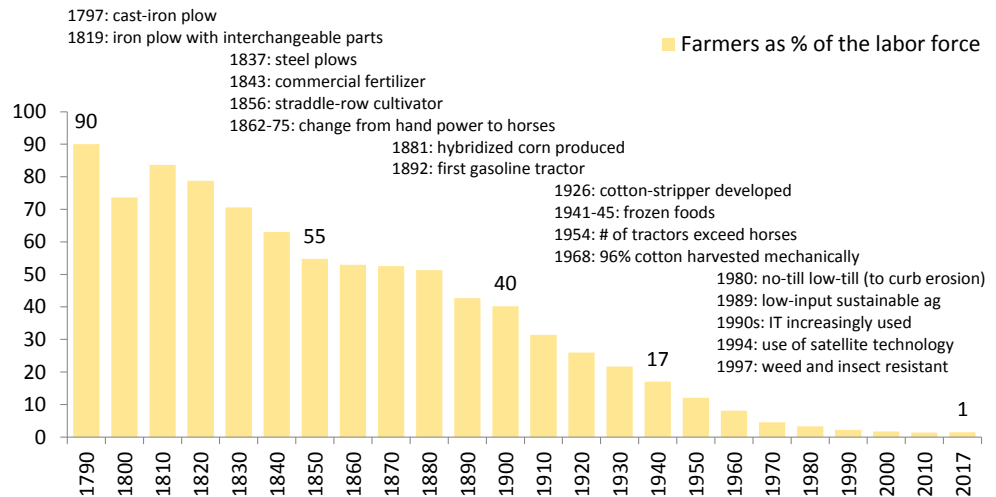
Assessing AI's impact on the economy

Labor: Displacement vs Replacement

We believe the labor market disruption from Narrow AI will be quite similar to the effects observed historically in industries such as farming and manufacturing with significant enhancements in productivity of the automated sector leading to subsequent slowing and eventual decline in overall employment in that space. This could also come with a commensurate creation of industries we cannot even conceive of today. Was "app developer" in the lexicon 20 years ago?

The farming sector is the most obvious and perhaps best-recorded example of technological disruption. We won't get into all of the history here. Instead, just note some of the impressive productivity gains in farming over the last couple of centuries:

- Labor hours required to produce one bushel of wheat fell from 272 in 1830 to 45 in 1890 and just 3 by 1987
- Labor hours required to produce 100 bushels of corn slipped from about 85 in 1850 to 18 in 1930 and just 3.5 by 1975
- One farmer can now supply nearly 200 people from just 10 less than 90 years ago

Was "app developer" in the lexicon 20 years ago?

RBC Capital Markets

Exhibit 48: Farmers as % of labor force

1797: cast-iron plow
1819: iron plow with interchangeable parts
1837: steel plows
1843: commercial fertilizer
1856: straddle-row cultivator
1862-75: change from hand power to horses
1881: hybridized corn produced
1892: first gasoline tractor
1926: cotton-stripper developed
1941-45: frozen foods
1954: # of tractors exceed horses
1968: 96% cotton harvested mechanically
1980: no-till low-till (to curb erosion)
1989: low-input sustainable ag
1990s: IT increasingly used
1994: use of satellite technology
1997: weed and insect resistant

Farmers as % of the labor force

Source: RBC Capital Markets U.S. Economics, BLS, USDA

Manufacturing has followed a similar path. Overall manufacturing production is up 190% since 1972 while employment has declined by about 27%. Thus, productivity has moved up by a multiple of 4 in that span.

Interestingly, while these productivity-enhancing mechanisms tend to usher in the sector's peak share of the labor force, outright declines in employment levels in the space take a bit longer. Farming peaked as a % of the LF in about 1820, but it took nearly 100 years for the level of farming employment to peak and begin to roll over in earnest. Manufacturing's labor share peaked and began to roll over by about the 1950s and the level of employment in that space began declining in earnest in the late 1990s.

To be sure, globalization had a lot to do with this more rapid decline in manufacturing employment than automation. In other words, if not for the low-cost labor model abroad, it is likely that the declines in U.S. manufacturing employment would have been much more gradual. But it is also true that given a much faster pace of technological innovation today, the time between peaks in LF share of employment and employment levels will probably be much shorter.

Nonetheless, this draws out the difference between labor displacement (declining share of LF) and immediate replacement brought on by technology. This suggests a symbiotic relationship between human labor and machines in the early stages of adoption.

Farming peaked as a % of the LF in about 1820, but it took nearly 100 years for the level of farming employment to peak and begin to roll over in earnest.

It is also true that given a much faster pace of technological innovation today, the time between peaks in LF share of employment and employment levels will probably be much shorter.

RBC Capital Markets

Exhibit 49: Farmers as % of labor force; farming employment
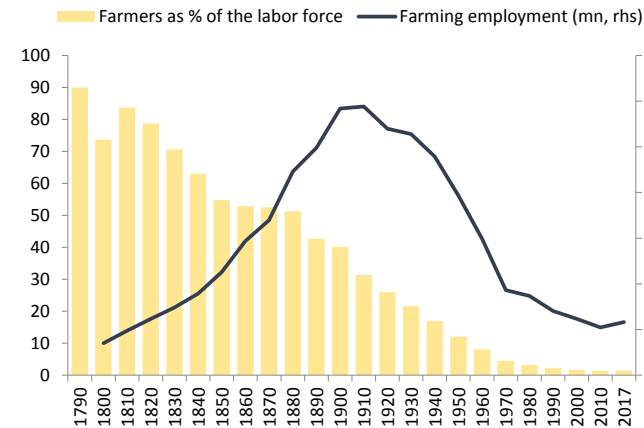
Source: RBC Capital Markets U.S. Economics, BLS, USDA

Exhibit 50: Manufacturing as % of labor force; manufacturing employment
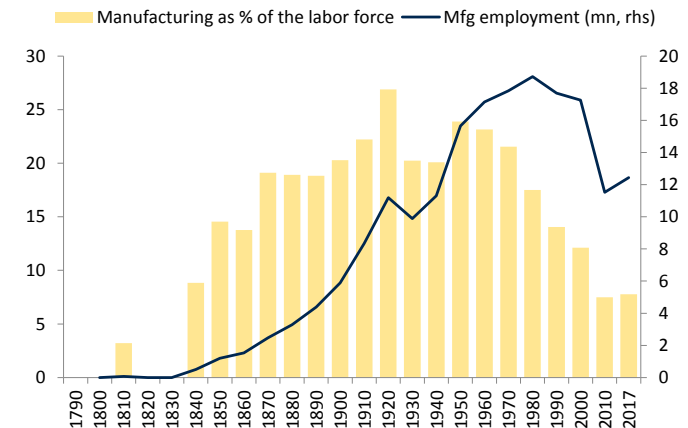
Source: RBC Capital Markets U.S. Economics, BLS, USDA

For a near-term case study of this phenomenon, we can look at manufacturing in the auto sector. This space has one of the highest rates of robotics penetration. For the U.S., the IFR estimated robotics use in auto manufacturing at more than 10x the rate of all other sectors (>1,200 robots per 10,000 employees vs <100 for all other manufacturing). Yet even here the effects from automation have been quite modest.

The number of domestically produced vehicles sold in the U.S. per auto sector employee is up 40% in the last 18 years and yet the level of employment is down a much less daunting 11% in that span. This employment impact is inclusive of the major shock to the sector that came not from robotics, but from the financial crisis. Employment in this space was down a staggering 30% y/y in mid-2009 and is up more 55% since hitting the crisis lows. That the most exposed sector is seemingly mirroring what has occurred historically with the advent of automation provides more evidence of the "symbiotic" thesis.

Exhibit 51: Number of multipurpose industrial robots per 10K employees

Number of Multipurpose Industrial Robots (all types) per 10,000 Employees in the Automotive and All Other Industries - 2015
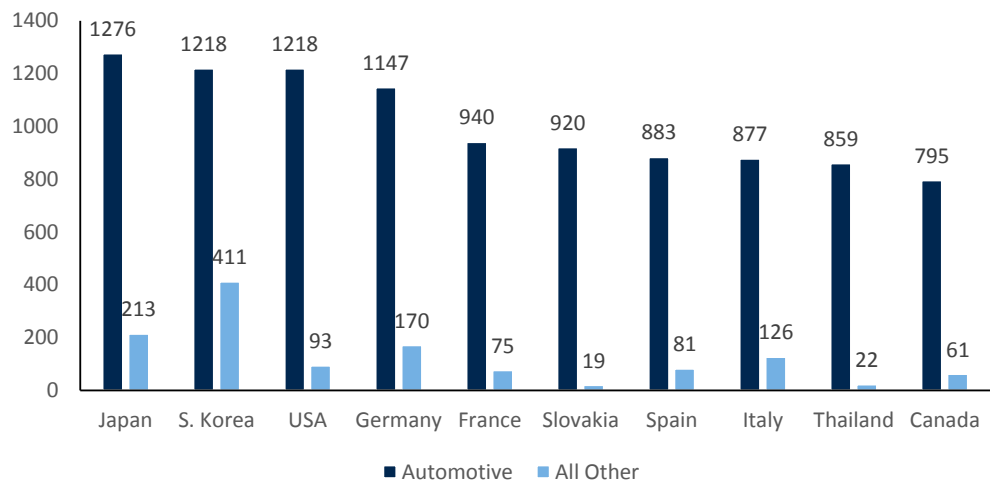
Source: RBC Capital Markets U.S. Economics, BLS, USDA

During the last 2 decades of significant technological advancement, the average workweek for U.S. production workers (about 80% of the employment pie) has basically moved sideways.

In a world where AI becomes ubiquitous in the workplace, we believe productivity is poised to replace labor force growth as the dominant factor behind economic growth.

For areas of the world with slowing population growth, we think the proliferation of Narrow AI in the labor market is actually a blessing.

India stands out, at present, as one of the potentially worst positioned from both angles.

A final point on this. We are struck by the fact that during the last 2 decades of significant technological advancement, the average workweek for U.S. production workers (about 80% of the employment pie) has basically moved sideways. Either there is a serious measurement problem when it comes to actual hours worked, or productivity-enhancing technologies have been much more symbiotic than conventional wisdom would have one believe. This does not mean that we are not at the precipice of some monumental productivity-enhancing revolution led by robotics/AI. Just that it has taken a while thus far to see the fruits from this. Still, in a world where AI becomes ubiquitous in the workplace, we believe productivity is poised to replace labor force growth as the dominant factor behind economic growth.

Productivity divergence

For areas of the world with slowing population growth, we think the proliferation of Narrow AI in the labor market is actually a blessing. At a time when one of the critical components of potential growth (population) is slowing, the other can be materially enhanced (productivity).

But the opposite is also true. The more machines are able to replace unskilled labor, the less the developed world would rely on low-cost labor markets in the developing world. Thus population projections have some staggering social implications.

According to the United Nations, Africa and Asia (mostly India) are expected to add more than 400 million people to their working age population over the next decade and nearly 800 million over the next 20 years. How to employ all of these people (or, alternatively, pay them some form of basic income) will be a challenge indeed.

These areas of the world have thus far had little in the way of robotics penetration even in the manufacturing space. Of the 43 countries we have robotics data on (from the International Federation of Robotics) only one is from Africa. And even here, South Africa has both modest robotic penetration (28 per 10k manufacturing employees) and high LF growth projections (1.2% per year over the next decade). India stands out, at present, as one of the potentially worst positioned from both angles.

Exhibit 52: Robotics penetration per 10K mfg employees and labor force growth
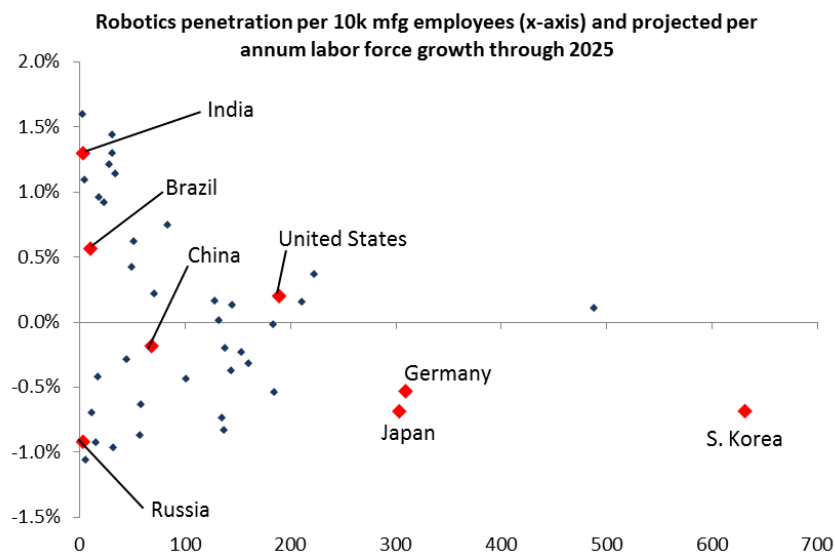
Source: International Federation of Robots

The United States has both very low LF projections and a good level of robotics penetration—something that should give those promoting secular stagnation some pause. And while European and Japanese economic growth has been anemic over the last decade (slowing LF growth being a major factor here), they look extremely well positioned for the AI-age.

Globalization has been able to flourish largely on the basis of the affordable labor cost structures abroad. The AI-age has the very real potential of upending the current order and leading to a de-globalization of sorts—thus flipping the classic investment thesis, where population dynamics are an important element of economic growth and progress, on its head.

Basic income and budget deficits

Though our base case is that increasing integration of AI into labor markets will lead to a gradual displacement of labor, any societal friction from this trend (even in the developing world) is likely to be met with incrementally louder calls for so-called universal basic income.

While some lament that the labor share of income has been in perpetual decline, it is hardly ever mentioned that the share of total personal income (which includes entitlements) has grown relentlessly as a share of GDP over the last six decades. We would argue that some form of basic income already exists in the United States. When we add up all government social programs ($2.8 trillion per the latest personal income data) it shakes out to $30,000 per year for every person older than 16 not in the labor force (currently 95.3 million).

Thus we can envision a scenario where basic income replaces all other government social programs as a plausible compromise. It placates those on the left that want the safety net in place and appeases those on the right that want some reform to the unruly entitlement system. This is likely to be the path of least resistance as layering on yet another social program to an already strained fiscal outlook seems foolhardy and difficult to accomplish politically.

While the conventional thinking is one of a bleak fiscal outlook, we take a nuanced view on this. If AI reaches the point where it is advanced enough that it can indeed displace (or outright replace) many in the labor market, thereby moving basic income from a mere prospect to a reality, technological advancement should also be at a point where for the first time ever we can bend the healthcare cost curve. Indeed the medical arena and the entire cost structure are primed for disruption. We believe that solving the medical cost problem solves the fiscal problem.

Though "entitlements" get most of the attention in discussions about reining in fiscal spending, the reality is that healthcare-related items are the clear problematic standout. Much is made about the looming insolvency of Social Security, but we think this element can be solved by making a few tweaks to the current program (raising retirement ages, lifting income cut-offs while lowering the tax rate). Social Security as a share of both total government social benefits (34% and falling) and GDP (4.7% and right where it was back in 1982) is not worrisome in our view.

On the flipside, Medicare and Medicaid continue to grow dramatically on a relative basis. They now represent 45% of all government social benefits (up from 24% in 1982) and 6.5% of GDP (up from about 2.5%). These programs are likely only going to swell further as the U.S. population continues to age. Thus, the impact from cost/outcome-enhancing AI in the medical space could be significant for the fiscal health of the country.

While European and Japanese economic growth has been anemic over the last decade (slowing LF growth being a major factor here), they look extremely well positioned for the AI-age.

The AI-age has the very real potential of upending the current order and leading to a de-globalization of sorts

We can envision a scenario where basic income replaces all other government social programs as a plausible compromise.

We believe that solving the medical cost problem solves the fiscal problem.

Wrapping up AI and the economy

General AI or strong AI has wider implications not only for the economic environment but for pretty well every facet of human experience

We have been careful in limiting the analysis here to Narrow AI. As we said at the onset, so-called General AI or strong AI has wider implications not only for the economic environment but for pretty well every facet of human experience. Indeed, keep in mind that General AI is defined as super human intelligence (the ability to do everything a human can do but better and faster). On that point, and just to draw out what is required to get there, it is fair to say that at present the debate amongst experts is centered more around do we get there at all. Inserting ourselves into that debate and indulging in a full discussion of those ramifications is beyond the scope of this piece both in terms of the content and our 2025 window. Suffice it to say that if we ever truly solved the problems of creating a general intelligence, this would be disruptive in ways we can only imagine and not merely for the labor market.

Indeed, the opinions from experts in the field range from that of a human utopia to the utter destruction of humanity. We are not experts in the field by any means and thus will not dive into the debate here. But we believe highlighting Narrow AI as potentially the most (and probably only) truly job-destroying force is necessary in the interest of completion.

What if…? The Artificial Intelligence (AI) Race

What if AI precision farming ushers in the next global "green revolution" and cuts food costs in half? Will this accelerate the long-term decline in the percentage of income spent on food? Or will consumers use savings to trade up to more expensive and nutritious foods? How will this impact grain-reliant packaged food companies? Healthcare companies?

What if the Internet of Things and AI could be utilized as a reliable tool to help predict or mitigate loss events? Would insurance companies switch to monitoring for claims rather than adjusting them? Where would liability for claims detection begin and end?

What if AI-enabled autonomous driving turns your vehicle from a depreciating asset to an income-earning one – being put into a shared fleet or used for last-mile delivery when not in personal use? What if the vehicle could mine for crypto currencies or other future crypto assets with its computing capacity when not in use, generating additional income for owners and operators?

What if domestic robots and voice assistants complete most home services tasks – lawn mowing, cleaning, cooking, shopping, appointments, and food ordering? Will the $400B U.S. services industry shrink?

What if the Robo-taxi shared autonomous vehicle model becomes widespread and economic for consumers? Will consumers simply stop purchasing their own vehicles?

What if the combined forces of AI, Big Data *and machine learning eliminate all but the most entrepreneurial, highly skilled and creative jobs in the economy? Will there be a need for a living wage? Will artists and philosophers be among the most in-demand jobs?*

What if automation considerably reduced the need for labor in the manufacturing industry? What resonating impact would this have on the unemployment rate? Could the government step in and have a say in the direction of automated manufacturing?

What if optronics and hardware technology become so cost-effective as to negate the need for computing at the edge, since lighting up fiber becomes less costly?

What if wireless and RF security protocols are not becoming ineffective against miscreants, negating the entire UAV and drone opportunity in urban centers due to safety concerns?

What if newer wireless technologies really are proven to be carcinogenic, dramatically slowing down the proliferation of wireless devices and IoT?

What if continued advancement in self-driving car capabilities leads to increased market penetration and demand for autonomous vehicles? Will urban centers like New York and San Francisco that have such tight commercial real estate supply still be as highly valued? Will it be imperative for individuals to live close to their work if they don't have to drive themselves and could instead work, be entertained, or rest on their commute in?

What if…? continued

What if an AI personal assistant acted more like a central advisor that handled everything, including personal financial management, and was given authority to manage a person's bank account according to financial goals? Would a person be able to save more? Would certain industries decline because people were saving more? Would certain industries grow because people were able to save for products/services in those industries, like the travel industry or real estate? Would personal bankers and financial advisors become obsolete?

What if autonomous vehicles give way to new forms of "entertainment"? If autonomous vehicles allow occupants to not pay attention to the road, does media consumption rise? Will the cars of the future not have windows and instead have media screens? Are other advertising outlets negatively impacted?

What if farming drones and robots could turn U.S. consumers' lawns into food-producing assets? How would the global food and farm equipment supply chains adapt to a world in which consumers become far more self-sufficient?

What if machine learning advancements make predictive analytics a reality? Will it eliminate the gaming industry?

What if autonomous cars become the norm for personal transportation? Would this reduce the need for parking lots in urban areas allowing developers to acquire land sites to build competing product in submarkets that investors thought were supply constrained?

What if automation eliminates the need for physical manpower on construction sites? Does equipment become more differentiated to replace specific jobs, or more generalized to replace a worker's full range of capabilities?

What if machine learning software is able to write code? Will that eliminate the need for software developers?

What if artificial intelligence advancements take the human element out of picking stocks? Will we have access to such extensive data that we will experience singularity between the empirical and analytical? Will this eliminate the need for traditional Analyst and Portfolio Manager roles?

What if artificial intelligence makes business sales a thing of the past? Will commerce simply be transacted through a series of machines based on programmatic algorithms?

What if autonomous driving promotes more alcohol consumption given drunk driving might no longer be an issue? As vehicles learn the likes, dislikes, and intricacies of each individual rider, what if those same vehicles could act as matchmakers?

What if machine learning capabilities are embedded into the human thought process? Will that mean the end of education as we know it?

What if…? continued

What if cyber and artificial intelligence become more prevalent in modern warfare? What if the opposite occurs and AI is able to make the world safe through predictive capabilities?

What if autonomous vehicles come to market quicker and are adopted more quickly than currently expected? How will legal systems adapt to revised liabilities? Where will coverage and responsibility begin and end? How will insurance companies adapt their policies and right-size their cost structure? Will all related insurance coverage become commercial rather than individual? What responsibilities will individuals bear for the safe conduct of the vehicle and the safety of the asset? Will anyone even buy liability coverage?

What if autonomous driving puts truck drivers out of a job? What about the 433k public transit employees? What new jobs will be created by the advent of autonomous driving?

What if artificial intelligence improvements take the human element out of farming? Could that usher in the age of bot farming?

What if everything we are surrounded by is made "smart"? Will humans live like "robots" and robots become more humanized? What if robots are made to look and sound like humans – will it become difficult to distinguish between humans and robots? And if it becomes difficult to distinguish between the two, will we have to re-think traditional norms of companionship and commitment?

What if personal digital data becomes decentralized and fully owned by individuals instead of corporation? Will this slow the recent acceleration of AI? Will corporations have to compensate individuals with tokens for their data?

What if we lose our grip on AI? *What if* people didn't believe in "Don't be Evil?": Since 2012 the amount of compute used in the largest AI training runs has been increasing at a rate of 2X per 3.5 months (i.e., over 5X faster than Moore's Law) and since 2012 AI compute capacity is up 300,000X. AlphaGo Zero is being trained on operations of >2,000 Petaflops, a truly astounding amount of compute power. *What if* security and policy making does not keep up with the rapid AI technological development? *What if* a breach originates from the trusted hyperscale sources and cascades from within?

What if AI and machine learning techniques become so advanced that data and logic drive every human decision over emotions, and devices help humans decide what they want to do, eat, watch, buy, wear, and even feel? Will it decrease humans' ability to think independently? Will humans become machine-dependent for life?

What if vehicles develop their own sense of morality? As vehicles become more intelligent and increasingly learn more about the environment and the humans that occupy it, will they start making their own value-based decisions? Which rider or citizen has more of a right to avoid injury in an accident? Would a child riding their bike be saved in lieu of an older person riding in a car?

Theme III: In Cloud We Trust

The adoption and utilization of cloud technology is rapidly changing the landscape of corporate IT as well as corporate competition across industries. The democratization and affordability of cloud computing and storage is fueling the rate at which companies can start, scale, and succeed. As basic cloud services become more affordable with price cuts, we think premium services such as intelligence, machine learning, and advanced compute will continue to be introduced at affordable rates, giving high-power tools and capabilities to businesses of all sizes. Access to, and utilization of, these tools increases the ability of small and new entrants to industries to keep giants on their toes.

What you need to know…

The cloud provides for the democratization of immense computing power. The cloud gives anyone the same access to powerful computing on tap without having to set up costly data centers. This is what has allowed start-ups and new companies to grow at explosive rates. Importantly, a cloud-centric world moves faster. Digital transformation within companies will be necessary to keep up in the environment of rapid change, churn, and disruption. And as companies engage in digital transformation, they will become increasingly more dependent on the cloud infrastructure and the companies that provide it.

Just for context on increasing data storage capacity: Over the last two years, 90% of the world's data has been created. In an Internet minute, there are 38M Instant Messages, 3.7M Google searches, 2.4M Snapchats, 973,000 Facebook logins and 481,000 Tweets. The computational power of neural networks has increased 300,000X from AlexNet in 2013 to AlphaGoZero in 2017. Cisco estimates that data center storage will grow to 2.6 Zettabytes by 2021 . . . that's the equivalent of 10,000 books per person on the planet. Hyperscale data centers are expected to almost double by 2021 and will represent >50% of all data centers globally.

Enabling Anything as a Service (XaaS): While Software as a Service (SaaS), IaaS, and PaaS have generated significant interest, there seems to be no limits as to what can be delivered "as a Service" including DaaS, ITaaS, or Storage as a Service. Given advancements in cloud computing, we believe that there are few limits as to what can be delivered "as a Service," which we refer to as Anything as a Service or XaaS.

Cloud reinvestment continues: Cloud infrastructure spending has extensive runway ahead. Companies are starting to re-architect operations around these large-scale digital innovation networks.

Cloud services will become cheaper: The most commoditized portions of cloud (storage and computing) will get cheaper with scale and time; premium services (intelligence, processing, advanced compute) will continue to be introduced and utilized.

Cloud: Changing the game in software and much more

Before we dive deeper into understanding the future of Cloud Computing and its widespread implications across industries the world over, we thought it would be helpful to understand cloud computing basics. Remember, our IMAGINE 2025 research is intended to challenge current thinking not just for AI, Cloud or Geopolitical experts among others, but for all investors and executives from across disciplines.

To begin, just consider the following according to "Augmented: Life in the Smart Lane" by Brett King:

- Between 1990 and 2005, the capacity of hard disks increased a thousand fold, and it continues to increase today.
- We produce the same amount of content as stored in the Library of Congress, the largest data library in the world, more than 8,500 times per day.
- Today, the U.S. National Security Agency (NSA) collects as much information as held in the entire Library of Congress every six hours.
- There is already enough storage or disk space in the world to store everything people write, say, perform or photograph every day – with ease.

Exhibit 53: Organizations of all types, the world over, are becoming increasingly dependent on and trusting of cloud computing

Source: What's Big Data

Transitioning from on-premise (traditional software) to cloud (modern software)

Prior to the advent of the cloud computing delivery model, software was traditionally sold as a perpetual, upfront, license-based, on-premise solution where the customer would buy, implement, and support and/or maintain the code in-house while waiting for enhancements from the software sponsor. Under this model, a customer pays an upfront license fee and annual maintenance for support. This is software as we know it in our home or business, where we are also likely beginning to transition our software requirements from on-premise (traditional software) to cloud (modern software).

The on-premise software model, which typically requires heavy upfront costs, began to break down around 2005 as the cloud computing delivery model was introduced, thereby freeing the customer of many vendor and consultant dependencies. The new cloud model allows customers to subscribe to a service in a vendor-hosted model, which is accessible over the Internet via a web browser. This model removes the upfront software investment, as well as the additional costs to maintain and support the software on an ongoing basis – leading to increased convenience and cost savings for subscribers.

We believe some of the greater growth opportunities in software should come from further adoption of cloud computing services in all segments of the market, including the small and medium business (SMB) market, Global 2000 companies, and the further development and implementation of XaaS (Anything as a Service).

Global cloud computing market to grow at an impressive ~15% CAGR over the 10-years from 2017-2027

This transition is happening quickly, driving the global cloud computing market to grow at an impressive ~15% CAGR over the 10-years from 2017-2027, according to Market Research Future.

Exhibit 54: Global cloud computing growth
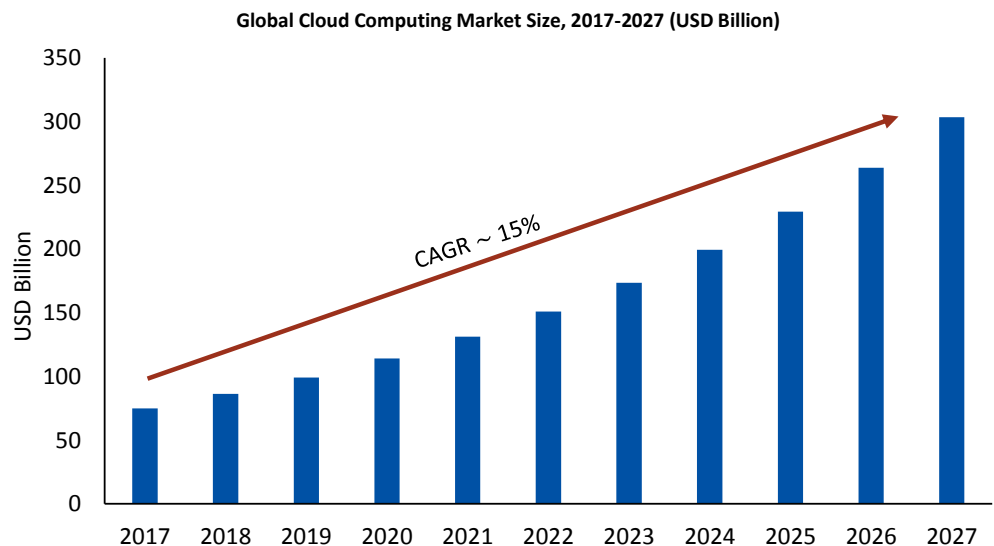
Source: Market Research Future

Cloud computing enables Anything as a Service (XaaS)

While Software as a-Service (SaaS), IaaS, and PaaS have generated significant interest, there seems to be no limits as to what can be delivered "as a Service" including DaaS, ITaaS, or Storage as a Service. Given advancements in cloud computing, we believe that there are few limits as to what can be delivered "as-a-Service," which we refer to as Anything as a Service or XaaS.

Exhibit 55: Examples of cloud computing
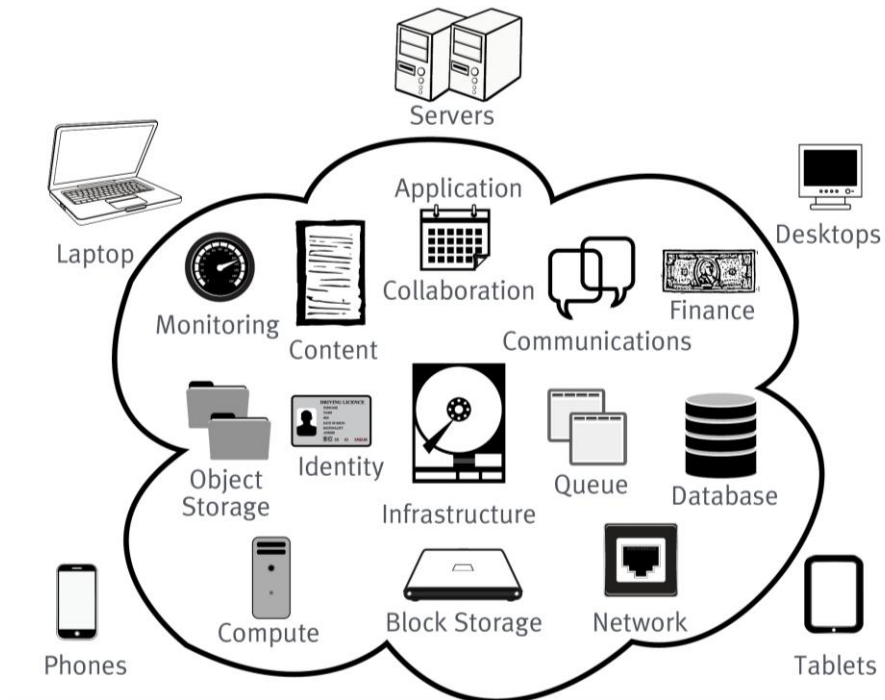
Source: RBC Capital Markets

In the example above, we illustrate cloud computing as a series of tasks that are accessed via a variety of endpoints including desktops, laptops, tablets, phones, etc. Going forward, we believe that there are few limits to what can be delivered via the cloud; i.e., "as-a-Service."

At its core, cloud computing is a "utility-like" method of delivering solutions versus the traditional method which we refer to as "on-premise."

Understanding cloud computing from a service provider business

As defined by Amazon AWS, cloud computing provides a simple way to access servers, storage, databases and a broad set of application services over the Internet. Whether running applications that share photos to millions of mobile users or supporting the critical operations of a business, a cloud services platform, such as Amazon Web Services (or Microsoft Azure, we add), provides rapid access to flexible and low-cost IT resources. These services save companies from making large upfront investments in hardware and spending a lot of time and resources managing that hardware. Rather, organizations can provision exactly the right type and size of computing resources required to power their latest idea or simply operate their IT department. These services enable companies to access as many resources as they need, almost instantly, and only pay for what is used.

Cloud is a new substitute for nearly everything in computing, leaving us more and more dependent on this technology

In Exhibit 56, we illustrate how the rise of cloud applications has abstracted everything but the application layer – the final point of contact at the end user. When applications are delivered from the cloud, the vendor takes on responsibility for delivering the application, the underlying infrastructure (database, storage, compute, etc.), the operations of the stack (i.e., keeping it up and running) as well as upgrades and innovation at the application layer.

Infrastructure as a Service (IaaS)*:* On-demand cloud services that provide underlying network infrastructure like physical computing resources, data portioning, scaling, backup, processing, and storage.

Platform as a Service (PaaS)*:* Cloud services that allow developers and companies to develop, run and manage applications without the complexity of building and maintaining the relevant infrastructure (Runtime, middleware operating system, virtualization, servers, databases, storage and networking).

Software as a Service (SaaS)*:* A licensing and delivery model in which software is centrally hosted and delivered on a subscription basis, basically on-demand software.

Exhibit 56: The end user is concerned with less the higher up the stack we go
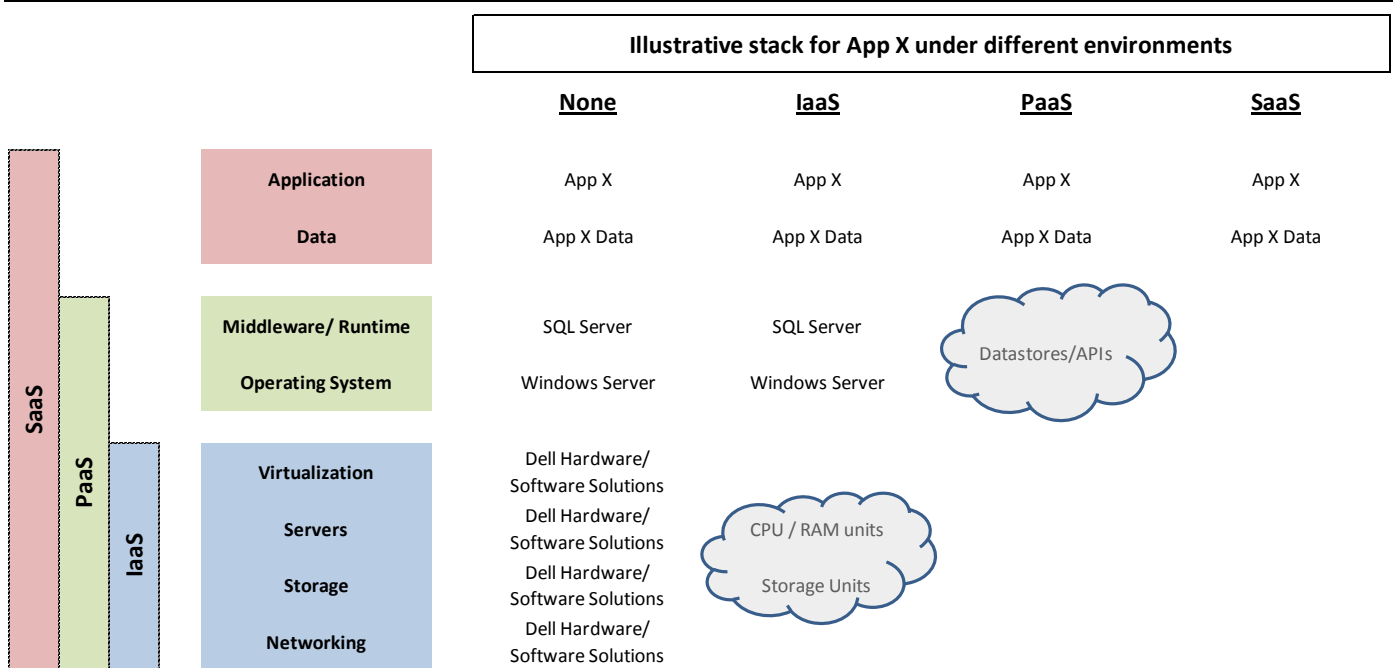
Source: Strategi; RBC

Comparative advantage at work – hyperscale providers are now reliable, scalable and secure enough that Application Software providers can focus on what they do best – building and designing apps.

It is becoming apparent that cloud applications are starting to leverage the hyperscale platforms. The arguments are reasonable – let Amazon, Microsoft, and Google handle the petabytes of storage, pull together the thousands of servers and stitch together the networking capabilities, while software makers concentrate on their comparative advantages – designing great software and applications for customers. For the majority of use cases, the public cloud does provide better economics than wholesale datacenters, especially when you fully burden/allocate costs like technical expertise, personnel, development and maintenance.

We are also starting to see philosophical adaptations of the Cloud trend in IT across other industries:

Maximizing excess capacity: AWS evolved out of the excess compute and storage of Amazon's data centers. We're seeing similar next generation business models like Classpass for Fitness/Lifestyle, Airbnb/Homeaway for housing and WeWork for co-working embrace similar concepts (although partially on external instead of owned capacity).

Abstracting complexity: Keeping users further away from the underlying complexity of a process in an attempt to deliver a more holistic value proposition. Think about the evolving role of grocery stores with the advent of meal kits and multiple delivery services (Postmates, UberEats, Instacart); or the role of Uber and Lyft in revolutionizing transportation (impacting car ownership, public transport, etc). Customers simply want the lowest, most convenient option available to them, but are willing to pay only the layer most visible (or with closest interaction) to them.

Concentration of power and speed of growth: Cloud hyperscale providers have grown because of powerful network effects on an unprecedented scale, allowing the big to get even bigger. Additionally, next-generation companies who can utilize this infrastructure/roadmap have been able to scale a lot quicker than their first-generation iterations.

Exhibit 57: Cloud scale and network effects enable growth, with next-gen leaders growing faster than the previous
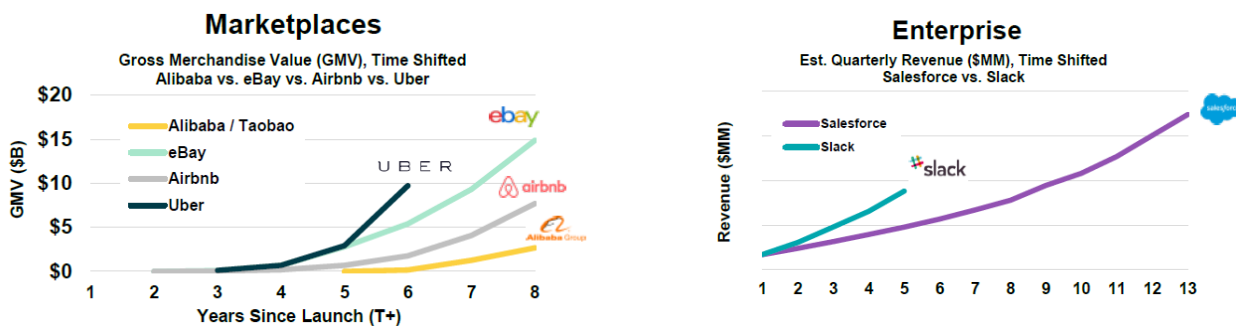
Source: KPCB 2016 Internet Trends

Rapid commoditization: Cloud effects have negatively impacted legacy hardware and service players as new workloads have captured the bulk of overall growth. Previously, tech moats that resulted in some form of vendor lock-in have been chipped away as cloud services have come up in feature and cost parity. Through this lens, we remain cognizant of how traditional business moats like Brand (vs. private label in a zero-barrier ecommerce world), Shelf Space (less relevant with mall foot traffic trends) and Distribution (B2B processes, logistics and warehouses) can rapidly get eroded if a large incented player is willing to price aggressively for extended periods of time.

Breaking down what makes the Internet of Things possible

Cloud: With billions of devices expected to be connected by 2025, the amount of data generated would be enormous. Companies cannot afford to develop in-house infrastructure to process and store this data, and that is driving the need for the cloud to process and store data continuously. Cloud computing is the ideal way, in our opinion, to address the demand for deploying hundreds of application servers that are needed to support these devices.

Data management: As more and more devices become connected, they transmit large amounts of data through sensors and other machines that need to be managed and analyzed continuously across large data systems. The need to manage unstructured and geospatial data coming from the devices is becoming increasingly important. IoT calls for specific capabilities to handle diverse data constantly streaming from numerous sources. It is driving data management from the central repository toward the edge of the network, saving time, improving efficiency, and preventing the need for overwhelming databases. Managing the data at the edge also allows for performing some of the real-time analytics without the need to access the central network.

Application enablement: Application enablement is a middle-ware platform primarily needed to ease connectivity, manage devices, and data-collection activities of any IoT solution. One of the

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better ways to link the IoT devices to applications is through the application-enablement platform. This allows for the creation of a reliable, scalable, and cost-effective platform for the IoT solution. Application enablement also provides features such as access control and easy options for any future changes.

Connectivity management: This piece of the IoT platform stack is required to ensure the connectivity paths between the devices and servers are managed and monitored. It also provides additional tools such as real-time connectivity status, reporting, troubleshooting, and profile creation.

Device management: Device management involves managing multiple IoT devices remotely for specific functions such as reboot, factory reset, firmware download, or firmware update. Several devices can be managed at once through an application programming interface (API) on the managing agent. For example, retail products that are connected through IoT at the end consumers can all be upgraded for firmware remotely. Connectivity logs within individual devices help address specific problems remotely without the need for in-person troubleshooting.

Hardware: Hardware in the IoT platform includes the end devices that are used to collect information and transmit for analytics. The hardware specific to IoT consists primarily of sensors to collect information and RF chips to transfer information to the cloud through the network.

Market size

Gartner has estimated that the IoT hardware endpoints spend totaled $1.7 trillion in 2017 with connected devices in the total install base of 8.1 billion units (up ~30% y/y). By 2021, Gartner expects total hardware unit spend to be ~$3.4 trillion, which reflects a five-year CAGR of 19%. Within hardware units, Gartner expects Automotive & Transportation to be the largest market by a wide margin. During the same forecast period, Gartner expects Automotive & Transportation hardware units to grow at a 32% CAGR, representing a ~25B unit install base by 2021.[4]

Exhibit 58: IoT hardware market growth forecast ($ in billions, 2016–2021E)
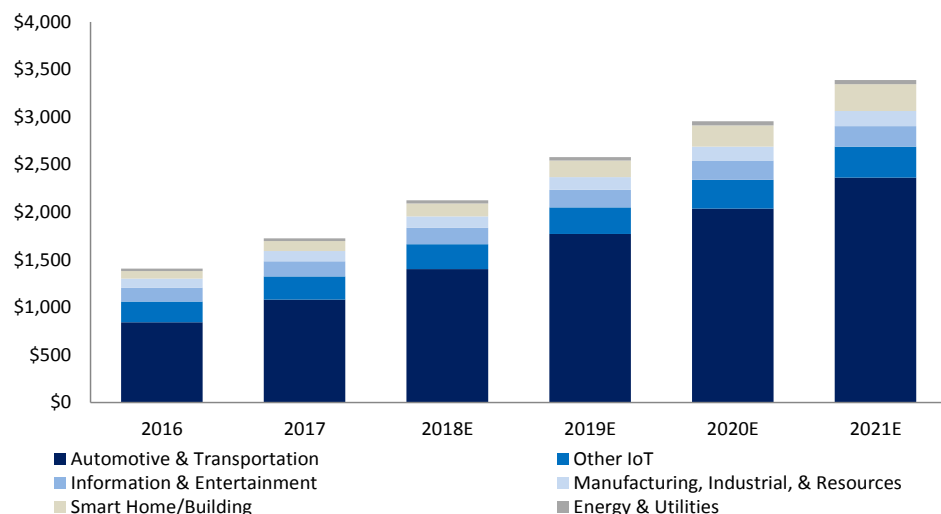
Source: Gartner "Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2017", by Peter Middleton et al , Tracy Tsai, Masatsune Yamaji, Anurag Gupta and Denise Rueb (December 21, 2017)

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[4] "Forecast: Internet of Things – Endpoints and Associated Services, Worldwide, 2017" by Peter Middleton, Tracy Tsai, Masatsune Yamaji, Anurag Gupta and Denise Rueb (December 21, 2017).

We believe software and component companies are best positioned to reap the benefits from a broader IoT adoption.

From an end-market perspective, we are most bullish on markets that have a defined refresh cycle (automotive) or industries that can enjoy substantial cost savings from IoT (industrial, manufacturing, and energy).

Driving forces behind IoT: We think IoT is creating a fundamental shift in how enterprises approach their business. Organizations across all industries are seeing incremental benefits from sensor data that identify areas of both cost and operating efficiencies. In recent years, the explosion of data volumes and the number of connected devices used by consumers and enterprises have vaulted the IoT market and its ancillary markets, such as networking, as organizations have begun to invest in network infrastructure and capacity to manage the high data traffic from the sensors. We expect the IoT industry to remain prominent and grow at a more than 20% rate over the next several years.

Expanding use cases: In its early stages, a connected device was primarily used for tracking and asset management. With technological advances, sensors have become increasingly more powerful in a smaller form factor. These advanced sensors enable use in cases beyond simple location-based services such as home automation, connected vehicles, smart energy, service management, and factory automation, among others.

Robust growth expected for software and component companies: We believe software and component companies are best positioned to reap the benefits from a broader IoT adoption. Analytics software provides the end tool that makes sense of the massive amount of data collected from the devices, enabling companies to gain real-time visibility into their business. Beyond the software vendors, component companies that supply endpoint chips and sensors should also see robust growth as more organizations seek to gain competitive advantage by making everyday objects "smart."
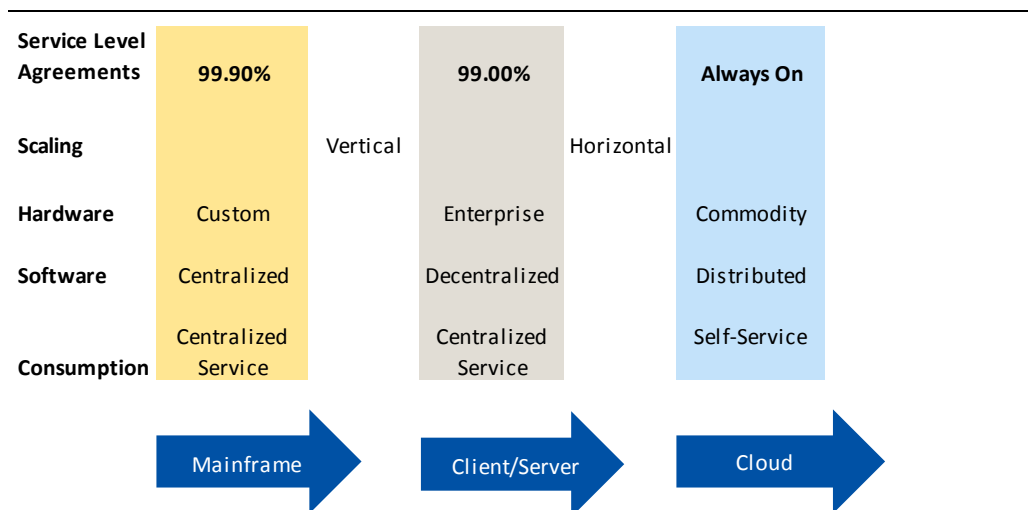
End-market beneficiaries: From an end-market perspective, we are most bullish on markets that have a defined refresh cycle (automotive) or industries that can enjoy substantial cost savings from IoT (industrial, manufacturing, and energy). We highlight our expectations for key end-markets below.

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Accelerating the disruptors and failures

Getting into more detail on the future of cloud and transitioning from the prior Agility Imperative theme, it is clear that cloud also plays a role in agility. The rule of thumb in Silicon Valley is that disruption does not happen unless something is 10x Cheaper, 10x Better or 10x Faster; but you will not get funding from VCs until you can fulfil all of the above.

Amazon Web Services was the ultimate Disruptor: Social Capital's founder Chamath Palihapitiya believes that "Ecommerce was Amazon's way to dogfood AWS, and continue to do so, so that it was mission grade." AWS was formed by Amazon taking the decade worth of experience in building out its ecommerce platform and exposing it to the outside world. At its heart is a set of dedicated software and operating procedures that allows Amazon to drive performance, reliability, operational quality and security at massive scale. Amazon also allowed access to its catalogue of services and innovative developers started to leverage both the infrastructure and the services that Amazon was sharing with the outside community. The cost to build AWS was justified because the first and best customer is Amazon's ecommerce business.

Exhibit 59: A cloud world moves faster

Service Level Agreements	99.90%		99.00%		Always On
Scaling		Vertical		Horizontal	
Hardware	Custom		Enterprise		Commodity
Software	Centralized		Decentralized		Distributed
Consumption	Centralized Service		Centralized Service		Self-Service

Mainframe	Client/Server	Cloud

Source: Cloudscaling.com, RBC Capital Markets

We're seeing increasing conversations at the C level of companies that are trying to embrace Digital Transformation processes that center around the same concepts. For example, Agile Development – not just for engineers, but trying to introduce the concept of Moving Fast and Breaking Things across standard business processes/project management – becomes more relevant and possible in a cloud centric world with faster feedback loops.

Inevitably, once there's a large audience, companies have to disrupt themselves through innovation or they will be victims of their own success.

How do companies become irrelevant? Slowly, then suddenly

Because a cloud world is Inflationary (winners get bigger quicker), the countervailing observation is that legacy players are deflationary. Being caught on the wrong side of relevance has seen disastrous consequences (one need look no further than the traditional and specialty retailers who failed to embrace/adapt to the ecommerce revolution).

Inevitably, once there's a large audience, companies have to disrupt themselves through innovation or they will be victims of their own success.

Exhibit 60: Number of times Amazon and Google are mentioned on conference calls 2017 YTD
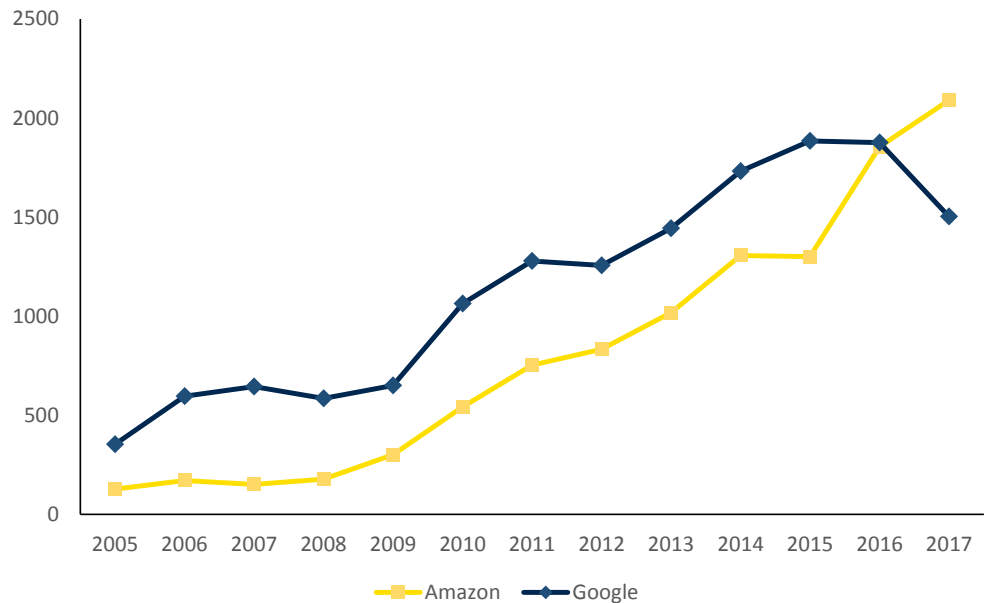
Source: Factset, Recode.net

A trend investors have been watching for the past several years is a number of infrastructure vendors going private, including BMC, TIBCO, Informatica, Compuware and Riverbed, while other public vendors have underperformed, including CA and Teradata. Why is this happening?

As more services move to the cloud, it means CTOs need to purchase less on-premise infrastructure hardware and software for private clouds. That means less load balancers, less middleware, less general datacenter plumbing. Instead of customers absorbing the cost for infrastructure, cloud or platform vendors assume those costs that can be spread over a larger number of customers. It is effectively an economy-of-scale situation where the economics favor the cloud and platform players vs. the on-premise vendors. Effectively the spending on overall infrastructure software and hardware decreases and at the same time shifts.

Reinvestment to compete with the Day One mindset: The pace of innovation/investment is torrid in Tech land relative to other "undisruptable" industries, especially in a world where capital is abundant. Companies are starting to realize that nothing is sacred – not even low-margin businesses like grocery that can be re-imagined under the cloud (IoT farm-to-table avocados?).

Cloud adoption going mainstream

Cloud adoption is rapidly changing the landscape of corporate IT. According to IDC in 2016, U.S. companies allocated ~53% of their total IT spending to in-house IT (enterprise datacenters) and traditional (non-cloud) IT outsourcing. By 2020, the situation is expected to reverse, with public and private cloud (onsite and hosted) accounting for the majority (54%) of total enterprise IT spending. IDC predicts that by 2020, enterprise spending on cloud services, the hardware and software to support cloud services, and the services for implementing and managing cloud services will exceed $500 billion, more than three times what it is today.

Companies are starting to realize that nothing is sacred – not even low-margin businesses like grocery that can be re-imagined under the cloud (IoT farm-to-table avocados?).

According to IDC in 2016, U.S. companies allocated ~53% of their total IT spending to in-house IT (enterprise datacenters) and traditional (non-cloud) IT outsourcing. By 2020, the situation is expected to reverse, with public and private cloud (onsite and hosted) accounting for the majority (54%) of total enterprise IT spending.

While small to medium business (SMB) early adopters led the way, multi-year trends of agility, security and resiliency, high availability, standardization of IT infrastructure, Internet of Things, the explosion of Big Data and new AI/ML techniques are all contributing to the accelerated adoption of cloud across enterprises of all sizes. Companies are starting to re-architect operations around these large-scale digital innovation networks. As a result, we've seen enterprise adoption of cloud start to increase dramatically, with >30% of organizations reaching a level that IDC labels "mature" – that is, building repeatable, managed, or optimized cloud strategies.

Software as a Service accounted for just 8% of enterprise application spending in 2012, but it has grown at a ~40% CAGR (vs. 2% for non-cloud), and now tracks at ~30% of 2017 spend.

To illustrate the scale at which cloud adoption has been scaling, we look at publicly listed company revenues as a % of overall enterprise application spend. Software as a Service accounted for just 8% of enterprise application spending in 2012, but it has grown at a ~40% CAGR (vs. 2% for non-cloud), and now tracks at ~30% of 2017 spend.

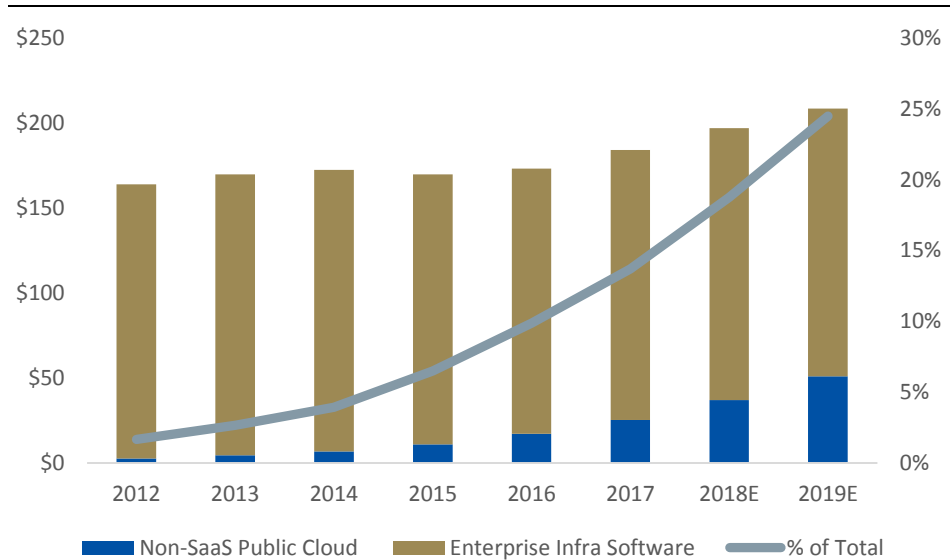Exhibit 61: ($M) Public SaaS revenues as % of overall Enterprise App spend
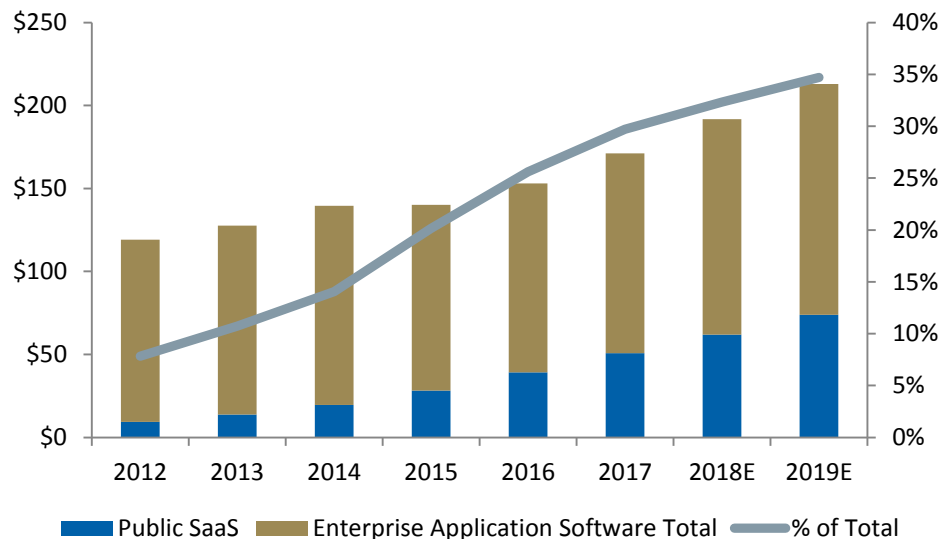
Source: Company reports, FactSet, Gartner estimates of Enterprise Application Software Total[5], RBC Capital Markets estimates of Public SaaS spending

We see Cloud Infrastructure spending following a similar (though slower) adoption curve, implying it has extensive runway ahead. While growing at an even faster ~56% CAGR over the last 5 years, it started from a much lower base, increasing its share of enterprise infrastructure software spend from 2% to 14%.

Under the same methodology, we see Cloud Infrastructure spending following a similar (though slower) adoption curve, implying it has extensive runway ahead. While growing at an even faster ~56% CAGR over the last 5 years, it started from a much lower base, increasing its share of enterprise infrastructure software spend from 2% to 14%.

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[5] "Forecast: Enterprise Software Markets, Worldwide, 2014-2021, 4Q17 Update" by Hai Hong Swinehart, Terilyn Palanca, Neha Gupta, April Adams, Robert P. Anderson, Fabrizio Biscotti, Bindi Bhullar, Matthew Cheung, JP Corriveau, Alan Dayley, Sid Deshpande, Federico De Silva, Yanna Dharmasthira, Chad Eschinger, Jim Hare, John Kostoulas, Nigel Montgomery, Chris Pang, Julian Poulter, Craig Roth, Michael Warrilow, Alys Woodward, Laurie F. Wurster (December 15, 2017)

Exhibit 62: ($M) Public IaaS Revenues as % of overall Enterprise Infrastructure Spend

Source: Company reports, FactSet, Gartner estimates of Enterprise Application Software Total[6], RBC Capital Markets estimates of Public SaaS spending

A general concept is that the most commoditized portions (storage/compute) get cheaper with scale/time, while premium services (intelligence, processing, advanced compute) continue to be introduced and utilized within the mix – allowing more reinvestment, scale and cost compression.

Affordability and profitability keeps improving: As Jeff Bezos has said, there are "Companies that work hard to charge you more and companies that work hard to charge you less." We firmly believe most cloud providers are in the latter camp, with continual price improvements alongside service enhancements.

We've seen continual announcements of price cuts across key platforms for compute and storage since 2011. However, providers still manage to generate very healthy margins (AWS running at 25% NGOM EBIT). A general concept is that the most commoditized portions (storage/compute) get cheaper with scale/time, while premium services (intelligence, processing, advanced compute) continue to be introduced and utilized within the mix – allowing more reinvestment, scale and cost compression.

If data = oil, cloud = extractors, pipelines, refineries

If we were to think of data as the new natural resource (the idea of data as the new natural resource is hardly a new or original concept and has been championed by leading technology companies and pundits), then cloud should abstractly be thought of as the machinery used to help collect/create, extract, transport, store, analyze, and refine data.

One analogy for the development of cloud is the advent of alternative oil extraction/processing methodologies. These include directional drilling and hydraulic fracturing. In addition, the ability to refine/process shale and tar sands has provided the oil and gas industry access to natural resources in unconventional deposits that were previously unreachable or cost prohibitive to extract. These alternative extraction methodologies have effectively altered the landscape in the oil and gas industry and essentially positioned the U.S. as a leading oil production country. We think something similar could occur in the technology industry with the proliferation of cloud's impact to data (natural resource). If we were to think of data as the new natural resource (the idea of data as the new natural resource is hardly a new or original concept and has been championed by leading technology companies and pundits), then cloud should abstractly be thought of as the machinery used to help collect/create, extract, transport, store, analyze, and refine data. The vast majority of the world's data is currently unstructured and previously thought to hold limited value for its stakeholders. However, the cloud provides users with the ability to discern actionable

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[6] "Forecast: Enterprise Software Markets, Worldwide, 2014-2021, 4Q17 Update" by Hai Hong Swinehart, Terilyn Palanca, Neha Gupta, April Adams, Robert P. Anderson, Fabrizio Biscotti, Bindi Bhullar, Matthew Cheung, JP Corriveau, Alan Dayley, Sid Deshpande, Federico De Silva, Yanna Dharmasthira, Chad Eschinger, Jim Hare, John Kostoulas, Nigel Montgomery, Chris Pang, Julian Poulter, Craig Roth, Michael Warrilow, Alys Woodward, Laurie F. Wurster (December 15, 2017)

insights from data sets that were previously thought to have held limited value. Looking into the future, we think the role of cloud within data analytics will continue to expand driven by the exponential growth of data and combined with new methods to realize value from data.

It is hard to debate the growth in data. IDC believes worldwide digital datasets are growing at a breakneck pace – from 4.4 zettabytes in 2013 to 44 zettabytes by 2020, to 180 zettabytes by 2025 (a zettabyte is 10^{21} bytes, or 1 billion terabytes). Technological innovations such as social media, cloud computing, mobile, new web based applications such as SaaS and Internet of Things have created a constantly connected pipe of data generation.

The three main big properties are:

- **Volume:** Beyond simply sampling core inputs/outputs to the process, metadata around observation and tracking processes is also recorded.
- **Velocity:** The speed at which data is collected and sent – in real time, low latency, high frequency intervals.
- **Variety:** Numerous formats, structured and unstructured data, text, voice, imagery, etc.

The scale and advent of Big Data has resulted in new methodologies of capture, storage, analysis, search, sharing transfer, visualization, interpretation etc. Andrew Ng's (one of the pioneers at the forefront of modern AI/ML) analogy that data is the rocket fuel feeding the engine for machine learning processes (which are ultimately finely refined statistical relationships) is a helpful one.

Hidden value of data

We think true cloud applications have a durable competitive advantage based on the data that can be collected, analyzed and measured across users on the platform. Many companies outside of the software world are only just awakening to the importance of their owned, unique datasets.

- **The use of the application is completely transparent** to the application vendor. This has material advantages for the vendor, such as being able to tell when customers are at risk of leaving the platform (low usage) or which features development should focus on (those being used most often). This transparency was never available in the on-premise application world.
- **Aggregate data has significant value.** Another advantage for cloud application vendors is the view on aggregate data across their customer base. While vendors don't own their customers' data, they still glean significant insights from it. This could be relatively simple (e.g., peak transaction times across a certain application) through to more sophisticated data (best practices that can be provided to other customers on the platform based on their characteristics).
- **Data network effects:** In the cloud application world, there is greater opportunity to leverage networks from the data/content. A simple example is Adobe's use of the Behance Creative network alongside its creative tools. Creative professionals can post their portfolios of work on the network, which in turn can be seen by companies and agencies. This has driven new hiring and job features on the platform and so in some ways Behance has become a creative industry-specific LinkedIn tool used by professionals and recruiters alike.

We think true cloud applications have a durable competitive advantage based on the data that can be collected, analyzed and measured across users on the platform.

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Internet of Things/ Edge Compute enabled by cloud

IoT refers to a network of connected devices that contain embedded software, sensors, and IP technology to enable them to interact with and gather data on their environment, as part of a broader integrated system. The data collected from this process is then transmitted over the Internet and can be analyzed to improve performance, cost, and operational efficiency.

Exhibit 63: IoT architecture
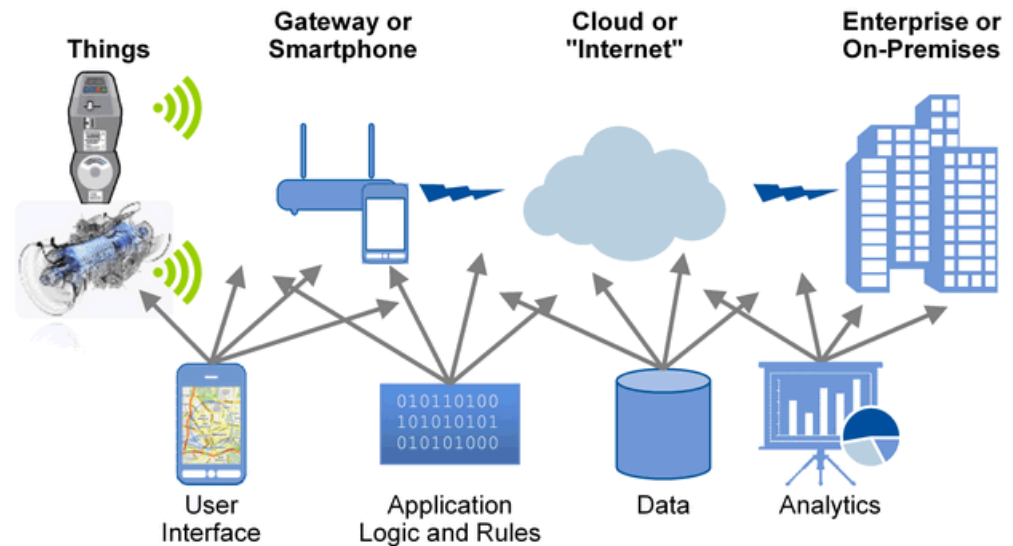
GUI, application logic, data and analytics can be placed anywhere

Source: Gartner Top 10 Strategic Technology Trends for 2016: Internet of Things Architecture and Platforms

One of the goals of IoT is to help integrate two segments: Machine-to-machine (M2M) communication services and operational technology. M2M communication services link connected devices to a central system autonomously, without the need for human interaction, while operational technology monitors and controls the devices (enterprises or end-users).

Case study: Connecting the industrial Internet

Software and digital capabilities are supplanting physical assets in importance among the industrials. Market leaders within the industrials have long depended on their "moats" to maintain their dominant positions within their respective domains – such as their expansive installed bases of equipment built over decades of operations and their long-term multi-year service contracts. But we believe that the next frontier of growth and innovation within the industrials will not be tethered to physical assets, but rather, will be comprised of digital services that can control and monitor equipment and aggregate data. Specifically, we would argue that the value proposition of physical engineering is reaching its upper limit; from here, the bulk of incremental cost efficiencies and improved asset utilization for customers will come from the "Internet of Things" and software as a service (SaaS) capabilities. Importantly, digital solutions are exponentially more flexible and responsive to continuous improvement than physical assets (i.e., the amount of time it takes to revise a line of code is a mere blip compared to the time it takes to revamp a product's engineering or a factory's assembly line). As the rate of change accelerates within the industrials, we believe the speed at which companies are able to embrace and leverage the disruptive power of software will keep them at the forefront of this sea-change from the "physical" to the "digital."

We would argue that the value proposition of physical engineering is reaching its upper limit; from here, the bulk of incremental cost efficiencies and improved asset utilization for customers will come from the "Internet of Things" and software as a service (SaaS) capabilities

Exhibit 64: Evolution of services at GE
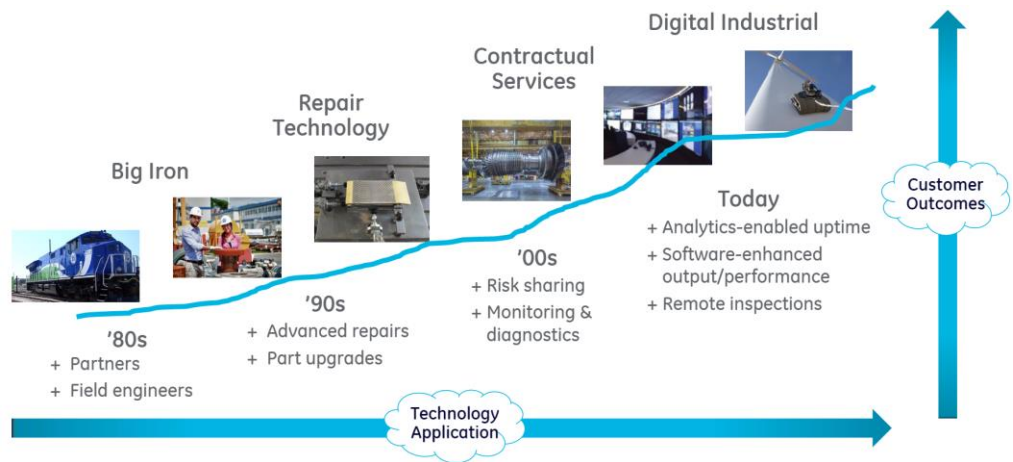
Source: GE Company reports

Cloud enabling new business practices?

We lean on the insightful piece "The New Moats" by Jerry Chen of Greylock Partners, which talks about how "Systems of Intelligence" – the fabric that spans across multiple datasets and systems of record – are the new defensible business moats in today's software world.

Exhibit 65: Value in linking disparate data sources across engagement and record
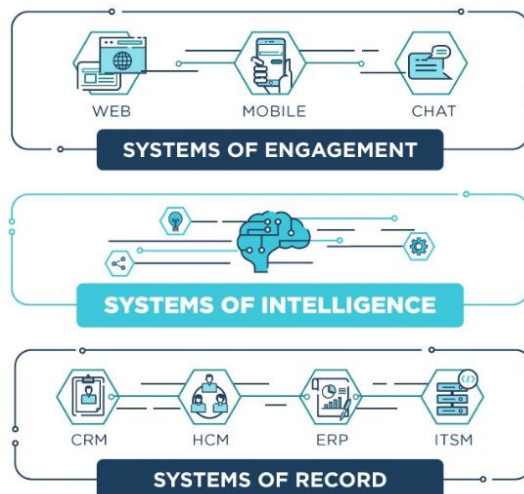
Source: Jerry Chen, "The New Moats", Greylock Ventures, April 24, 2017

An example is that of an application that combines web analytics with customer data and social data to predict end user behavior, churn, LTV, or serve more timely content. Incumbents such as Salesforce (Einstein) and Adobe (Sensei) would be advantaged on their own data.

Mr. Chen highlights three major areas where these systems can be built (coincidentally overlapping with the three largest public systems of record cloud companies): **1) Customer facing applications** around the customer journey (*Salesforce*), **2) Employee facing applications** like HCM, ITSM, Financials (*Workday*); or **3) Infrastructure systems** like security, compute/ storage/ networking, and monitoring/ management (*ServiceNow*). Additionally, he highlights the potential and value of verticalization – where companies can use data specific

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to an industry (i.e., healthcare, financial services) to solve a strategic problem, replace or automate workflows or create a new value-added workflow.

Payments and the cloud

While developing from different roots, we believe that three large emerging Asian Payment/Lifestyle platforms (Alipay, Paytm and WeChat Pay) have built large, consumer-centric solutions, which combine ecommerce, social media and mobile app/functionality with payments included. We believe it's helpful for investors to look at these providers as "models" as to how other technology companies with similar roots could develop deeper into payments. In general, we see three different evolutionary paths that these platforms experienced based on the industry the platform originally grew out of – (1) a payment solution arising from a mobile-phone top-up network (Paytm); (2) payments arising from an ecommerce portal (Alipay), and (3) a payment solution arising from a social media network (WeChat Pay).

Exhibit 66: Payment platform taxonomy

Evolutionary Path	Example
Ecommerce + payments	Alipay
Social media + payments	WeChat Pay
Mobile top up + payments	Paytm
Others?	India's Unified Payment Interface (UPI) and RuPay China's UnionPay

Source: Company data, RBC Capital Markets

From a technical perspective, we note that all three generally match in terms of functionality, including (1) services offered, (2) funding sources for the payment capability, (3) ecommerce, mobile commerce and physical retail payments, and (4) the payment networks that each of these platforms use.

Exploring the risks of blockchain on remittance

The question always asked when disruption is at issue is "can the incumbent innovate fast enough, before the disruptor can gain scale"? Well, we believe in the world of cryptocurrency and blockchain technology this question remains relevant.

The remittance market size, economic model, and inefficient structure make it worth disrupting…

The global remittance market, which by our definition represents C2C flows, was $613.5 in 2017 and is estimated to reach and reach $640B by 2019, according to the World Bank.

Exhibit 67: Global remittance market ($B) and growth
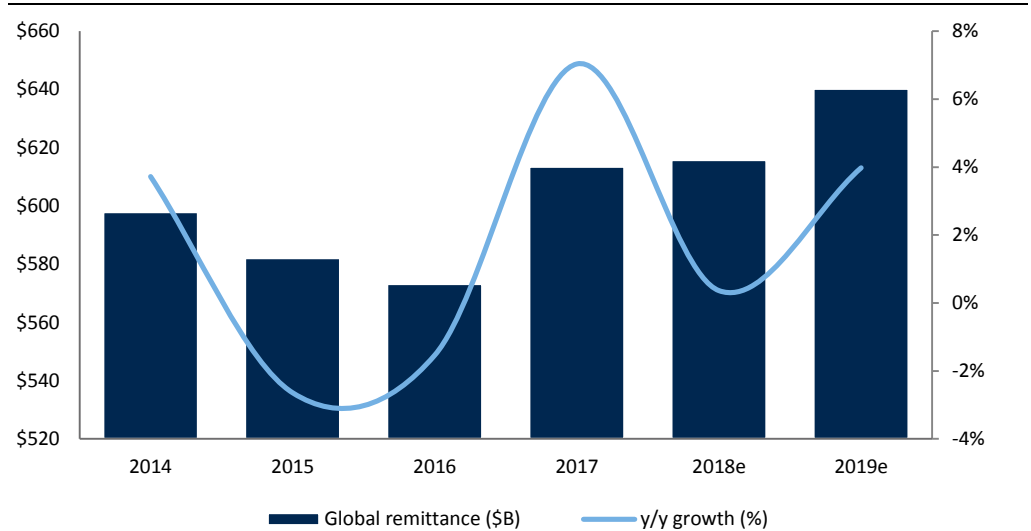
Source; World Bank estimates, RBC Capital Markets estimates

Traditional remittance providers and banks dominate the market today

Consumers predominantly use traditional channels including commercial banks, retail money transfer operators, such as Western Union (WU) or MoneyGram (MGI) or online transfer providers such as TransferWise or PayPal (Xoom), for C2C transfers.

### Blockchain addresses pain points

We believe that blockchain addresses the pain points of the remittance industry by reducing intermediaries, cost and with greater transparency.

Ripple

Ripple created an open source, peer-to-peer, decentralized protocol, with a network of participating financial institutions (RippleNet) and a series of individual technology solutions including payment processing (xCurrent), liquidity support (xRapid) and payment access (xVia). While not necessary for xCurrent and payment processing, we believe that it is helpful to use the "complete" solution as an example of how blockchain could disrupt the remittance market, including the use of XRP and its corresponding ledger. In this solution, XRP is used as a bridge asset, meaning that it is a store of value that can be transferred between parties without a central counterparty and thus support liquidity between any two currencies. As a result, banks can consolidate their liquidity into one XRP account instead of holding local currency in accounts around the world. By making markets directly between banks' domestic currencies and XRP, banks minimize the number of intermediaries.

We believe that blockchain addresses the pain points of the remittance industry by reducing intermediaries, cost and with greater transparency.
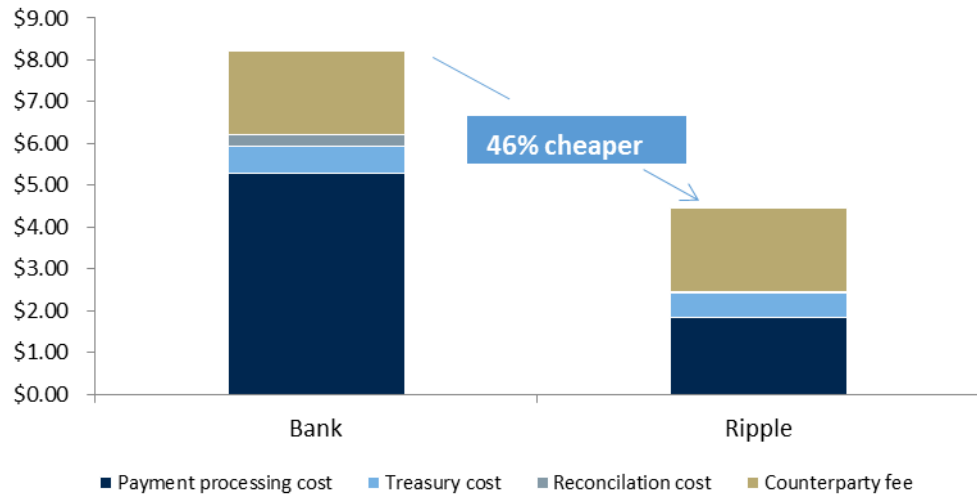
Exhibit 68: Cross-border transfer through Ripple using the XRP Ledger
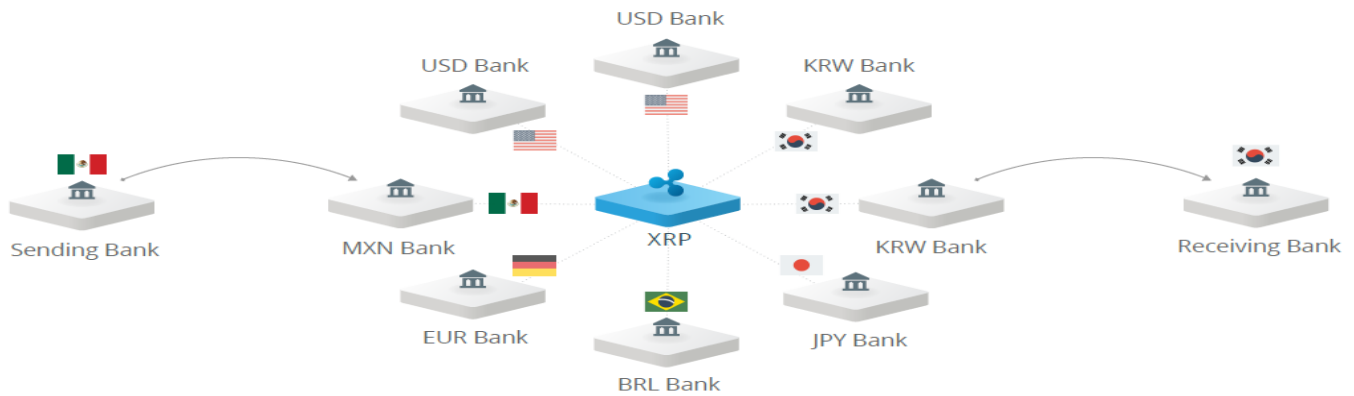
Source Recode.net

Cost: RippleNet (with or without XRP) offers transparency of forex rates and fees, before the transaction is originated, and can reduce the cost per payment for financial institutions.

Exhibit 69: Average bank cost savings per payment

Source: Ripple, RBC Capital Markets

Speed: Transactions processed through Ripple are immediate, 24-7 with real-time confirmation of receipt. Exhibit 71 illustrates the various settlement times required by multiple providers.

Exhibit 70: Comparison Metrics

Channels	Settlement time
Bank to Bank	2-5 days
MoneyGram	2-5 days
Western Union	0-3 days
PayPal	0-1 day
TransferWise	3-5 days
Ripple	0 days (3-5 seconds)

Source; Ripple, Currency Shop, RBC Capital Markets

Transparency: Ripple combines payment messaging with funds settlement enabling easy tracking of funds which might not be currently available for cross-border inter-bank payments.

Case study: Blockchain in Food Retail

The underlying blockchain technology can increase the transparency in the food supply chain, offer a solution to food safety, and help everyone in the vertical better manage inventory. The Food Retail vertical is very fragmented, making shared databases very difficult to execute (e.g., need a unique inventory database for each supplier partner). Blockchain can allow retailers to aggregate data from multiple distributors in one place without sacrificing competitive sensitive details of their partners (given unique public and private keys, competing suppliers would not be able to see the others' transaction strings, but the retailer could view the transaction history of all its products).

According to the FDA, 1 in 6 Americans contract foodborne illness every year (~48 million cases). This results in ~128,000 hospitalization and 3,000 deaths, despite U.S. food supply being one of the safest in the world. Identifying the point of food contamination can take weeks, sometimes months.

By design, blockchain is a decentralized ledger system that establishes an immutable consensus of ownership. By tagging individual perishable items, food retailers, distributors, and consumers can trace a particular food item to its origin and develop a better understanding of inventory days and levels across multiple supplier partners. Of particular importance would be age of item and its chain of custody. In the summer of 2017, IBM announced a collaboration with major players in the global food supply chain to tackle the food safety issue utilizing blockchain technology. Companies include: Walmart, Kroger, Dole, Driscolls' Tyson, Nestle, and Unilever. The IBM blockchain platform is available via the IBM cloud. Ultimately, this technology should reduce waste, eliminate inefficiencies in transportation logistics, and help identify sources of foodborne illnesses.

By tagging individual perishable items, food retailers, distributors, and consumers can trace a particular food item to its origin and develop a better understanding of inventory days and levels across multiple supplier partners.

Consumers can trace where the food item has been in the supply chain thanks to blockchain.

Exhibit 71: Blockchain technology being utilized in the food industry
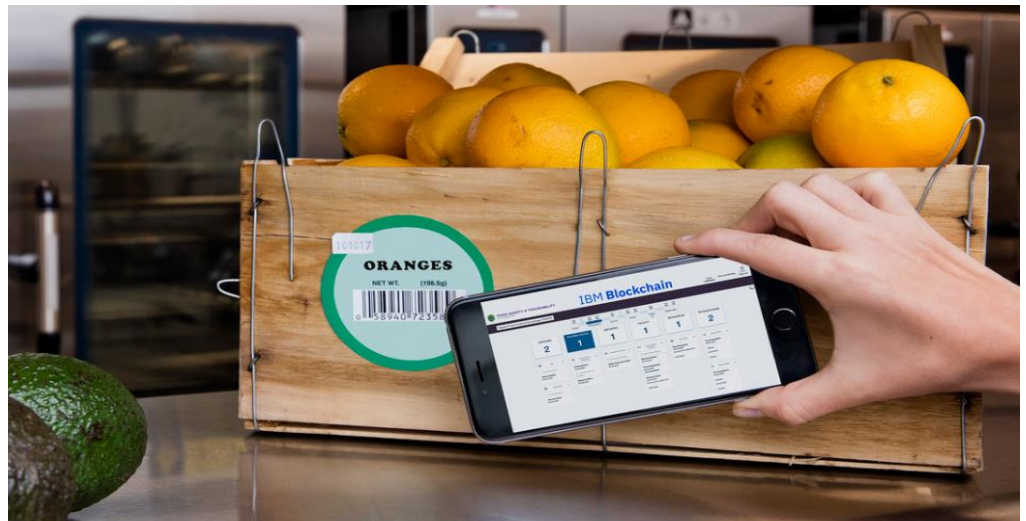
Source: IBM website and press release

RBC Capital Markets

What if…? In Cloud We Trust

What if *the "Asian Hyperscale Threat" becomes real? We could see companies like Alibaba, Baidu and Samsung scale their public cloud offering beyond the current regional presence and offer an alternative to the big three (Amazon, Microsoft and Google). What if Alibaba is Amazon's Amazon? What if this sparks a new round of national security conversations, along with all data sovereignty/safety issues that are associated with them?*

What if *there was a cyber event so vast that it shut down extensive portions of business, communications, utilities or infrastructure for days or weeks or longer? Would insurance be able to respond to the losses? Would governments have to step in to backstop? Would they? What if the event was perpetrated by a terrorist group or foreign government – would losses be excluded as an act of war?*

What if *data shortage becomes an issue? If data growth sustains the rampant pace we have seen and supply additions do not scale as they historically have, will we see a fundamental re-evaluation of data storage costs as the delta between data growth and capacity growth widens?*

What if *private datacenters become relegated to obsolescence (tape drive storage anyone?) because new workloads like machine learning and AI are born and scaled in cloud environments, resulting in another one of tech's infamous melting ice cubes?*

What if *the majority of hyperscale vendors shift their processing to self-developed ASIC solutions for their workloads? Could this be the next step to commoditizing storage and networking, to commoditize the processing stack?*

What if *legislation across geographies and regions becomes even more pronounced, resulting in the "HyperLocalized Cloud"? The importance of data usage and security in a cloud world cannot be understated. How will companies continue to adapt?*

What if *edge computing becomes an alternative to public cloud computing, taking the "data power" away from the hyperscale vendors and placing them back to the edge devices? This would bring power back to edge manufacturers – Samsung, Siemens, LG, Fanuc, etc., instead of the hyper-concentration of the Big 3 (Amazon, Google and Microsoft)?*

What if…? continued

What if governments around the globe decide that having the world's compute sitting in the hands of 3 or 4 companies is not acceptable. Regulation could come down hard, forcing a split-up of hyperscale companies into regional players and potentially forcing some other high-bar regulatory restrictions. Could IaaS companies become regionally regulated utilities?

What if the network becomes more valuable than compute? Despite this land-grab for compute and storage, what of the network? Could we see a land-grab for metropolitan cable operators and infrastructure? What about long-distance transport and who dominates that? Is the Microsoft and Facebook partnership on a new sub-Atlantic 4K cable just the start of a new capex arms race?

What if major consumer-facing software companies like Amazon, Apple, or Google decide to expand into industrial IoT? How do legacy equipment manufacturers compete against these well-established software titans from Silicon Valley?

What if hackers gain access to smart and connected vehicles?

What if IoT and a world of connected devices drive transaction speeds in payments beyond the capacity of the existing infrastructure? Will traditional payment rails be required to create their own token on blockchain to accommodate accelerated processing speeds?

What if apps become the bargaining chip and he hyper-scale war becomes a knife fight? Could O365 and Windows become available only to businesses who use Azure? Could Google buy Salesforce and force migrations, throttling usage for non GCP users? Could Amazon buy Adobe and bundle AWS storage and an Alexa interface with every Creative Cloud subscription? Would bidding wars erupt for key application leaders, and App software vendors find unique/exclusive captive homes within the larger respective players in a fight for market share?

Theme IV: Collective Action

The power to act collectively has never been greater given technology and the viral speed with which social sharing can occur. As a result, long-held beliefs in traditional institutions, social norms, and commerce are being challenged. Trust in one's peers vs. legacy institutions is quickly taking hold, as is the idea of decentralized organizations vs. centralized ones. As a result, we believe the pace of disruptive change will accelerate, but also believe increased collaboration between historical adversaries could increase, as incumbents seek to partner for survival via self-cannibalization and disruptors seek change at scale. In either case by 2025, we believe, as history has taught us, collective action will have transformed industries, evolved business models, and challenged the status quo.

What you need to know…

The power of collective action is undeniable, as history has illustrated through the years, ranging from the Civil Rights Movement, to the uprisings of the Arab Spring (Tunisia and Egypt among others), and most recently with the Me Too Movement.

The power to act collectively has never been greater given technology and the viral speed with which social sharing can occur. Today only about 54% of the global population has access to the Internet, but Moore's law is changing that quickly. It is estimated that by 2020 this figure will jump to 65%. As a result, developing countries are leapfrogging technologies (i.e., skipping landlines and going directly to mobile devices). We implore investors to imagine a world with 100% global Internet penetration (helped by more lower costs of devices/access and emerging mesh technologies). Where will society be 5 years thereafter? What inefficiencies will be brought to light?

Deterioration in trust is a key catalyst for Collective Action: While rapidly improving connectivity is a central driver of our Collective Action theme, it is the general deterioration in trust levels between consumers/citizens and traditional institutions/organizations that is motivating this phenomenon.

Key Collective Action developments include:

Independent work as rising distrust of large organizations appears to be felt across generations, which we believe is leading to the growing desire to "be one's own boss" and have more control over what work is done, what projects are chosen, and where and when work is performed.

Resale retail is expected to be bigger than fast fashion within 10 years. Resale disruptors – meaning online consignment sites – will own nearly one-third of closets by 2027, growing nearly 24x faster than retail as a whole.

Democratized finance, as Amazon and the other technology companies, either helped or hindered by the financial services firms, may disintermediate current banking models, we believe a more interesting model will arise in 2025 in which the consumer combines the aspects of self-sovereign IDs and control over their ID to remove most of the intermediaries in financial transactions.

Regulation as we believe Europe's new regulatory framework, General Data Protection Regulation (GDPR), will fall heavy on industries that rely on consumer data collection for their economic models. We believe this type of regulation could act as a blueprint for other developed and devolving countries to adopt, as such we see regulation as potentially reshaping many industries over the coming years.

Collective action – Power to the people!

Advancements in global connectivity have increased the pace at which groups can unite and catalyze change (versus relying on traditional institutions).

The idea of "collective action" is by no means a new phenomenon; but advancements in global connectivity have increased the pace at which groups can unite and catalyze change (versus relying on traditional institutions). Take for example the Civil Rights Movement. The efforts of activists and countless protestors brought about legislation to end segregation, black voter suppression and discriminatory employment/housing practices – but it took 14 years (1954–1968). How would this have differed with today's technology in place?

In 2008, a terrorist organization called the FARC (Revolutionary Armed Forces of Colombia) controlled approximately 40% of Colombia. The group was notorious for terrorism, drugs, arms dealing and kidnapping (at the time FARC was holding ~740 hostages, including Colombian presidential candidate Ingrid Betancourt and her campaign manager, Clara Rojas). Frustrated with a lack of government intervention, Oscar Morales created a Facebook group called "One million voices against the FARC." 12 hours later the group had 1,500 members. A day later 4,000. Within a month, Morales and 400k volunteers mobilized approximately 12M people in 200 cities across 40 countries to protest against the regime.

In 2009, Iranian presidential election protests were organized via Bluetooth (after the government shut down all Internet access to limit news flow). Much of the Arab Spring (2010–2012) was organized on Facebook. The Me Too movement grew through Twitter/Facebook. And this year's Brazilian truck driver strike was organized via WhatsApp.

This is just one example of technology's ability to unite individuals. In 2009, Iranian presidential election protests were organized via Bluetooth (after the government shut down all Internet access to limit news flow). Much of the Arab Spring (2010–2012) was organized on Facebook. The Me Too movement grew through Twitter/Facebook. And this year's Brazilian truck driver strike was organized via WhatsApp. But collective action is not just about shedding light on social injustices or unethical practices (e.g., lack of trust in traditional institutions). It is about the power of scale.

During the 17th century, Isaac Newton and Gottfried Wilhelm Leibniz (among others) each independently discovered calculus. Oxygen, too, was discovered independently by several people (Carl Wilhelm Scheele, Joseph Priestley, Antoine Lavoisier and others). Throughout history there are countless examples of "multiple discovery" including the theory of evolution of species (Charles Darwin and Alfred Russel Wallace), the blast furnace (invented independently in China, Europe and Africa), the crossbow (invented independently in China, Greece, Africa, northern Canada, and the Baltic countries), and magnetism (discovered independently in Greece, China, and India). Some of the most brilliant people throughout history have wasted years of their lives on technologies already in existence. Part of collective action is improvement in the sharing of information, which can catapult society forward.

Some of the most brilliant people throughout history have wasted years of their lives on technologies already in existence. Part of collective action is improvement in the sharing of information, which can catapult society forward.

Before the invention of the wheel, the concept of the cart, the carriage, the automobile, the wheelbarrow, the roller skate, and a million other offshoots of wheel-reliant transport were not imaginable. What if the blast furnace was invented once and others shifted their attention towards second and third derivative inventions? Or other fields altogether?

Just think about the exponential developments in content creation as a result of YouTube. On average, Hollywood produces 500 films per year and reaches a worldwide audience of 2.6B. Assuming an average length of two hours per film, Hollywood produces 1,000 hours of content annually. YouTube users upload 48 hours' worth of videos every minute. This means, every 21 minutes, YouTube provides more content than Hollywood does in 12 months.

Today only about 54% of the global population has access to the Internet, but Moore's law is changing that quickly. It is estimated that by 2020 this figure will jump to 65%. As a result, developing countries are leapfrogging technologies (i.e., skipping landlines and going directly to mobile devices). We implore investors to imagine a world with 100% global Internet penetration (helped by more lower costs of devices/access and emerging mesh technologies). Where will society be five years thereafter? What inefficiencies will be

We implore investors to imagine a world with 100% global Internet penetration (helped by more lower costs of devices/access and emerging mesh technologies). Where will society be five years thereafter? What inefficiencies will be brought to light?
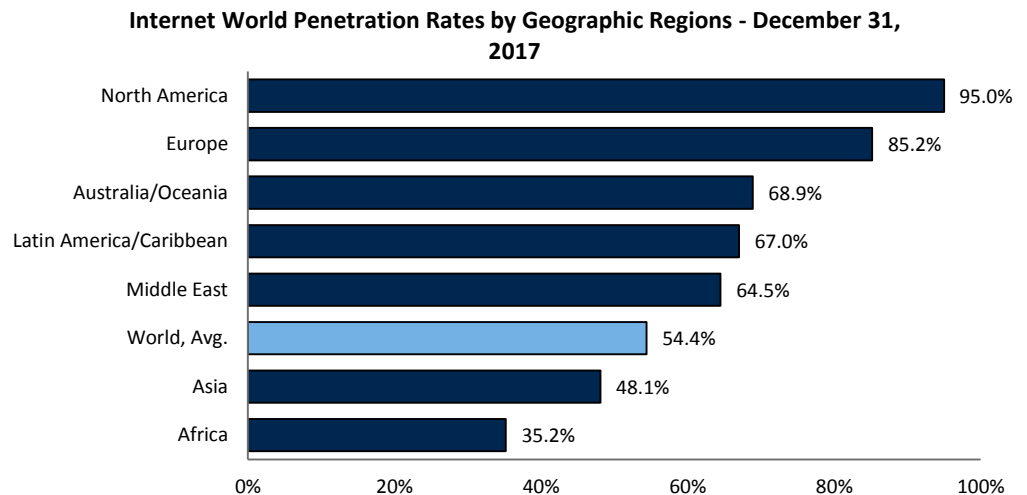
brought to light? In this section, we hope to frame potential cultural, societal and technological advancements as functions of collective action.

Exhibit 72: Global population and Internet users, 2000–2020

Global Population and Internet Users, 2000-2020
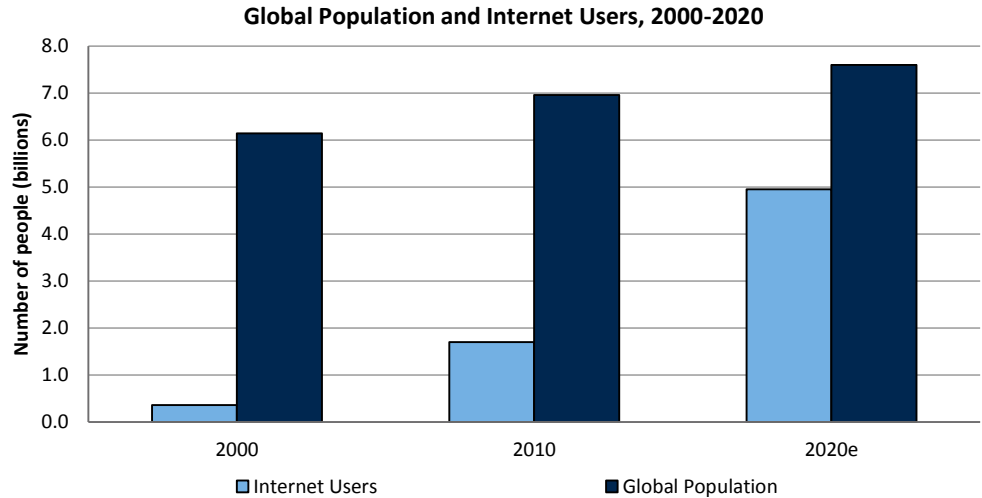
Source: www.futuretimeline.net, RBC Capital Markets estimates

Exhibit 73: Internet penetration rates

Internet World Penetration Rates by Geographic Regions - December 31, 2017

| Region	Rate
North America	95.0%
Europe	85.2%
Australia/Oceania	68.9%
Latin America/Caribbean	67.0%
Middle East	64.5%
World, Avg.	54.4%
Asia	48.1%
Africa	35.2%

Source: World Stats, RBC Capital Markets

With deteriorating trust for traditional institutions/organizations, consumers/citizens are more frequently both forming organizations of their own or acting independently – in turn putting pressure on larger, traditional organizations to retain both talent and customers.

Deterioration in trust is a key catalyst for collective action

While rapidly improving connectivity is a central driver of our Collective Action theme, it is the general deterioration in trust levels between consumers/citizens and traditional institutions/organizations that is motivating this phenomenon. With deteriorating trust for traditional institutions/organizations, consumers/citizens are more frequently both forming organizations of their own or acting independently – in turn putting pressure on larger, traditional organizations to retain both talent and customers. Consumers have even gone as far as banking directly with one another. These emerging preferences (all in part rooted in lack of trust) have become manifest in the ideas we discuss in this section, including: the "gig and sharing economy" and democratized finance.

Exhibit 74: Government trust levels continue to reach new lows

% who trust the govt in Washington always or most of the time
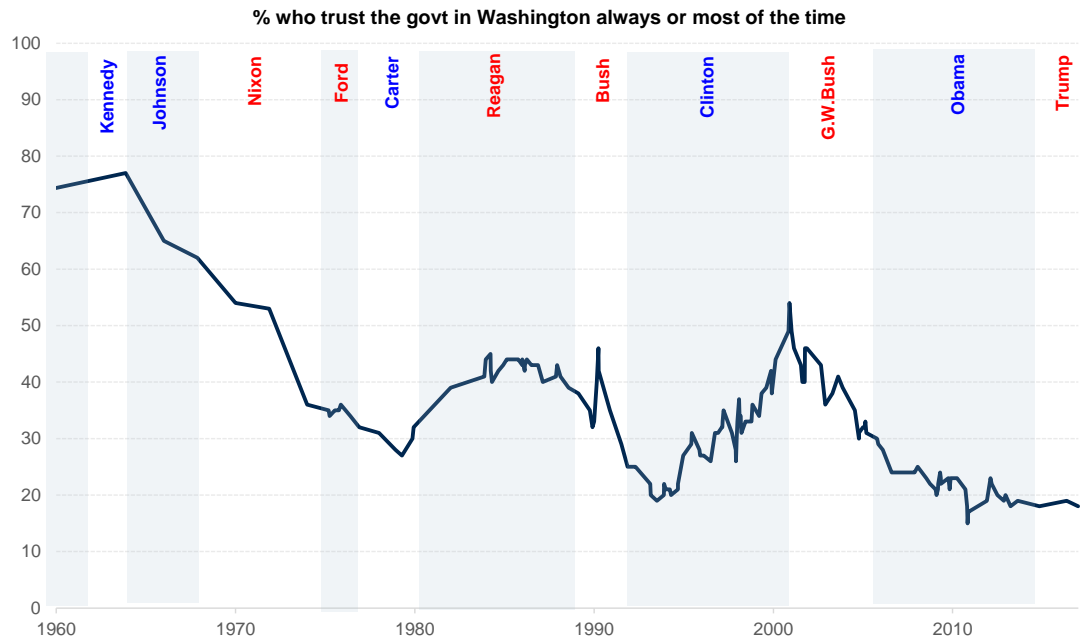
Source: PEW Research Center

Disruption, emerging business models and improving value propositions

With trust levels continuing to deteriorate and global connectivity increasing at a rapid clip, we expect to see Collective Action become a more powerful driver of change as we look out to 2025. This phenomenon is already starting to manifest in several ways: 1) improvement in value propositions across industries, 2) the evolution of the labor force, 3) the creation of new business models, 4) rising empowerment of the consumer, and 5) the democratization of finance.

Evolving and improving value propositions through the "collective good"

As we look across global industries, we see many great examples of how industries from healthcare to leisure are vastly improving their value propositions to consumers/citizens by participating in "collective action."

Take, for example, the healthcare industry. Today, medical systems mostly act as competitors and do not share data. However, advancements in data sharing technology and security are beginning to enable a more open architecture as it relates to healthcare. One example of this is at Intermountain Healthcare, where the Oncology Precision Network (OPeN), an initiative to end cancer, allows physicians in 11 states, 79 hospitals, and 800 clinics to share data involving approximately 50,000 new cases per year – changing the world of oncology by collecting, storing, and sharing genetic data. This massive network allows its members to make new diagnostic associations, which are then get shared among medical professionals. Aetna estimates that enabling open sharing in just 10 percent of the $3 trillion cost of U.S. healthcare would surpass the knowledge gained by all of the funded clinical research. Consumer healthcare costs could also be lowered through the development of incentive plans that paid consumers for their data up to a certain threshold (to discourage both consumers and doctors from seeking excessive medical treatment in exchange for data compensation).

We see many great examples of how industries from healthcare to leisure are vastly improving their value propositions to consumers/citizens by participating in "collective action."

Advancements in data sharing technology and security are beginning to enable a more open architecture as it relates to healthcare.

The rise of the "gig" and "sharing" economies

The days of lifetime
employment with a single
company that provides a
pension and retirement
health insurance are long
gone for most workers, and
many will (either by desire
or necessity) cycle through
more than a dozen jobs in
their working years.

This more recent consumer-
driven change has spurred
growth of the "gig"
economy, which Wikipedia
defines as "a labor market
that is distinguished by the
prevalence of short-term
contracts or freelance work
rather than permanent
jobs."

According to a December
2016 paper in the National
Bureau of Economic
Research, alternative
workers comprised 15.8%
of the U.S. employee base
as of 2015, up from 10.7%
in 2005.

The days of lifetime employment with a single company that provides a pension and retirement health insurance are long gone for most workers, and many will (either by desire or necessity) cycle through more than a dozen jobs in their working years. Much of this change in recent decades has been driven by corporate efficiency initiatives, global competition, and changing regulations. However, in the last decade, the shift has also been pushed more aggressively by workers demanding more control over their careers, the work they do, the hours they work, and the environment in which they work.

This more recent consumer-driven change has spurred growth of the "gig" economy, which Wikipedia defines as "a labor market that is distinguished by the prevalence of short-term contracts or freelance work rather than permanent jobs." Much of the recent media coverage of the gig economy has focused on the Millennial generation and their desire for more work flexibility, and also on the "sharing economy" through digital platforms like Uber, Task Rabbit, and Airbnb. Both are meaningful drivers, and the sharing economy is indeed growing rapidly. However, we believe that a broader definition including temporary workers, on-call workers, contract labor, freelancers and independent contractors more fully describes the sub-set of alternative or independent workers (i.e., those doing project or task-based work and without a long-term relationship with an employer).

According to a December 2016 paper in the National Bureau of Economic Research, alternative workers comprised 15.8% of the U.S. employee base as of 2015, up from 10.7% in 2005. This is acceleration from the more modest shift towards independent workers in the prior decade. It is also interesting to note that the increasing penetration occurred across all income levels, though by a lesser rate at the lowest income tier.
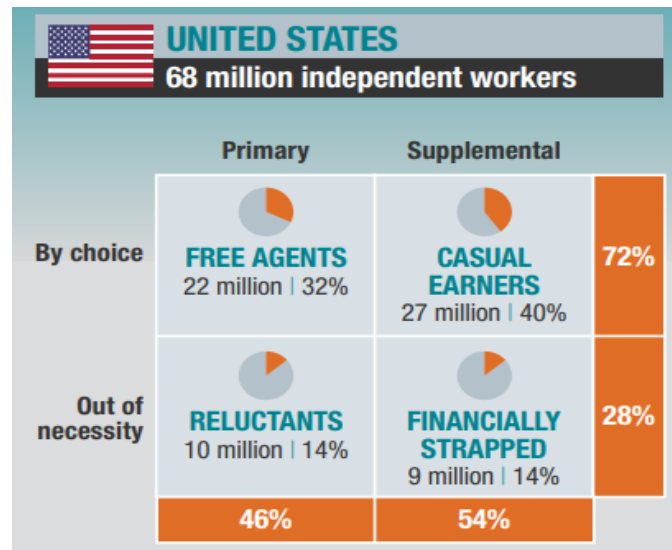
Exhibit 75: Alternative work arrangements on the rise across income levels
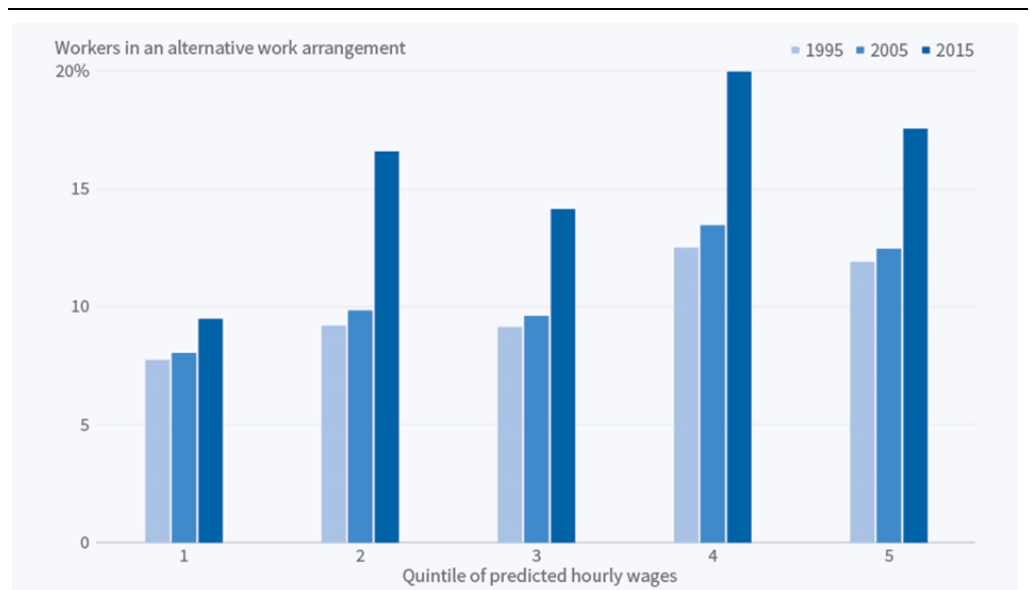
Source: National Bureau of Economic Research article, *"Putting Price Tags on Alternative Work Arrangements"* (December 2016)

40% of U.S. workers
participate in some form of
alternative work, with 28%
pursuing that path out of
necessity, and 72% doing so
by choice.

A McKinsey Global Institute study (*Independent Work: Choice, Necessity, and the Gig Economy*, October 2016) takes a broader definition that includes those doing freelance or independent work for supplemental income. Under this definition, the study argues that more than 40% of U.S. workers participate in some form of alternative work, with 28% pursuing that path out of necessity, and 72% doing so by choice.

Exhibit 76: Breakdown of United States independent workers

Source: National Bureau of Economic Research, "The Rise and Nature of Alternative Work Arrangements in the United States, 1995-2015 (December 2016)
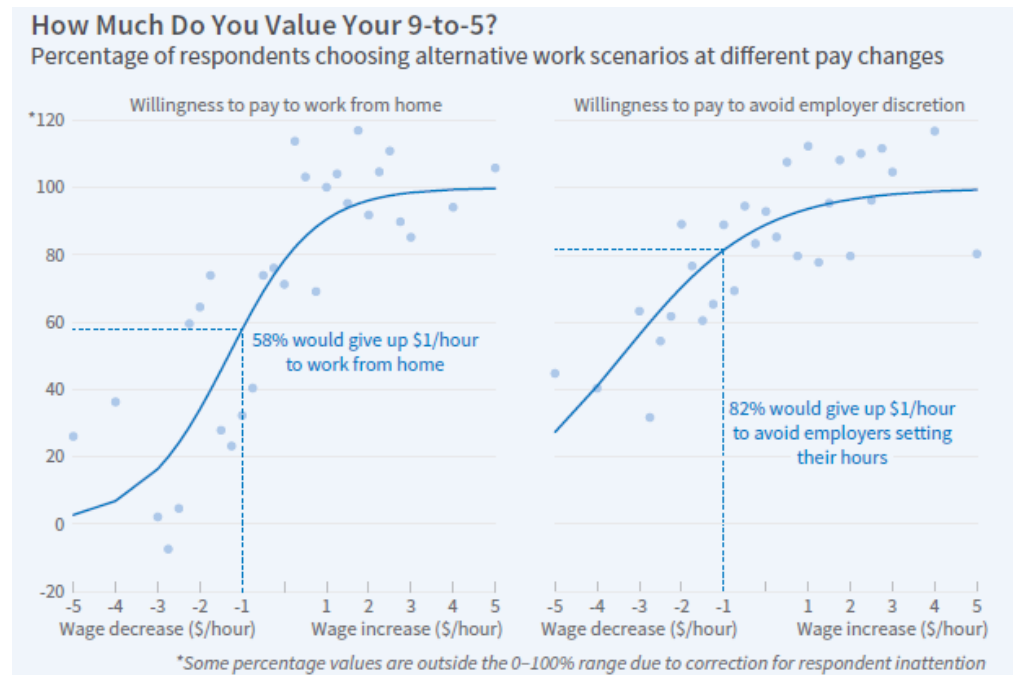
Motivations for independent work

While some of this shift towards independent work is driven by corporate agendas and/or regulatory reasons, there are several motivations for workers' increasing desire to work independently. One key motivation appears to be the waning appeal of a traditional 9-to-5 long-term job with a single employer. For many, this may be rooted in the disappointment and disillusionment workers experienced during the 2001 and 2008 recessions (and for younger workers, the experience of their parents). Why should an employee stay devoted to one job/one boss if there is no reciprocity?

Another facilitator of the growing trend towards alternative work arrangements is the growth of the sharing economy and in particular digital platforms that act as efficient marketplaces to connect workers with consumers or companies looking to acquire their services. This includes a wide range of businesses like Uber (ride hiring), TaskRabbit (a lower-skill freelancer marketplace), and Airbnb (accommodation rentals). These and many other digital marketplaces harness technology and provide an efficient way for independent workers to connect with those needing their services. The McKinsey report estimates that 15% of independent workers use these digital marketplaces today.

Generalizing broadly, the Millennial generation in particular is seen as demanding more flexibility and work–life balance, and having more desire to understand the motivations of their employer and be contributing to an organization that is doing community good in addition to just driving profits. However, rising distrust of large organizations appears to be felt across generations, which we believe is leading to the growing desire to "be one's own boss" and have more control over what work is done, what projects are chosen, and where and when work is performed. The exhibit below illustrates the appeal to U.S. workers of non-traditional arrangements, with 58% and 82% of survey respondents willing to give up $1/hour of compensation to work from home and avoid employers setting their hours, respectively.

Another facilitator of the growing trend towards alternative work arrangements is the growth of the sharing economy and in particular digital platforms that act as efficient marketplaces to connect workers with consumers or companies looking to acquire their services.

Exhibit 77: Survey data shows that U.S. workers value characteristics of independent work

Source: National Bureau of Economic Research, *"The Rise and Nature of Alternative Work Arrangements in the United States, 1995-2015"* (December 2016)

With widespread Internet and mobile use and productivity software, many job functions can literally be done anywhere.

The tailwinds driving the growth in the current gig economy are unlikely to subside, in our view. In the National Bureau of Economic Research report cited earlier, the authors calculated that ~94% of U.S. job growth between 2005 and 2015 was from the range of alternative arrangements (contractors, temps, freelancers, etc.).

Corporate behavior and technology progress are also driving this trend. It makes sense that before the onset of wireless networks and the Internet, being in the office was of critical importance. However, now with widespread Internet and mobile use and productivity software, many job functions can literally be done anywhere. This has allowed workers to be productive outside of a traditional office setting, which we believe has been key to many workers' demands for more flexibility. The technology revolution of recent decades has also allowed corporations to successfully use more contract and temporary labor in their drive for efficiency, while the trend of outsourcing non-core capabilities has also spurred the growth of independent contractors. We believe that technology has arguably been the largest driver of the expansion in alternative or independent work (both in terms of the mix of workers and the growing desire of workers to pursue these arrangements).

Growing mix of independent workers to continue

So, where does this trend go from here? The tailwinds driving the growth in the current gig economy are unlikely to subside, in our view. In the National Bureau of Economic Research report cited earlier, the authors calculated that ~94% of U.S. job growth between 2005 and 2015 was from the range of alternative arrangements (contractors, temps, freelancers, etc.). Looking forward, we expect the growth of independent workers to continue, and for them to be a meaningful driver of employment growth from here. We see technology remaining a key facilitator. And, the relatively early stage of many of the sharing economy digital platforms likely points to continued strong growth, if not acceleration from here. The McKinsey Global Institute report cited above also indicated that 1 in 6 employees in traditional arrangements would like to become primary independent earners in the future, which supports the thesis that growth of alternative working will continue.

Implications for businesses and workers

While traditional employment arrangements with businesses are likely to remain the largest employers of U.S. workers by 2025, we expect the mix of alternative workers to continue to

rise, which has a number of implications for both workers and businesses. From a worker perspective, independent workers (whether temps, freelancers, or other) are less likely to get health insurance, retirement savings contributions, or many other benefits that full-time employees in traditional arrangements generally receive, which could raise the risks and/or costs for these workers. On the other hand, increased flexibility and the ability to work for oneself is a meaningful (in many cases more than offsetting) positive for many workers.

From a business perspective, continued worker demand for flexibility, along with likely increased hiring difficulties as more qualified workers shift to independent arrangements, could pressure costs or limit growth. Corporations will likely need to become more flexible and focused on employee satisfaction, and have the difficult task of creating a good work environment and employee morale while also driving their bottom lines.

Emerging business models

Payment option evolution coupled with improved consumer connectivity and increased security measures have led to consumers sharing their assets, and what were once private experiences, with strangers in exchange for compensation.

Examples of this include uberPOOL, where consumers are not only sharing rides with strangers. Another example is the Coachsurfing app, a more affordable approach to AirBnB that offers the opportunity to "stay with locals in every country on earth." In the future, we think sharing will not be limited only to experiences but consumers will also share autonomous vehicles, clothes and even furniture among other physical possessions.

Exhibit 78: uberPOOL has proven to be effective
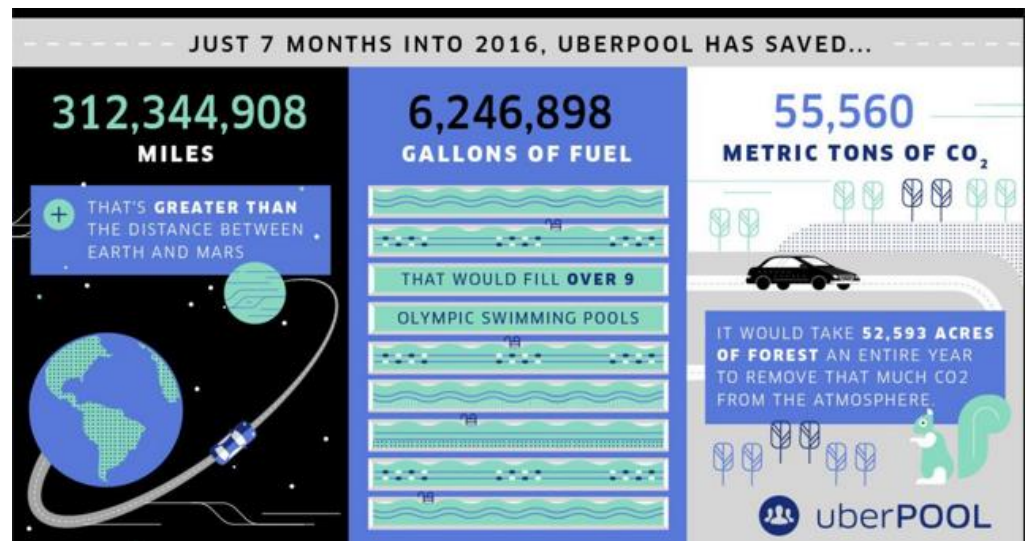
Source: Uber

Empowering the consumer

In the retail world, where most transactions have traditionally been purely based on material value (aka lowest price), we have only recently started to see other factors also matter in purchase decisions. More specifically, for decades a race to the bottom in terms of pricing has been the name of the game, particularly with the emergence of fast fashion (H&M, Zara, Uniqlo, Primark etc.). However, we believe this will continue to rapidly change as:

Side notes (left column):

From a business perspective, continued worker demand for flexibility, along with likely increased hiring difficulties as more qualified workers shift to independent arrangements, could pressure costs or limit growth.

Payment option evolution coupled with improved consumer connectivity and increased security measures have led to consumers sharing their assets, and what were once private experiences, with strangers in exchange for compensation.

In the future, we think sharing will not be limited only to experiences but consumers will also share autonomous vehicles, clothes and even furniture among other physical possessions.

1) Millennials prioritize social values over price and ask for greater transparency of the manufacturing process,

2) growth in peer-to-peer retailing significantly surpass traditional retailers, and

3) influencer posts and peer reviews become key marketing tools.

Transparency matters

Transparency is a new word in retail, as until recently consumers did not have tools to question where the goods came from or what corporate values the retailers stood for. However, we believe as fast fashion retailers stretched traditional pricing bands (think Forever 21's $7.99 dress and Uniqlo's $50 cashmere) with questionable manufacturing practices, consumers have increasingly started to question how ethically the products were made and delivered to the shelves.

Millennials day: Social values > price

According to Nielsen, 66% of consumers are willing to spending more on a product ("Corporate Social Responsibility Matters: Ignore Millennials at Your Peril", Huffpost blog, February 5, 2016) if it comes from a sustainable brand. Millennials gave an even more impressive showing, with 73% of surveyed Millennials indicating a similar preference. Additionally, 81% of Millennials even expect their favorite companies to make public declarations of their corporate citizenship ("Millennials Expect More Than Good Products, Services To Win Their Loyalty", Forbes, May 22, 2014). Additionally, according to a 2016 Deloitte Millennial Survey, 87% of Millennials believe that a business' success should be defined by more than just financial performance, and 73% of Millennials said that business should have a positive impact upon wider society. With these stats in mind we have begun to see the emergence of "socially conscious retailing" with brands that employ a "buy one give one" philanthropy model. This altruistic model has attracted others including Warby Parker (eyeglasses) Bombas (socks), Roma (boots), Smile Squared (toothbrushes), SoapBox (soaps), Figs (medical scrubs), State (backpacks) and WeWood (watches) to name a few.

Exhibit 79: Tom's shoes is one of the first socially conscious retailers


Source: mic.com

This approach has proven successful, becoming a storytelling tool and good opportunity to acquire customers away from traditional retail models. As we look out, we expect more retailers will not only be forced to make sure their products are ethically produced, but also provide greater transparency, including the whole manufacturing journey of the product.

Transparency is a new word in retail, as until recently consumers did not have tools to question where the goods came from or what corporate values the retailers stood for.

We expect more retailers will not only be forced to make sure their products at are ethically produced, but also provide greater transparency, including the whole manufacturing journey of the product.

Transparency in manufacturing: I need to know how you made this product

Everlane's website gives shoppers of its $168 modern loafer a look at how its COGS breakout.

Digitally native retail business models are looking for ways to help acquire customers and give them a new "story" to tell other consumers. One way some digitally native companies have achieved this is through the transparent model – giving the consumer a peek behind the curtain to see exactly how the product is sourced, produced and ultimately priced to the end user. Founded in 2010, Everlane, an apparel company that subscribes to the transparent model, sought "to exploit the market inefficiency of brick-and-mortar retail." Viewed as the pioneer of the transparent model, Everlane's website gives shoppers of its $168 modern loafer a look at how its COGS breakout (Materials $18.25, Labor $29.16, Freight $1.47, Duties $4.75) help contribute to the "only" 2–3x markup of Everlane product compared to 5–6x of traditional retailers. And while the shopper now feels empowered with knowledge of exactly what they are paying for, they can also browse information on the 23 factories around the world currently being used by the company to make goods. Other direct-to-consumer companies that take the consumer behind the scenes include Beauty Pie Oliver Cabell, Noahny, and Elizabeth Suzann.

Exhibit 80: Everlane and Beauty Pie are among the retailers that break out the production cost of products on their website
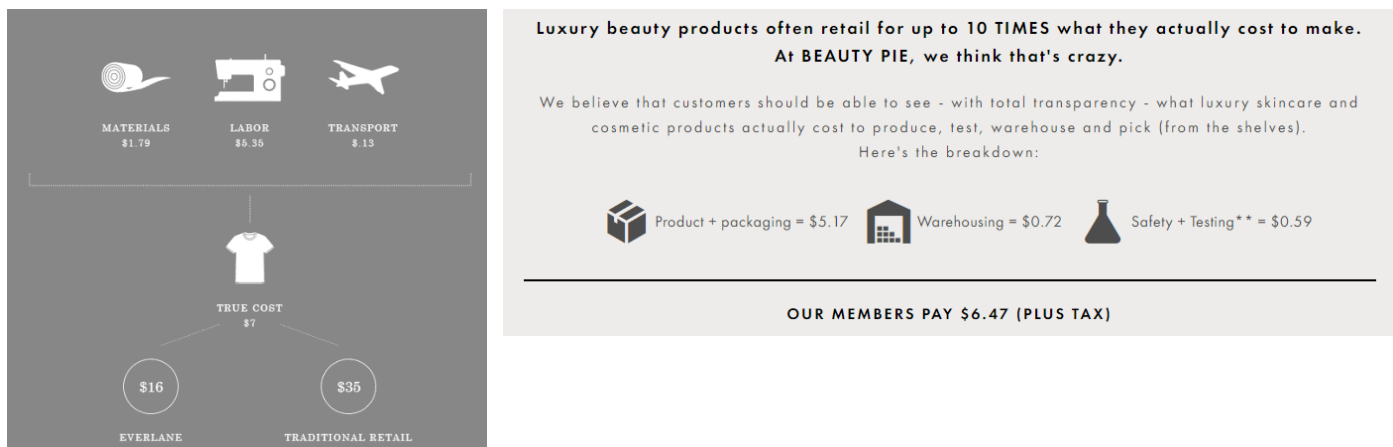
Source: Everlane & Beauty Pie websites

Will peer-to-peer retailing consumers bypass traditional retailers?

Over the last two years, the peer-to-peer or resale model has been gaining traction much faster than anticipated (showing +49% growth vs +2% growth in overall apparel category), and doesn't seem like it will it doesn't appear likely to slow down.

Everyone's favorite customer segment, Millennials, are both incredibly wasteful and sustainability-minded at the same time. They are an impulsive generation when it comes to shopping (typically discard items after 1-5 wears) but at the same time, 77% of them say they prefer to buy from environmentally conscious brands and they are "more likely to switch to thrift for environmental reasons." Capitalizing on this, resale sites, as well as sharing platforms have often positioned themselves as sustainable alternatives to fast fashion: a way to satisfy a constant social media-driven desire for newness without contributing to the negative environmental impact of buying disposable fashion from companies like Zara, H&M, and Forever 21.

We believe it is important to highlight that particularly over the last two years, the peer-to-peer or resale model has been gaining traction much faster than anticipated (showing +49% growth vs +2% growth in overall apparel category), and it doesn't appear likely to slow down. More notably, according to thredUP, a leading resale website, over the next 5–10 years peer-to-peer purchases will account for up to 15%, a significant increase from ~5% today.

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Exhibit 81: Direct to consumer is expected to account for 1/3 of clothing purchases


RETAIL IS CHANGING, NOT DYING

Meet the Closet of the Future
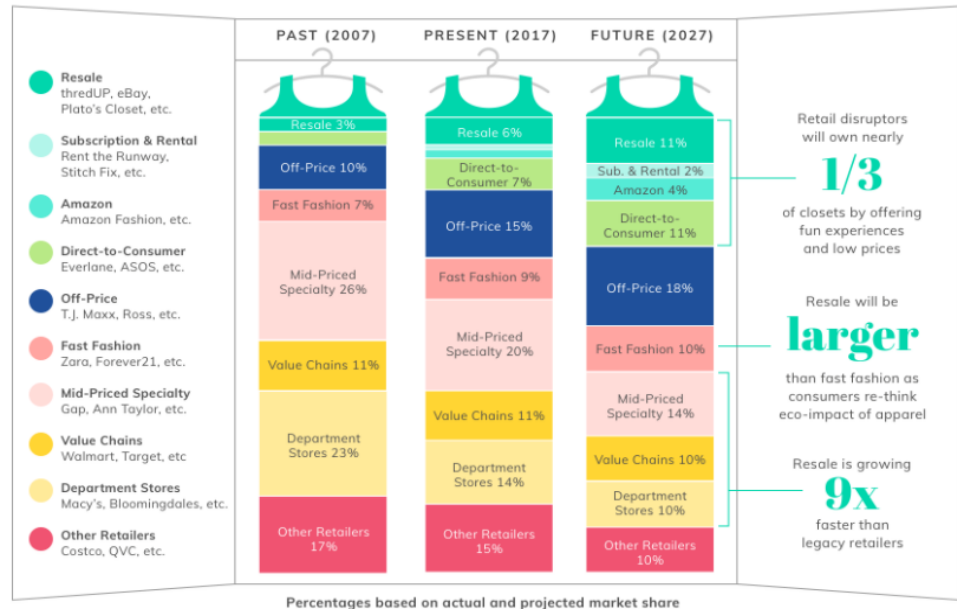
Source: thredUP

Resale is expected to be bigger than fast fashion within 10 years. thredUP says the resale market will be worth $41B by 2022, and 49% of that will be apparel. Resale disruptors — meaning online consignment sites — could own nearly one-third of closets by 2027, growing nearly 24x faster than retail as a whole: 49% YoY vs. 2%. The 3 leading resale disruptors are said to be thredUP, The RealReal, and Poshmark, which have raised $130M, $173M, and $153M respectively (Fashionista, 4/3/18).

Exhibit 82: Resale model
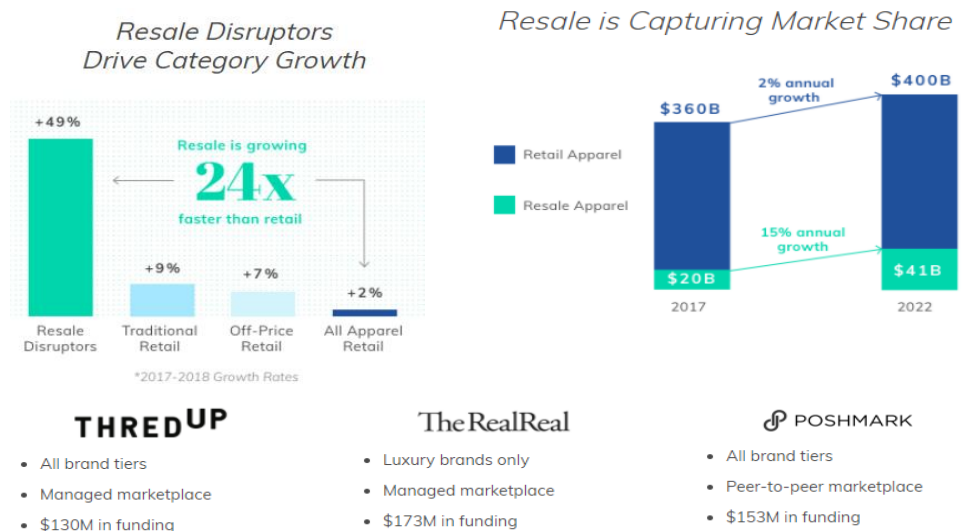
Source: Tradesy

Clothing as a service is the future of fashion. According to online plus-sized retailer Gwynnie Bee, subscription is a superior model for the modern fashion consumer – and the company is white-labeling its CaaS (Clothing as a Service) platform, which would allow retailers to offer a subscription clothing rental business alongside their existing way of doing business. Most Gwynnie Bee customers prefer to swap items rather than own them because they are renting fashion-forward items that may be too on-trend (and therefore too temporary) to invest in. To work with the CaaS platform, retailers are required to send over their inventory, and Gwynnie Bee takes it from there, performing all of the delivery and cleaning logistics in their own warehouses, building a consumer-facing, front-end suite in the retailer's name, and getting paid on a per-customer basis every time a consumer signs on with the retailer's CaaS offering. In this way, the consideration barrier becomes much lower and consumers are more willing to wear many more types of clothes than they are willing to buy outright, which can ultimately lead to more purchasing on the whole as consumers expand their taste and broaden their fashion preview (PYMTS, 3/29/18).

New era marketing

As consumers begin to lose trust in large retailers due to various reasons including lack of pricing integrity and loss of fashion authority, influencers and peer reviews have been emerging as a more reliable source for product reviews and recommendations. Especially in this 'You' era where consumer-generated content significantly surpasses the more static company/retailer-generated content, product reviews and peer opinion is becoming the most trusted contributor to purchase decisions.

> As consumers begin to lose trust in large retailers due to various reasons including lack of pricing integrity and loss of fashion authority, influencers and peer reviews have been emerging as a more reliable source for product reviews and recommendations.

Exhibit 83: The You era: Consumer-generated content disrupting traditional media

Source: Flickr

Social media the new #1 marketing platform

In addition to product reviews on retail websites, Instagram is the primary platform for product reviews. On Instagram #ootd (outfit of the day) has ~180M posts and the LIKEtoKNOW.it app, which is one of the more prominent platform influencers used to monetize posts, sends 20M+ monthly emails linking back to products, and features 1K+ new content posts daily.

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Exhibit 84: Instagram fashion influencer posts


Source: Instagram

Looking at social media user/content growth metrics and retailers' shift of marketing spend to digital from traditional, coupled with consumers' willingness to hear the voice of peers versus retailers, we have confidence that over the next few years peer reviews will be the most important marketing tool for any retailer.

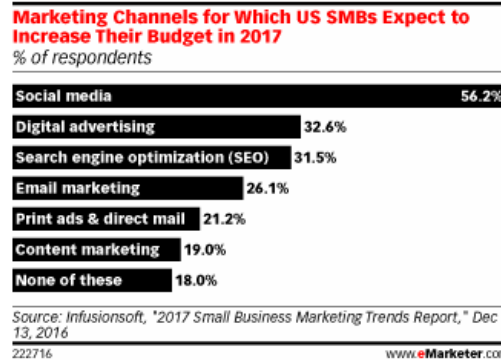Exhibit 85: Total number of social network users worldwide from 2010 to 2021 (in billions)
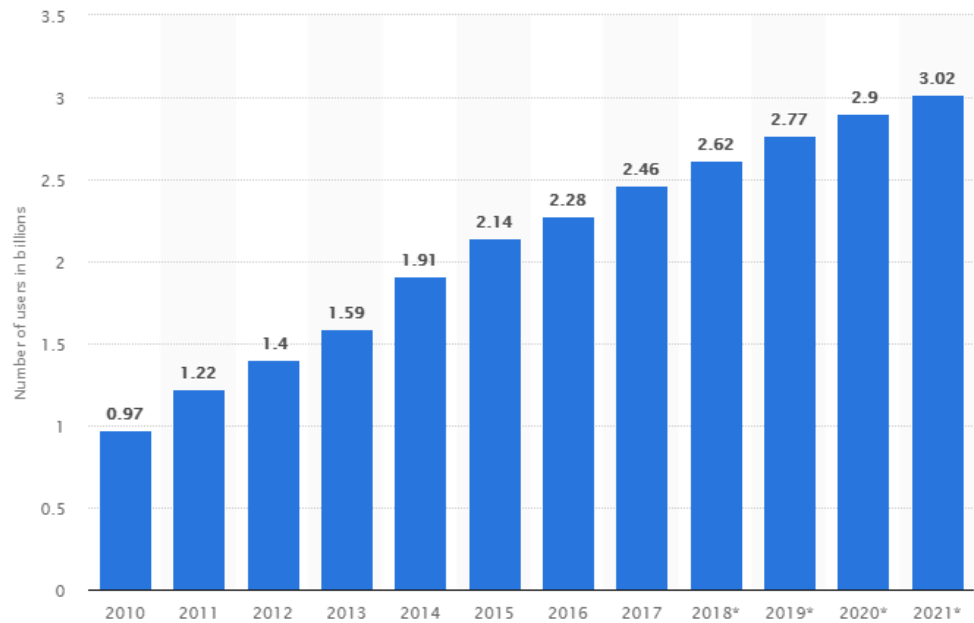
Source: Statista

Exhibit 86: Marketing spend shifting to digital from traditional
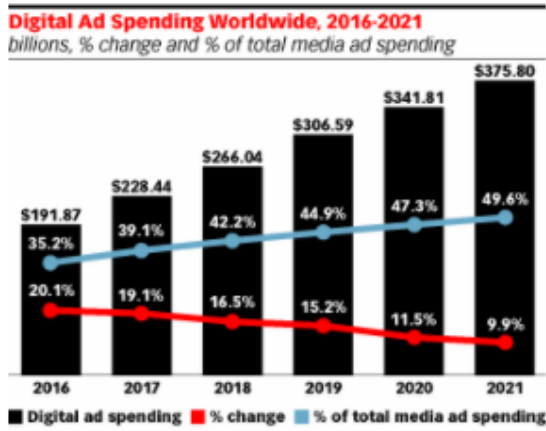
Source: eMarketer

For skeptics of social media marketing, we highlight that the parent company of the LIKEtoKNOW.it app, rewardStyle, has already facilitated over $1.8B of sales since 2011, which implies 78% annual growth rate. We expect social media marketing to continue to grow at 50%+ and become the most effective marketing tool.

Exhibit 87: rewardStyle facilitated sales
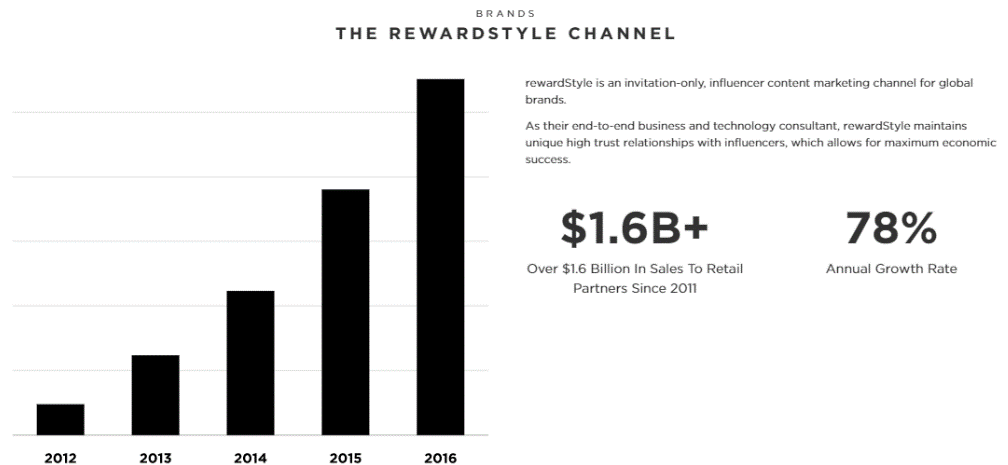
Source: rewardStyle

Similarly, product reviews on retailer websites are one of the most important drivers of product sales, particularly for new brands and products.

Similarly, product reviews on retailer websites are one of the most important drivers of product sales, particularly for new brands and products. Hence, more and more newer brands are working with influencers to have honest reviews featured with the product to capitalize on the power of product reviews.

Exhibit 88: Peer reviews significantly help sales of new brands and products

Source: Bazaarvoice

Democratized finance – technology & financial services for the underbanked
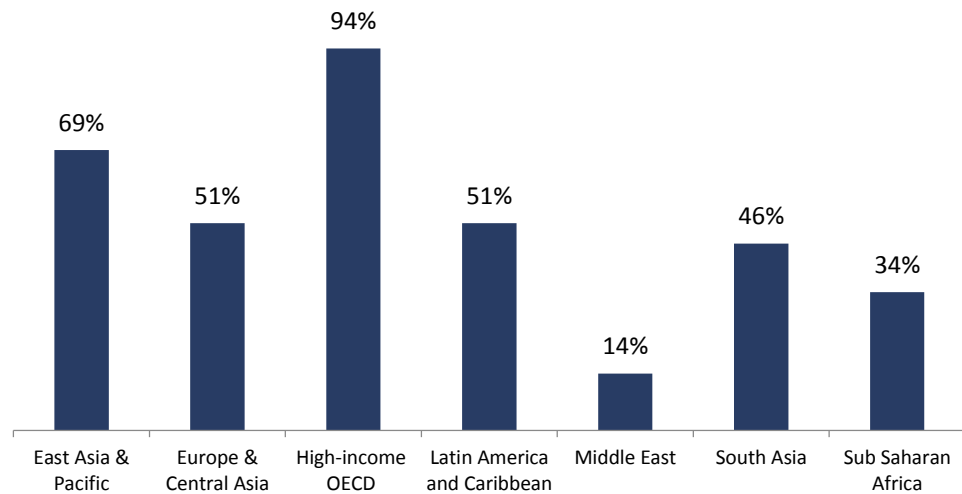
According to the World Bank, in 2017, ~2B adults globally did not have a financial account, while 200M micro-, small- and medium-sized enterprises (MSMEs) in emerging economies lacked adequate financing. Although 59% of adults cited a lack of money as the main reason for not having a financial account, a significant number noted the distance from a financial provider, the lack of necessary documentation and a lack of trust in financial institutions. We believe that technology will work to solve many of these issues by 2025 and note the efforts discussed above when it comes to "necessary documentation," i.e., self-sovereign IDs, and trust, discussed above.

According to World Bank data, 62% of the world's adult population had an account with a financial institution or mobile money service in 2014, up from 51% in 2011. However, there are still 2B unbanked "people," though down from 2.5B in 2011. In developing countries, account ownership has increased to 54% in 2014 from 41% in 2011. Of those, 58% of account holders use their account to directly make or receive electronic payments, 39% use it to save and 12% use their account at least 3 times a month.

Exhibit 89: Financial inclusion across regions, 2017

Region	Value
East Asia & Pacific	69%
Europe & Central Asia	51%
High-income OECD	94%
Latin America and Caribbean	51%
Middle East	14%
South Asia	46%
Sub Saharan Africa	34%

Source: World Bank, RBC Capital Markets

Technology for the underbanked

We believe that financial services firms (such as Amazon and "fintechs") are looking at technology solutions such as mobile phones to service the underbanked.

We believe that financial services firms (such as Amazon and "fintechs") and financial services firms are looking at technology solutions such as mobile phones to service the underbanked. We note that mobile payment use first saw its greatest adoption in the emerging economies with such solutions as M-PESA and has distinctly lagged in locations such as the U.S. that have a well-developed financial ecosystem. Even in these "developed" economies, a large portion of consumers are underbanked (for example, according to U.S. government statistics, ~30% of the U.S. population is considered underbanked).

Exhibit 90: Number of U.S. households (left) and individuals (right) at various banking levels
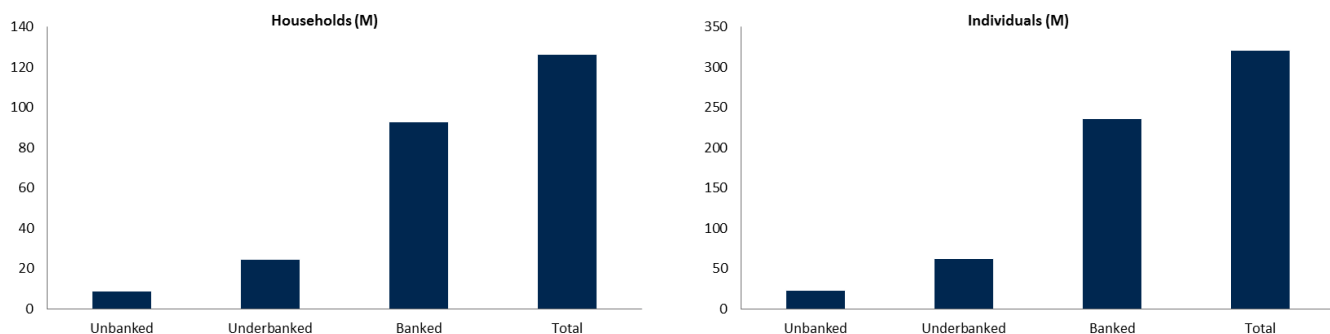
Source: FDIC, U.S. Census Bureau, RBC Capital Markets

An example - financial products as part of a broader Amazon ecosystem

Longer term, offering checking accounts in partnership with banks could be the first step in Amazon offering a broader suite of financial services products for both consumers and businesses.

Longer term, offering checking accounts in partnership with banks could be the first step in Amazon offering a broader suite of financial services products for both consumers and businesses. While not a direct parallel, we note that the "Big 3" Asian payment platforms (Alipay, WeChat Pay and Paytm) all offer lifestyle apps, combining ecommerce with a host of other services including travel and financial services and a "potential playbook for large technology providers." In many ways, we can equate Alipay to a combination of Amazon and PayPal and WeChat Pay to a combination of Facebook and PayPal.

On January 30th of this year, Amazon, Berkshire Hathaway and JPMorgan Chase announced that they were "partnering on ways to address healthcare for their U.S. employees, with the aim of improving employee satisfaction and reducing costs."

We believe a more interesting model will arise in 2025 in which the consumer combines the aspects of self-sovereign IDs and control over their ID to remove most of the intermediaries in financial transactions.

Interestingly, on January 30th of this year, Amazon, Berkshire Hathaway and JPMorgan Chase announced that they were "partnering on ways to address healthcare for their U.S. employees, with the aim of improving employee satisfaction and reducing costs." The three firms created an independent company focused on technology solutions "that will provide U.S. employees and their families with simplified, high-quality and transparent healthcare at a reasonable cost" according to the press release.

We could almost see Amazon combining its consumer data analytics on spending habits, with financial analytics from the "open banking" information, of which the checking account partnerships could be just the first step, to extend its solutions into such areas as household budgeting, retirement planning, financial planning and healthcare insurance planning, etc.

Banks may not look like banks in 2025

While Amazon and the other technology companies, either helped or hindered by the financial services firms, may disintermediate current banking models, we believe a more interesting model will arise in 2025 in which the consumer combines the aspects of self-sovereign IDs and control over their ID to remove most of the intermediaries in financial transactions. At the end of the process, we believe that financial transactions are essentially about trust – trust that a consumer will receive the good or service wanted, trust that a merchant will receive the correct value for that good or service, trust that contracts will be enforced, and so on. Currently, that "trust" can only be found in governments and large financial institutions when it comes to money. If trust can be found in different parties then new business models could emerge.

As an example, consider the credit card networks. They are built on trust. The consumer has a trust that she will have access to purchasing power at many locations on a global basis and some protection from fraud, etc., while the merchant, who has no information about the consumer at all, has trust that a transaction is "good funds" and will be willing to provide the good or service.

Non-traditional lending

We expect the trend of financial democratization to further expand its reach, as consumer demand for non-traditional lending products continues – from the advent of the marketplace/peer-to-peer lending space in 2006, and the founding of Prosper and Lending Club soon after in 2007, growth in both total loan outstandings as well as annual volumes have expanded exponentially. We expect expansion to continue meaningfully into the foreseeable future, with the impetus of demand stemming from lack of traditional forms of financing for borrowers seeking loans that are outside of the box (e.g., uncollateralized loans, loans for borrowers not meeting typical underwriting characteristics). On the consumer side, these loans primarily include debt consolidation products and personal loans, though given typically attractive rates and longer repayment terms; they're also increasingly utilized as a source of consumption. Small business loans are a modest component of the whole, but a growing contingent as well. Traditional lenders also offer personal loans, though usually in the form of debt consolidation products vs. alternative forms of funding, and mostly on a much smaller scale/focus and with more restrictive underwriting.

Exhibit 91: U.S. personal lending balances outstanding ($B)
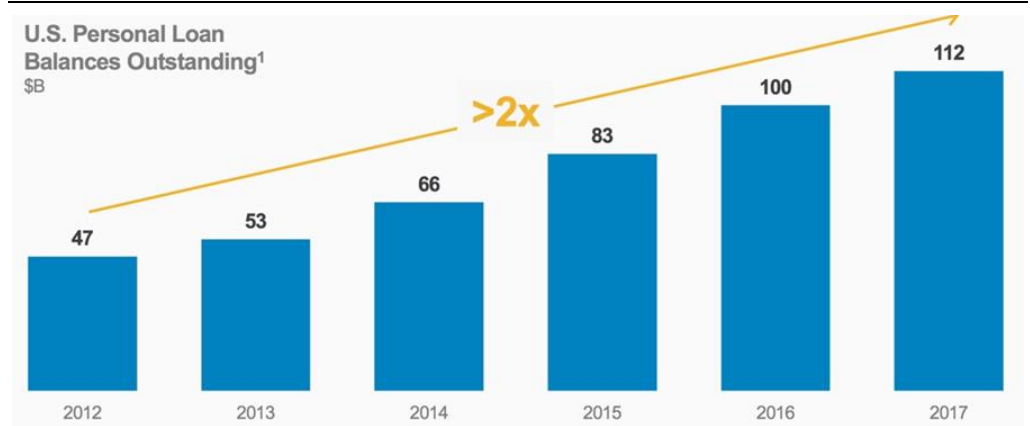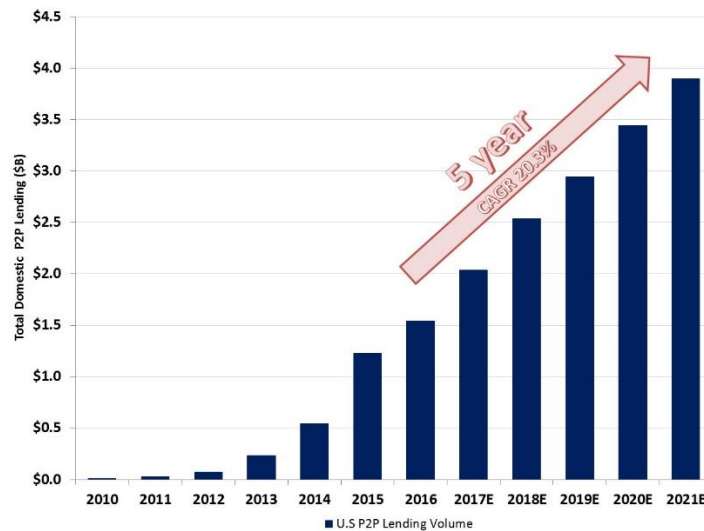

Source: Lending Club, TransUnion Industry Insights Report

Exhibit 92: Total estimated P2P consumer and business market growth
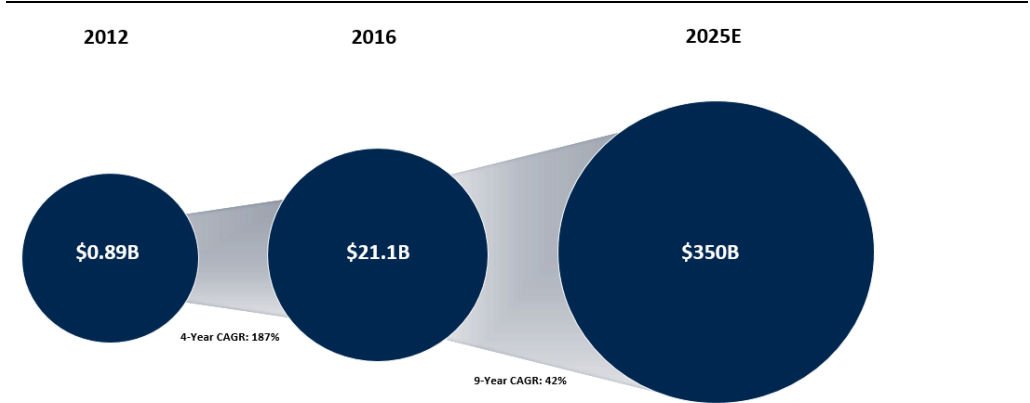
Source: Cambridge Centre for Alternative Finance, Polsky Center for Entrepreneurship and Innovation, Medici Insights

Exhibit 93: Total annual U.S. P2P loan origination volume – 2017E

Source: IBIS World – Peer to Peer Lending Platforms

Exhibit 94: Market share by model (2016)
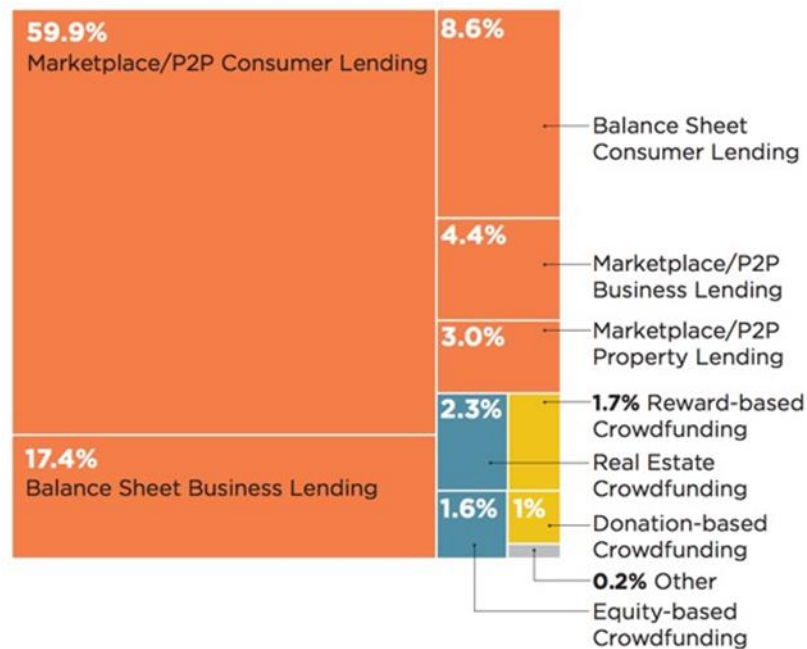
Source: Cambridge Centre for Alternative Finance Industry Report 2017

What's next/What's in store ahead?

We expect growth to continue its path ahead in non-traditional lending into the middle part of the next decade and beyond, as these lenders continue to grow in number and scope and offer a product that is attractive to consumers. The consumer lending market is very large at approximately $13.1 trillion, and while not all of it is addressable via alternative/marketplace lenders (several cite the addressable market as $300–$350 billion), a sizable portion of it is certainly open for share gains, while we view consumer capacity to service additional debt as

supportive of growth as well. Marketplace/P2P lending may even expand into other lending categories such as student lending and asset-backed lending such as auto/mortgage in underserved borrower categories.

Exhibit 95: Consumer debt is a $13.1 trillion market – Room for expansion

Total Consumer Debt Balance and its Composition

As of 4Q17. Source: FRBNY Consumer Credit Panel/Equifax
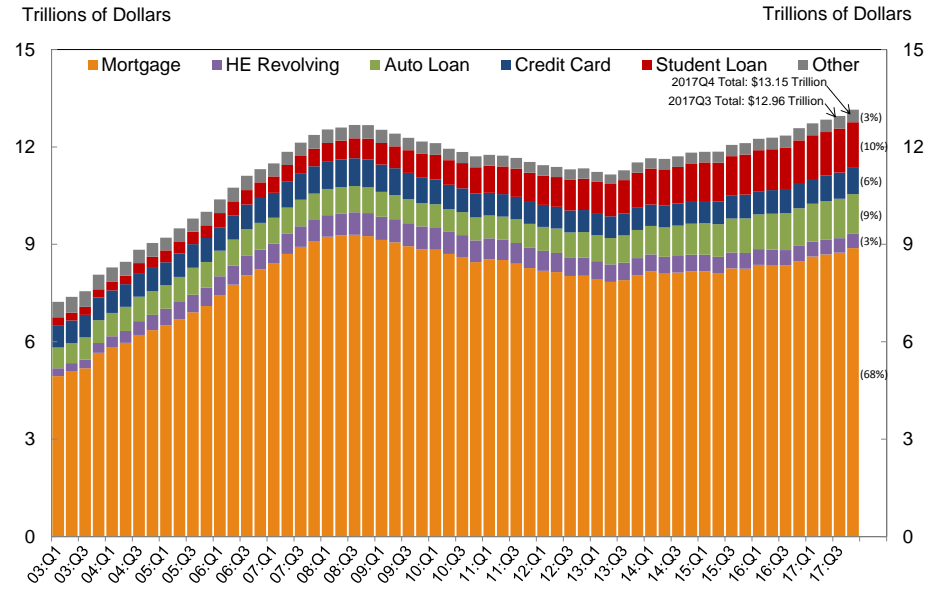
Exhibit 96: Capacity to borrow – Debt service payments below 1980s lows

As of 4Q17. Source: Federal Reserve Board
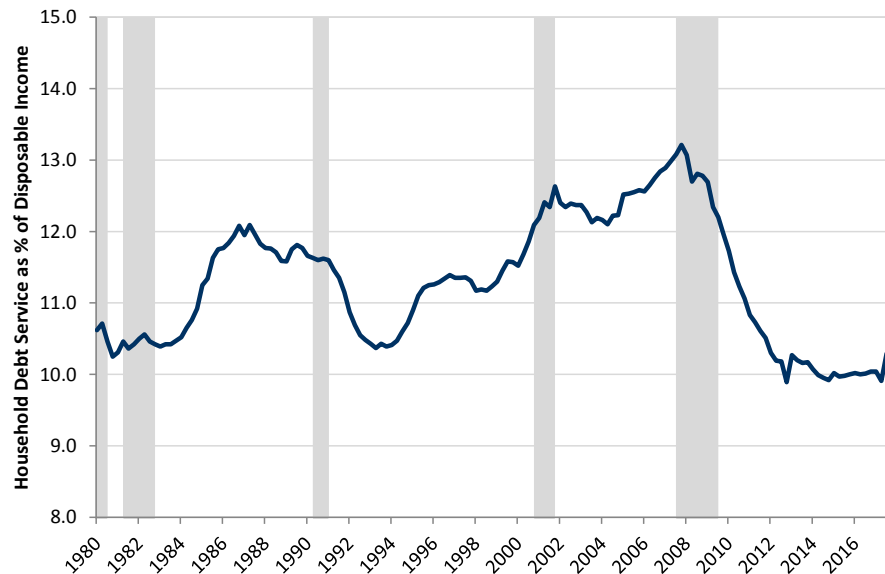
That said, while the growth opportunity may still offer significant upside, we believe several key challenges ahead will need to be addressed among the non-traditional marketplace/alternative lenders:

Issue #1 – How to sustain growth?

One obstacle to growth in this market segment is funding – unless established as a regulated bank or Bank Holding Company (BHC), significant growth and funding availability is limited. The financial business model requires at least some leverage, so this tends to be the biggest obstacle to growth for non-bank lenders, and one that tech companies generally choose to avoid given the high capital requirements (particularly for higher-risk loans) and other regulatory burdens imposed on these entities. Marketplace lenders currently utilize traditional banks to either warehouse/securitize marketplace loans, or as investors in the loans themselves.

Issue #2 – How will credit losses affect model funding?

We also believe those consumer-focused strategies that are third-party funded will eventually come to face a major model test at the next macroeconomic downturn – if credit losses are higher than these relatively new lenders forecast in their models, funding availability at a minimum will come at a potentially substantially higher cost, or funding could potentially dry up all together.

Issue #3 – Will bank regulatory relaxation lead to increased competition?

Another possible challenge to the space is via banks, who with regulatory relaxation may find opportunities to enter the space. Changes have only recently begun in earnest, but in addition to new entrants, competition from traditional lenders could emerge. Goldman Sachs' new Marcus personal lending business is a good first example of a large financial delving into the space – given Marcus has its own online deposit-gathering capabilities, it also already has a leg up on issue #1 above.

Private label card: Another way of voting with dollars

While general purpose credit cards will almost certainly remain the industry leader, we do believe there is a potentially large opportunity for private label cards given the unlock of online/mobile consumer spending.

Beyond seeking additional forms of financing, we also expect consumers to increase their focus on greater control of how they pay for goods and services. We see the private label card space as a key beneficiary of democratization of finance – with cardholders taking greater control of how they are served by issuers, and how they are rewarded for their spending. In the past, private label card issuers struggled to offer appealing economics/utility to borrowers to incent them to take on private label credit cards, particularly with attractive rewards/interest rates and utility offered by general purpose card issuers. While general purpose credit cards will almost certainly remain the industry leader, we do believe there is a potentially large opportunity for private label cards given the unlock of online/mobile consumer spending.

Online and mobile unlock robust potential growth

Online and mobile consumer retail spending growth continues dramatically, outpacing traditional in-store retail spending, and is showing no signs of changing course. We view this shift as a critical component to support the growth of private label card; card utility and physical wallet space have always been key limiting factors to private label card uptake and use. We see further expansion of mobile consumer spending as a substantial opportunity for growth—with card accounts loaded into a consumer's online account vs. a physical presence, eliminating the "wallet space" obstacle. In combination with increased consumer utility, we believe that economic appeal has been on the rise (attractive rewards and discounts for card use), while merchants find private label cards appealing given the lack of merchant discount fees for purchases (vs. general purpose cards), profit sharing with card issuers, along with increased consumer engagement and marketing opportunities.
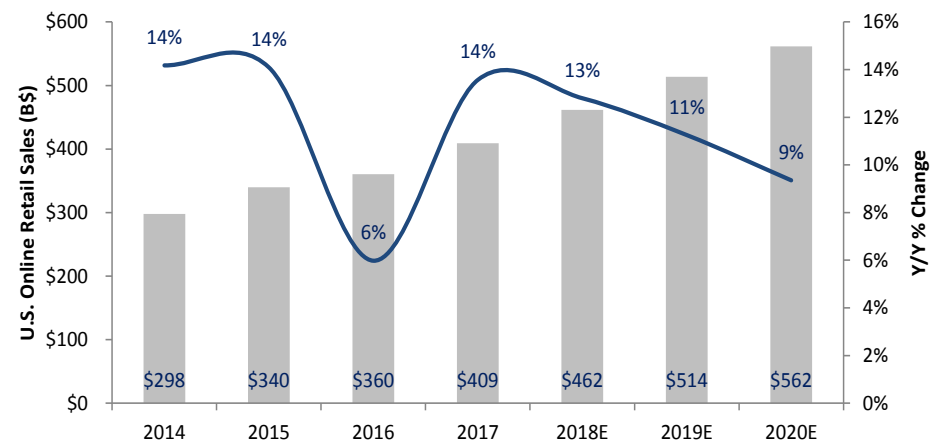
Exhibit 97: Card online & mobile purchase volume rising rapidly
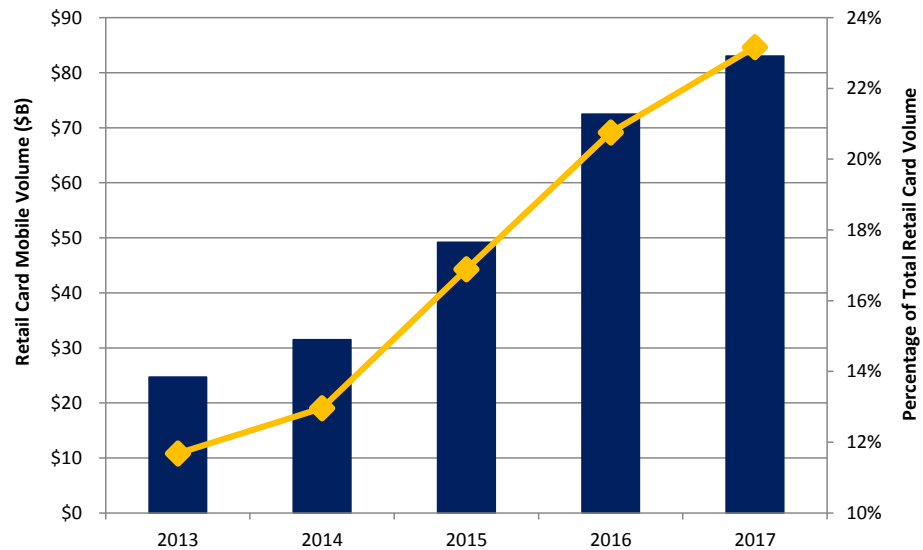
As of FY17. Source: ComScore Ecommerce

Exhibit 98: U.S. online retail sales estimates

As of 4Q17. Source: United States Census Bureau, Commerce Department, Statista Digital Market Outlook

Mobile wallet a particularly compelling long-term opportunity

Mobile wallet technology has been in existence for 8–10+ years, but so far there have been significant constraints to consumer uptake and use—varied technology (online wallet, cloud-based, near-field communications [NFC], and other app-based platforms have all been targeted for use) along with limited merchant acceptance have been the more meaningful obstacles. Apple Pay launched in 2014, and we view it as one of the most successful platforms thus far in terms of consumer adoption, though it remains highly constrained by the economic structure (with Apple retaining more of the economics than bank issuers prefer in most cases), and limited push from merchants to promote acceptance. Merchant acceptance is also a major constraint, particularly given the very slow rollout of NFC-capable point-of-sale (POS) terminals. Google Wallet, PayPal, Amazon, Android Pay, and Samsung Pay are among the larger competing participants in mobile wallet platforms, but these too have seen relatively limited consumer adoption thus far due to either limited merchant

Apple Pay launched in 2014, and we view it as one of the most successful platforms thus far in terms of consumer adoption.

RBC Capital Markets

acceptance or other factors. Additionally, most mobile payment platforms do not provide the ability for consumers to add private label card acceptance—they typically only target general purpose credit and debit cards.

Exhibit 99: Plastic and virtual plastic work together, not apart

Source: RBC Capital Markets

Exhibit 100: Global mobile NFC worldwide market forecast
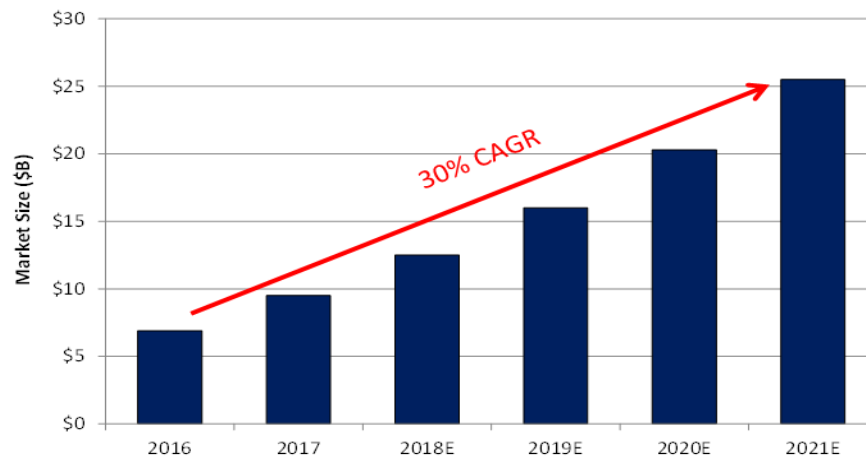
Source: Statista Digital Market Outlook

We believe that either one of the current mobile wallets or a new platform will emerge over the next several years with a business model that addresses most or all of those currently present in the market – it will have:

1) Acceptance at most merchants accepting plastic for payment, with a potential work-around for those that do not accept plastic (potentially via Zelle).

2) Ability to load any card (general purpose or private label) into the mobile wallet.

3) Very limited to no drain from the payment network/acquirer or card issuer economics – so card issuers and networks/acquirers are incented to promote the use/acceptance.

4) Direct marketing capabilities – paired with Big Data, this could be a powerful new tool in consumer marketing.

Important to note that we continue to believe that mobile payments will maintain a symbiotic relationship with physical cards and bank issuers.

Important to note that we continue to believe that mobile payments will maintain a symbiotic relationship with physical cards and bank issuers. Occasional media stories suggest mobile payments will be the end of plastic cards, or the "Uber-ization" of card-issuing banks by tech firms—we see neither as likely anytime soon. Mobile payments should be viewed as a convenient alternative to plastic, and an "accelerant" of the longer-term shift to cashless payments that is already well underway. With banks and other lenders a critical component of the equation funding consumer spending via borrowing, we also see very little likelihood of tech firms entering the space without this capacity—no tech firm we could imagine would desire to become a bank holding company.

"You have got to own it" – Self-sovereign IDs could be a game changer

Although the Internet was built on a decentralized and open protocol, it lacked a standard from which to directly identify individuals or organizations, which ultimately gave rise to specific companies and websites establishing usernames and passwords for individual identification. As the power of the Internet began to accrue to centralized organizations, large amounts of siloed-data specific to each site have emerged, resulting in large scale data breaches, rising privacy concerns, and lack of control over one's own identity.

Exhibit 101: The identity issue still remains today

"On the Internet, nobody knows you're a dog."

Source: The New Yorker 1993, RBC Capital Markets

We believe self-sovereign IDs will emerge as the solution, both securely protecting one's identify, through cryptographic encryption, while empowering the individual to determine with whom and how to share their digital identity and data.

We believe self-sovereign IDs will emerge as the solution, both securely protecting one's identify, through cryptographic encryption, while empowering the individual to determine with whom and how to share their digital identity and data. The ultimate goal is to achieve four basic requirements:

1) Governance: The network must be "Trusted" by all stakeholders

2) Performance: Providing self-sovereign IDs at Internet scale

3) Accessibility: Ensure the identity is available to all

4) Privacy: Strongest privacy standards in the world

The evolutionary process is developing across four stages as illustrated in Exhibit 103.

1) Centralized – in which the consumer's identity is owned and controlled by a single entity

2) Federated – enables user portability by allowing the user to sign on to multiple sites with the credentials of another; think of using your Facebook credentials to sign in and create accounts on various websites

3) User-centric – relies on independent personal data stores (sometimes large social networks), but is still beholden to the contractual user agreements

4) Self-sovereign ID – independent of individual data silos, is decentralized, and entirely controlled by the individual

Exhibit 102: Evolution to self-sovereign IDs

| Centralized | Federated | User-Centric | Self-Sovereign |

Source: The Path to Self-Sovereign Identity, RBC Capital Markets

We believe two significant technological innovations are occurring to enable self-sovereign IDs to come to fruition: 1) the World Wide Web Consortium (W3C) is standardizing the format of digitally signed credentials and 2) public blockchains can provide decentralized registration and discovery of the public keys needed to verify digital signatures.

Blockchain enables self-sovereign IDs

The significance of standardizing digital credentials is that an entirely new global ecosystem can be created consisting of credential issuers, owners, and verifiers, which would enable the exchange of interoperable verifiable claims. An example would be if Matt wanted to open a banking account with XYZ bank, the bank then requires two forms of proof-of-identity, to comply with "Know Your Customer (KYC)" rules. Matt chooses two government-supplied verifiable claims: 1) a postal address and 2) a driver's license. Once confirmed and the account opened, Matt is then issued a **digitally signed credential**, which can be utilized across multiple access points when KYC regulation is required. This simple use case can be replicated in healthcare, insurance, education, retail etc., thus developing a credential repository, stored in a public blockchain and embedded and controlled by the individual via a self-sovereign ID. With an estimated one seventh (~1.1B) of the world's population not having a legal identity today, we believe the implications for self-sovereign IDs are enormous, not the least of which is to democratized finance.

The potential to create new "gig-like" business models through the "monetization of self" by controlling and owning one's own data and only sharing this data with companies, entities, and governments of the individual's choosing could massively disrupt traditional advertising models. We could see businesses created (similar to Filecoin, which incentivizes open hard drive sharing by earning Filecoins for a user's available hard drive space), by incentivizing users to share their data in return for "data coins." In this regard, companies like Facebook and Google that freely capture our data, would be required to incentivize/compensate the users for data capture in order for their existing economic business models to work. We could foresee a scenario whereby Facebook and Google begin to embrace the blockchain in such a way as to issue their own individual tokens (think Facebook coin or Google coin) as the behavioral incentive mechanism to capture individual data, although we think this is an extremely unlikely event – black swan – in the next 10 years.

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The potential to create new "gig-like" business models through the "monetization of self" by controlling and owning one's own data and only sharing this data with companies, entities, and governments of the individual's choosing could massively disrupt traditional advertising models.

Rage against the machine: The revolt against "data gatherers"

While Collective Action normally works in a positive way, we believe the care of our personal data will become increasingly important and we are already starting to see movement in this area outside the U.S. (which could at some point, bleed into the U.S.).

We think political and regulatory outcomes are going to help redefine who will control and influence the "greater good" brought about by "Collective Action." We believe Europe's new regulatory framework, General Data Protection Regulation (GDPR) will fall heavily on industries that rely on consumer data collection for their economic models. We believe this type of regulation could act as a blueprint for other developed and devolving countries to adopt; as such, we see regulation as potentially reshaping many industries over the coming years.

We think political and regulatory outcomes are going to help redefine who will control and influence the "greater good" brought about by "Collective Action."

Consumer trust is disappearing

According to Pew Research, close to 50% of Americans do not trust the federal government or social media sites to protect their data.

Even before recent headlines around data breaches and Facebook privacy, American consumers' trust in key institutions to protect their personal information was low. According to Pew Research, close to 50% of Americans do not trust the federal government or social media sites to protect their data. Consumers around the world also vary widely in the level of privacy that they would prefer or find acceptable. In a Pew survey, 85% of Germans favored the more stringent European data privacy standards, while only 29% of Americans felt the same.

GDPR in Europe vs. the U.S.

In January 2012, the European Commission set out plans for data protection across the EU and a reform package entered into force in May 2016 that includes General Data Protection Regulation (GDPR) that will be applicable as of May 25, 2018.

In January 2012, the European Commission set out plans for data protection across the EU and a reform package entered into force in May 2016 that includes General Data Protection Regulation (GDPR) that will be applicable as of May 25, 2018. Under the regulation, every organization doing business with EU customers will need to make changes to its oversight, technology, processes, and people to comply with the new rules. Any organization processing data relating to an identified or identifiable person, called data subject, needs to comply with GDPR and the consequences of not following it can result in fines of up to 4% of the organization's turnover or up to €20M, whichever is higher.

Exhibit 103: Table of key GDPR components

Area	Definition	Requirement
Consent	Freely given, specific, informed and unambiguous indication of the data subject's agreement to the processing of personal data relating to him or her.	Consent can be written or oral statement, it can even be ticking a box when visiting a website; but silent consent, inactivity and pre-ticked boxes do not constitute consent.
Personal data definition	Any information relating to an identified or identifiable natural person.	This will include unique identifiers including IP address and cookies. This makes cookie use subject to the same consent requirements.
Right to access	The person, whose data is collected, has the right to obtain confirmation of whether personal data is being processed and for what purposes.	Right to access must be provided free of charge unless the request is repetitive, excessive or unfounded.
Right to be forgotten	The right to be forgotten means the right to demand the erasure of data.	The data subject has the right to be forgotten for which he/she no longer consents to data processing or which are no longer necessary to process.
Breach notification	Security breaches must be reported.	Controller obliged to report the breach to supervisory authorities unless the personal data breach is unlikely to result in a risk to the rights and freedoms of natural persons.
Privacy by design	Controllers must implement appropriate technical and organizational measures to meet the GDPR requirements.	Controllers are required to hold and process only data that is necessary for the completion of duties, and limit access to personal data to those doing the processing.
Data portability	Right to transfer data means that the data subject at any time should be allowed to receive, in machine-readable format, the personal data concerning herself.	Organizations, on request, must be able to deliver a person's data in a suitable format.
Data protection officers	A contractor, new hire or a member of the organization's staff.	All organizations are obliged to have a DPO.

Source: RBC Capital Markets

RBC Capital Markets   Theme IV: Collective Action
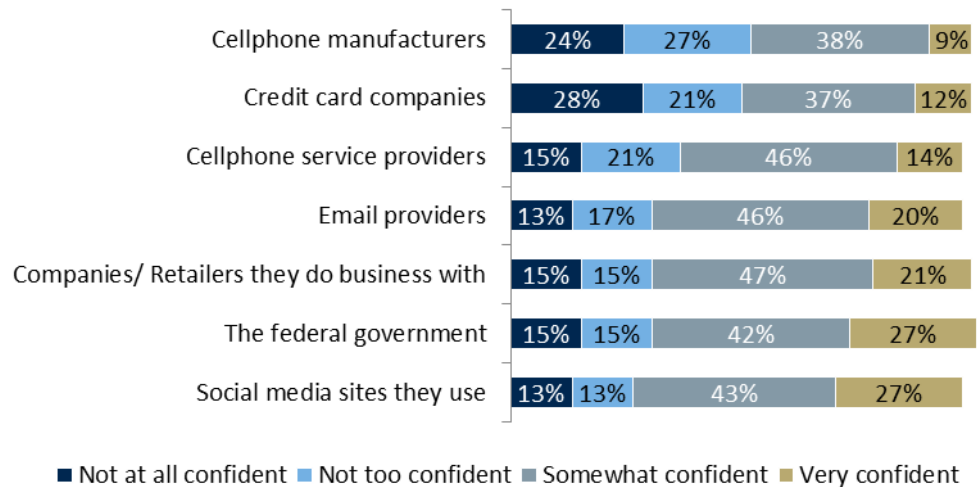
In our opinion, GDPR will give consumers higher control of their personal data. A new study by Pegasystems found that 82% of European consumers plan to exercise their new rights to view, limit or erase the information businesses collect about them. Additionally, 90 percent want direct control over how companies use their data, while 89 percent want to see what the data companies store on them. However, only 21 percent know what GDPR is or what it will enable them to do, indicating that widespread consumer action may be delayed until more awareness of these rights reaches the mainstream.

Given the global reach of GDPR, as all companies doing business with EU citizens must implement it for those citizens, we expect its standards to become global (in developed markets) practice by 2025, replacing significantly looser standards in the U.S. and elsewhere. We note, for example, that Facebook has recently stated its intention to apply GDPR to the U.S. as well as the EU.

Consumer pushback after Facebook & breaches

Given recent data breaches including Equifax and Cambridge Analytica/Facebook, we believe that consumers have become more concerned over the security and use of their data. A recent Reuters' survey that coincided with the Cambridge Analytica/Facebook revelations, found that while most people used Facebook through the day more than they used Twitter, Instagram, Pinterest, Tumblr, Snapchat or Google+, 51% said they don't trust the platform "at all" or "very much." Even before the revelation, a survey by The Verge found that roughly 30% of U.S. consumers either "somewhat" or "greatly" distrusted Facebook's handling of their personal data. The Reuters' survey further found that 41% of Americans trusted Facebook to some extent to obey laws protecting user data privacy, while Amazon had the highest trust score (66%) followed by Google (62%), Microsoft (60%) and Yahoo (47%).

Exhibit 104: % confidence of U.S. adults in companies to protect their personal data, by type (2017)

Source: Thomson Reuters, RBC Capital Markets

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Exhibit 105: % of U.S. consumers who trust companies to protect personal data (2017)

Company	Trust	Don't Know	Don't trust
Amazon	66%	10%	24%
Google	62%	9%	29%
Microsoft	60%	12%	28%
Apple	53%	16%	31%
Yahoo!	48%	16%	37%
Facebook	41%	9%	51%

■ Trust ■ Don't Know ■ Don't trust
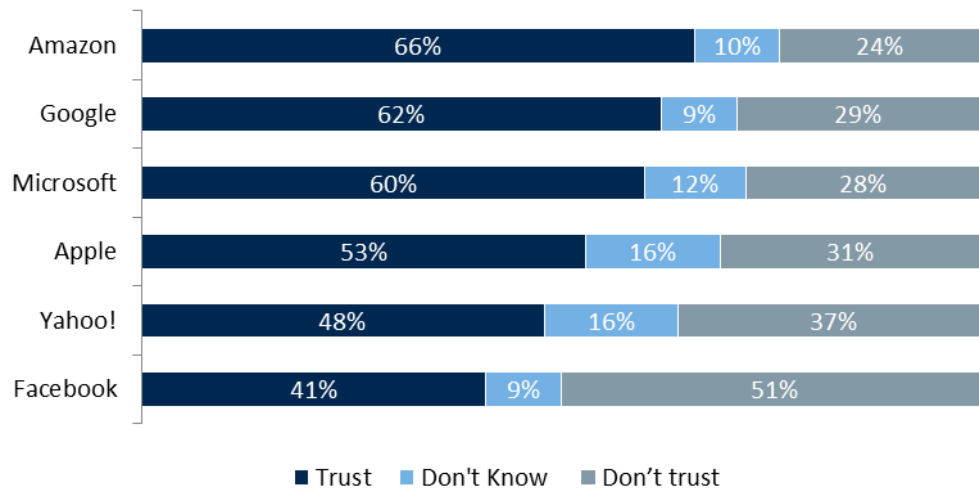
Source: Thomson Reuters, RBC Capital Markets

Consumers create and own their own data in 2025

Taking this lack of trust and increasing collective action forward to 2025, we can see a situation where it is not companies or government regulators themselves who create and control data, but consumers themselves.

Implications for sectors and companies

Consumer…**Real-time feedback loops** driven by AI, machine learning and IoT could enable insurance companies to predict & prevent loss, driving down costs and changing the way consumers manage risk.

The shift towards **"gig" economy independent workers** in lower-skilled areas (Uber, TaskRabbit, Handy, etc.) would increase competition for workers and likely increase costs across people-intensive industries. Digital platforms that connect independent workers with those needing their services (Uber, Airbnb, TaskRabbit, etc.) will likely be winners.

The rise of collective consciousness drives retailers to **clearly identify and fully integrate their values** into their products and services (think of American Eagle Outfitters Aerie's body positive marketing, Lululemon's leadership in athletic lifestyle "live your best life" and Tiffany, which blends its more than 100-year heritage with its ethical sourcing of diamonds). As consumers **holistically demand quality, ethical sourcing, and newness**, we believe peer-to-peer retail ecosystems will evolve and resale players such as thredUP and Tradesy increasingly are share gainers.

Energy & Utilities…**Urbanization of rural America (without the urban footprint)** – we could see Walmart's increasing focus on ecommerce and home delivery becoming more widespread, allowing non-urban areas to begin to enjoy urban conveniences as large scale retailers/businesses increasingly consolidate transportation and logistics into the hands of the few. In addition, as distributed workforces grow in scale the demand for utilities should decline over time.

Energy and exploration companies could benefit from **pro-active loss avoidance and mitigation,** as insurance tech shifts the model to **predictive science vs. reactive loss model**.

Utilities are vulnerable to an increasingly interconnected world, which depends upon them for a stable and robust grid system – while **disruption frequency** can be greatly mitigated by interconnectedness, **disruption severity** can be greatly enhanced because the magnitude of an event(s) that disables the grid would be that much harder to recover from (Puerto Rico).

Financial & Real Estate…Tech companies could become **distribution assets** for pure-play financial service companies as banks are not good at consumer-facing technologies, while tech companies are, which could prove to be a positive for companies like AMZN, PYPL, SQ, SHOP. Commercial real estate could become less valuable in a gig economy with companies like WeWork creating a more diverse and fragmented workforce that doesn't require as much centralized real estate.

A robust collaborative **cyber liability system** that shares responsibility for data breaches and the consequences of cyber threats could create a new industry for insurance.

The **value of real estate becomes more bifurcated**. Real estate in vulnerable areas or with vulnerable designs could become massively more expensive to insure while "safer" structures could see rates reduced significantly. Indeed "premium" real estate in high-risk areas could become effectively un-insurable other than via an assigned risk pool.

Healthcare…Insurance underwriting will likely become **DNA-based**, which could prove to be a negative for Pharma companies, as drug costs could come down. Clinical trial refinement should increase and thus drive down drug development costs long term, which could prove to be an offset. Hospitals and other payers could generate better treatment at lower cost given **personalized medicine**.

Increasing targeted healthcare coverage forces the industry to look increasingly to government-funded plans for resources to cover more uninsurable risk. The delivery of healthcare would need to become more tangibly socialized.

Industrials & Materials…**Supply chain for raw materials and food using blockchain** and provenance tracking will likely play an increasing role in both U.S. trade relationships with international partners (think China exporting steel to the U.S.) and the desire for consumers to get their food from socially conscientious farmers globally.

The **eco-impact of the growing resale apparel market** could have big implications on all facets of the global supply chain. For instance, if every garment was given a second life, waste and emissions would be reduced by 73%. This could change the dynamics for shipping and logistics companies as well as paper and packaging suppliers.

Technology, Media, and Telecom…Traditional models that have historically relied on capturing consumer data via consumer-facing applications, (FB, GOOGLE, SNAP etc.) which provide meaningful utility to the consumer, could have to **rethink their consumer acquisition cost models**. As social media has proven to be a machine in driving down customer acquisition costs, the monetization engine has relied on accessing consumer data, which we believe will be increasingly controlled by the consumer, thus driving up customer acquisition cost in order to gain access to valuable data.

Positive impacts from **cyber liability risk sharing** and active loss mitigation. Negative on potentially increased consequences of data management and security, vulnerability to interconnectedness and frequency vs. severity loss trade-offs.

What if…? Collective Action

What if self-sovereign IDs become the norm? Will large-scale consumer–data-derived models be required to directly compensate consumers to gain access to data? Will banks become "token vaults" holding consumers' digital tokens/currencies as a new on-demand deposit account or will they be disintermediated as new digital token wallets become the on ramps to gain access to a decentralized network of value?

What if large-scale data breaches occurred in multiple global financial institutions? Would it drive consumers to replace traditional currencies with distributed digital currencies?

What if digital real-time credit at the point-of-sale becomes the norm? Would the revolving credit model cease to exist and shift trillions of dollars of credit from legacy providers?

What if banks become regulated utilities, whereby the brands no longer matter, as the services and technology offered become totally homogeneous as new technologies massively outpace the innovation curve of banks?

What if blockchain was used for ID authentication purposes like your Facebook ID, with the authenticity of your identity being based on the culmination of all your historical transactions? Would opening a bank account and applying for a loan be easier because your transactions are recorded and easily transferable? Would the number of mortgage brokers and personal bankers decline as processing would be automated? Would there be an increase in the numbers of online loan providers? Would a FICO score become obsolete because all financial information is in one's blockchain ID and could be transferred? Would credit rating agencies become more like FASB, a non-profit organization standard-setting body?

What if augmented and virtual reality allow people to experience the world, both near and far, from within the home? Will this make societies more open-minded and globally oriented?

What if employers continue to heavily invest in software that increases employees' connectivity to their place of work? Would this de-value centralized offices making it less imperative to be located in major market hubs, and in turn, would this trend reduce commercial real estate values?

What if the shift towards distributed workspaces creates a massive shift toward home offices? What would be the impact to commercial real estate, small businesses supporting urbanized footprints and the demands for at-home delivery?

What if 5G makes mobile broadband ubiquitous relatively quickly, taking traditional cable/sat distributors out of the media ecosystem? Without this intermediary pushing Pay TV packages at consumers, will this accelerate the trend towards a la carte? Is this good or bad for Media?

What if the rise of the collective conscience drives proof-of-sourcing, ranging from food, clothing, and raw materials, as consumers demand specificity on providence tracking? An example would be scanning a QR code with a smart device. Will the cost of tracking inherently increase the cost of goods and services making it more attainable by the wealthy vs. the poor? Will more people be willing to pay more to support natural/organic, non-GMO, all natural or local products?

What if…? continued

What if peer-to-peer sales and marketplaces replace traditional brick-and-mortar retailing?

What if all clothing is disposable as customers print out/rent/share all items rather than purchasing and owning?

What if construction and farming equipment becomes completely connected between construction sites, allowing the sharing of idle equipment? Would we see a faster replacement cycle for the manufacturers?

What if consumers grant access to their home? Will the delivery person become a trusted partner stocking your shelves in the same way a merchandiser is stocking a store?

What if Big Data dictates what customers want rather than customers searching for what they desire?

What if there is a meaningful distributed ledger hack on top of the already vertical breaches? How do consumers and enterprises respond when all types of networks can be breached?

Theme V: Escalating Uncertainties: The Beginning of the Beginning

Even as we struggle with a staggering amount of change, we can envision a future where this rate of change goes parabolic, making our present concerns seem quaint, heightening uncertainty, and expanding the list of threats and challenges posed to the world's nations, institutions, and corporations. The sheer scale of change has significant economic, environmental and resource considerations. We have already seen the shoots of violent extremism and economic and political nationalism as nations react differently to shifting societal realities. As we look forward, we see the potential for two paths – an adherence to the post-war tenets of globalization, inclusion and joint solutions, or a hard turn towards nationalism and isolation in all its forms. These uncertainties create the opportunity for innovative solutions to global conflicts and resource allocation, but equally increase the potential for a fragmentation of global institutions, military and economic threats, and a chasm between the haves and have-nots.

What you need to know

In tandem with the disruptive technological change we have discussed broadly in this report, the magnitude of geopolitical instability also seems to be accelerating, often as collateral damage of this technological revolution. Corporations and heads of state alike range from underprepared bystanders to contributors to these exogenous systemic shocks that can have far-ranging impacts. As Director of National Intelligence James Clapper told Congress in 2016, "unpredictable instability is the new normal." Below we will examine this through the lens of changing climate and environment, widening and radicalized politics, and mass migration.

Recent examples with profound impacts and ripple effects: The Brazilian trucker strike (goods and services unavailable throughout Brazil), Hurricane Maria ($102B in damages, 4k estimated dead), the JCPOA (Iran Nuclear Deal) exit, the Equifax data breach, the Cambridge Analytica data scandal, and the Trump administration's tariff policy among others.

Key developments to consider looking forward:

Growing populations – Expanding urban centers and climate change will accelerate stresses on existing resources, necessitating innovation on the margin of sustainability, geoengineering, society and the economy.

Mass migration and displacement – Since 2010, the number of displaced persons has almost doubled from 33.92 million to 67.75 million as of 2016.

Uprisings and unrest – The growing footprint of autocratic regimes and illiberal democracies looks unlikely to reverse as long as income inequality remains so pervasive.

Authoritarian Leadership – The slow erosion of democratic standards and the transition to more authoritarianism rule on several continents increases global security concerns as autocratic countries have less predictable economic policies, choppier economic growth, and are more prone to conflict.

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Chaos!

Director of National Intelligence James Clapper told Congress in 2016, "unpredictable instability is the new normal."

In tandem with the disruptive technological change we have discussed broadly in this report, the magnitude of geopolitical instability seems to be accelerating as well, often as collateral damage of this technological revolution. Corporates and heads of state alike range from being underprepared bystanders to contributors to these exogenous systemic shocks, which can have far-ranging impacts. As Director of National Intelligence James Clapper told Congress in 2016, "unpredictable instability is the new normal." Below we will examine this through the lens of changing climate and environment, widening and radicalized politics, and mass migration.

Exhibit 106: Exogenous events and rippling effects

Event	Impact	Ripple Effects
Brazil Trucker Strike	Goods and services unavailable to Brazilians as truck drivers go on strike.	Soybeans, sugar, coffee, and iron ore all affected in commodities market. Companies with global presence miss sales goals. For example, Unilever sales impacted -$177m.
Hurricane Maria	$102B in damages 4,000+ killed (estimate)	Shortage of IV bags as three Baxter manufacturing sites damaged. Baxter impacted -$70m; other healthcare companies guided down earnings for the quarter.
JCPOA Exit (Iran Nuclear Deal)	Oil prices moved higher at Donald Trump's announcement that the U.S. will withdraw from the JCPOA.	Rising fuel costs put pressure on gross margins across sectors.
Equifax Data Breach	Over 145 million Americans' personal information was exposed in a data breach at one of the nation's major credit reporting agencies.	Equifax stock price fell more than 30%. Additional companies stepping up data protection.
Cambridge Analytica Data Scandal	Personally identifiable information of more than 80 million Facebook users was obtained and used to influence the U.S. 2016 elections.	Facebook's stock price fell more than 15% on the news. Twitter and Google also investigating Russian meddling via use of their platform.
Trump Tariff Policy	Initially imposed tariffs on steel (25%) and aluminum (10%), as well as 25% tariffs on $50 billion of Chinese imports covering an estimated 1,300 products and a 10% tariff on several hundred billion dollars more of Chinese imports depending on how/if China responded with retaliatory tariffs. Additionally, the U.S. has threatened to withdraw from or significantly change the current terms of NAFTA.	We believe that as companies are forced to raise prices to protect profit margins from the impact of rising wages and increased tariffs, the U.S. consumer will bear the ultimate cost of such policies.

Source: RBC Capital Markets, NOA, FactSet

Climate change, environment, energy and natural resources…oh my!

One of the biggest cross-border challenges has to do with the intertwining implications of climate change, energy and the environment, and their effects on natural resource-based economies and the consumer.

How the world adapts and develops policy rests collectively in the hands of the public, the countries that enforce regulation, and the businesses that innovate to find new, better solutions.

One of the biggest cross-border challenges has to do with the intertwining implications of climate change, energy and the environment, and their effects on natural resource-based economies and the consumer. These forces may introduce new challenges ranging from energy uncertainty, to fossil fuel resource management, hydro-politics, the need for climate mitigation frameworks, renewable resource development, and adaptations to life in changing climates through innovation and regulation. Innovation and new technologies in particular may help drive efforts to clean up the ocean and improve conservation of resources, but if potential toxic zones do develop, they may widen the gap between the haves and the have-nots. How the world adapts and develops policy rests collectively in the hands of the public, the countries that enforce regulation, and the businesses that innovate to find new, better solutions. While the debate on how to deal with climate change intensifies in certain geographies, the proposition of grappling and dealing with that change becomes an increasingly borderless challenge.

Consider the following:

- It will be 4°C warmer than it was before the Industrial Revolution if our greenhouse gas emissions continue to increase at the rate they have been over the last 50 years.
- There has been an 8-inch global sea level rise in the last century. The rate of increase in the last two decades, however, is nearly double that of the last century.
- The fraction of carbon dioxide just crossed 400 parts per million, and high-end estimates extrapolated from current trends suggest it will hit 1,000 ppm by 2100.
- The National Climate Assessment model runs use assumptions about possible future development patterns and greenhouse gas emission rates. Two future scenarios are shown: B1 and A2.

Exhibit 107: Future climate scenarios
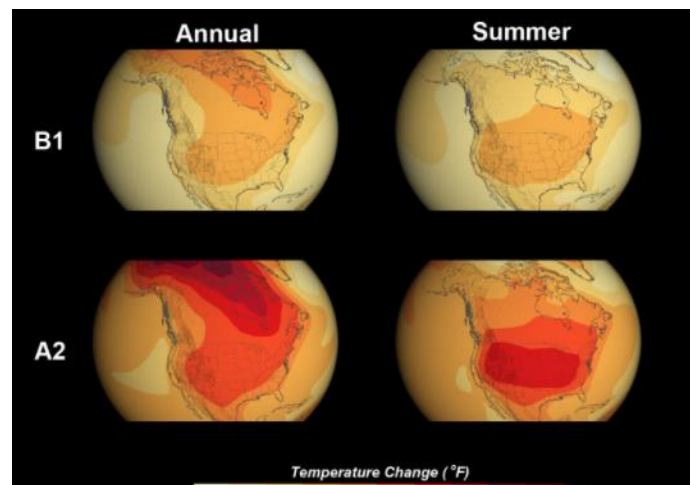
Source: Sterling Rice Group, NASA

The amount by which atmospheric carbon dioxide increases each year has approximately quadrupled since the 1960s, and in recent years represented the largest annual increase in records going back nearly sixty years.

We have already seen an alarming rise in the trajectory of global temperatures, and carbon dioxide levels today are higher than at any point in the past 800,000 years. The amount by which atmospheric carbon dioxide increases each year has approximately quadrupled since the 1960s, and in recent years represented the largest annual increase in records going back nearly sixty years.

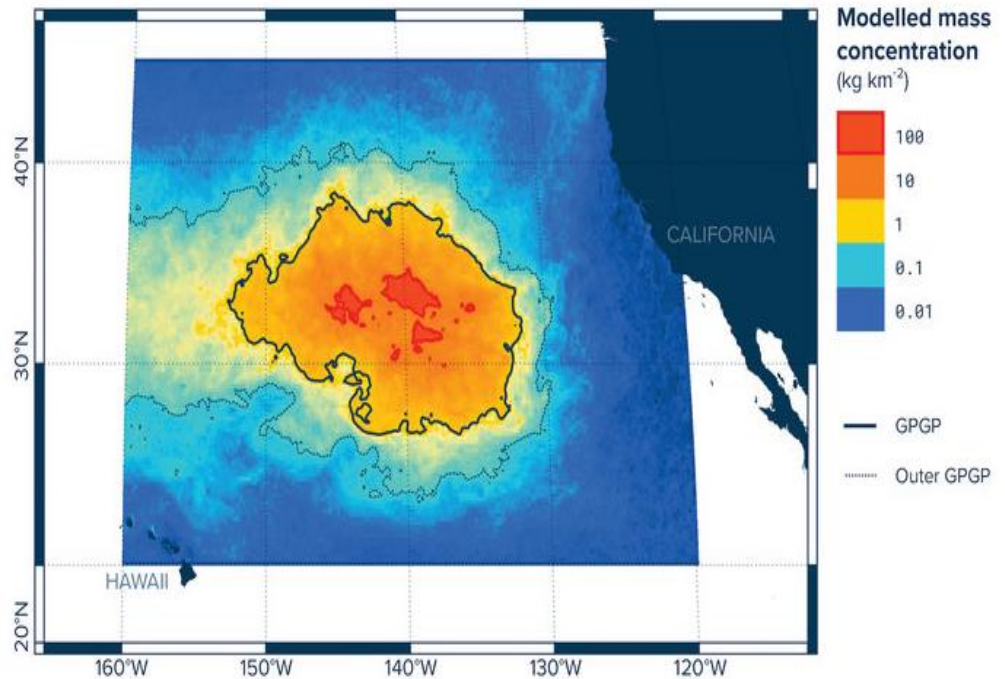Exhibit 108: Greenhouse gas concentration
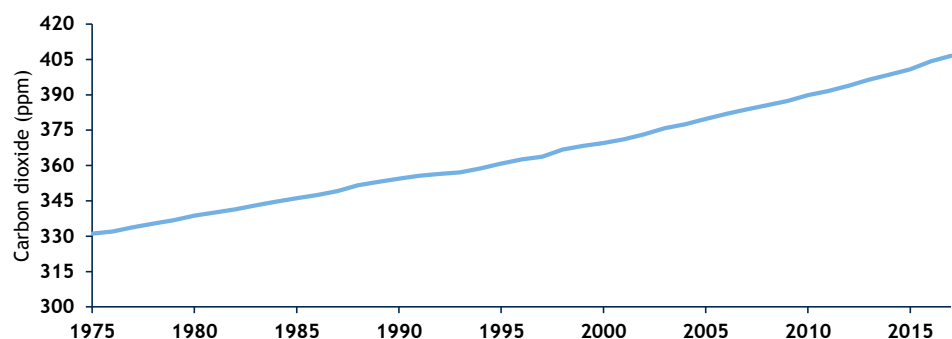
Source: Sterling Rice Group, NASA

We have seen a similar, and equally unfortunate rise in the amount of pollution and waste produced globally. Americans today produce on average 130 pounds of trash a month and at this rate, we are on pace to globally produce 11M tons of waste daily by the year 2100. The

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By 2050, it is estimated that there will be more waste plastics in the sea than fish.

impacts are being seen in real-time. One million people die a year in China due to the effects of air pollution, and by 2050, it is estimated that there will be more waste plastics in the sea than fish.

Exhibit 109: The Great Pacific garbage patch – 2x larger than Texas

Source: Sterling Rice Group, NASA

I thought hurricane season was over

We have seen an increasing frequency and intensity of heatwaves and wildfires in the west, flooding in the east, and droughts in the southwest.

The severe effects of climate change are usually presented as threats that will manifest in the more distant future – measured by the century. However, extreme weather events have already begun to occur and the trend has been one of increasing intensity. We have seen an increasing frequency and intensity of heatwaves and wildfires in the west, flooding in the east, and droughts in the southwest. The consequences of such events could be catastrophic, solutions will be costly, and it seems we are mostly underprepared for the magnitude of change.

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Exhibit 110: U.S. weather & climate disasters with $1b+ damages
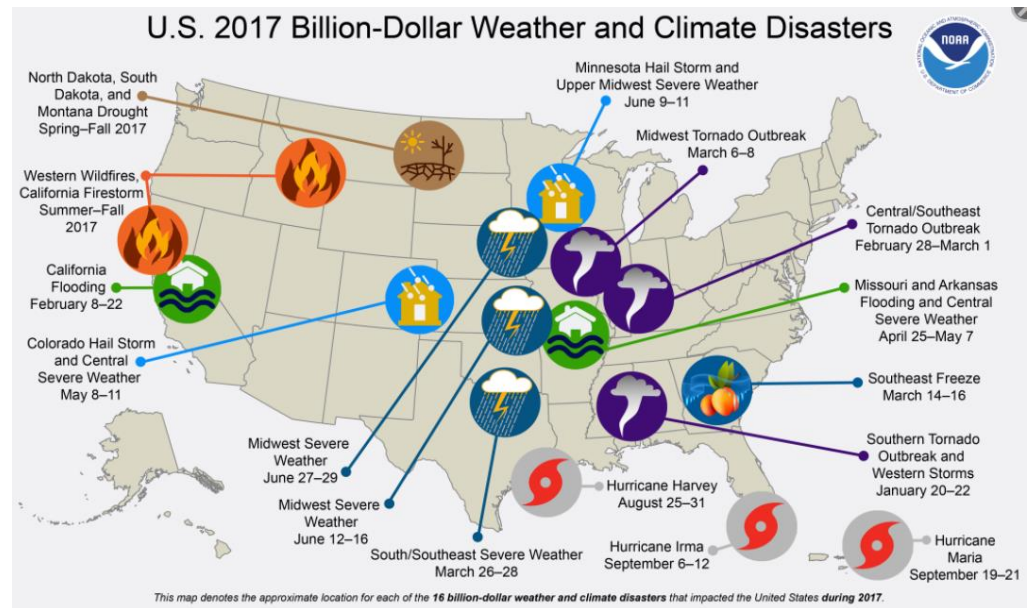
Source: NOAA

One example of the ways in which our present day lives are ill-equipped for a warmer future happened in February 2018 when temperatures rose to over 118°F in Phoenix, Arizona. This resulted in over 50 flights being cancelled or rerouted as the heat exceeded the aircrafts' maximum operating temperature.

Infrastructure and travel also face a threat from the oceans. A government study found that 13 of the 47 largest U.S. airports have at least one runway within 12 feet of the current sea level. As evidenced by the airport shutdowns during Hurricane Sandy, storm surges can easily shut down airports, with rippling global effects. The impacts reach beyond the passenger. In a world becoming more dependent on ecommerce, severe weather events throw a wrench into logistics of all kinds.

A government study found that 13 of the 47 largest U.S. airports have at least one runway within 12 feet of the current sea level.

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Exhibit 111: Don Muang Airport flooded in Thailand

Source: Getty Images

. In 2017, 10 hurricanes formed over 10 weeks, matching a record that was last set in 1893.

The strength and frequency of hurricanes have increased in the past 30 years with an uptick in Category 4 and 5 storms. In 2017, 10 hurricanes formed over 10 weeks, matching a record that was last set in 1893. The total cost of weather and climate disasters in 2017 set a new record in the U.S., topping $300 billion.

Exhibit 112: 1980–2018 YTD U.S. billion-dollar disaster event frequency (CPI-Adjusted)

Source: https://www.ncdc.noaa.gov/billions/
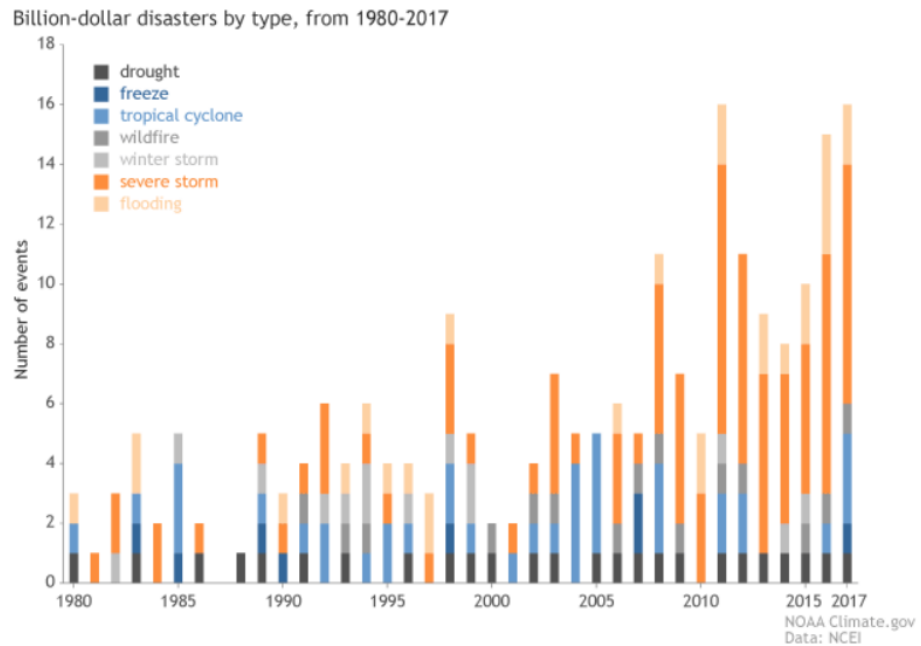
A recent report on the impact of rising sea levels on real estate prices by the Union of Concerned Scientists finds that across the Continental U.S., about 311,000 homes are at risk of being inundated with seawater by 2045, or about $135B of assessed property. Florida, New Jersey and Louisiana, with their low-lying seaboards and sprawling coastal development, have the most to lose. However, the report also notes that California has $15B worth of property at risk as well.

Exhibit 113: California homes at risk of flooding
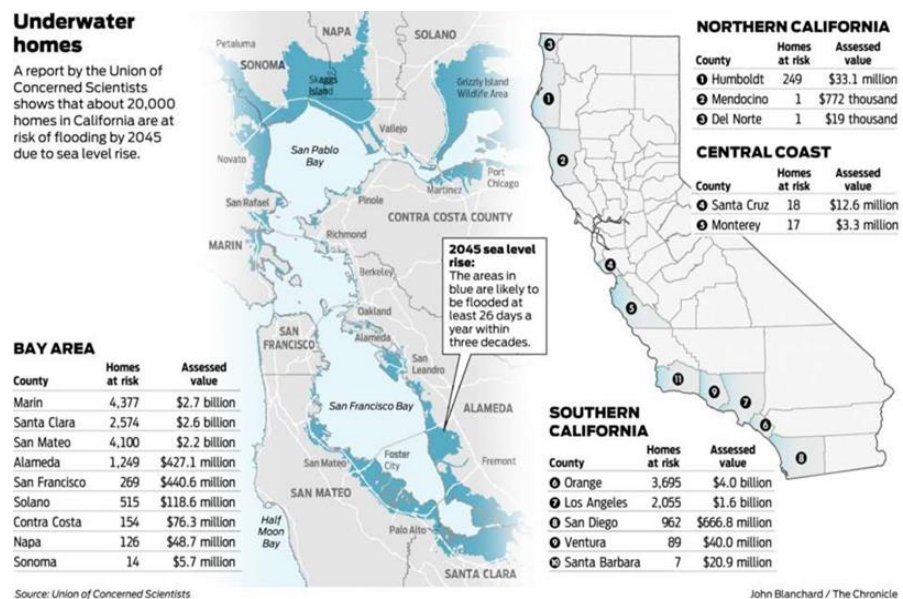
Source: Union of Concerned Scientists

Global warming has opened up new shipping lanes with implications on trade and military planning, new access to minerals, and potentially prompting new territorial disputes.

It seems a sad irony that melting ice and rising sea levels have consequently increased the accessibility of the Arctic for development of the natural resources that have arguably contributed to that very climate change. Global warming has opened up new shipping lanes with implications on trade and military planning, new access to minerals, and potentially prompting new territorial disputes. The U.S. Geological Survey estimates that the Artic may contain up to 13% of the world's undiscovered oil and up to 30% of its natural gas. With the ice receding at an 11% rate each decade according the U.S. National Snow and Ice Data Center, huge reserves of manganese, copper, cobalt, zinc, gold, and untouched fisheries have become accessible. Russia, in particular, has moved to capitalize on these opportunities since it planted a Russian flag on the Arctic seabed in 2007. Abandoned Soviet military bases have been reopened in tandem with the establishment of a series of new ones and the bolstering of Russia's fleet of nuclear-fueled icebreakers. However, Russia is not alone in its endeavors. The U.S., Canada, Denmark, Norway, and Iceland are all actively participating in the Arctic land grab and seeking potential access to its abundant natural resources.

Russia is not alone in its endeavors. The U.S., Canada, Denmark, Norway, and Iceland are all actively participating in the Arctic land grab and seeking potential access to its abundant natural resources.

Mass migration & displacement

Sea rise not only poses a physical threat to land assets, but could displace people.

As militaries scramble to race for the Arctic amidst rising sea levels, the rate of ice melt and sea level rise poses significant problems for coastal communities in particular. Sea rise not only poses a physical threat to land assets, but could displace people. In a November 2017 report by the Environmental Justice Foundation, climate change was cited as potentially causing the largest refugee crisis in human history. Unpredictable weather patterns and disasters such as floods, wild fires, droughts, tsunamis, hurricanes, and other weather events, coupled with surrounding geopolitical and even public health concerns, are also likely to be a factor in causing mass migration of people. The NIC report shows that "human and animal health will increasingly be interconnected" and that "unaddressed deficiencies in national and global health systems for disease control will make infectious disease outbreaks more difficult to detect and manage, increasing the potential for epidemics to break out far beyond their points of origin." The onslaught of climate change related issues present both a challenge and a potential platform for international discussion and cooperation.

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Since 2010, the number of displaced persons has almost doubled from 33.92 million to 67.75 million as of 2016.

The level of mass migration and displacement has dramatically increased in the past few years, a trend we do not expect to resolve in the near future, as both are highly driven by severe weather events or conflict. Since 2010, the number of displaced persons has almost doubled from 33.92 million to 67.75 million as of 2016.

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Exhibit 114: Number of displaced persons, globally (in millions)
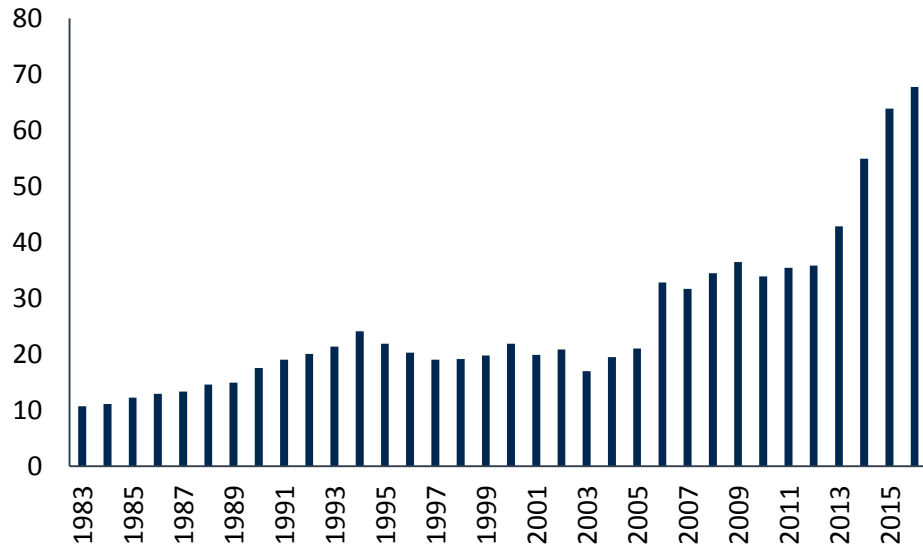
Source: United Nations High Commissioner for Refugees

The Pentagon also recognizes climate change as a "conflict magnifier." Resource shortages can set the stage for or exacerbate conflicts. In Syria, prior to the protests and the resulting civil war, the country faced its worse drought in 900 years, which killed off scores of crops and livestock. Failed farmers moved en masse to the cities, creating and heightening economic pressures and resource shortages. Similar climate events in the U.S. have also caused internal displacement, such as after Hurricanes Katrina and Maria. In the aftermath of Hurricane Katrina, attitudes towards the growing number of evacuees became increasingly negative in both Louisiana and neighboring Texas.

Exhibit 115: Persons of concern, globally (in millions)

Number of Persons of Concern (in millions)

Source: United Nations Commissioner for Refugees
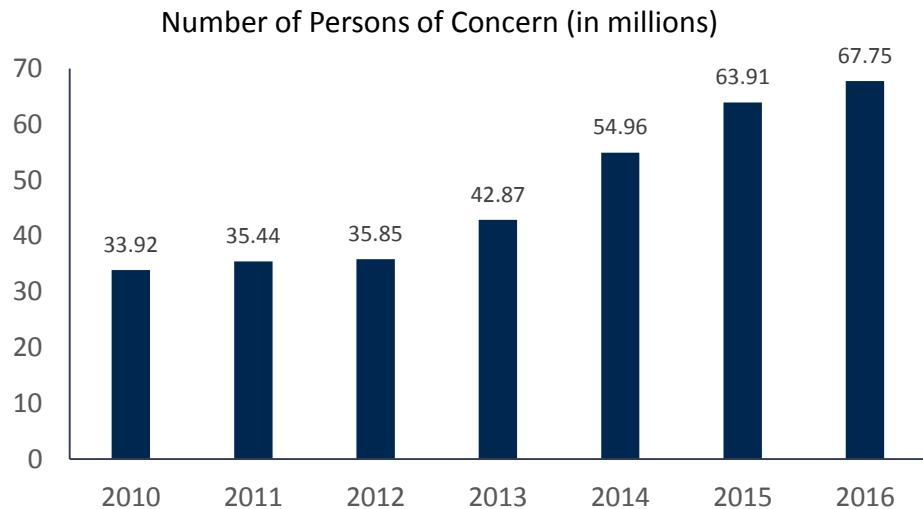
RBC Capital Markets

Exhibit 116: Persons of concern, globally 2005 vs. 2016
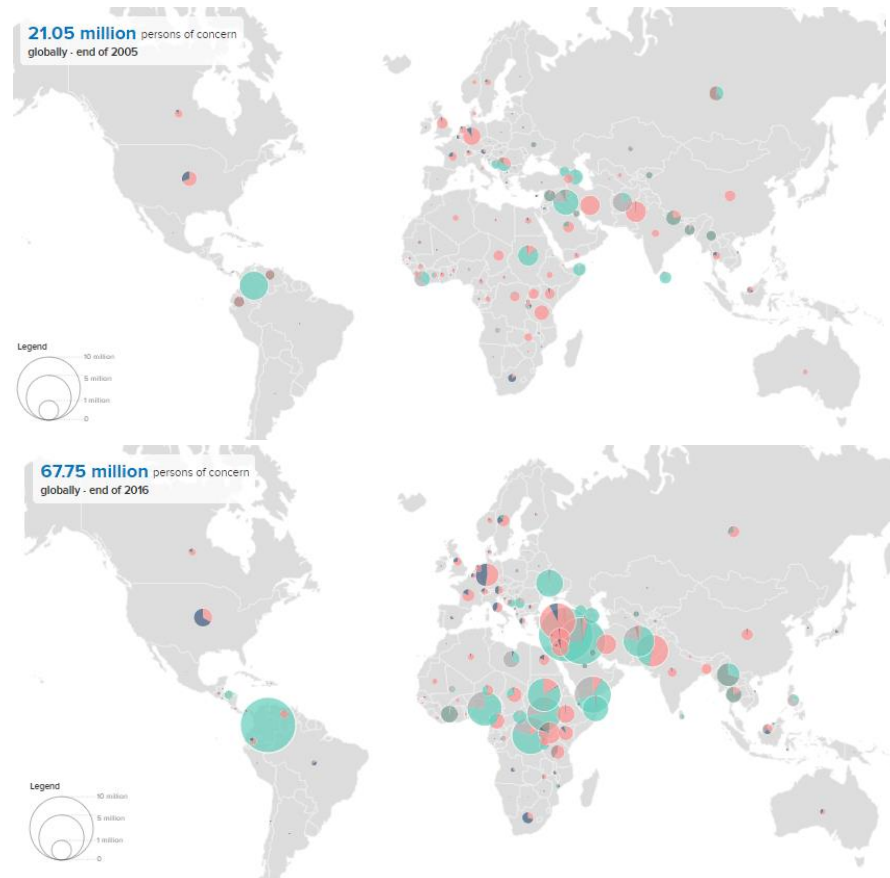
Source: United Nations Commissioner for Refugees

As pressures mount to combat the effects of global warming and pollution, it is easy to imagine a future where alternative energy sources play a more prominent role.

Petro economies – Talking about the future…

As pressures mount to combat the effects of global warming and pollution, it is easy to imagine a future where alternative energy sources play a more prominent role. One of the challenges for resource-dependent economies is planning for a future less "driven" by fossil fuels. These economies must thread the gap of maximizing profitability of their existing enterprises while building institutions for a "fossil-light" economy in the future. This gets even more challenging for developing nations that face meaningful population growth and youth unemployment.

Exhibit 117: Saudi Arabia population

*IMF Forecast
Source: IMF
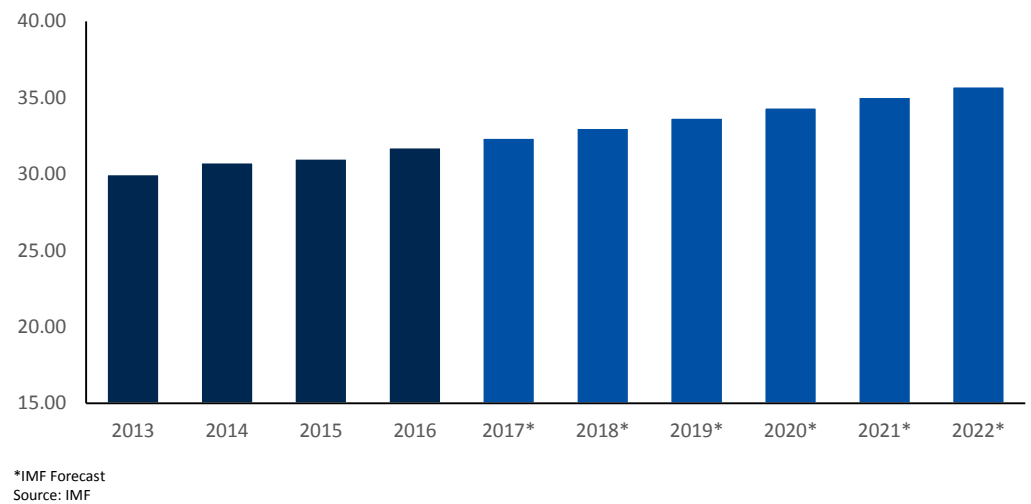
Exhibit 118: Saudi Arabia unemployment rate %

Source: Bloomberg
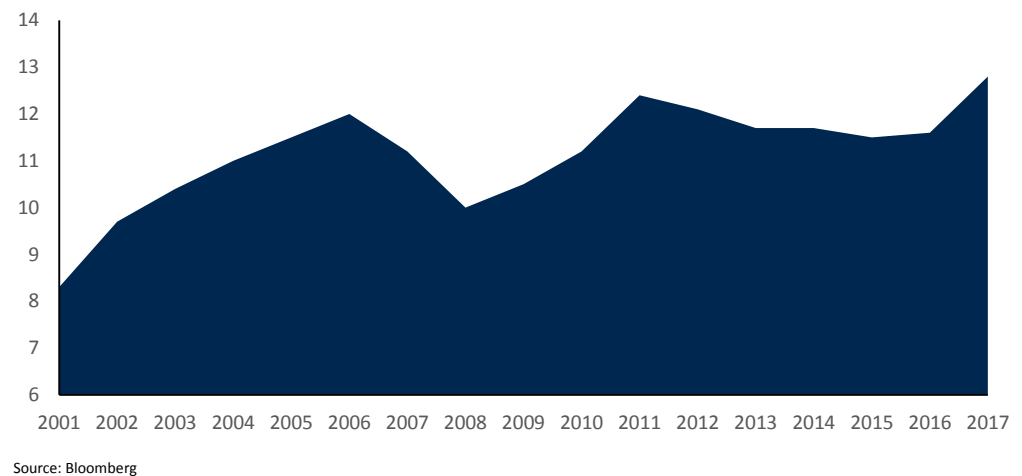
The dramatic fall in oil prices in 2014 had serious implications for the Middle Eastern, African and Latin American oil producing nations. Many of these states experienced significant economic, political and social challenges when oil fell above $100/bbl, and the loss of so much revenue left a number of sovereign producers on the brink of collapse. No producer has fallen faster and further than Venezuela, which continues to see massive numbers of people leaving the country in what is now one of the largest human migration crises in Latin American history. On the other hand, a small number of petro states have used the decline in energy prices as a catalyst to embark on sweeping reforms aimed at diversifying their economies away from oil, shrinking the state, and promoting their local private sectors. The Gulf Cooperation Council (GCC) countries have been at the forefront of this effort, with various "Vision" initiatives. Saudi Arabia's Vision 2030 program has garnered the most public attention to date. Key goals include increasing the private sector contribution to GDP from 40% to 65% and increasing non-oil government revenue from SAR 163 billion to SAR 1 trillion.

Exhibit 119: Saudi Arabia fiscal 2018 budget
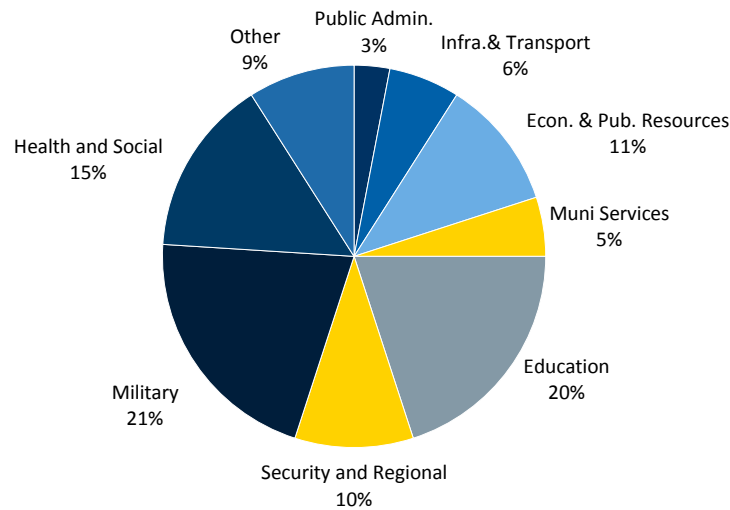
Source: Saudi Arabia Ministry of Finance 2018 Budget Statement

According to the 2017 Arab Youth Poll, young Arabs in the Gulf are overwhelmingly optimistic about the direction of their countries. Eighty-five percent of GCC respondents expressed confidence that their countries were heading in the right direction, compared to 51 percent in North Africa.

Conversely, the oil price collapse has not spurred similar reform efforts in Latin America, North Africa and Sub-Saharan Africa. These natural resource rich regions are already struggling with many of the acute cross-border difficulties discussed throughout this report – including water shortages and other climate change related problems, mass migration, restless youth and violent extremism. We think these areas are set to experience more pain and dislocations if they remain behind the curve in diversifying their economies away from near exclusive dependence on traditional hydrocarbon revenue.

Hydro-politics could become an important issue for a number of the world's states.

A NIC report highlights that around 50% of the world's 263 international river basins do not have a management agreement.

Hydro-politics – Is water the new oil?

In a world powered by battery electric vehicles, water stress may become the primary resource challenge. Hydro-politics could become an important issue for a number of the world's states. Dam building, industrial water pollution, and potential neglect of water cooperation agreements could threaten geopolitical security. A NIC report highlights that around 50% of the world's 263 international river basins do not have a management agreement. Without clear guidelines on water management and cooperation, it is likely that more regions will be incubated for future conflict. While the researchers do not define drought as a "cause" of conflict, it is considered a factor that creates conditions for more conflict to arise.

Exhibit 120: Water stress by country
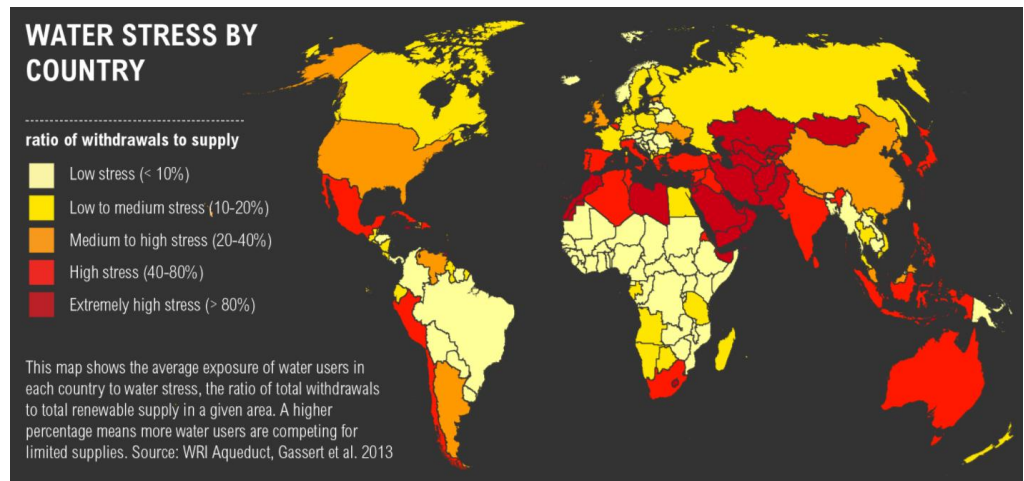
Source: WRI Aqueduct, Gassert et al 2013

Water demand globally is expected to increase globally 55% between 2000 and 2050.

Even as weather patterns create supply concerns, demand driven by population growth and a rising middle class is exacerbating the issue. Water demand globally is expected to increase globally 55% between 2000 and 2050.

Consider this:

- By 2050 with the growing global population, the year we are estimated to use up all land on the planet suitable for agriculture.
- Agriculture uses 70% of water worldwide.
- 90% of rare earth metals are mined by China, who claims its resources could run dry in the next 20 years.

New world out of order

Following the fall of the Berlin Wall in 1989 and the conclusion of the Cold War, the Stanford academic Francis Fukuyama posited that we were witnessing "the end point of mankind's ideological evolution and the universalization of western liberal democracy as the final form of human government." This theory is borne out by recent political trends and events that have shocked the global political system. The age of one country as a super power – most recently the U.S. – standing willing and able to exert its authority beyond its borders has seemingly passed. And the entire post-WWII rules-based system of global governance – enshrined in a network of international organizations and regulations and enforced by powerful western countries – appears imperiled at the very time when we most need collaborative global solutions to environmental, economic and immigration issues.

Going to extremes

Democracy, in particular, appears to be in retreat and authoritarianism on the ascendancy. In their "Freedom in the World 2018" report, Freedom House finds that 2017 was the 12th consecutive year of decline in global freedom.

The challenge has come from rising and revanchist states, surging populist and nationalist sentiment amidst a growing disillusionment with globalization and the ideology of open borders and markets, as well as from rapid and widespread technological change. Democracy, in particular, appears to be in retreat and authoritarianism on the ascendancy. In their "Freedom in the World 2018" report, *Freedom House* finds that 2017 was the 12th consecutive year of decline in global freedom. Seventy-one countries registered net declines in political liberties in 2017, with only 35 states posting gains. Amongst the once promising states suffering from this backslide in democratic standards are Turkey, Venezuela, Poland and Tunisia. China and Russia have taken advantage of this trend to export their influence to other countries.

Exhibit 121: Countries with the largest declines in freedom over past decade
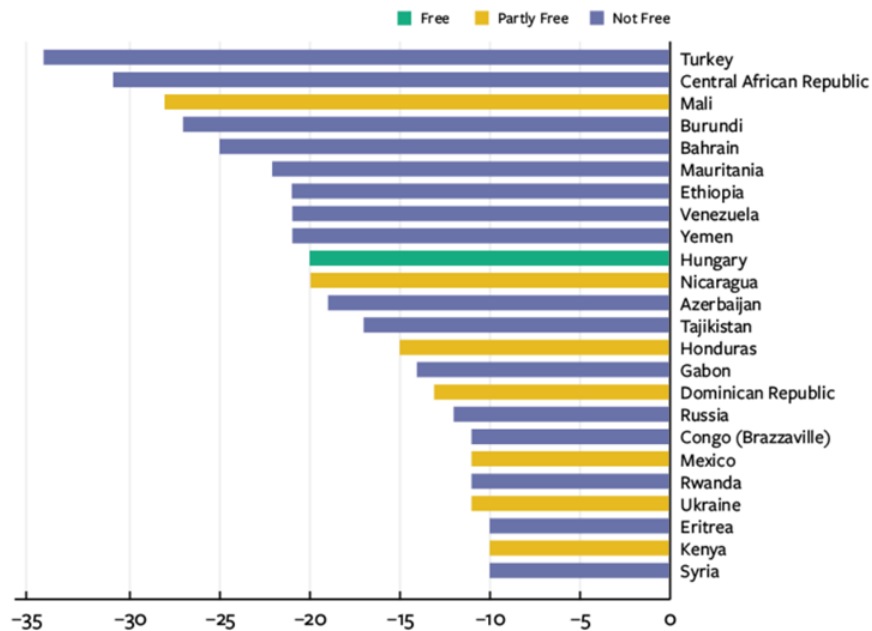
Source: Freedom House

A National Intelligence Council (NIC) Global Trends paper finds that democracies are generally more likely than autocracies to have predictable economic policies and produce steady economic growth and political liberalization is associated with higher subsequent quality of life.

A National Intelligence Council (NIC) Global Trends paper finds that democracies are generally more likely than autocracies to have predictable economic policies and produce steady economic growth and political liberalization is associated with higher subsequent quality of life. Moreover, the NIC notes that democracies have seldom gone to war with one another and have generally supported one another during international military conflicts. They attribute this to the tendency of democracies to advocate for the public good. The waning influence of the world's democratic bloc of nations has mirrored their relative economic descent. Established democracies such as the U.K. and U.S. made up the bulk of GDP in the late nineteenth century and this trend continued well into the second half of the twentieth century as the democratic alliance expanded to include Japan and Germany. For the first time in over a century, the democratic bloc's share of global GDP has fallen below half, and the IMF states it will slump to less than a third in the next decade.

Exhibit 122: China GDP as a percent of global GDP has quadrupled over the past 20 years

China as a percentage of global GDP has grown from just 4% or less since the 1990s to 16% today
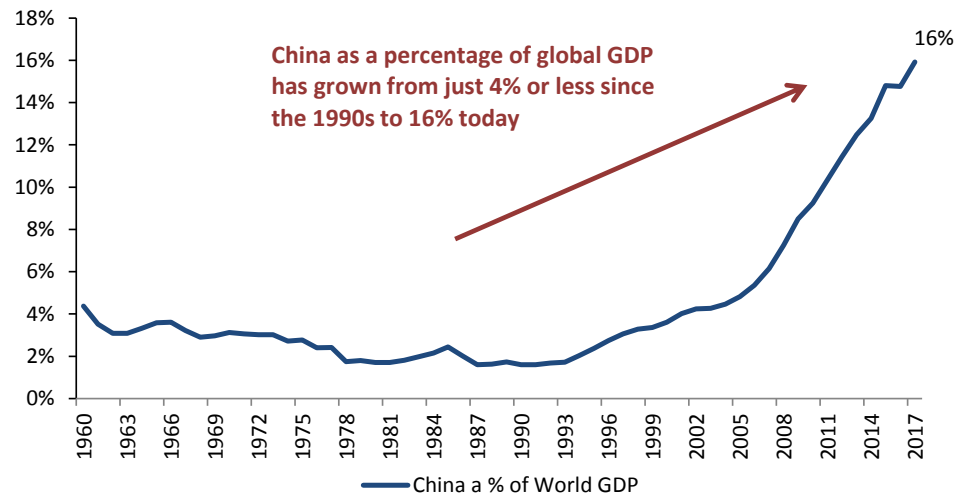
Source: World Bank

In the U.S., U.K., and EU, polls show a widening divide in political attitudes.

What is more disconcerting is that the traditional democratic bloc has become more polarized with regard to their own internal politics. In the U.S., U.K., and EU, polls show a widening divide in political attitudes. Brexit, widely perceived to be a low-probability event, was a manifestation of growing populism and polarized attitudes within the democratic bastion of the European Union.

Exhibit 123: Ideological divides on EU

Ideological splits on EU favorability

Favorable view of EU
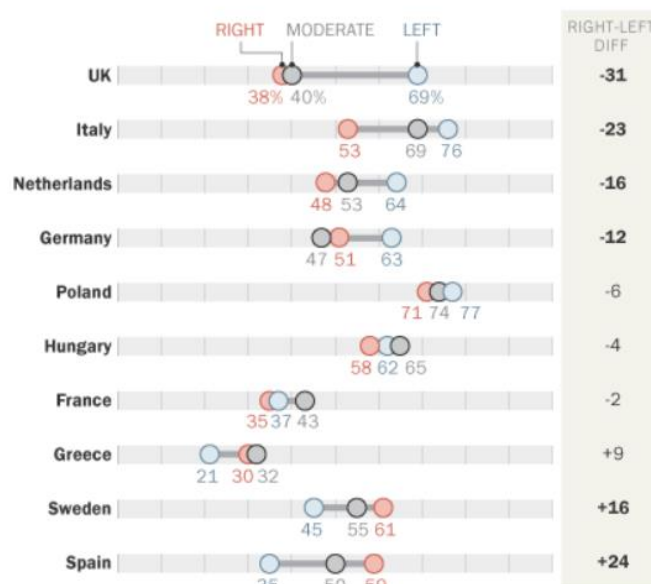
Source: Pew Research Center

Similarly, in the United States, the Trump election was considered a victory for populism and a rejection of the establishment of both parties. Ideological divides are deepening with

moderates in decline. Alarmingly, views of the opposing political party have sharply changed with more Americans having an unfavorable view of the other, and seeing the other as a threat to the nation's wellbeing, exhibiting signs of polarization turning into sectarianism.

Exhibit 124: U.S. Ideological divides growing wider
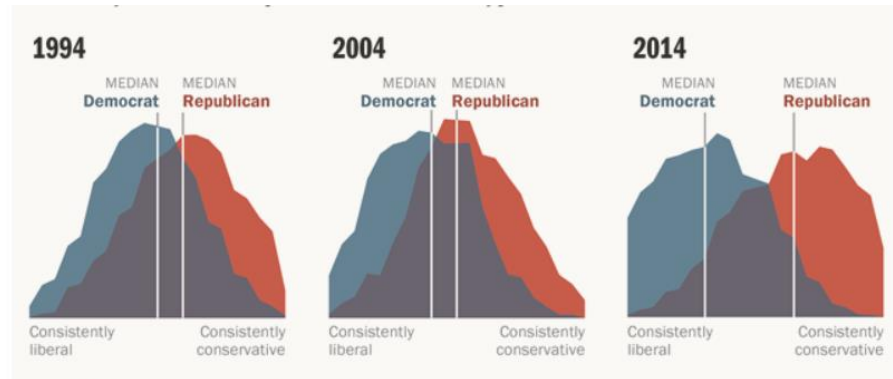
Source: Pew Research Center

Exhibit 125: U.S. Views of opposing political party
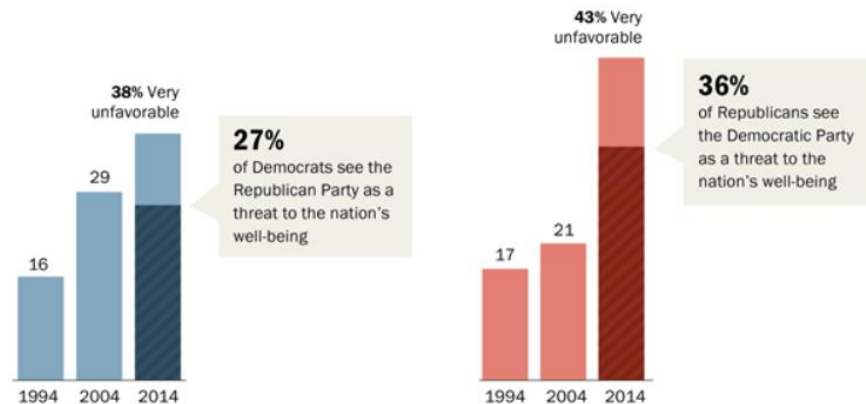
Source: Pew Research Center

Power to the people: Uprisings and unrest

The growing footprint of autocratic regimes and illiberal democracies looks unlikely to reverse as long as income inequality remains so pervasive. There is a burgeoning consensus in political science literature about the incompatibility of extreme inequality with democracy. Experts studied income inequality in the U.S., France, Germany, the U.K., and Switzerland and found that improvements in income inequality in the second half of the twentieth century made it so that by 1970 the wealthiest ten percent of the population in all five countries had fallen to a range of 25 to 35 percent of total income. However, the trend since 1980 has been a complete reversal, moving back towards deepening inequality. Today in the U.S., the top ten percent in terms of wealth take home almost half of the national income. Even in the heart of the liberal democratic world, support for democracy appears tepid.

Exhibit 126: Inequality around the world (darker indicates higher inequality)
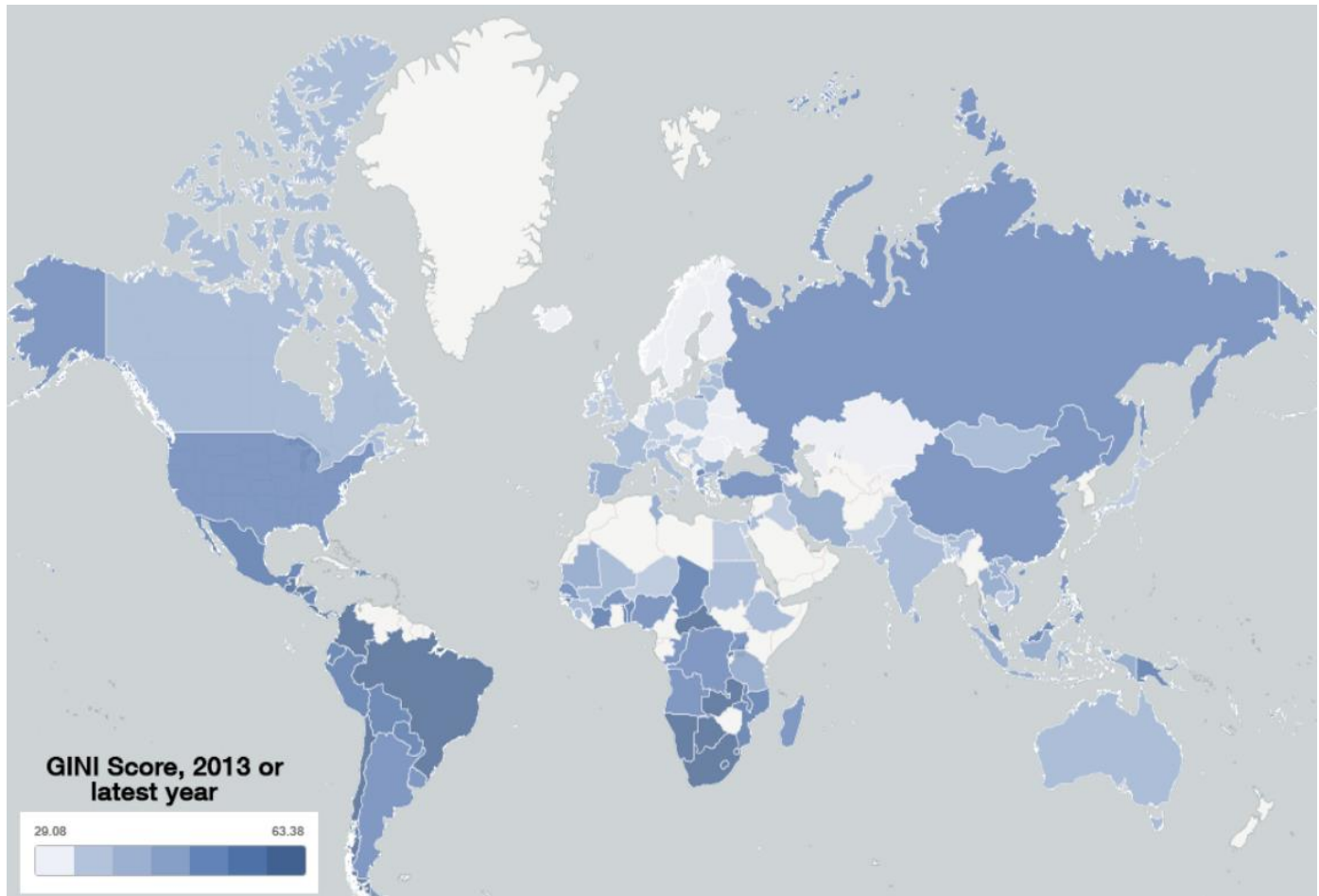
Source: World Economic Forum, World Bank

Dissatisfaction with democratic institutions and populist movements in the U.S., U.K., and Catalonia have been fueled not only by the present divide between haves and have-nots but a sense that this gap will only widen as middle class jobs are lost to technology advances and innovation.

Consider this:

- 20% of CEOs' activities hold the potential to be automated using current technologies.
- $2 trillion in annual U.S. wages could be affected by automation, putting even highly-compensated occupations on the chopping block.
- 1.7M robots are already in use around the world – largely in industrial settings.

The ascent of authoritarianism over the past few decades mirrors the climb in inequality, and leaders of political thought believe that the recovery of democracy hinges on the ability of wealthy states to address escalating inequality.

Two-thirds of Americans over 65 claim that it is imperative for them to live in a democracy, but less than one-third of those under the age of 35 agree. In Europe, between 1995 and 2017, the number of French, Germans, and Italian citizens in favor of military rule more than tripled (*Foreign Affairs*). The ascent of authoritarianism over the past few decades mirrors the climb in inequality, and leaders of political thought believe that the recovery of democracy hinges on the ability of wealthy states to address escalating inequality.

June 26, 2018

Common themes amongst uprisings have been inequality, corruption, unemployment, inflation, and weakened institutions.

Whose streets? Our streets

When inequality manifests itself as political backlash, the outcomes and results are uncertain, ranging from surprising political evolution to worst-case scenarios of civil wars and genocide. And the events and consequences, small and large, can ripple globally. Common themes amongst uprisings have been inequality, corruption, unemployment, inflation, and weakened institutions.

A recent example of this is a massive strike of Brazilian truckers who brought the country's economy to a halt in a protest of rising fuel prices. The anger towards the government was exacerbated by corruption and kickback scandals at the state oil company, Petrobras. Blocking the roadways and refusing to make hauls emptied the shelves of markets, closed schools and businesses, and began to impact global commodities such as soybeans and sugar where Brazil is one of the world's leading exporters. The ensuing chaos had pockets of the country calling for a return to military rule. Truckers in China and Argentina are considering or starting similar strikes.

Exhibit 127: Population growth could lead to resource scarcity in the emerging world, including fuel

Source: World Economic Forum, World Bank

Iran also saw a wave of protests in 2018 fueled by anger over rising food costs, high inflation, and corruption. Swarms of Iranians across the spectrum took to the streets and even government buildings, disappointed by the lack of improvements they expected from the JCPOA (Iran nuclear deal). Some chanted "be afraid, be afraid; we're all in this together," an augmented version of the popular 1979 revolution protest chant "don't be afraid, don't be afraid; we're all in this together." Iran's waves of protests over the past 10 years, and likely in the future, have been driven by their young population which struggles with high unemployment.

Exhibit 128: Iran youth unemployment rate remains elevated

Source: Statistical Center of Iran

Despite the differences in these regions and populations, they are all fueled by anger towards the government and establishment institutions that the populace sees as corrupt and thriving while they themselves struggle economically. They are also enabled by technology; the Brazilian trucker strike was mostly organized through WhatsApp (owned by Facebook) and the most recent Iranian protests were organized through a similar messaging app called Telegram. We believe countries facing the combination of youth unemployment, growing populations, and resource scarcity are the most vulnerable to uprisings and prolonged unrest. Nigeria in particular is facing a population boom that will make it the third most populous country behind China and India, while facing tremendous unemployment and resource scarcity, making conflict and mass migration almost inevitable.
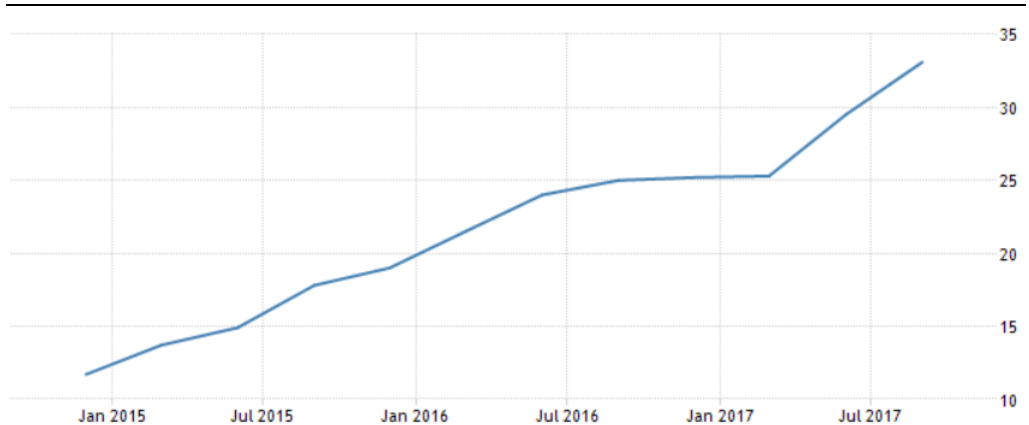
We believe countries facing the combination of youth unemployment, growing populations, and resource scarcity are the most vulnerable to uprisings and prolonged unrest.

Exhibit 129: Nigeria youth unemployment rates are rising

Source: National Bureau of Statistics, Nigeria

Exhibit 130: Nigeria population density rising as part of population boom

Source: Trading Economics

These waves of backlashes, uprisings, and movements seem unlikely to dissipate and their outcomes are highly uncertain. We can now see that they are not confined by time and geography in the sense of the Arab Spring. Nationalism and dissatisfaction with "the system" are on the rise globally – East and West, in developed and in emerging nations.

A turn to authoritarianism

The erosion of democratic ideals, unhappiness with the status quo, and concerns about an uncertain future have led to a rise in authoritarian rule. Historically, autocratic rule has increased security concerns as authoritarian countries have less predictable economic policies, choppier economic growth, and are more prone to conflict. The trend towards increased authoritarian leadership is evident across continents, and sometimes as a result of failed uprisings and unrest. NATO-member Turkey is a notable example of a shift away from democratic norms under President Recep Tayyip Erdogan. In the Philippines, President Rodrigo Duterte has also displayed populist authoritarian characteristics by declaring martial law to combat an ongoing rebellion by supporters of the Islamic State, and ratcheting up military involvement in southern Philippines that was recently extended for another year. This comes at a time when the U.S. is taking more of an inward focus, arguably creating an opportunity for Russia and an ascendant China to play a greater role in shaping the world order.

The erosion of democratic ideals, unhappiness with the status quo, and concerns about an uncertain future have led to a rise in authoritarian rule.

Exhibit 131: Ascending authoritarianism

Source: RBC Capital Markets

While the U.S. has pulled out of the TPP, walked away from the Iran nuclear pact, withdrawn from the Paris Climate Accord, criticized global bodies like the United Nations (UN), and restricted immigration policies, China is filling the void with its massive Belt and Road Initiative investments in partner countries and has taken on an increased role at the WTO. For its part, Russia signed a highly scrutinized missile defense deal with Turkey, despite concerns voiced by Turkey's NATO allies over security issues.

The United States has further ratcheted up international tensions through its turn to an aggressive tariff policy. The U.S. Department of Commerce initially imposed tariffs on steel (25%) and aluminum (10%), but this was just the first shot across the bow on the tariff front. The U.S. has since proposed 25% tariffs on $50 billion of Chinese imports covering an estimated 1,300 products and furthermore, has promised a 10% tariff on several hundred billion dollars more of Chinese imports depending how/if China responds with retaliatory tariffs. Additionally, the U.S. has threatened to withdraw from or significantly change the current terms of NAFTA.

Economic implications of rising nationalism

Besides the obvious security concerns, there are easy-to-identify reasons why the markets have sold off as economic nationalism has risen. The imposition of duties has the effect of slowing overall trade activity and can be a major source of consumer inflation over time, as costs/tariffs are eventually passed along to the end user. Further, in the United States, immigration limitations are exacerbating already-sizable labor shortages in most sectors and many companies have or will be forced to raise prices to protect profit margins.

Wages already on the rise… In the U.S., we are already at virtually full employment, with the unemployment rate at 4.1%. Businesses have been forced to raise wages to recruit new staff and to keep existing employees in their seats. Businesses of almost every ilk have talked about the challenges and the difficulties in recruiting new employees, both skilled and un-skilled. We have seen it manifest in a wide variety of industries, from retailers and restaurants to farming and manufacturing to the ongoing trucker shortage in the U.S. With more businesses competing for people in an increasingly tight labor market, related wages and costs have continued to rise for a broad range of businesses in addition to regulatory mandates to increase lower-end wages.
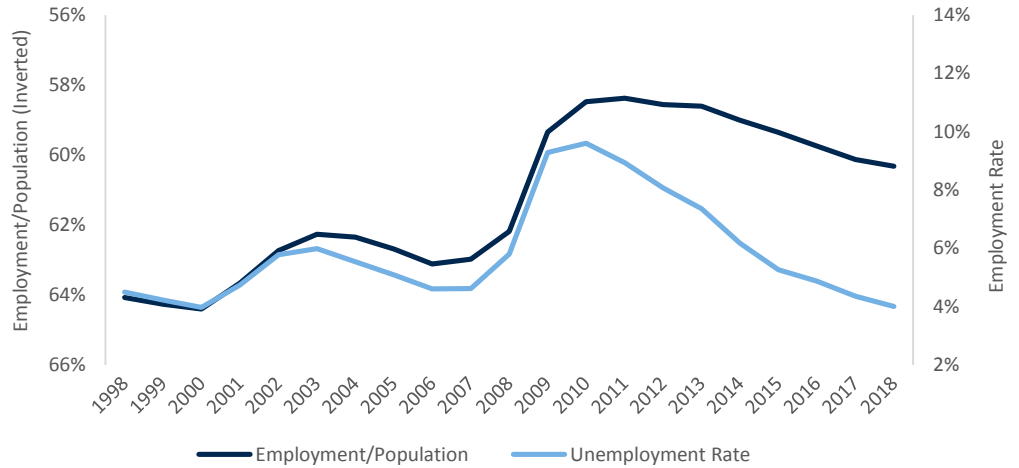
Besides the obvious security concerns, there are easy-to-identify reasons why the markets have sold off as economic nationalism has risen.

RBC Capital Markets

Exhibit 132: Employment to population ratio vs. the unemployment rate

Source: RBC Capital Markets, BLS

Exhibit 133: % minimum wage increases by state

% Increase in 2017

State	%
Arizona	24.2
Maine	20.0%
Washington	16.2%
Colorado	11.9%
Oregon	10.8%
Massachusetts	10.0%
Hawaii	8.8%
District of Columbia	8.7%
New York	7.8%
Arkansas	6.3%
Maryland	5.7%
Connecticut	5.2%
California	5.0%
Michigan	4.7%
Vermont	4.2%
South Dakota	1.2%
Montana	1.2%
Missouri	0.7%
New Jersey	0.7%
Ohio	0.6%
Florida	0.6%
Alaska	0.5%

% Increase in 2018

State	%
Maine	11.1%
Colorado	9.7%
Arizona	9.2%
Maryland	9.2%
Rhode Island	5.2%
Arizona	5.0%
Vermont	5.0%
California	4.8%
Washington	4.5%
New York	4.1%
Michigan	3.9%
Florida	1.9%
Missouri	1.9%
New Jersey	1.9%
Montana	1.8%
Ohio	1.8%
Minnesota	1.6%
Alaska	0.4%

Source: RBC Capital Markets, National Conference of State Legislatures

Immigration limits exacerbate the labor shortage – The labor challenge has gotten even more acute with the threat of further immigration limitations. As seen in the chart below borrowed from RBC Economist Tom Porcelli, job openings continue to increase as employment continues to tighten, and these labor shortages drive costs up across the labor spectrum for companies**.**

Exhibit 134: Job openings vs. the unemployment rate
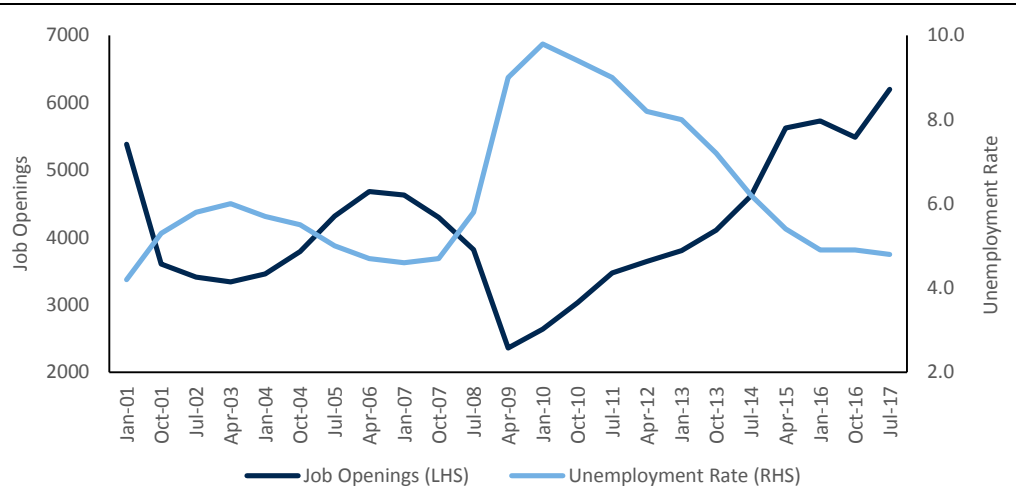
Source: U.S. Bureau of Labor Statistics

Similar to the wage cost situation noted above, we believe that consumers will ultimately bear the incremental costs related to these tariffs.

Consumers may bear the costs on both sides of a tariff war – Similar to the wage cost situation noted above, we believe that consumers will ultimately bear the incremental costs related to these tariffs. In the U.S., Chinese goods will cost more for the average consumer due to the extra duties being applied to those goods. Will Chinese firms cut the cost of their products by 25% to keep their end-selling price flat? Highly unlikely in our view, as most companies simply won't be able to bear such a price cut and margin hit. Therefore, costs on these Chinese goods will go up sharply if these tariffs are enacted. For example, The Consumer Technology Association estimates that while Chinese TVs will increase in price by ~23%, all TVs will go up by ~4% due to the sourcing of various components. On the flip side, companies that are exporting goods to China, who are then disadvantaged in the marketplace (because they are now paying 25% duties in China), may be forced to raise prices domestically to help make up for volume declines overseas. In this scenario, U.S. consumers would end up paying the price on both ends of the tariff war, and we would expect this situation to worsen if these trade tensions intensify.

Net/Net – The U.S. consumer pays – We believe that as companies are forced to raise prices to protect profit margins from the impact of rising wages and increased tariffs, the U.S. consumer will bear the ultimate cost of such policies.

U.S. preparing for increase in "Great Power" competition

Rising defense spending in China has allowed Beijing to catch up and encroach on the U.S.'s technologies and capabilities over the past few years, which was a heavily-debated topic during President Trump's pro defense presidential campaign.

Rising defense spending in China has allowed Beijing to catch up and encroach on the U.S.'s technologies and capabilities over the past few years, which was a heavily-debated topic during President Trump's pro defense presidential campaign. The Trump administration identifies an ascendant China and combative Russia as the two greatest threats to the U.S., driving an increased focus on "Great Power" competition that it outlined in its National Defense Strategy in February 2018. The Obama administration viewed the U.S.'s primary challenges as "four plus one" with the primary threats being China, Russia, Iran, and North Korea, plus terrorism, but this mantra seems to be shifting to a "two plus three" approach with China and Russia now standing on their own as the primary threats under the Trump administration. This is a logical

evolution of the prior administration's view; a June 2015 Military Strategy update by the Department of Defense noted that while the probability of U.S. involvement in an interstate war with a major power was low, it was growing. The focus on Great Power competition should drive a shift in defense spending towards investment in readiness and equipment modernization, particularly the high-end equipment that can act as a deterrent to Great Power competition. In this scenario, resources would shift away from the Middle East and terrorism, and less investment in equipment that is not survivable against more advanced adversaries.

Exhibit 135: Global defense spending
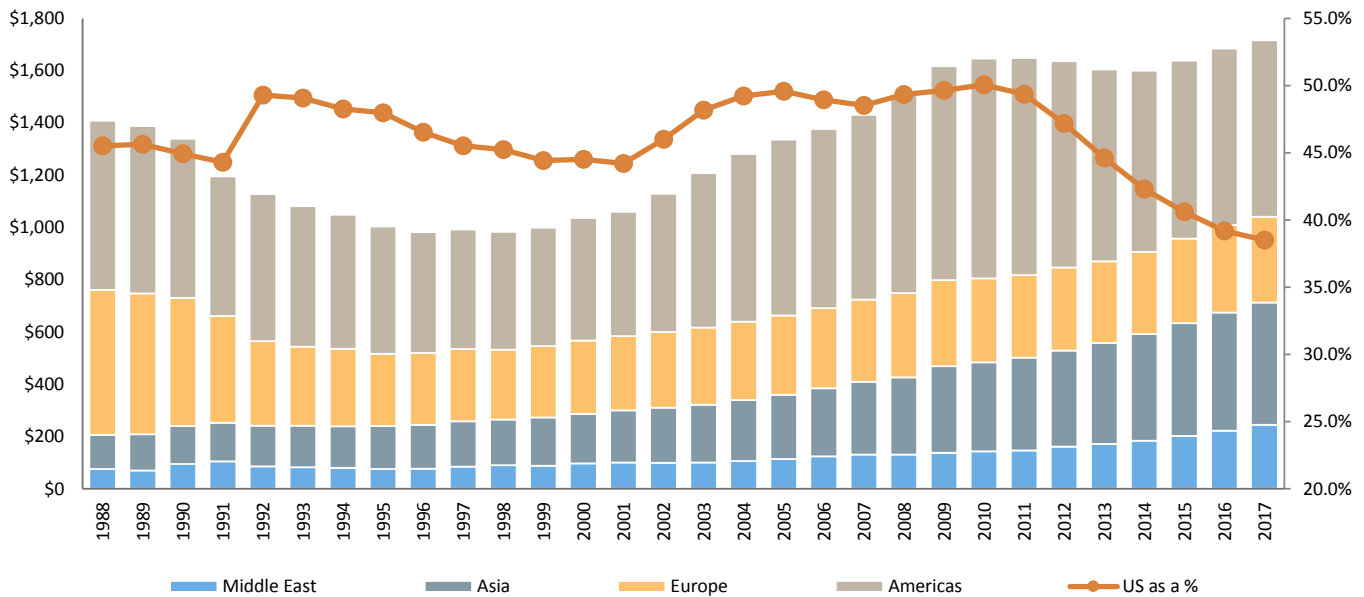
Source: SIPRI, RBC Capital Markets estimates

How defense spending changes under Great Power competition

Recap the nuclear triad. The nuclear triad is the primary deterrent against Great Power competitors, and therefore becomes more important in the current threat environment. The Nuclear Posture Review published in February 2018 essentially settles the debate on whether each leg of the nuclear triad should be updated, as the administration clearly favors continuing ongoing modernization of the three portions of the triad: sea, air, and land.

Space becoming more contested. Russia and China have been working to develop anti-satellite capabilities, challenging the U.S.'s prior viewpoint that space was a sanctuary for its commercial and defense equipment. Over the past few decades the U.S. has put valuable assets in space that are used for a variety of military and reconnaissance purposes with little regard for defensibility. We believe there could be long-term refresh of space assets with a focus that may include a more distributed system of satellites that would be more resilient to potential disruption.

Investment in advanced capabilities. Investments in cyber, electronic warfare, plus more emerging technologies including artificial intelligence and hypersonics becomes more important in Great Power competition. Undersecretary of Defense and Research Michael Griffin recently noted at a House Armed Services Committee hearing in April 2018 that "the most significant advance by our adversaries has been the Chinese development of what is now today a pretty mature system for conventional prompt strike at multi thousand kilometer ranges." Hypersonic missile development by China and Russia cannot be detected by current U.S. missile defense systems, exposing vulnerabilities to the U.S. mainland.

Exhibit 136: Department of Defense Budget (Base + OCO; $billions)
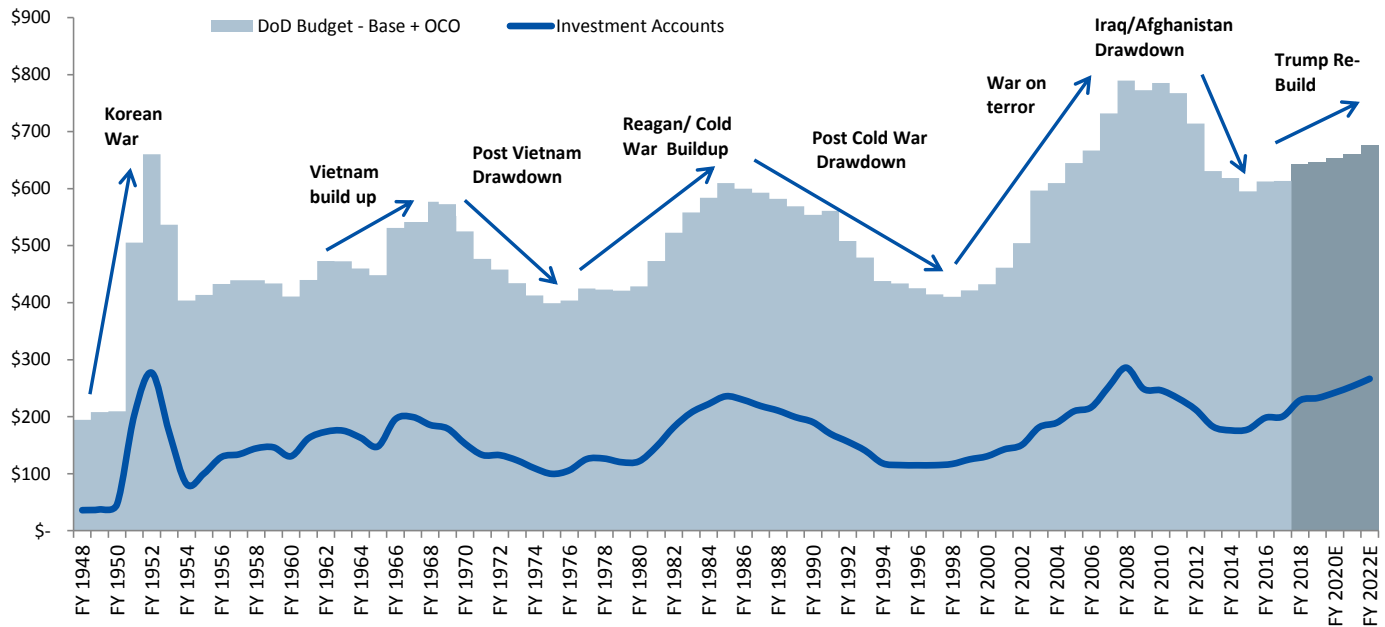
Source: Department of Defense, RBC Capital Markets estimates

Increased cyber threats

The increasing reliance on networks and connected devices and systems has opened new security vulnerabilities, increasing the importance of investment in cybersecurity. The proliferation of cyberattacks against U.S. companies, political organizations, and government officials show how important it is to enhance protections around critical communications infrastructure and data that might previously have been assumed to be secure. Starting in 2013, the Director of National Intelligence has named cyber threats as the number one strategic threat to the U.S., the first time anything ranked ahead of terrorism since the 9/11 attacks. Cyber threats often blur the lines between these categories:

Starting in 2013, the Director of National Intelligence has named cyber threats as the number one strategic threat to the U.S., the first time anything ranked ahead of terrorism since the 9/11 attacks.

- **Military:** Cyber is of increasing importance to military conflicts and potential conflicts given the proliferation of connected equipment, potential plausible deniability of attacks and ambiguity about rules of engagement, and lower cost to entry and broader applicability than traditional military equipment. For example, an adversary like North Korea is unlikely to quickly match the U.S.'s capabilities in traditional weapons, but they can be highly disruptive with cyber operations. Cyberattacks also have the benefit of plausible deniability since it is difficult to conclude definitively where an attack came from. Even when the source country can be discerned with reasonable likelihood, a state can easily claim that rogue hackers, operating independent of the government, conducted the attack.
- **Political:** Recent political cycles also highlighted the aggressiveness with which adversaries can use cyber operations for espionage and to potentially influence elections.
- **Commercial:** Commercial enterprises are also constantly under cyberattacks, demonstrated by high-profile intrusions of companies including Yahoo, Target, and Equifax. Research firm Garnet forecasts worldwide enterprise security spending will total $96.3 billion in 2018, representing a +8% Y/Y increase, and expects 60% of organizations to invest in some form of cybersecurity by 2020, up from roughly 35% today.

ESG – A new hope

It's not all bad… a growing number of corporate bellwethers have recognized the broad societal and environmental issues we are collectively facing and taken steps to make proactive, positive changes to their operating models. Investors are increasingly interested in backing these types of environmentally and socially conscious companies and the expectation for businesses to adopt sustainable practices has risen. These trends have led to a growing market for environmental, social, and governance (ESG) investing, which is graining traction globally. ESG investing, a form of sustainable investing, is focused on the systematic evaluation of environmental, social, and governance related issues in fundamental investment analysis and asset allocation decisions. A United Nations supported initiative, *Principles of Responsible Investing (PRI)*, introduced a voluntarily framework in 2006, outlining six principles aimed to include and promote awareness of ESG related issues among global investors. PRI now counts almost US$70 trillion in AUM amongst its signatories, including asset owners, investment managers, and service providers, with a 24% CAGR in signatory AUM since the framework was introduced over ten years ago.

Exhibit 137: Historical growth of PRI signatory AUM and signatory count

Source: Principles for Responsible Investment (PRI)

Once considered a "niche" area, the consideration of ESG factors in investment analysis is now widely accepted. For a recent example of this broader shift, consider the 2017 annual letter from BlackRock founder and CEO, Larry Fink, in which he stated, "*Society is demanding that companies, both public and private, serve a social purpose. To prosper over time, every company must not only deliver financial performance, but also show how it makes a positive contribution to society.*" Overall, we believe this mindset is becoming increasingly important for companies not only in the assessment of investment value but to remain competitive with rapidly changing societal preferences. Going forward, we think growth in ESG investing could have profound impacts on both investors and companies. The growth of ESG investing presents a risk for companies that may not "screen" well in some of these areas. We think the onus will fall increasingly on company board and management teams to fulfill these new investor demands by clearly articulating both profit-motivated goals and societal value or potentially face losing a social license to operate.

Going forward, we think growth in ESG investing could have profound impacts on both investors and companies.

In 2010, Home Depot set a goal of reducing their per-store energy usage by 20%, but through focused efforts, they actually achieved a 30% reduction in energy usage by 2015.

Big Box taking the lead – In 2010, Home Depot set a goal of reducing their per-store energy usage by 20%, but through focused efforts, they actually achieved a 30% reduction in energy usage by 2015. Similarly, they targeted a 20% reduction in carbon emissions within their supply chain between 2008 and 2015, but ended up achieving 35%. Best Buy also set a goal in 2010 to reduce carbon emissions by 20% by FY20, but they achieved this target in FY16 and then raised their target to 45% by FY20. By 2017, Costco was using solar powered systems in 100 warehouses and started to install fuel cells as an alternate source of electricity. Walmart has been one of the leading advocates in corporate America regarding sustainability efforts. They have focused not only on energy usage and related carbon emissions, but have extended their reach to include deforestation efforts and even reducing the usage of sodium and sugar in foods to improve healthy eating habits. They are also pushing their environmental efforts to their supplier base through their "Project Gigaton," where their goal is to reduce emissions *throughout their entire value chain* by one billion metric tons by 2030. In other words, Walmart is increasingly pushing their environmental agenda to other companies that want to do business with Walmart.

According to the U.S. SIF Foundation, total U.S. assets dedicated to ESG mandates grew 33% from 2014–2016 and represent nearly 22% of total professional AUM.

Rewarding good behavior – We think it is important to note that financial and risk mitigation benefits can accrue to companies that are currently focusing on resource sustainability efforts. Although many of these positive initiatives are internally driven, the sizable, growing pool of investment assets that are focused on ESG mandates can further drive beneficial corporate change. According to the U.S. SIF Foundation, total U.S. assets dedicated to ESG mandates grew 33% from 2014–2016 and represent nearly 22% of total professional AUM. The pool is even bigger in Europe (usually with stricter mandates) where nearly 53% of professional AUM have an ESG mandate and many of these investors will explicitly exclude the securities of companies that do not follow specific ESG requirements. This leaves an ever bigger pool of assets to invest in companies that are the best stewards of resources.

Conclusion

It is clear that uncertainty is escalating as we think about the challenges of climate change, resource scarcity, and national and economic security. These are borderless challenges where geographical boundaries are less important, requiring unique technologies and global solutions. There is an opportunity for multinational cooperation based on mutual shared interests, reinvigorating moribund international institutions in the process. However, we are fighting the headwinds of a more conflict-ridden world, in which multiple actors exercise veto power through disruptive, asymmetrical action, and one in which some of these key cross-border problems go unaddressed and potentially even metastasize. Hope is not a strategy.

What if…? Escalating Uncertainties

What if we have seen a permanent escalation in global military tensions – Middle East, North Korea, South China, Ukraine – which require a step function change in global military spending? What does it mean for allocations of public spending? Will we see a cut to entitlement spending leading to further unrest? Does it lead to more authoritarian rule globally?

What if populism ends the growth of the tech juggernaut? What if Brexit and Trump 2016 are signs of more to come? What if popular unrest regarding job loss as a result of technological automation continues to rise and we see a more significant political and regulatory backlash? Is there a threshold where technological efficiency becomes illegal?

What if we have seen the end of globalization as we know it? What if different climate regimes, tensions around economic policy, resource shortages, and concerns about a shrinking labor pool lead to trade balkanization and an end to the free flow of goods and human capital?

What if the impacts of global warming and climate change, which have been a growing threat to coastlines and weather volatility for many years, were to rapidly accelerate? How would insurance companies respond to increased loss frequency and severity? Would coastal areas become "uninsurable" by private companies, leaving the coverage to state run organizations? How would reinsurance be impacted? What would be done about coastal buildings that became uninhabitable or not safely inhabitable?

What if carbon levels and temperatures continue to accelerate at unprecedented levels causing a population shift to more northern regions around the globe where infrastructure is not able to handle the inflow?

What if climate change opens up new shipping corridors or access to natural resources in the Arctic?

What if rapid advancements in solar energy production and storage enables vertical farms to proliferate in urban centers – further exacerbating rural population declines? How will this impact existing infrastructure already strained by rapid urban population growth?

What if the merging of policy, finance, and technology cannot keep pace with the negative effects of climate change?

What if artificial preservatives are not needed in the future thanks to Hyperloop freight distribution, enabling super-fast transportation of fresh foods from the "salad basket" of California and the "bread basket" of the Midwest to consumers in New York in a matter of hours? Will packaged-food companies sell anything consumers actually want to buy?

What if rising nationalism and the resulting growth of military expenditures forces significant cuts to social programs, exacerbating today's economic divide between the "haves" and "have-nots"?

What if the nascent rise of protectionism/nationalism forces companies to reevaluate their geographic manufacturing footprints and retrench in their home countries?

What if…? continued

What if water becomes the new oil? Do we see countries become more valuable on the global stage because of their water resources?

What if the U.S. closes its borders/enforces more stringent immigration policies? What impact does that have on the employment base in the U.S., especially for many lower-end jobs where it is already difficult to recruit workers? Do such policies accelerate U.S. and global wage pressures, creating a massive tailwind to inflationary pressures? Could increasingly disenfranchised/hopeless people being pushed out of "Western" societies increase social unrest and increase the probability of civil war across the globe?

What if American cultural hegemony ends and India, China, and other faster-growing nations begin exporting their values and taboos around the world rather than vice-versa? How will this impact media and advertising? Consider the far more sophisticated gift-giving culture in China versus the West. And how will this impact the categories in which large food and beverage companies participate? Consider how pork is prohibited in Islam (25% of all humans) or how beef is largely prohibited in Hinduism (15% of humanity).

What if space assets that were previously viewed as protected become increasingly contested by U.S. adversaries?

What if climate change causes consistently unpredictable and unfavorable weather to the detriment of crop production amid a growing population?

What if countries expand the use of renewable energies and improve technological efficiency quicker than previously assumed?

What if natural resource economies are not able to successfully monetize their resources as a bridge fuel? What happens in the case of stranded assets? How do we think about this particularly in regions with growing populations and persistent unemployment?

What if the use of alternative energy fuels causes lower oil prices, creating civil unrest in economies that rely primarily on hydrocarbon revenues (Venezuela, Saudi Arabia, Russia, etc.)?

What if large companies, under profit/shareholder pressure, abandon resource management efforts? If renewable energy becomes less economic than traditional petroleum-based sources due to reduced tax credits/improved drilling capabilities, can companies really afford to pursue renewable energy sources? Would shareholder activism increase at companies that diverted capital resources away from better economic alternatives? How would countries deal with accelerating degradation in air and water quality? How big of an economic impact would there be from rising healthcare costs as a result? At what point would we reach a point of "no return" in environmental wellness?

What if "nationalism" efforts continue to gain steam across the globe? Which companies and industries would suffer the most from reduced trade activity? What would the ultimate impact be on consumers as companies try to pass on tariff pressures? How much would consumers change their buying habits if the cost of imported goods rose sharply?

Theme VI: The Agility Imperative

The Agility Imperative is based on the increasing need for companies to be flexible and able to quickly adapt to the societal change forces. An asset base and existing brand equity will no longer be enough to carry companies through changing times, or to sustain dominance and relevance in a category. In fact, it may lead to their extinction. Companies will have to change their structures and culture to adapt.

What you need to know…

No company regardless of size of the sector they compete in, is immune from disruption. And we may be approaching a breaking point for many companies. The longer a company defers tough decisions (which will likely disrupt top line or cause earnings pressure), the less relevant these companies could be to their customers, employees, and investors.

Why be agile?

Because things can change rapidly and unpredictably. The discovery of the helicobacter gut bacterium rewrote medical textbooks and proved that even the smartest people in the room can be proven wrong. But being wrong is OK. Failing to course correct before your competitors is NOT.

Because network effects and feedback loops are making fewer winners and more losers. As we discuss below, businesses and brands that are considered to be the best may enter a flywheel of success too difficult for competitors to dislodge or penetrate. And our increasingly interconnected world puts more value on asset light networks (i.e., Facebook, Uber, AirBnb) than weighty assets.

The four agility mandates

Make people believe. The brain drain towards the best companies is accelerating as the global labor force is increasingly open to all. This underscores the need to create compelling and inspiring cultures and incentives. **Netflix** is refreshingly clear about its mission – to entertain the world – and it pays top dollar to attract only the highest performers.

Consider a new business model. The right business model can create a path to success and also encourage agility. At times, the best future business model may require investment (e.g. a near-term EPS sacrifice) or otherwise seem like a risky bet. **Apple** was not the first to bring digital music players to market when it introduced the iPod in 2003.

Seek allies. Food and restaurant companies are in the convenient meals and snacks business – not the medical diagnostics or transportation businesses. But over the next 5-10 years these two sectors may augment eating patterns more than any particular type of food. **Campbell Soup** invested in Habit, a company that invites consumers to send blood samples for DNA testing, and ultimately prescribes a custom diet based on the results. Delivery aggregators like **UberEats**, **GrubHub** and **DoorDash** all strive to be the dominant delivery platform, but won't get there without the right foodservice allies.

Lighten up. Ownership of physical assets has become less important and we believe this trend will continue. Asset-lite models thrive in the ever-increasing digital world and the shared and gig economies. **Roper Technologies** recently reached a negative working capital milestone thanks to its prescient and early embrace of SaaS and asset-light businesses.

Feeling disruption in our gut

According to a KPMG survey of CEOs, almost six out of 10 business leaders are concerned that their organizations do not have the sensory capabilities and innovative processes to respond to rapid disruption. According to an Accenture study, 52% of corporate employees surveyed said they had pursued what they thought to be an innovative or entrepreneurial idea but only 20% said they believed that management was supportive of such new ideas.

Even in the world of medicine, where the establishment prides itself in an evidential approach and discoveries can be "proven," ideas can die unless put in the hands of a persistent entrepreneur or the right organizational structure.

Consider the case of the helicobacter.

At one point or another, roughly 1 in 10 people around the world suffer from stomach ulcers. For centuries, it was believed that this agonizing ailment was caused by stomach acid, which in turn was believed to have been caused by high levels of stress often, in more recent times, brought about by one's lifestyle or career choices. Then in 1982, Australian research scientists Barry Marshall and Robin Warren discovered the *helicobacter pylori* bacterium. They posited that it, not acid caused by stress, was the primary cause of the common stomach ulcer in humans, responsible for 80%–90% of cases, and possibly a major cause of certain gastrointestinal cancers as well.

The helicobacter heretics

Despite being right about the connection between ulcers and helicobacter, Marshall and Warren struggled to publish their discovery since it, rather inconveniently, upended current conventional medicine. Their initial research was rejected by the Gastroenterological Society of Australia, where the committee ranked their findings within the "bottom 10%" of submissions. Then two years later – faced with few willing volunteers – Marshall famously infected himself with helicobacter by drinking broth mixed with the bacteria. The experiment helped to further prove their findings and made Marshall something of a celebrity scientist. In 1999, the Royal Society called Marshall's work "one of the most radical and important changes in medical perception in the last 50 years." And in 2005, Marshall and Warren won the Nobel Prize in Physiology or Medicine.

Exhibit 138: The heliobacter pylori disrupts the stomach
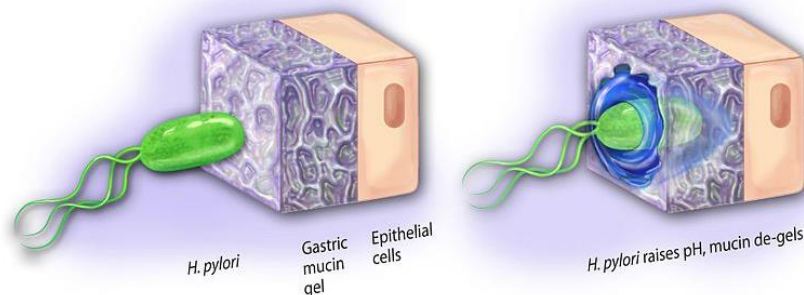
Source: National Science Foundation

Removing barriers to the best ideas

Most scientists would tell us that their profession is the practice of questioning and experimenting against prevailing beliefs – that facts are facts until they're not. No better has this been demonstrated than by the struggles and ultimate success of Marshall and Warren. But despite these principles, myopia and institutional barriers can slow progress—even in the hands of the world's smartest thinkers.

Clearly, when a paradigm shifts, the prior strategic imperatives and outlooks of companies and whole industries can be upended, and existing public companies would love to be the ones inventing these disruptive technologies. However, those that are built to last will—at a minimum—react swiftly by spawning new strategies while lumbering companies often react more to the agile companies' reactions rather than the change force itself.

Marshall and Warren's discovery led to a paradigm shift that forever altered the medical community's understanding of gut bacteria and the impact to our internal ecosystem. Yet their research took far too long to become a benefit to the world. In 1985, Dr. Marshall published the results of that legendary self-induced infection. Yet, it was years before hospitals like the Mayo Clinic viewed antibiotics to kill the H. pylori bacterium as the primary treatment of stomach ulcers and a full 20 years before Warren and Marshall were awarded the Nobel Prize for their discovery.

A "short-term" crisis of conscience

More "helicobacter"-scale disruptions are on the horizon. It is not hard to believe that somewhere in the greater Bay area, there is some entrepreneur thinking about technologies impacting virtually every business segment.

Disruption is inevitable as a result of numerous agents of change

Just consider a fraction of the many provocative "What If" scenarios lining the pages of this report. Yet despite the accelerating change and disruption already present (i.e., automation and AI, emboldened start-ups thanks to rapidly lowering barriers to entry, extreme weather events, geopolitical turmoil), many companies struggle to embrace disruptive change forces.

Causes of a failure to innovate and quickly adjust include:

1) scale and organizational hierarchies,

2) aversion to risk,

3) the need to report results on a quarterly basis.

The reasons for this failure to self-disrupt are numerous and seem to include organizational hierarchies, aversion to risk, and the need to report results to shareholders on a quarterly basis. In a recent Duke University survey, executives were asked how they would consider reacting if the quarter was ending and it looked as though the company might come in below the desired earnings target. Approximately 80% of respondents suggested they might decrease discretionary spending (R&D, advertising, maintenance, etc.) and over half said they would delay the start of a project. Are these decisions accretive to long-term survival? We think not.

Criticism of short-termism is nothing new, but bigger fish are growing more vocal lately. Warren Buffet and J.P. Morgan CEO Jamie Dimon recently wrote an op-ed in the Wall Street Journal (link/06/6/2018) criticizing the perceived increase in short-term thinking among corporate management teams. One of the biggest contributors to short-termism, in their view, is the providing of quarterly earnings guidance to investors. Their view can be summed up in the following quote:

> *"In our experience, quarterly earnings guidance often leads to an unhealthy focus on short-term profits at the expense of long-term strategy, growth and sustainability." – Buffet and Dimon*

Buffet and Dimon go on to explain how the pressure to deliver on quarterly earnings expectations leads to value-destructive behaviors on the part of management, such as delaying investments in people or technology. They go on to posit how this short-term

dynamic is a contributor to the decline of public equity issuance, which in turn boxes out small retail investors, retirees or pensioners from participating in long-term economic growth via public equities.

Exhibit 139: Within an era of accelerating disruption and change, companies are over-emphasizing the short term at the risk of long-term success

$$\text{Value} = \boxed{\frac{CF^1}{(1+dr)^1}} + \frac{CF^2}{(1+dr)^2} + \ldots + \boxed{\frac{CF^n}{(1+dr)^n}}$$

Too much focus.   Not enough focus.

Source: RBC Capital Markets

We agree with the spirit of Buffett and Dimon's "call to action," and agree that the pervasion of short term is anathema to long-term profitable growth. But reality is also a bit more nuanced. An argument can be made that CEOs who provide quarterly guidance are simply doing so because shareholders demand such transparency. Shareholders are the ultimate decision makers – not boards of directors or management teams. If our line of thought is a fair one, then consider why such guidance might be valued by those shareholders. For one, in a world of accelerating change, investors may be losing confidence that even the smartest and most competent management teams can successfully navigate a faster-approaching future. Instead, investors are increasingly confident that the world may change more in the next 3–6 months than it has in the last 3–6 years. They want to be assured of what management sees and expects not only over the horizon, but also before it. We live in a society in which – for better or for worse – consumers are checking their smart phones every 20 minutes (46 times per day according to a recent Deloitte study). And these consumers and investors are the same people.

Companies should be courageous and transparent in the communication of long-term and short-term expectations

In our view, companies would be wise not to alienate certain classes of investors that may have varying risk tolerances and investment horizons. If a company has shared a laudable long-term vision with investors, then why not also signal short-term expectations? Are companies scopophobic – fearful of being watched? If short-term minded investors sell stock on a quarterly expectation missed, then is that not a buying opportunity for the long-term minded? America is also aging fast. How will retirees and pensioners feel if management traded dividend stability for investments in a future they may never see?

RBC Capital Markets

Because in a period of accelerating change, perhaps there is no such thing as the short term

Exhibit 140: Amount of data and information available is accelerating rapidly
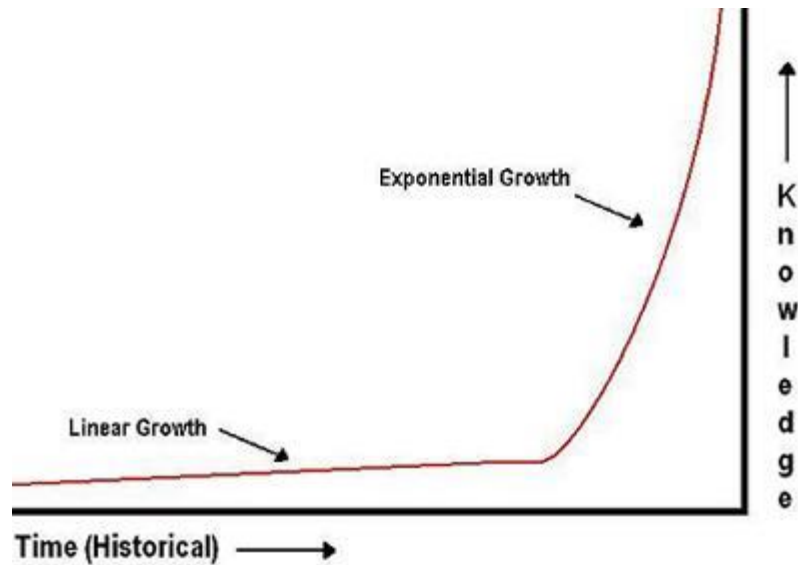
Source: The Buckminster Fuller Institute

Those companies focused on the long term are often the most agile

Despite our discourse, we view the "short-termism" argument as one to be left up to the world of academia. In the world of investing in stocks, we recommend investors identify those individual companies already careening towards the future with confidence. In this report, our general aim is not to chastise short-term–minded companies, but instead extol the long-term minded so as to inspire the others. And our findings suggest that the long-term companies are also the most agile companies – often the result of long-term oriented missions and value-creating cultures. Those companies that agree the next 3–6 months may change more than the previous 3–6 years acknowledge that they too must be able to change just as rapidly if not more so. This leads to the rising importance of four agility mandates:

1) Make people believe
2) Consider a new business model
3) Seek allies
4) Lighten up

In this section, we explore *case studies* on each of these agility imperatives. We explore how Netflix has succeeded in making customers and employees alike believe in the company and what it stands for. We explore how alliances and partnerships are becoming even more important in the world of packaged food and restaurants. And we explore how asset-light business models are upending the industrial and retail worlds. But first, we explore why we believe agility will become a mandate for survival – the winner-take-all future.

If you ain't first, you're last

We believe "winner-take-all" is creeping into many business segments—particularly as technology provides a path to rapid scalability, reinforces feedback loops and promotes mindshare

Many CEOs of large companies have spent the better part of their professional careers in a company. By the time they have reached the "C-suite" they are reaching the twilight of a long and lucrative career. The first instinct may be to "not screw things up," with many personal loyalties and legacy thinking further constraining bold choices and lateral thinking. Mix together these leadership biases with an accelerating rate of change and you have a typical starting point for many leadership teams. However, the picture is getting more scary for those companies that do not embrace change and grab the leadership position.

In 1995, economists Robert Frank and Philip Cook wrote the socio-economics classic "The Winner-Take-All Society." The book describes how despite often very small relative performance deltas, a victor's spoils are often far higher than those of second place, third place, and so on. In other words, someone only marginally better than the next person is disproportionally rewarded, and that this trend may be increasing. Consider two top lieutenants being groomed to be the next CEO of a large corporation. One's skills or capabilities may inch out the other's by 0.01%, but he or she will earn 100% of the financial and social rewards of becoming the "next CEO." When we look at the widening income and wealth gap in the U.S., for example, this 20-year-old text looks ever more prescient. Some early critics of Frank and Cook's research suggested that the "winner-take-all" effect was largely confined to the sports and entertainment industries. For example, only five players can start for an NBA basketball team, and those players are the only ones with Nike and Gatorade endorsements. But as we discuss below, we believe "winner-take-all" is creeping into other segments of business and society—particularly as technology provides a path to rapid scalability, reinforces feedback loops and promotes mindshare.

Exhibit 141: The Winner-Take-All Society

Frank and Cook may have been ahead of their time in saying fewer at the top will get so much more than the rest of us
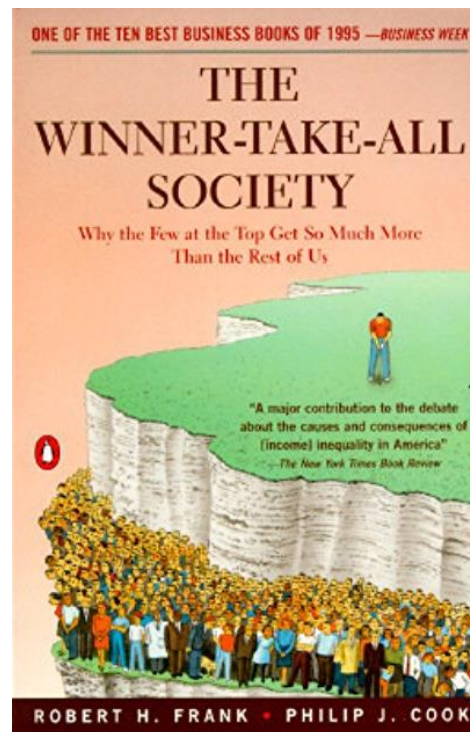
Source: Penguin Books

Feedback loops and network effects are accelerating

Feedback loops and network effects are two of the biggest contributors to the "winner-take-all" effect. A feedback loop occurs within a system when the reaction to a stimulus affects future reactions in either positive or negative ways. For example, the more skilled a person becomes at, say, golf the more the person will enjoy golf. The more enjoyment, the more playing, which makes the person even better, and so on. Similarly, the more people seen running out of a building in panic will influence how many more people will be running out of the building in panic. In the consumer world, a previous experience that was positive suggests that future experiences will also be positive. A network effect is a similar phenomenon whereby the perceived value of a system is increased as the number of participants rises. Think of the value of Facebook (plus Instagram and WhatsApp) and Uber. These companies stand among the world's most valuable because of the size of their user networks – not necessarily their assets or profits.

Be the best, move first, and dare to self-cannibalize

For companies in legacy technologies or leadership positions the price of future leadership may be the courage of self-cannibalization.

Feedback loops and network effects are forcing companies to fight to be **the best** in their categories, or at least strive to be. And in categories on the precipice of ubiquity (i.e., AI, self-driving vehicles, robotics), the pressure to be the best – the first and fastest mover – is even greater. For companies in legacy technologies or leadership positions the price of future leadership may be the courage of self-cannibalization.

Companies who try to stall innovation for fear of cannibalization will eventually fail. We point to the case of Kodak who first invented the digital camera in the 1970s but, out of fear of cannibalizing its own film business, pushed the idea in the closet. Contrast this to Apple and the iPod, which launched in 2001, selling for $400, and becoming Apple's most iconic product at the time. However, the iPod business was cannibalized by the iPhone, launched in 2007. The need for a separate, standalone music player essentially disappeared once its functions were integrated into a phone. The iPod classic was discontinued by Apple in 2014 and the iPhone went on to become the best selling tech product year after year.

Try to brainstorm the merger or alliance that would be a nightmare (or dream come true) for your investment or business.

Exhibit 145 shows the rapid market share gains of Apple's iPhone in the smart phone market beginning in 2010. What if a similar inflection occurs in the U.S. luxury automotive market, making Exhibit 146 look more like Exhibit 145? What if Uber's aggressive promotions to gain users, aggressive spending in autonomous-driving capabilities, and the right alliances earns it 80%+ of the global transportation market in the future versus a highly fragmented one today?

RBC Capital Markets

Exhibit 142: Network effects can increase in valuation quickly and dramatically

$50 billion

July 2015: Strategic investors including Microsoft and India's Times Internet group invested at a $51B valuation.

Jan. 2011: Goldman Sachs arranged a private offering of shares at a valuation of $51B, half its IPO valuation a year later.

Uber   Facebook

40

30

20

10

0

Years from launch

0   1   2   3   4   5   6

Source: staff reports

THE WALL STREET JOURNAL.
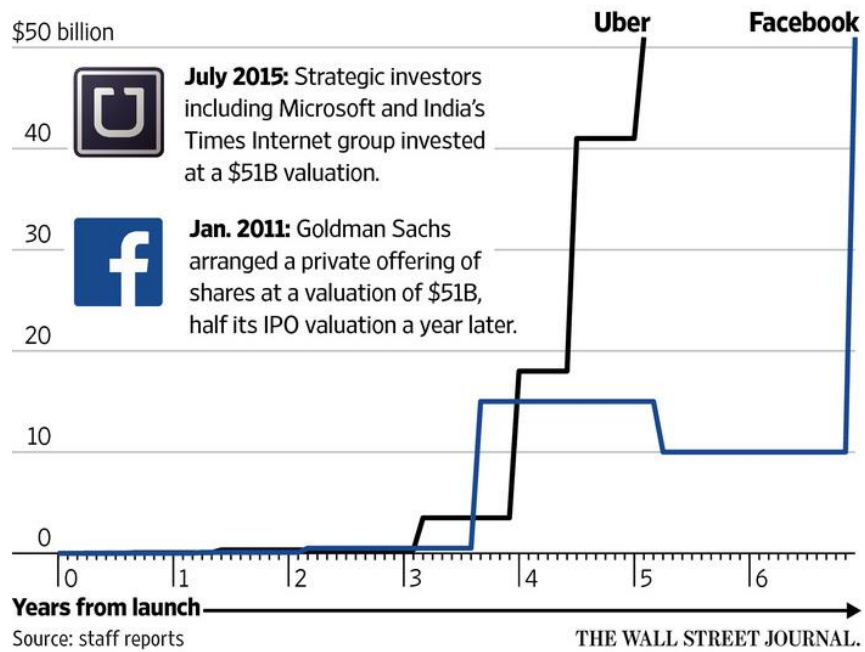
Source: The Wall Street Journal

Exhibit 143: Apple unit sales by product (millions)
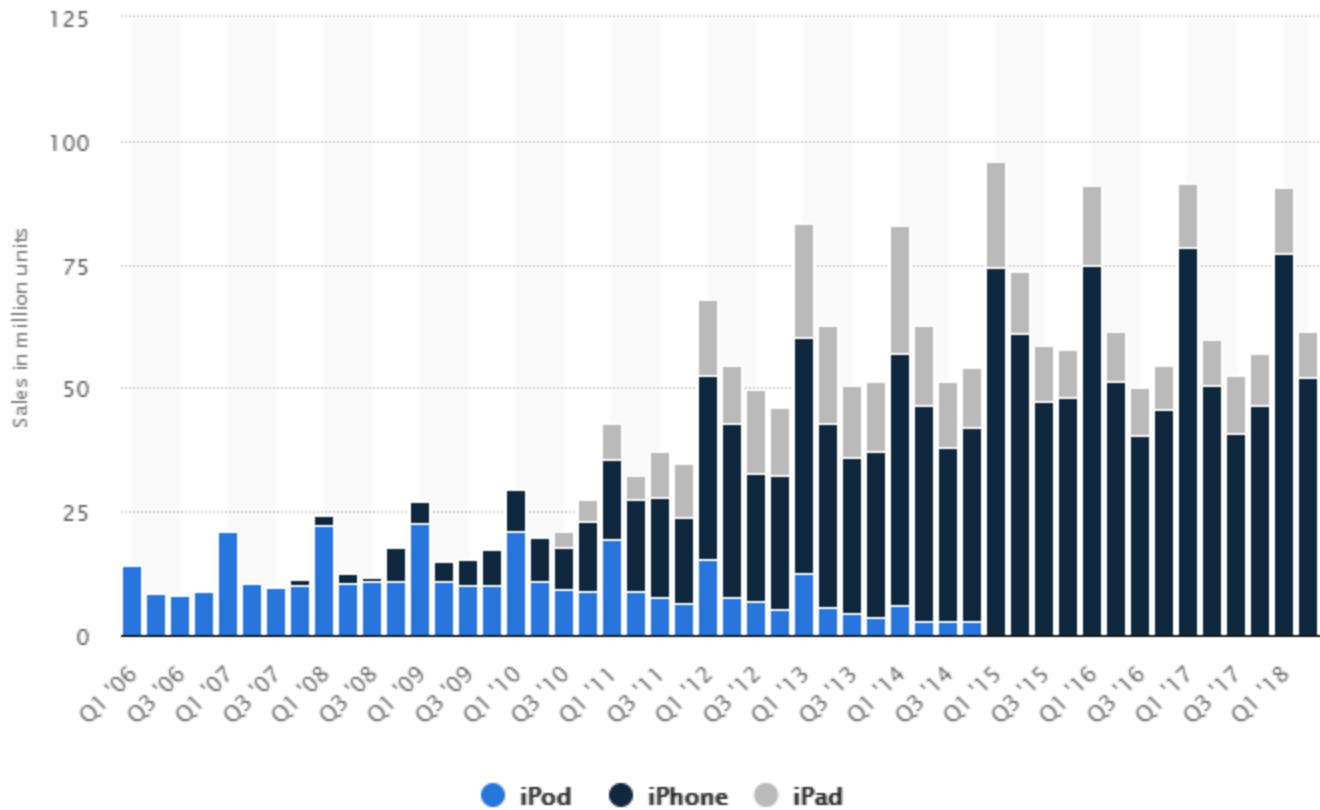
Source: Company Filings, Statista, RBC Capital Markets

Exhibit 144: U.S. smartphone platform market share
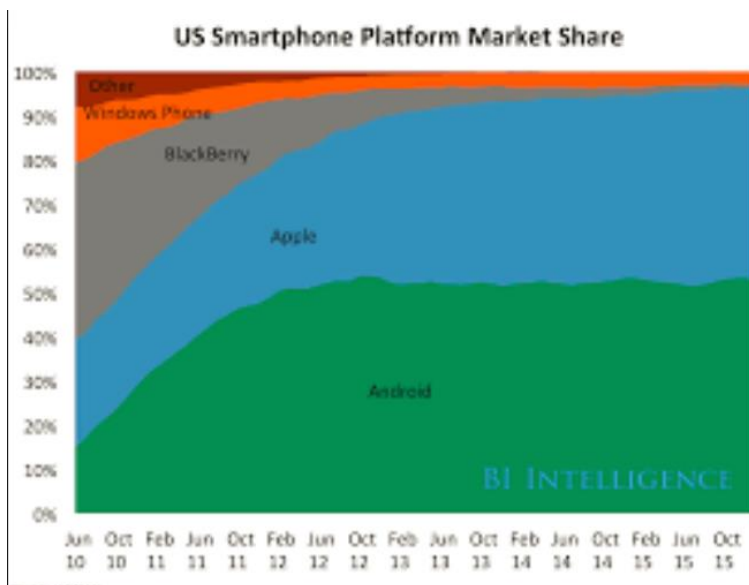
Source: Business Insider, Reuters, Company reports

Exhibit 145: U.S. luxury auto share
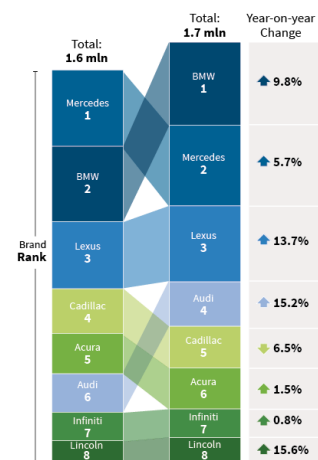
Are consumer reviews on Amazon becoming the new "brand"?

"The best" has become far more accessible

In the consumer world, the battle to be the best is becoming even more important in an age of instant consumer reviews, 24/7 news cycles, accelerating user-generated content, and the rising democratization of influence (i.e., social media influencers). Fifty years ago, outside of traditional advertising, consumers mostly had only their own prior experience, recommendations from close friends and office colleagues, and the occasional newspaper or magazine review to help influence what products they should buy or what places they should visit.

Today, anyone with access to the Internet (88% of Americans, 47% of humanity) can quickly find out "who's the best?" with a Google search (e.g., "best car insurance in California," "best SUV for growing families," or "best chicken wings in Buffalo, NY"). Sometimes these search results will include aggregators that rank products and services based on qualitative user feedback or star-based ratings. Other results might simply be subjective "top-10" lists on a popular blog or news page. Or in a world in which consumers, especially Millennial consumers, increasingly distrust large institutions and instead rely on social media influencers or their own individual networks, word of mouth is making a massive comeback, accelerated by ubiquitous communication technology. In any of these cases, what is increasingly said to be the best may begin to display a flywheel of success too difficult for competitors to dislodge or penetrate.

Are sites like Rotten Tomatoes making Marvel the fastest-growing superhero movie franchise of all time?

James Bond's suit is flashy, but Tony Stark's can fly

Perhaps an even better example than the iPhone is the rapid rise of Disney's Marvel Cinematic Universe (MCU). In just ten years, beginning with the seminal Iron Man film, the MCU has meteorically risen into the top five all-time movie franchises by U.S. box office revenue (Exhibit 147). The MCU now sits just a tad below Star Wars and well above James Bond with over $7B in inflation-adjusted U.S. box office receipts and is head and shoulders above the competition in global box office receipts of almost $17B. Surely, a major contributor to Marvel's accelerating success (e.g., Avengers: Infinity War released April 27 surpassed $2B global box office mark) is its consistently superior reviews on sites like Rotten Tomatoes versus competing studios' superhero lineups (Exhibit 147). Consistent quality scores combined in part with the viral nature of media and information means that future Marvel films will likely be the "most anticipated of all time." And the MCU has achieved this "favored franchise" status in a fraction of the lifespan of Luke Skywalker and James Bond. Marvel appears to be a winner taking the whole of the box office.

Exhibit 146: Top U.S. movie franchise box office sales
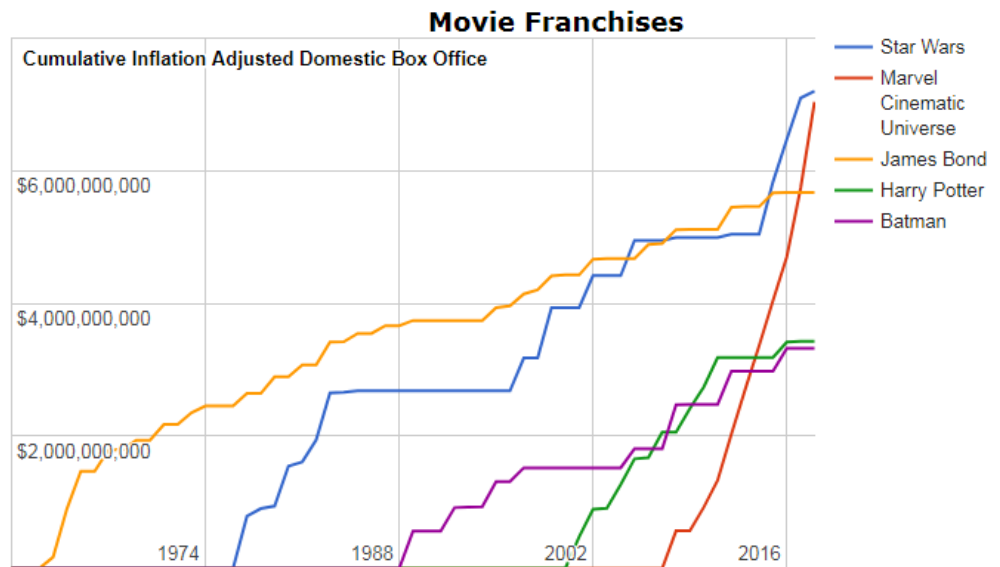
Source: the-numbers.com

Learning from Amazon: A prime example

Amazon's sales really exploded after 2005 with the launch of its paid subscription service, Amazon Prime. Free shipping is practically a baseline expectation for consumers now but, in 2005, free two-day shipping was a big idea for what began as an online bookstore. Since then, Amazon Prime boasts more than 80 million subscribers, and has consistently posted 20%+ sales growth since 2002. By other metrics, Amazon would not look as attractive relative to some of its retailer peers. Amazon has a 2.9% estimated EBIT margin compared to 4.6% at Best Buy, 4.6% at Walmart, 6.0% at Target, and 6.2% at Bed Bath and Beyond. And, through the years, Amazon's earnings growth has been inconsistent. These have been some of the sacrifices Amazon has made to earn and retain market share over the long run, and to create value in the process.

Exhibit 147: 2018 estimated EBIT margin
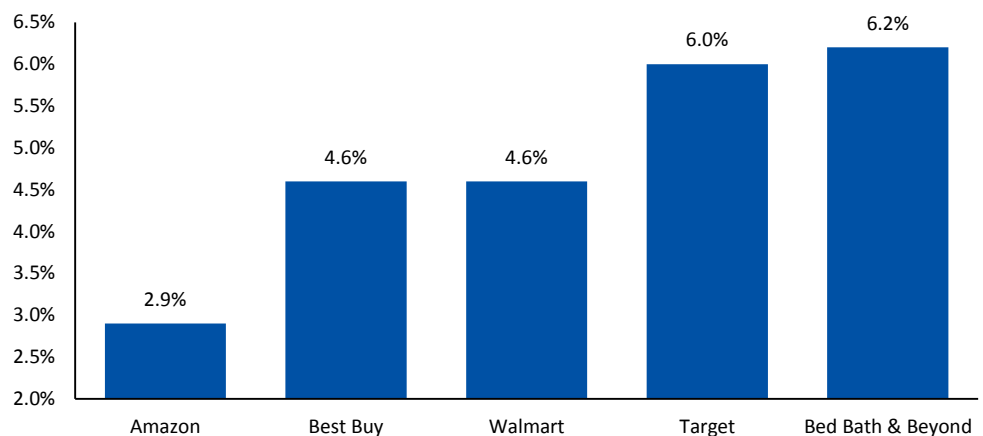
Source: FactSet

Exhibit 148: Amazon annual sales

Amazon Annual Sales ($b)

amazon *Prime*

FREE
2-day shipping

Year	Sales
1	$1
2	$2
3	$3
4	$3
5	$4
6	$5
7	$7
8	$8
9	$11
10	$15
11	$19
12	$25
13	$34
14	$48
15	$61
16	$74
17	$89
18	$107
19	$136
20	$178

Source: FactSet

Consider Amazon reviews. Jeff Bezos shared the origin story of book reviews at the Bush Presidential Center's Forum on Leadership Conference at SMU in 2017. The company decided in 1995 to allow consumers to post reviews of books on the site, much to the chagrin of book publishers who thought Amazon could boost its sales if it only allowed positive reviews. Only 23 years later, this seems preposterous. But what it has led to is an environment in which access to value and rating information, democratized across real world consumers, has never been more freely and readily available. And we believe this will accelerate in ways highly impactful to companies across all industries.

Accelerating asymmetries of punishment

Investors already understand negative feedback loops. When a company fails to execute against plan or targets, earnings go down and they develop a track record of poor execution. This reduces their forward earnings multiple – often trading at a discount to competition. This devalues the company's equity with which to finance further investments or acquisitions, potentially leading to either cutting corners or second-rate assets, which further heightens execution risk. However, in a world of accelerating change, we believe negative feedback loops can accelerate the downside. Take Chipotle…

Exhibit 149: Negative feedback loop
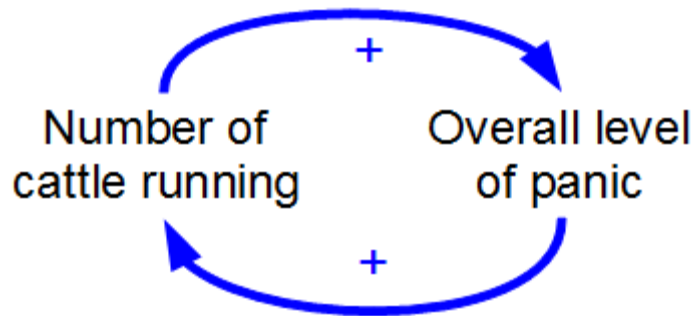
Source: Metadesigners

Bad news travels fast, so move faster

Bad news travels faster in today's information age…The most agile companies will get in front of negative news and create their own positive news.

In early November 2015, reports surfaced that several people became ill with an E.coli strain traced to several Chipotle locations. The health scare appeared to be short-lived and localized at first, but more sick customers made the headlines in the ensuing weeks. While an even more deadly strain broke out at Costco in late November, Chipotle's E.coli media mentions dwarfed those of the club store. Chipotle customers ran for the exits and the CDC did not issue an official "all clear" until February 2016. Perhaps Costco is an unfair comparison since it is not a restaurant – its E.coli strain was traced to a pre-packaged chicken salad SKU. A better comparison is the 2006 Taco Bell E.coli scare, which led to more than double the hospitalizations than during Chipotle's – 55 patients versus 22. But only ten years ago, social media was in its infancy and viral news was far less infectious than it is today. For every Chipotle-related E.coli patient, the modern media published almost 300 unique articles versus less than 40 per patient related to the 2006 Taco Bell scare.

Despite the "all clear," deep discounts, new suppliers, changes in the cooking process, and employee sanitation training, Chipotle's stock price dropped from $732 before the incident to $462 two years later. And, at their worst in Q1 2016, same store sales declined 29.7%. In Q3 2017, Chipotle introduced queso to its menu for the first time in a bid to regain its footing, but quality scores missed the mark. While the company acknowledged it could improve the queso recipe, we have to wonder if its recent execution issues with respect to biosafety have caught it in a negative feedback loop among consumers. In a twist of irony, Taco Bell president Brian Niccol was recently hired to take the lead at Chipotle and we are intrigued by whether he can reverse the negative feedback loop.

Exhibit 150: Number of articles including company name and "E.coli" since initial outbreak
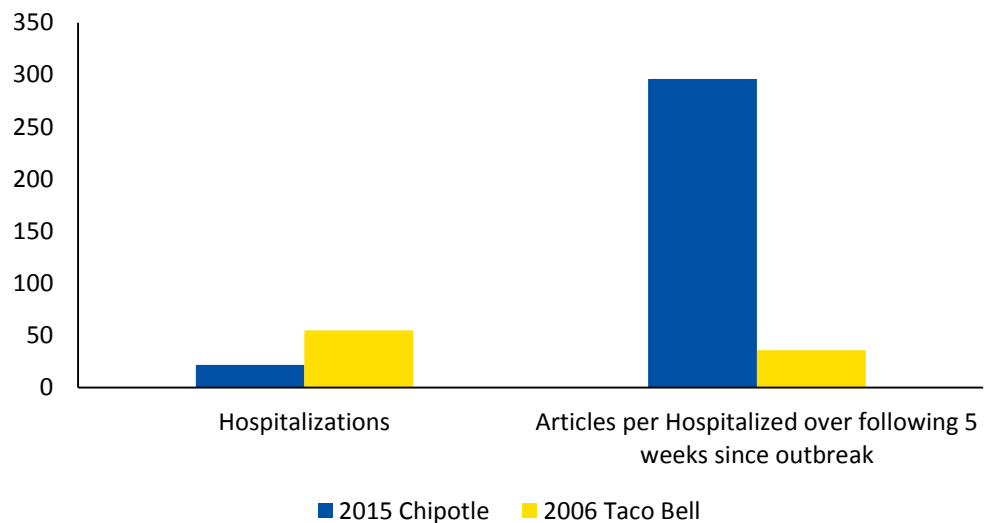
Source: RBC Capital Markets; outbreakdatabase.com

Exhibit 151: Chipotle same store sales growth

Chipotle's managed to lose its brand momentum because it could not replace the negative news cycle with positive news
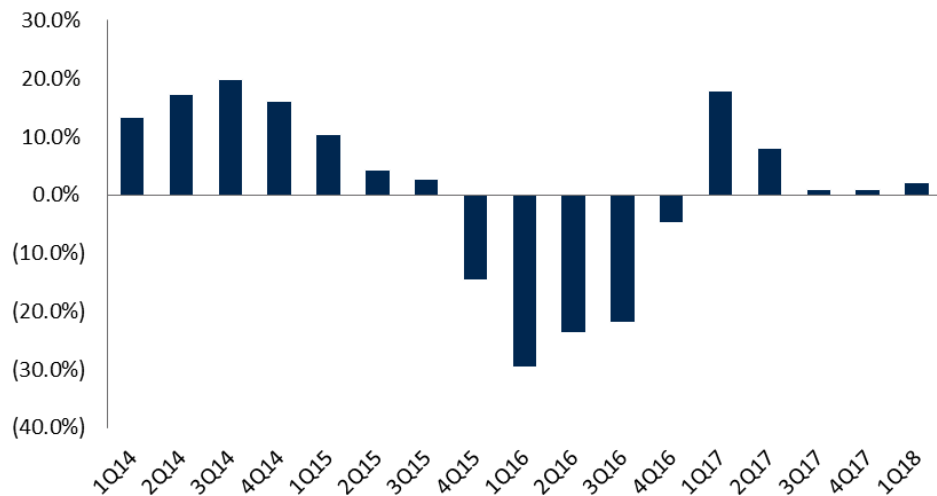
Source: Company reports

Domo arigato, Mr. Roboto

In the case of Chipotle and Taco Bell – as in all similar health scares – human beings are the ones reacting and deciding to go elsewhere. What if AI assistants run our day-to-day consumption decisions in the future? Imagine AI assistants (e.g., Alexa, Google Home) of the future are loaded with and maintain our preferences, such as our favorite burrito place or favorite pizza place. In a future in which consumers may never physically interact with restaurants – thanks to autonomous vehicles and faster delivery networks – consumers may never even need to know about E.coli outbreaks. But our AI assistants will know instantaneously, and will reroute orders to competitors. They may even drop the compromised brand from our preferences all together, at least for a period of time. And if

everyone consumes restaurant food this way in the future, imagine a post-outbreak scenario in the future where traffic declines 100%!

Alexa, why wouldn't I want the very best?

Few people bother navigating to the second or third page on Amazon, for example, which makes "being the best" increasingly more important by the day. And nobody searches for "second best coffee shop in Townsville." We can already envision a future in which products on the first page of Amazon or restaurants on the first page of Yelp or GrubHub take all market share. But even in these cases today, a human is making the ultimate decision about what he or she buys or consumes. What if robots or personal assistant algorithms decide for us? What if Amazon fulfillment centers – fed by personal preference and prior shopping data collected from millions of Alexa devices – know exactly what we want and ships or delivers it to us without prompting? Imagine a future hypothetical algorithm that reads as follows:

[When weight on pantry shelf < 1oz, reorder cookies, where price = LOWEST]

OR

[When weight on pantry shelf < 1oz, reorder cookies, where rating = HIGHEST]

What happens when human emotion, biases, distractions, and impulses are removed from future shopping decisions? In a future where consumers may increasingly come to view certain categories as commodities or become ever more disloyal to brands, they may elect to automate purchase decisions based on simple algorithms, such as best value or best quality. In a world like this, service providers and product manufacturers unable to satisfy at least one of these two algorithms may find themselves out of place and out of time.

Make people believe

In screening a company for a case study on corporate culture, by what metric should an analyst rely? Employee satisfaction scores? Social or environmental impact? How about stock price performance? In this section, we take a deeper look into the culture at Netflix, the #1 best-performing stock in the Russell 3000 over the last ten years (+11,172% vs. Russell 3000 +138%). The company has built and maintained a unique corporate culture that it believes enable it to outperform the competition by a wide margin, and more importantly, remain agile in the face of accelerating change.

Iconoclasts of corporate culture

Netflix compares itself to a professional sports team, but without roster limits. To that end, it strives to have only the absolutely highest performing people. And its bold, nontraditional corporate values are clearly and succinctly laid out in its "Culture Deck." A 120+ page slide deck publically available online (here), the manifesto "may well be the most important document ever to come out of the Valley" according to Facebook COO Sheryl Sandberg in a GQ article in 2013. All of the principles in the document relate to what Netflix believes is necessary in order to only hire and retain the best people. Rather than rank employees against each other, Netflix simply works to ensure that ALL of its employees are in the 10% of the global labor pool in the skills and behaviors it values. The company admits that working at Netflix is not for everyone. As it says, "adequate performance gets a generous severance package."

It may be easier and easier to buy the best-rated or cheapest products—leading to accelerating market share shifts

Exhibit 152: NFLX stock price

Source: Google Finance

The greenest pasture has no sacred cows

There are very few sacred cows at Netflix. It criticizes traditional corporate "nice sounding" mission statements and instead believes the truest corporate values are displayed by which employees are rewarded, promoted, or terminated. It does not believe in "hard work" either. Hours are not tracked, nor is a physical office presence valued. It does however value superior performance, which even if achieved with little effort, earns ever more increasing responsibility and top-of-market compensation. There is no policy for vacation, dress code, entertainment, or expensing beyond "Act in Netflix's Best Interest." In other words, high-performing adults do not need to be instructed how to behave or spend their time.

The company believes in granting its people the freedom and responsibility to be creative – to attack problems and respond to market forces dynamically. This often means limited to no bureaucracy or approval processes. Netflix is refreshingly clear about its mission – to entertain the world – and exceptionally blunt about what they are not – surgeons or nuclear engineers. This means that errors in their business are unlikely to have life or death consequences. While it is tempting to create rules to prevent errors, Netflix believes that in its business, spending to prevent errors is in fact no cheaper than fixing them afterwards. This reminds us of our conversation with Hostess Brands executive chairman Dean Metropoulos at the 2017 RBC Consumer Conference, at which he discussed the culture he worked to create at the company.

> *"…it's all about an intense results-oriented mindset; if something doesn't work, you bob and weave, **be agile**, test it out, move to the next idea. But it has to be highly disciplined, and you have to be held accountable. Your people have to be accountable for execution, and to me it is that culture that wins. And behind that you really have to do some fun things with the brand. And this doesn't have to be traditional."*

Netflix is working to fight the ailments of big companies by trying to maintain the density of high-performance employees while minimizing complexity growth

To stay agile, increase the high-performance people ratio faster than complexity

Netflix believes that most companies curtail freedom as they grow. As companies grow larger, processes and bureaucracies are often put in place to manage the natural growth in complexity. However, these rules limit employee freedom and autonomy to make quick decisions and to be agile. The growth in routine, process-oriented work also reduces the ratio of high performers to average to low performers within the company. Netflix believes the best way to build a coveted workplace is to populate it with "stunning" high-performing employees, so this diminishing ratio forms a negative feedback loop in which high-performing employees leave the company in droves for greener pastures. Netflix aims to have the greenest pasture all of the time. It accomplishes this by INCREASING the high-performance employee ratio FASTER than the growth in complexity. The focus on hiring and retaining only high-performing people is critical. As the company explains, high performers are 2x better in routine tasks but 10x better at creation and invention. Companies that fail to elevate this ratio "generally grind painfully into irrelevance" as new technologies or competition overwhelms employees who are only adept in deferring to process.

A winner-take-all… HR department?

Are organizations not simply collections of individual people leveraging certain assets – both tangible and intangible – in pursuit of a common goal? In a post-*Citizens United v FEC* world, it is easy to sometimes think of companies as living entities with their own competencies or motives. But the best and most agile companies know that they are only as strong and successful as the sum of their parts. This further fuels a positive feedback loop insofar as being identified or perceived as a leader can increase the odds of remaining so. Popular press is legion opining on the "brain drain" of the world's most talented people in the direction of Silicon Valley and away from the favored industries of yesteryear. But are the categories (i.e., Internet, mobile, self-driving cars) making Silicon Valley attractive? Or is it the culture that has seemingly gone hand in hand, attracting only high performers? In our view, this "winner-take-all" brain drain may be accelerating as the global labor force is increasingly open to all companies across the world thanks to accelerating global interconnectivity.

It is difficult to argue that corporate culture and corporate agility do not go hand in hand. In many respects, they are equivalent. Is Netflix's culture and those like it the best culture? Is Netflix the most agile company? Well, only 18 years ago this company operated in the shadow of Blockbuster (now bankrupt) and began its journey by mailing physical DVDs to consumers reliant on the U.S. Postal Service. Today, Netflix's streaming service takes up 35% of evening broadband usage in the U.S., is bigger than 94-year-old Disney (as of 06/18), has won 44 Emmy awards and Academy Awards, and is the #1 top performing company in the stock market over the past decade.

Exhibit 13: Netflix culture deck
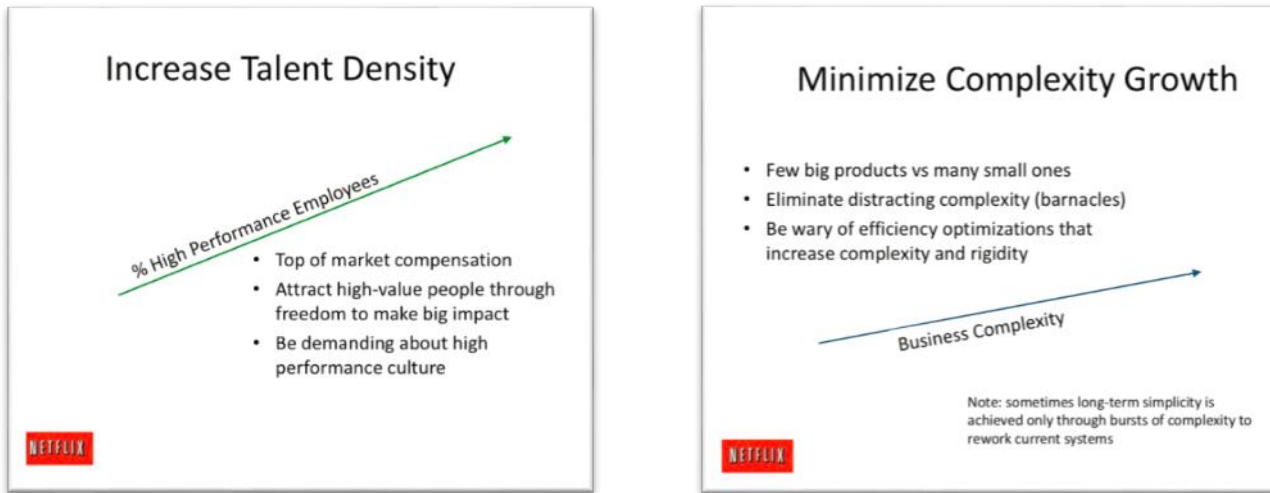
Source: Netflix Culture: Freedom & Responsibility; slides 56-57

The oak and the reeds

One of Aesop's better-known fables is that of the oak and the reeds.

A very large Oak was uprooted by the wind and thrown across a stream. It fell among some Reeds, which it thus addressed: "I wonder how you, who are so light and weak, are not entirely crushed by these strong winds." They replied, "You fight and contend with the wind, and consequently you are destroyed; while we on the contrary bend before the least breath of air, and therefore remain unbroken, and escape." [Townsend edition]

The moral of the story is, of course, that to succeed and thrive under pressure, one must bend, not break. Like the reeds, we believe the companies most likely to succeed and thrive in the future are those with lean overhead structures and efficient, meritocratic corporate cultures. In other words, principles and priorities that enable companies to be agile in the face of accelerating change. The change forces we lay out in this report are the winds in Aesop's fable.

Consider a new business model…

The right business model can create a path to market leadership and corporate agility

One way to adapt and win is by embracing a new business model. The right business model can create a path to success and also encourage agility. At times, the best future business model may require investment (e.g., a near-term earnings sacrifice) or otherwise seem like a risky bet.

Blockbuster should have self-disrupted when it had the chance

In 2000, Netflix founder Reed Hastings famously approached Blockbuster with an offer to partner in a new subscription DVD rental model. Blockbuster rejected that offer and was bankrupt in 2010. Of course, Netflix has continued to be an outstanding example of agility and self-disruption – subsequently augmenting its DVD subscription service with digital streaming of entertainment and even its own entertainment production.

RBC Capital Markets

For companies in legacy technologies or leadership positions the price of future leadership may be the courage of self-cannibalization

Apple shows how a bundled offering can ultimately drive loyalty

Apple was not the first to bring digital music players to market when it introduced the iPod in 2003. Diamond Multimedia introduced the Rio in 1998. Another firm, Best Data, introduced the Cabo 64 in 2000. Like the iPod, both products performed well, were portable and also stylish. That said, Apple's product had an advantage over previous devices – a bundled value to the consumer. Similar to Gillette's blades-and-razor model, Apple provided iTunes music at low cost (and low margin to Apple) to lock in the sale of the higher margin iPod. Ultimately, this iTunes relationship was a gateway to greater Apple "ecosystem" sales in the future.

Altria leans into the future despite past and present controversy

This past May, new CEO Howard Willard announced 1) the establishment of two divisions – core tobacco and innovative tobacco products; 2) the creation of a Chief Growth Officer function to accelerate speed to market for innovative products and technologies; and 3) the aligning of product development efforts more directly to the core and innovative tobacco product businesses. Altria's new Chief Growth Officer function will identify and pursue Altria's strategic and innovative growth priorities across the tobacco landscape. This function will identify marketplace and adult tobacco consumer insights and translate them into strategies for product development, consumer engagement, future of commerce and business development. This group will also be responsible for innovative product development and enhancing the company's capabilities by building and acquiring the competencies, technologies and talent to achieve Altria's aspiration of being the U.S. leader in authorized, non-combustible, reduced-risk products.

How is McDonald's trying to become closer to the consumer?

When a fast food company stopped responding quickly to the consumer, it adjusted its business model for agility

More recently, McDonald's has been altering its business model to enable more rapid decision making, encourage the right behavior from its franchisees and ultimately deliver an improved consumer experience. In 2015, when Steve Easterbrook took over as CEO, McDonald's and its franchisees enjoyed leading market share in virtually all of its major markets around the world with annual investment of $10 billion—including capital expenditures, SG&A and global marketing (including franchisee share). Yet, McDonald's was losing share in many of its major markets including its U.S. home market. The company knew it had to improve execution and the collective return on the collective investment of franchisees and the company. Since that time, McDonald's has taken several steps to refocus the organization on the consumer, and make the company more nimble in its decision-making. These steps have included:

- Refranchising restaurants and licensing entire markets (such as China) to strong operators that are also willing to reinvest in digital capabilities, unit growth, food improvements and restaurant renovation. By moving from ~82% franchised restaurants to ~95% franchised, the company was selling over two-thirds of its owned restaurants, which has allowed the company to focus on brand management while rewarding the best franchisee partners with increasing scale (and franchisee level overhead leverage). We believe the refranchising process will not only allow better corporate focus, it will enable lower oversight expense and drive customer satisfaction higher through better franchisee operations.
- The company is flattening its management structure to bring senior leaders closer to the regions and – ultimately – real consumer-facing issues. For example, the company created the International Lead segment – a collection of five similar markets (U.K., Australia, France, Canada, and Germany) in size and consumer dynamics. This has allowed division president, Doug Goare, to have only five direct reports versus over 30 countries in the Europe segment he managed previously. Ultimately, this has pulled Doug closer to consumer and operational issues and better enabled him to share best practices across these developed markets.

- The company has also dramatically reduced its U.S. overhead while making other changes to enable a better ear to the consumer. These included: 1) a move of the headquarters to downtown Chicago (closer to younger tech and marketing talent), 2) a streamlining of U.S. regional overhead (decreasing the number of U.S. divisions by over half), and 3) reduced the number of franchisees committees (to further enable quick decisions).

…even if that means asking allies for help

In no way is the future coming at us faster than in the connection of retail and restaurants to home. Digital and delivery convenience is ramping, direct consumer data sharing is increasing and category shifting is accelerating. Already, the Millennial generation is showing itself to be homebodies. Increasingly, they are working, eating, shopping and being entertained at home. Our increasingly "smart" homes and the services that are wired into them are enabling this shift in behavior. It is not hard to imagine the day when most services and products will be available instantly or delivered to us within an hour of telling our smart device in our own voice. How will that change the shopping behavior of middle- or upper-income shoppers? How will it change the nature of marketing and promotions and impulse purchases? Food and restaurant companies are in the convenient meals and snacks business – not the medical diagnostics or transportation businesses. But this is no excuse to remain ignorant to the change forces affecting these sectors and their impact on consumption patterns and behaviors. Partnerships and alliances will fill this capabilities gap.

Responding to digital threats by incorporating some of the benefits of the e-commerce business model

Digital shelves may be a way food retail can become more Amazon-like

To brick-and-mortar retail, the threat of online continues to grow with the aspirations of Amazon and others. The percentage of consumer-packaged goods (e.g., food, beverage and household products) that is sold online is still only 4%, but those sales are growing at a double-digit rate. Already, Amazon has the advantage of its Prime membership (100 million strong and growing 10.6% annually) with increasing convenience of delivery (already same day in over (25% [2016 estimate] or 8000 cities) of the U.S. and two-hour delivery in 50 cities). Amazon is using artificial intelligence and personalized marketing to optimize price and profitability on brands – and to grow its own retailer brand offerings. Amazon's retail ecosystem also benefits from third-party reviews and testimonies that provide much of the credibility once afforded to brands. Amazon has already purchased one food retailer (Whole Foods) and could continue its push into the CPG segment. How can a supermarket chain (e.g., Kroger) or broadline player (e.g., Walmart) respond?

One idea could be in the adaptation of physical assets to the digital world. This could include digital shelf labeling which could allow dynamic pricing and promotion offerings at the store shelf. If online prices are being updated faster than circulars can be updated, the stores can become as flexible as their online competitors and also price match their own online platforms. Such digital shelves could be a substantial investment, but could eventually enable better testing of price/promotion constructs and encourage a richer digital relationship with the consumer.

Exhibit 153: Digital price tag with Wi-Fi-enabled updates and promo experimentation

Source: RBC Capital Markets

We know who you are and where you live!

If power will increasingly shift to those with the consumer relationship, then it seems likely that the e-commerce giants (led by Amazon) will be in the driver's seat. Amazon of tomorrow will have information on its customers that brick-and-mortar retailers only dreamed of attaining. While consumer data companies such as Nielsen have helped manufacturers own the data (e.g., scanner data) that help drive purchase decisions, this data has missed the connection to the consumer. Manufacturers and their retailers do not know enough about who is buying their product and why.

E-commerce players better understand these connections and understand how to better promote and sell products on a personalized basis. These e-commerce players will also understand the return on convenience (e.g., one-hour or less delivery), and what that can mean to market share and loyalty across a variety of categories. In the future, a hybrid of e-commerce and retailer (Walmart.com) will be able to conduct rapid iterative tests of promotions, price points and bundles to drive consumer behavior. These promotions can be custom-made per consumer cohort or even the individual. Food companies will need to partner with these emerging data analytics providers in order to make best use of expanding troves of data – or else someone else will.

What happens as consumers learn more about their own perfect diet?

As consumers learn more and more about themselves, how can companies adjust their business model to accommodate personalized needs?

In recent years, professional golfer Phil Mickelson has attributed his own genetic testing and subsequent significant diet change to a cure of chronic joint pain, increased energy levels and string of successful tournaments well after most professionals retire from the PGA tour. Phil's diet change began with a genetic test that cost thousands of dollars. However, it is not too hard to believe that this sort of testing will become commonplace in the next decade—perhaps reinforcing the perception of food as "health maintenance" and not just "fuel" for energy.

In 2016, Campbell Soup invested in Habit, a company that invites consumers to send blood samples for DNA testing, and ultimately prescribes a custom diet based on the test results. This initial test costs a consumer a relatively low $400 with more profit made on the "back end" through subscription meals. Over time, the companies that can help make our prescribed diets into a tasty, convenient, and inexpensive reality will win. Is it hard to imagine us inputting our dietary goals into Amazon in the future and having that solve for our family food shopping and restaurant-prepared meals? Surely, the right partnerships within new areas of expertise (i.e., medical diagnostics hard/software) will make this a possibility.

The rise of restaurant aggregators

As new versions of convenience are created (like digital order foodservice delivery), will old categories and channels begin to respond…or fall into atrophy?

Americans are eating more meals at home. Consumers are also moving to cities and commuting less by car. While heads of household do not want to cook, they want to serve their families high-quality ingredients. The standards for the U.S. restaurant consumer are rising both in the demand for better quality food, but also for a multi-dimensional experience when that consumer eats out at a restaurant. Given the importance of U.S. food and restaurant spending (each equal to about 7% of U.S. household expenditures) and the synergies of this spending with convenience, we find it imperative that restaurants accelerate their partnerships with aggregators, especially those with their own delivery capabilities or partnerships. Foodservice delivery aggregators like UberEats, GrubHub and DoorDash are all striving to be one of the few dominant delivery systems – in addition to the U.S. pizza chains. The increasing scale and potential consolidation of these delivery networks could create a virtuous cycle of reduced cost and increasing market share. Can you envision how the winner-take-all future will apply in this scenario?

Ultimately, the rise of aggregators will put pressure on mid-sized chains with average food, an average in-restaurant experience and average restaurant density/convenience. We should consider America's increasing urbanization, stay-at-home lifestyles, needs for ingredient quality, and desire for an iPhone photo-worthy dine-out experience. If we do, it is not hard to imagine those chains with sub-par execution and scale fading away as delivery specialists gain share and American families prepare more high-quality meals at home.

Lighten up

Ownership of physical assets has become less important and we believe this trend will continue. Asset-light models thrive in the ever-increasing digital world and the shared and gig economies. In the case of logistics, and mature versus disruptive companies, we can compare FedEx and Uber. In terms of overhead, FedEx has more than 600 airplanes, and more than 45,000 vehicles, whereas Uber does not own any of its vehicles. FedEx also employs over 300,000 people, whereas Uber has about 6,000. Yet, these two companies have similar valuations and market cap of $60–70 billion.

Airbnb is an example of an asset-light model in the travel lodging sector, owning none of the properties it rents out, compared to Marriott. Airbnb tapped into the sharing economy, the open-mindedness and fluidity of the younger generations, and coupled it with an asset-light model to succeed. Airbnb is currently valued at $30 billion, and Marriott, the largest hotel chain in the U.S., has a $49 billion valuation.

Even in the traditional retail economy, ownership of brick-and-mortar stores has held back some major retailers, bogged down by empty stores. Companies that have changed to accept these new realities have survived, including Abercrombie & Fitch, which seemed on the brink of collapse, but made a surprising comeback after closing fleets of physical stores, and investing in omnichannel, with digital sales now driving 20% of its sales.

The risk for these companies however is venturing into uncharted regulatory territory. Both Airbnb and Uber have spent millions and ramped up their lobbying efforts, with Uber having to leave Austin altogether. Airbnb spent more than $8 million in lobbying against a ballot measure in San Francisco that would harm their short-term rental business, and they won. So while the regulation risk is there, when it is due to the absence of legislation, the disruptors have a leg up in lobbying for rules to be made in their favor, as is the case for the Self-Driving Coalition For Safer Streets which boasts the likes of Uber, Lyft, Google, as well as Ford and Volvo.

Exhibit 154: Uber has ramped up its annual spend on lobbying
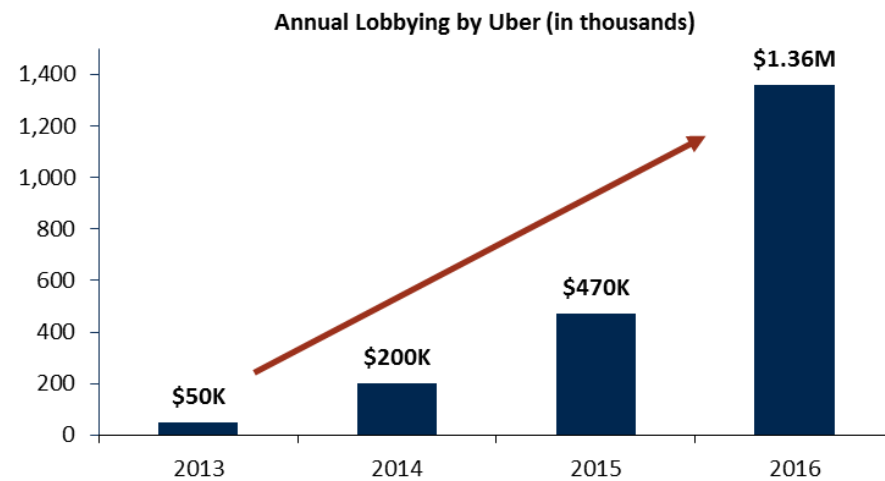
Source: Center for Responsive Politics

Agility makes strange bedfellows

The world of online grocery has reached a fever pitch as retailers race to be the first at the front door of the customer. Amazon acquired Whole Foods in summer 2017; Target acquired Shipt in December 2017. Amazon's, Target's, and Instacart's grocery delivery approaches rely on humans to pick items from existing stores. But one alliance that stands out from the pack is Kroger and Britain-based online-only grocer, Ocado – though Kroger did not buy Ocado.

Ocado, which has no physical stores, runs automated warehouses that do the work of picking the items for online orders, utilizing the cloud, artificial intelligence, robotics, and machine learning. Aside from groceries, including some own-brand/private label items, they also provide their platform as a product itself to other grocers, selling its technological advantage to competitors. They did this first in 2013 for rival British grocer Morrisons, from handling automation, to logistics and distribution. Some distribution centers filled orders for both Ocado and Morrisons orders. This is not too dissimilar from the idea of selling excess capacity. Kroger has now inked a deal with Ocado for 20 automated fulfillment centers in the United States.

Agile companies will consider alliances and acquisitions to leapfrog the competition

Exhibit 155: Asset-light companies are valued higher by investors
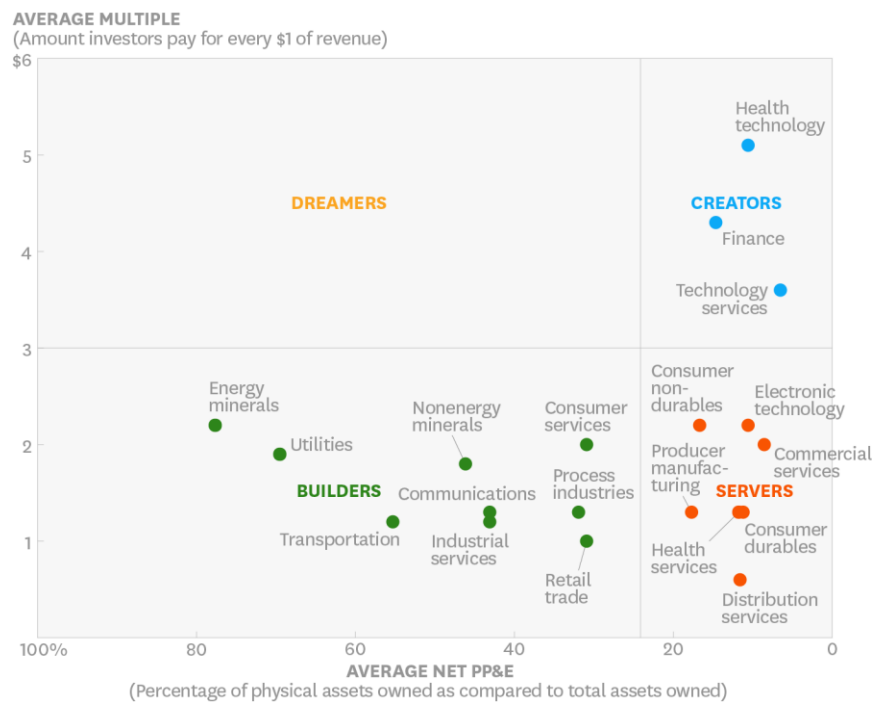
Source: Harvard Business Review

Migration towards asset-light business models and getting more out of smaller physical footprints

Over the past century, the value of industrial manufacturers was traditionally tied to the scale of their physical assets and footprint – whether it be the number of brick-and-mortar distribution branches, manufacturing facilities, installed base, fleet of vehicles, etc. But in the past decade, there has been a paradigm shift as the "digital" has arguably overtaken the

"physical" in their long-term strategic value. With the advent of Software as a Service and data analytics, OEM manufacturers and capital equipment customers alike have learned to produce more with less, streamlining their tangible asset load while leveraging the resources they retain more efficiently and with greater utilization. The benefits of an asset-light footprint are easy to define. Capital equipment and inventory depreciate over time and are costly to relocate or replace when demand trends or geographic needs suddenly change. In addition, entrenched networks of physical assets often prevent companies from adapting to changing business needs in a rapid and agile manner. As a result, within the industrials, there has been a growing preference among both investors and management teams for asset-light business models that can generate attractive cash flows with relatively low capex and working capital needs.

Roper Technologies: A case study

Roper Technologies' business model is both asset light, which drives free cash flow to fuel its M&A machine, and is decentralized, which enables faster decision-making

One of the best "asset-light" examples is Roper Technologies, which reached a negative working capital milestone in 1Q17 thanks to its prescient and early embrace of SaaS and asset-light businesses. Over the past decade, Roper has charted a unique path within the Multi-Industry sector by focusing on acquiring niche software and network-based businesses that are outside of the typical purview of industrial companies, such as healthcare GPOs, ERP software providers, and business management software for legal and professional services firms. The result is a company that manages among the sector's highest operating margins and a negative working capital balance, meaning that it generates rather than consumes cash as it operates. This asset-light nature allows Roper to continuously fuel its M&A engine, effectively becoming a high-quality compounder, and allows it to run a decentralized organizational structure where critical decision making occurs among individual business units, as there is little internal jockeying for capital investments.

Services versus goods – what we can learn from the industrials space

We believe the combination of faster pace of change will force more companies to look at providing a portfolio of services versus just selling goods. For instance, within the industrials, a typical strategy for OE manufacturers is to price the initial equipment sale as a "loss-leader" and then capture the actual returns from the profitable stream of aftermarket consumables, parts, maintenance, and servicing. As an example, over the course of their economic life, GE's aircraft engines will generate aftermarket revenues totaling ~8x the initial purchase price of the OE installation. Similarly, Flowserve's pump installations generate aftermarket revenues that are ~9x the initial purchase price. More importantly, to varying degrees, these aftermarket revenues always carry higher margins than the initial OE sale, cementing their importance to the companies' bottom lines.

As companies' software offerings for data analytics and predictive maintenance become more sophisticated, we expect that their service/aftermarket capabilities will become a more integral pillar of their value proposition. For instance, though Evoqua already generates ~$0.22 of annual service/aftermarket revenues for each $1.00 spent on capital projects, it is working to enhance its service capabilities with its new Water One software suite, improving its win rate for service contracts and its ability to push for premium pricing.

For industrial conglomerates, agility can come in the form of portfolio additions or subtractions

Although there are plenty of pure-play companies in the industrial space today, there are still a cadre of multi-industry conglomerates operating across dozens of end markets. Given rapid secular changes and evolutions can be hard to predict, it is no surprise management teams actively cultivate their portfolio of businesses through M&A and divestitures. M&A spending has averaged ~30% of total Multi-Industry capital allocation activities over the last 10 years (M&A, capex, dividends, and repurchases). We expect this trend to continue. To stay agile in

the industrial space, it is important for managements to foresee emerging trends and find new or complementary business targets to leverage their current set of offerings. There has been an increasing focus for industrials to acquire software companies to deliver customers more than just equipment and offer things like predictive analytics and other valuable data insights. Portfolio additions and subtractions are important for multi-industry industrials to stay at the forefront of their markets and to make investment in secular growth trends.

Using M&A as a proxy for R&D spending

Companies can use M&A as a means for accelerated research and development spending. Acquiring a business to quickly increase offerings gives a company the ability to have a broader or higher-tech portfolio for its customers. This can save the firm both money and years of research and development efforts. An example of this is Xylem acquiring Sensus for $1.7 billion. Sensus is a leading provider of differentiated communication systems, metering technologies, and data analytics solutions that enable the intelligent usage and conservation of water, gas, and electric resources for utility operations. In addition, Sensus maintains a differentiated Software as a Service platform known as FlexNet, which is an advanced, scalable solution for remote monitoring and diagnostics of water utility equipment. The deal vaulted Xylem into smart water networks, data analytics, and new SaaS opportunities, keeping it at the forefront of water technology offerings.

Keeping business lines smaller, more decentralized, and more entrepreneurial

To stay nimble in a competitive landscape, companies can concentrate on a more decentralized operating models where smaller and more entrepreneurial business lines focus on their respective core strengths. Smaller and leaner operations have a better ability to quickly adapt to new threats and emerging trends. Roper, for example, truly embraces the Multi-Industry model by structuring its enterprise as +40 distinct businesses each headed by a different operating company president and running independent P&Ls. There is no unifying ERP system, and each business is given enough autonomy to operate with a discrete strategy. The result is the company looks more like +40 separate micro-caps bound loosely together by a common ideology and operating culture. This has led to entrepreneurial-like businesses that are quick to react to any given change.

Automation will accelerate rewards

With fixed assets becoming more of a liability than a competitive advantage in the future, we believe companies will have to make significant cap ex investments to alter their supply chains and manufacturing operations to become more automated. However, the key will be to install automation that can be upgraded as technology evolves without having to do it all over again.

Industrial automation drives higher productivity, quality, uniformity, flexibility, and safety

Industrial automation is the use of controls systems (e.g., computers or robots) and information technologies for handling various processes and machineries in an industry to replace a human being. There have been leaps and bounds in the evolution of industrial automation, and bigger picture, the practice has evolved from initially increasing productivity (e.g., machines can work 24x7) and reducing human costs (e.g., wages and benefits) to increasing quality, flexibility, and safety.

High upfront costs are the main drawback

All of these aspects mentioned above remain vital to most industrial industries, and seemingly the only deterrent to utilizing industrial automation is the high initial investment cost associated with switching from a human production line to an automated production line (including training humans to handle the new, potentially sophisticated, equipment).

Companies can use M&A as a means for accelerated research and development spending

Automation can increase quality, flexibility and safety…but with high upfront costs

What if…? The Agility Imperative

What if food distributors and retailers can easily track every step of the food supply chain with blockchain technology? Will they be able to identify possible food contamination before it impacts any end consumer? Will they be able to stop the outbreak or even eliminate foodborne illness?

What if stores merely become distribution centers and all commerce shifts online? What does that mean for promotional activity and marketing? Do promotions, which we know are ubiquitous today, become more personalized, cross category and moment specific?

What if AI and blockchain were used to record all real estate transactions where the transactions were conducted under smart contracts? Would the number of real estate attorneys decline? Would there be a need for an escrow agent and what does it mean for the title insurance industry?

What if retail stores or restaurants paid for autonomous rides to ensure the consumer comes to their establishment? Does this high-ROI spend upend more traditional advertising?

What if your vehicle had a token-based payment solution embedded and provided reminders to purchase needed/wanted items as the driver approached the store or automatically pre-ordered at a restaurant?

What if having fully connected manufacturing and infrastructure facilities increases the risk of cybersecurity hacks from competitors or foreign agents? How will companies reallocate capital and business decisions to better prioritize software security?

What if the proliferation of connected devices led to a decentralized ecosystem where all products from any manufacturer could communicate with one another? How would this change the competitive landscape and how would companies differentiate offerings? What is the value proposition for consumers?

Appendix I: Disruptive Change Forces

Our iterative process synthesized a variety of inputs including RBC survey results, expert thinking, and primary and secondary research, boiling down hundreds of inputs to develop 23 Change Forces grouped under the broad categories of *Social, Technological, Environmental, Economic and Political*. While the accelerating pace of technological innovation from blockchain to bioengineering is an unavoidably dominant backdrop to this analysis, our work highlighted the necessity of contextualizing this with non-technological change forces such as the reemergence of populism, climate change and urbanization.

Exhibit 156: Change Force Tensions – Social

← SOCIAL CHANGE FORCE TENSIONS →		
Change Force	**Opportunities**	**Challenges**
A Changing Population	People will live longer, healthier lives.	Rapid population growth in developing countries creates pressure on resources.
Urbanization	Urbanization drives tech and social innovation, changing, cities into hyper-connected metropolitan centers.	Urbanization drives higher real estate prices, job competition, and pollution. Those in lowest income brackets increasingly marginalized.
Fluid Generation	Younger populations are more racially diverse, and more open- and globally-minded.	Younger generations demand values-driven business structures.
Rise of Women	Women will continue to enter and rise higher in the workforce, fueling economic growth.	Failures to change legacy workplace, social, and cultural barriers will hinder growth and ability to retain talent.
Changing Definition of Work & Working	The balance of power shifts from stability of employers to the unique skillsets and demands of the workforce	A shift in norms will require changes in corporate culture that current management may be uncomfortable with, leading to recruiting and retention issues.

Source: RBC Capital Markets

Exhibit 157: Change Force Tensions – Political

← POLITICAL CHANGE FORCE TENSIONS →		
Change Force	**Opportunities**	**Challenges**
Geopolitical Uncertainty	Governments lead with international collaboration to solve cross-border challenges, effectively bridge gaps and promote unity.	Fear and skepticism rise, increasing nationalist sentiments and further dividing nations.
Climate Change Policy	Nations enforce strict regulation and businesses innovate to find new, more efficient solutions.	Nations limit climate change regulation to reduce costs for their consumers and protect domestic industries.
Private Enterprising	Space innovation will be iterative with the presence of competition via private companies, leading to quick improvements and less time between trips and milestones.	Privatization will result in deregulation of the industry, allowing conflicting agendas to arise as programs are created to either explore or exploit space.

Source: RBC Capital Markets

Exhibit 158: Change Force Tensions – Technological

← TECHNOLOGICAL CHANGE FORCE TENSIONS →		
Change Force	**Opportunities**	**Challenges**
Big Data Gets Bigger, Faster	Big data helps personalize life, creating customized, tailored experiences, saving time and increasing efficiency.	If left unchecked, or in the wrong hands, we risk losing control of personal privacy and human empathy in the world's most important decisions.
AI & Cognitive Computing	Robotics become integrated into everyday life, improving collaboration and skillsets while minimizing the rate of human error.	Cognitive robotics outpace the need for human assistance and make human contributions obsolete.
Autonomous Cars	Automated transportation lowers costs overall, reduces accidents, and economizes the roads for everyone.	Car hacking becomes a real-life threat, and the world becomes reliant on a small number of companies to travel even short distances affordably.
Bioengineering	Widespread CRISPR applications in agriculture hold promise to improve yields and superior attributes.	Ethics of bioengineering will be questioned and challenged morally and legally.
Digital Engagement & Attention Economy	The online experience becomes more personalized as advertisers and other companies demand our attention.	The growing presence of second and third screens captivate attention more than the real world.
The New Reality	VR could revolutionize the way we learn, work, and spend our time with new potential to see the world (and beyond) without leaving the home.	With VR eliminating the need to travel, relationships with immediate family members, friends and colleagues risk becoming less personal leading to potential breakdowns in trust.
Cyber Security	Companies and online platforms will step up security measures, allowing customer data to flow freely between users, improving online experiences.	Continual high-tech hacking and security breaches leave millions vulnerable and distrustful.
Food & Agriculture Technology	Food production costs will decline dramatically as crop yields improve and technology becomes more efficient.	Bioengineered lab meat alternatives are deemed inferior to natural production.

Source: RBC Capital Markets

Exhibit 159: Change Force Tensions – Economic

← ECONOMIC CHANGE FORCE TENSIONS →		
Change Force	**Opportunities**	**Challenges**
Expanding E-Commerce	Consumers begin to satisfy all their retail shopping needs online and continue to marginalize excess retail space.	Online-only retailers acquire brick-and-mortar stores to augment brand experience.
Automation in the Workforce	Automation performs mundane tasks, freeing time to think creatively and solve problems computers cannot.	Massive job loss leads to increased unemployment and existential challenges for individuals and governments.
Protectionism Prevails	Governments and trade organizations work together to promote business and development.	Global commerce becomes restricted by protectionist policies and trade agreements begin to fail.

Source: RBC Capital Markets

Exhibit 160: Change Force Tensions – Environmental

← ENVIRONMENTAL CHANGE FORCE TENSIONS →		
Change Force	**Opportunities**	**Challenges**
New Resource Shortages	New innovations in desalination and vertical farming alleviate the increasing demand for natural resources.	Shortages in water cause it to become the new oil, starting a new arena of hydro-politics.
Energy Source Uncertainty	Advancements in renewable energies make them more efficient and affordable, sparking a new growth boom.	Economies stall as oil revenue decreases.
Climate Change	Mitigation and adaptation reduce the flow of heat-trapped greenhouse gases and adapting to life in changing climate while innovation and regulation find new solutions.	Severe weather events devastate and overwhelm societies unprepared and unable to prepare for them.
Evolution in Pollution	Innovation and new technologies drive efforts to clean up oceans and improve conservation of resources.	Toxic zones develop around the world, widening the gap between haves and have-nots.

Source: RBC Capital Markets

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