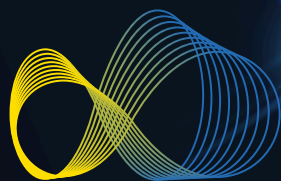




Capital
Markets

Preparing for Hyperdrive Themes that will Define Our New Future



RBC Imagine™

Thinking further forward

EQUITY RESEARCH | NOVEMBER 18, 2021

For required Non-U.S. Analyst and Conflicts Disclosures,
see page 259.



A message from the Directors of Research

Get ready for accelerated disruption. As we think forward to the future, progress will be faster than it has ever been and it will not be linear. Just as we did in our [Landmark 2018 Imagine Report](#), in this thought leadership study we have taken a global, cross-sector approach to determining the themes that will define our new future. Challenging our global research teams in their respective areas of expertise and coming together to share ideas in recent months, we identified five key themes investors and executives alike across all industries must collectively understand to prepare for the years ahead. The themes are:

1. **The Quest for Immortality** – Biopharma breakthroughs, life science real estate, 5G, autos, consumer wellness, space exploration and more come together to increase life expectancy rates globally.
2. **The Individual Revolution** – Data monetization, blockchain, gene editing and an evolving gig economy put the individual front and center like never before.
3. **Artificial Intelligence Activated** – This is no longer a drill. The path is set for the latter stages of AI to be integrated into our global economy. Don't be left behind.
4. **Hybrid Living** – Our physical and digital worlds are rapidly combining, suddenly becoming indistinguishable and the implications are radical.
5. **The Great Balancing Act** – An accelerating rate of change on multiple fronts has the potential to create unprecedented instability. Resources are constrained and as we make tremendous forward progress on global sustainability, we must always keep in mind the other side of the coin. Innovation will thrive and new tensions will arrive.

Each of these themes are supported in depth by examples from across industries in the report we present today; and we have conviction that understanding these themes will enable investors and companies to better take advantage of opportunities as they present themselves. What's important when consuming this content, is to think tangentially. Just as we have, consider how future developments in one industry will impact your own or another.

In order to translate these themes into action, we have also published an accompanying [RBC Imagine™ Best Ideas List](#) highlighting the companies we believe are best positioned to take advantage of the themes identified over the long term. As always, ESG considerations continue to evolve and remain fully integrated in RBC's fundamental research process.

We encourage you to read on and welcome you to partner with our Global Capital Markets Research team of over 190 analysts, macro strategists and associates, covering over 1,400 companies. Wishing you continued success as we journey into the new future together.

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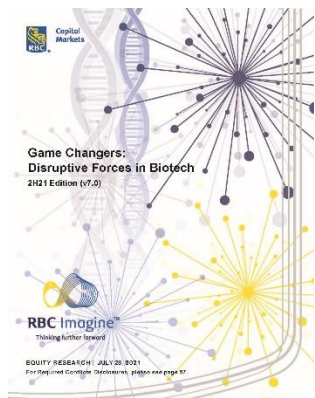
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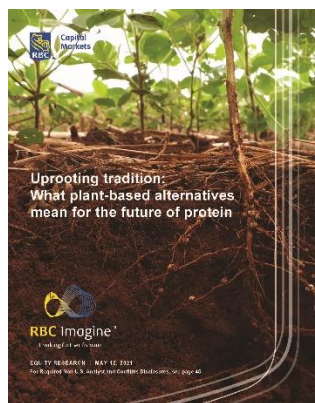
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All values in USD unless otherwise noted. Priced as of market close, November 17, 2021 ET, unless otherwise noted.

Executive Summary



Under-the-radar disruptive biotech products, technologies, and even epidemiological or legal developments which could transform the sector.



As consumers' environmental and health concerns mount and innovation provides more appealing alternatives, plant-based food penetration will increase rapidly.

The RBC Imagine™ research brand is a series of research reports focused on disruptive forces that we expect will transform the world, and is intended to help investors and organizations plan for the future. Our initiative began with a [Landmark 2018 Imagine Report](#) that presented six original cross-sector themes that would define the future, and with this report we further evolve those themes for the new world we see ahead. This report is comprehensive, global and cross-sector in nature, designed to prepare readers for the opportunities (and challenges) ahead, and made actionable with the publication of our [RBC Imagine™ Best Ideas for the Long Term](#) list. The ideas list highlights the companies in each sector and region across our coverage we believe are best positioned to take advantage of the future themes we identified over the long term. We have conviction Environmental, Social and Governance (ESG) considerations will only continue to play an increasingly important role in determining future outcomes and have thoughtfully integrated ESG into our future thematic framework and best ideas list.

Why you should read on

We see an arbitrage opportunity. The RBC Imagine™ brand challenges the status quo of the often short-term nature of asset pricing and analysis. While valuations are theoretically the present value of all future cash flows, the vast majority of discussion tends to focus on the next quarter (optimistically, 1 to 2 years), and rarely is the time and effort taken to think 5, 10, or even 15 years into the future. Yet it is on this time scale that we can attempt to identify key emerging structural themes and drivers. With this in mind, we engaged in strategic scenario planning and forecasting, with the key themes and takeaways presented here in this report. To arrive at these findings we asked how the emerging future trends and addressable markets in one industry are going to impact another, bringing to light both opportunities and risks.

Our future-defining themes

Our future-planning process culminated in five major, global, cross-sector themes we believe will define the future. These are: The Quest for Immortality, The Individual Revolution, Artificial Intelligence Activated, Hybrid Living, and The Great Balancing Act.

The Quest for Immortality

Emerging from the COVID-19 pandemic we see the simultaneous combination of breakthroughs in medicines and therapeutics (mRNA vaccines), further advancements in healthcare availability (telemedicine), improving transparency in the food/health connection, living conditions and other scientific/technological improvements likely to extend lifespans at an accelerated rate over the coming decade. However, how these dynamics play out across the global population could create a clear divide among populations based on income, demographics and infrastructure.

The Individual Revolution

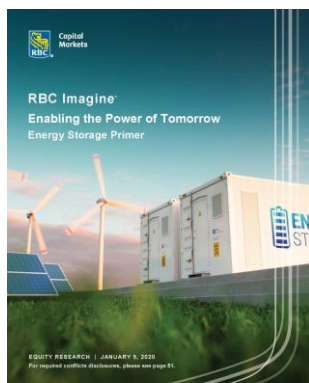
Social media, immense amounts of personal content and consumer-first applications are shifting the balance of power away from traditional institutions and into the hands of individuals. This will create a new world order in every aspect of the global economy and will likely be the single biggest disruptive force to existing centers of power. In addition, it could create new economies such as the monetization of personal data (and the associated parameters around that data ownership). Consequently, as power shifts away from institutions to individuals, global societies will deal with both the positives and negatives.

Artificial Intelligence Activated

While we are some time away from the general-purpose artificial intelligence that science fiction cautions us about, AI is becoming a critical component to all aspects of business. The battleground for AI is now migrating from understanding its potential and acquiring capabilities to putting the concept into action. And while AI brings plenty of benefits (solutions



The rise of resale, the next frontier for luxury brands, identifying the best ideas and early strategies.



The global energy storage addressable market is slated to attract ~\$1 trillion in new investments, growing 20 times (30 times) over the next decade to ~220GW (676GWh)

that learn and improve over time, more powerful software to automate mundane tasks, etc.), it also brings with it many risks, including security concerns and the potential for unprecedented job displacement/transition.

Hybrid Living

Our environment is increasingly becoming inclusive of our physical space as well as our digital world. As augmented and virtual reality continue to become more user friendly and easier to access, the lines between the physical and digital will continue to blur. This will have significant implications on how we interact as a society, the acceleration of workplace productivity, the creation of new opportunities to engage consumers and customers, and will become the catalyst for entirely new business models, including progress on diversity and inclusion across organizations.

The Great Balancing Act

An accelerating rate of change on multiple fronts has the potential to create unprecedented instability. Conflicts will arise between countries, among sub-populations and across regions on an increasing number of fronts, as well as behind the scenes. On top of a pickup in cyberterrorism activity, we believe new physical, cyber and trade conflicts will arise, particularly related to climate change, including the race for critical commodities to fuel the energy transition, agricultural nationalism and climate change targets and policies. Even basic systems like democracy and capitalism are set to undergo dramatic change. Within individual entities themselves, societies, corporations, institutions and even individuals, will face internal tension balancing speed and near-term costs as they strive to make progress in this increasingly complex global context.

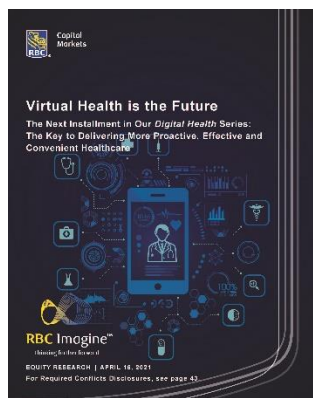
Imagine industry implications

Consumer

The movement towards a healthier lifestyle has been one of the most important consumer trends over the past few years, it has accelerated during the pandemic, and we believe will become even more important over the next decade driving the Quest for Immortality. Within the Individual Revolution, advances in science and the “shrinking” of technology will enable consumers to receive real time feedback on their lifestyle—heightening the need to develop more customized products that leverage their personal data. AI will accelerate R&D and reduce times to market, and consumer product needs will become fully anticipated. For Hybrid Living, brand building is redefined to the virtual world in video games, NFTs become a new luxury and stores transition from selling locations to event hubs. The tradeoffs between sustainability and price lunge to the forefront and multinational companies will seek to localize their business, increasing autonomy of local regions, and find new ways to secure raw materials in The Great Balancing Act.

Energy and Utilities

Extended lifespans would elongate the tapering tail end of the oil demand curve globally, increasing energy demand and requiring emerging technologies such as nuclear fusion (especially from small modular reactors) as well as decarbonizing fuels (e.g., hydrogen, renewable natural gas) for combustion turbines. In the Individual Revolution, the “Prosumer” rises where individuals will have increasing options to take greater control of their energy consumption. They will determine how and where their energy is produced and consumed (e.g., time of day, location), and take further steps to go “off the grid” or look to supply the grid with electricity via generation and/or connected battery storage. This enables individuals to both monetize and secure their digital world at home. AI will coordinate the grid including distributed battery storage, anticipate power demand and optimize maintenance schedules that will enhance energy infrastructure integrity. Energy demand shifts to the residence in Hybrid Living where more time is spent powering each person’s digital world and even virtual oilfields emerge. For the Great Balancing Act, an aggressive energy transition appears set to drive a bigger wedge in the socio-economic divide, so does this lead to a new era of



We are now more excited than ever about the potential Virtual Health holds. The intention is not necessarily to replace in-person care, rather the aim is to make it more efficient, effective and consumer-friendly.



What is clear is that HVAC systems upgrades will be needed to handle higher air exchange capacity, partly driven by new potential standards for indoor air quality.

cooperation or a new front for division across classes and the developed and emerging world? What is clear to us is that technology is poised to play a major role in offsetting politically unpalatable rising costs.

Financials

On the Quest for Immortality, financial solutions will be required to pay for the greatest health advancements, Buy Now Pay Later (BNPL) success at retail could very well translate to healthcare, and consumer digital health records will even be incorporated into this financing, effectively creating risk grades and/or rewards systems. Consumer lenders are also increasingly focusing on healthcare financing. Further, with increased life expectancy, the demand for sophisticated wealth management products only increases. In the Individual Revolution, self-monetization is an increasingly prevalent theme as consumers start to realize the value of their own data and exchange it for forms of utility, including customized insurance. Blockchain will drive accelerated model change and at the consumer level digital currencies and stablecoins are increasingly used to on-ramp financial transactions. With Artificial Intelligence Activated, risk management and fraud detection become further strengthened and AI integration into trading platforms and other financial decisions becomes critical. In Hybrid Living, it's the digital customer interface experience that wins, with financial services customer experiences delivered seamlessly for all products, across all devices. As part of the Great Balancing Act, institutions positioned to support the corporate transition towards sustainability stand to gain market share, while attracting potential valuation premiums for themselves; property & casualty insurers face rising catastrophe frequency and severity as climate and weather patterns inevitably change over time; and crypto is becoming a new conflict currency.

Healthcare

The dawn of a life science golden age begins, with drug development focusing more heavily on biologics, cell therapies, gene therapies, and gene editing – shifting paradigms, ranging from the targeting of previously undruggable cancer mutations to the correction of lethal childhood muscular dystrophies; even aging itself begins to be tackled by biopharma innovation in the Quest for Immortality. In the Individual Revolution, personalized therapeutics make waves and move from rare diseases to more common indications, expanding the total addressable markets and leaving fewer and fewer patients behind. Further, the “hospital at home” comes to life as healthcare services evolve and smart implants drive remote patient monitoring. Artificial Intelligence Activated simultaneously reduces R&D costs, maximizing efficiency and alleviating broader healthcare industry labor shortages, along with robotics surgery becoming the standard of care. Healthcare Hybrid Living is led by virtual healthcare which brings high quality, complex patient care at a low cost, still in the early ages of adoption amid a massive TAM (over \$3T on healthcare spend annually in the US alone). Even remote telesurgery becomes possible in our hybrid world. Globally however, a balance will need to be struck between innovation and access, and we watch as China begins to position itself as a biotech force.

Industrials

In the **Quest for Immortality**, automated smart vehicles will reduce fatalities, increase productivity, and provide potential health monitoring benefits, while the Indoor Air Quality (IAQ)/Healthy Buildings trend presses forward beyond COVID-19, and space travel provides the ultimate escape route. In the **Individual Revolution**, autonomous driving frees up passenger time making room for bespoke in-car media experiences, 3D printing offers a new paradigm for engineering design and manufacturing, along with new equipment to drive forward the life science golden age, particularly as gene editing technology is developed. Furthermore for autos, a lot of focus has been on the electrification of vehicles; we see a larger potential change in connected, software enabled vehicles. For **Artificial Intelligence Activated** in A&D we expect unmanned drones to fly as loyal wingmen in support of manned fighter aircraft. In **Hybrid Living**, we are moving beyond “smart” manufacturing to complete end-to-



We also expect metals markets to be highly volatile as different supply and demand shocks play through.



The pace of drug development will accelerate given an uptick in R&D funding along with key tech advancements, and in turn, should drive stronger life science real estate demand.

end connectivity across the supply chain allowing for significantly richer information and flexibility. We believe with this dramatic increase in factory IoT devices, manufacturing could be on the same cusp of scaling that the Internet saw when it scaled as devices moved from mainframes to computers to smartphones. Water scarcity and security issues are growing at an alarming rate in the **Great Balancing Act**, but solutions such as smart water and desalination are spearheading the global challenges. Additional industrial innovations in waste fuel, marine shipping and of course auto electrification all drive global sustainability forward.

Materials and Mining

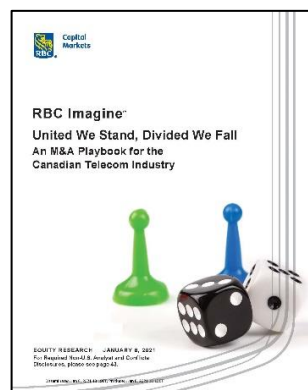
Advanced healthcare deployment to the emerging world increases mine productivity on the Quest for Immortality, and elongated lifespans and population growth could spur a productivity boom in emerging markets, increasing the demand for metals, fertilizers, forest products, specialty chemicals and packaging. Meeting increased energy demand from a growing population while achieving net zero carbon targets will likely require maintaining and growing global nuclear capacity, which should support long-term uranium demand. AI-enabled understanding of orebodies will further drive improved mine sequencing and planning with far less variance along with an ability to see into the mines' future at less cost and effort. In Hybrid Living, mines of the future could be operated completely remotely, though this could have unintended consequences for the finely balanced relationships with local communities whose economies are now dependent on the mine. The forestry industry could also adopt remote operation. This brings us to the Great Balancing Act, where the dominance of China in many metals, and a burgeoning requirement for the West to create supply chains of its own, combined with these metals occurring in many non-traditional resource countries, often with security and governance issues, will make the geopolitics of critical minerals rise in importance over the coming decade. More specifically, we believe the market should keep a particular eye on lithium, cobalt, graphite, nickel and copper and uranium given the likely need for new production (versus current levels), the importance to green technologies as well as the geographical supply concentration. The Substrate Wars also commence as consumer goods packaging continues down the sustainability route.

Real Estate

The dawn of a golden age in life science development has direct positive implications for life science real estate in the Quest for Immortality, in a virtuous cycle where increased life science real estate development in top cluster markets in turn fosters collaboration driving further innovation. Towers globally further enable virtual health connectivity, in turn saving lives. In the Individual Revolution, the 3D printing of homes enables home customization affordable to the masses. Artificial Intelligence and Hybrid Living drive substantial data center demand. Meanwhile Hybrid Living has broad based transformative implications across retail, office, logistics and residential as more people focus in virtual worlds at home. "Just In Case Inventory" replaces "Just in Time Inventory" in a global supply chain more exposed to macroeconomic shocks is an important development in the Great Balancing Act.

Technology, Internet, Media and Telecommunications

The rollout of 5G to rural areas and later emerging markets brings immediate healthcare to those in a virtual form who never had it before on the Quest for Immortality. For the Individual Revolution, new internet marketplaces provide the opportunity for a growing gig economy, though at times rapidly expanding profit pools lead to stress in the system between independent workers and corporates. Technology companies are the true leaders of Artificial Intelligence Activated, innovating automation software and leveraging information services data to provide a crystal ball into the future. On Hybrid Living, similar to how public transportation and internal combustion engines gave rise to the suburb, we believe modern technologies will further shift the future workforce and populations to be even more distributed across regions and even countries. We believe the economic, social, cultural, political and environmental impacts that the



We created a Canadian telecom M&A game with a playbook that attempts to untangle and sequence dynamics for investors to better identify M&A catalysts and evaluate logical M&A outcomes.



The conversations around the energy transition are evolving rapidly. We believe the majors have potential to present themselves as 'part of the solution' in key areas that require substantial scale.

second iteration of the Internet (often referred to as the "Metaverse") will bring will be nothing short of profound. Cyber-warfare, including that facilitated by non-state actors, drives the need for increased cybersecurity in The Great Balancing Act.

Navigating Imagine industry implications

We reiterate each future theme is driven through developments across industries, though to better help navigate the report's themes, we highlight which industries are especially relevant for each theme in the exhibit below.

Exhibit 1 - Navigating the RBC Imagine future themes by industry relevance

Industries	RBC Imagine Future Themes				
	The Quest for Immortality	The Individual Revolution	AI Activated	Hybrid Living	The Great Balancing Act
Consumer					
Energy and Utilities					
Financials					
Healthcare					
Industrials					
Materials and Mining					
Real Estate					
Technology, Internet, Media and Telecom					

Dark Blue = Relatively Most Impacted, Light Blue = Impacted

Source: RBC Capital Markets

Putting it all into action

To put the thematic ideas presented in this report into action, we direct you to our separately published [RBC Imagine™ Best Ideas for the Long Term](#) list. This list of 71 stocks spans across sectors globally and it's a list we see as differentiated in three material ways: (1) the ideas directly play into our five themes; (2) we take a long-term view beyond traditional 12-month price targets and ratings, which leads to the inclusion of a number of Sector Perform rated names on the list; and (3) ESG considerations are directly linked to our list.

Always evolving

We note our future defining themes are different from, but certainly rhyme with, the original themes presented in our [Landmark 2018 Imagine Report](#) – they have just evolved. *The Artificial Intelligence Race* has since progressed from the once theoretical to the absolutely practical as we look forward with *Artificial Intelligence Activated*. The original *Calibrated and Augmented Self* theme on personalization and *Collective Action* theme on individuals coming together to drive change merge into *Individual Revolution*. Our prior *Escalating Uncertainties* theme evolves into the *Great Balancing Act* as we continue to navigate environmental, social and geopolitical change forces across the globe. *In Cloud We Trust* has since manifested in our view, as investors and organizational leaders alike now recognize cloud will have a meaningful role in the future across sectors, as it continues to through this report, especially as the underpinning of *Hybrid Living*. *The Agility Imperative* theme, which was a call to action for organizations to reinvest and prepare for the unexpected will always remain relevant, though is now more clear in a post COVID-19 world. *The Quest for Immortality* emerged as a new theme from our future planning process, as we analyzed the simultaneous, future developments across industries that will come together to extend lifespans at an accelerating rate. We will continue to evolve and provide additional insight on thought provoking Imagine ideas with research reports like those you see here along the margin. As always, we encourage you to reach out to the team with any questions; we are here to help and look forward to continuing on this journey with you together.

The Quest for Immortality

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Quest for Immortality – Introduction

The Quest for Immortality: Emerging from the COVID-19 pandemic, we see the simultaneous combination of breakthroughs in medicines and therapeutics (mRNA vaccines), further advancements in healthcare availability (telemedicine), improving transparency in the food/health connection, living conditions and other scientific/technological improvements likely to extend lifespans at an accelerated rate over the coming decade. However, how this dynamic plays out across the global population could create a clear divide among populations based on income, demographics and infrastructure.

Let's face it: as human beings, we love life, and we want more of it. The drive to live longer, healthier, better lives is not new – stories about the fountain of youth date back to the 5th century B.C. And while immortality in itself remains elusive, science has dramatically accelerated our goals. Global life expectancy has doubled since 1900, and in just the past decade, prior to COVID-19, it went up by another six years. Inequalities clearly remain, but since 1950 almost all parts of the world have benefited dramatically from this surge.

Cellular therapies, mRNA vaccine technologies, gene manipulation, personalized medicine – all concepts that seemed unrealizable just 10–20 years ago – are now integral parts of our arsenal for preventing and treating illness. As we sit on the cusp of major further developments in brain health, genetic medicine, and cancer, it is clear that such innovations are showing no signs of slowing down.

The science underpinning our quest for longer, healthier lives will no doubt continue accelerating, as we move into a full innovation revolution in medicine and technology. Years of accumulating breakthroughs, starting with the Human Genome Project and intensifying with new modalities for drug discovery and delivery, have pulled forward our understanding of disease biology and given us new tools to tackle challenging diseases and improve the human health-span. Cellular therapies, mRNA vaccine technologies, gene manipulation, personalized medicine – all concepts that seemed unrealizable just 10–20 years ago – are now integral parts of our arsenal for preventing and treating illness. As we sit on the cusp of major further developments in brain health, genetic medicine, and cancer, it is clear that such innovations are showing no signs of slowing down. Manufacturing demands are likely to continue to grow and shift as the drug development landscape continues to evolve, as well. How all of these innovations are paid for will likely continue to be a key topic of societal and political debate, as expensive development pathways escalate the price of novel treatments and curative therapies require novel payment modalities.

It's not only about better medicines – how healthcare is delivered and consumed will also play a major part in shaping our future healthier and more resilient selves. Telemedicine came into the spotlight during the pandemic, but even when COVID-19 wanes it is likely to improve the efficiency of healthcare interactions. Telemedicine claims, while down off of peak pandemic highs, are still up over 2000% vs. pre-pandemic levels, and the integration of more seamless interactions with caregivers should further improve disease recognition and treatment, enabling people to take better control of their health-related decisions. This individual empowerment is likely to go beyond patient–caregiver interactions as well. Beyond the doctors' offices – be they physician or virtual – wearables will enable people to better track and manage their health and fitness, with AI technology helping interpret results in real time. And 5G will allow expanded connectivity across underserved areas, breaking down barriers and facilitating more equitable access in the pursuit of better, healthier lives.

Our push towards these goals will affect how we eat, work, and even our consumer choices. Younger generations continue to prioritize healthy, sustainable foods, and innovations in these areas are likely to be driven by start-ups. Workplace well-being is increasingly becoming an expectation rather than just a privilege, with corporations likely to increase their alignment with employees on such initiatives. Air quality in office buildings, largely ignored prior to the pandemic, will likely take center stage to protect against the spread of future contagions. Even the cars we drive will be more heavily scrutinized for their safety not only for passengers but also pedestrians, as the shift towards autonomous driving continues.

Ensuring the innovations in healthcare and technology reach across classes and geographies will be crucial so as not to intensify our economic and political divisions. And control of our data (discussed more extensively in subsequent sections) will become particularly important as our health visits, records, and real-time monitoring are digitized.

Companies that can predict and take advantage of the invariable resulting demographic shifts could emerge as beneficiaries over the next decades. An aging population is likely to have different medical needs, consumer tastes, and even political inclinations. Additionally, the decades-old view of the elderly spending their last years in nursing homes could evolve towards more comprehensive living centers catering to a more vigorous, interactive older generation where physical therapy, wellness, and exercise facilities become increasingly incorporated – not to mention a potential evolution in family living dynamics. The different ways a growing population increases our global energy demand will also force a further re-examination of novel solutions like hydrogen power, which may become increasingly mainstream.

These changes will not be without their challenges. While we tackle some, other diseases of aging are likely to emerge, and companies and society will need to be poised to combat these and improve the way we fund and deliver them. Breakthrough therapies and vaccines may bring an end to the dominant phase of COVID-19 and enable a lifespan rebound, but this is also likely to expose longer-term problems brought about by the past two years of disruption – including mental health issues, long COVID-19, and education gaps. Ensuring the innovations in healthcare and technology reach across classes and geographies will be crucial so as not to intensify our economic and political divisions. And control of our data (discussed more extensively in subsequent sections) will become particularly important as our health visits, records, and real-time monitoring are digitized.

The quest for improved health is likely to permeate society in more ways than ever. How we pursue our dream of immortality and react to the changes it brings about will be core to how we invest – and live – in the future.

Biopharma: The dawn of a life science golden age

Looking beyond biology, we also now have the tools to better translate these breakthroughs into therapies, with more powerful computational algorithms for drug discovery and molecular modeling, more representative preclinical animal models for efficacy and toxicology screening, and greater scalability for complex cell and gene therapy manufacturing.

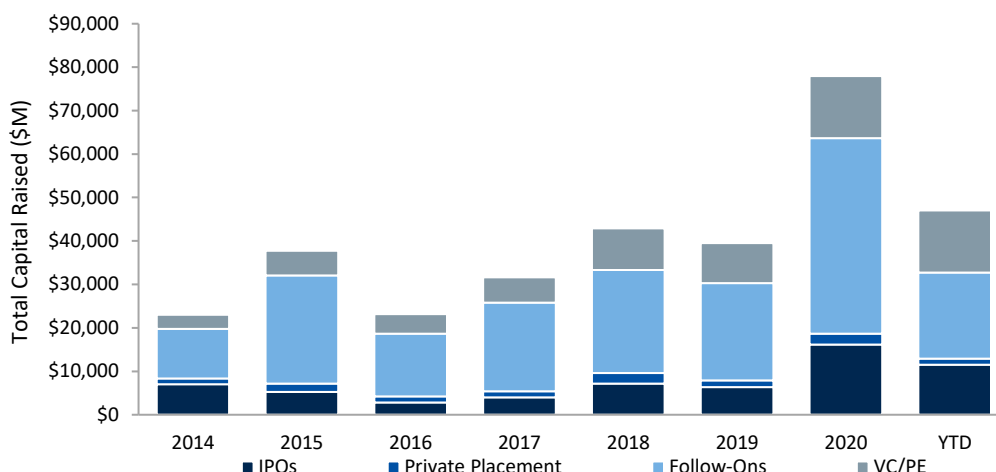
Public/private capital funding also noticeably jumped to ~\$80B in 2020 from the prior four-year trailing average of ~\$35B, which should also help fund research.

A core tenant of our “Quest for Immortality” directly comes down to life science and the culmination of factors that will drive an inflection in life science innovation. It all simply starts with our biology. Our understanding of biology has evolved dramatically over the past 30 years with initiatives such as the Human Genome Project, the discovery of the gene-editing tool CRISPR, and insights into neural circuitry brought on by techniques like optogenetics. This has led to a greater awareness of cellular pathways and the uncovering of novel targets and clinically relevant biomarkers across disease areas, all of which are accelerating the pace of drug discovery. These basic biology breakthroughs have enabled an ability to precisely target therapeutics, such as with synthetic lethal approaches in oncology (BRCA2^{-/-} tumors are highly sensitive to PARP inhibitors), precise correction of genetic mutations (in Duchenne muscular dystrophy), and novel mechanisms to target depression (NMDA and GABA). In turn, these developments have opened the door for future approaches that leverage gene editing and our growing understanding of the brain and tumor biology. Looking beyond biology, we also now have the tools to better translate these breakthroughs into therapies, with more powerful computational algorithms for drug discovery and molecular modeling, more representative preclinical animal models for efficacy and toxicology screening, and greater scalability for complex cell and gene therapy manufacturing. We believe biopharma is poised to leverage this greater understanding into the next set of medicinal breakthroughs, which can lead to a flurry of new medicines by the end of the decade that can enhance lifespans and quality of life.

Funding boost should allow companies to aggressively pursue R&D projects post COVID-19

The life science industry is critical to reduce healthcare costs, enhance quality of life, and protect against pandemics. The COVID-19 pandemic highlighted the need to advance medical research to protect not only the vulnerable population, but also the general economy and our way of life. The U.S. and governments across the world recognized this need, and private investors noted the significant potential returns. Both are plowing capital into the space. The Biden Administration has proposed increasing the NIH budget by 21%, to \$52B in FY22, in order to fund and advance basic research. This specific research is the foundation upon which life science companies can develop new, cutting-edge treatment options. Public/private capital funding also noticeably jumped to ~\$80B in 2020 from the prior four-year trailing average of ~\$35B, which should also help fund research. This trend has continued with the sector raising ~\$50B YTD through mid-October (~\$60B annualized). There are ~10K known diseases in the world, but only 500 are currently addressable with treatment options, according to Alexandria Real Estate Equities (ARE) – creating substantial opportunity for further life science progress, in our view.

Exhibit 2 - Public/Private funding popped in 2020 and remains strong today



Source: Factset and RBC Capital Markets Note: IPOs, Follow-Ons, and Private Placements only include those listed on NASDAQ/NYSE exchanges; Values through 10/15/2021

Conquering infectious disease – Novel vaccines developed in 2021 matter

The mRNA vaccines by Pfizer/BioNTech and Moderna were developed and approved for use within 10 months (with full approval 8 months later).

This is substantially faster than even the relatively speedy ~5-year timeline for an Ebola vaccine and the ~9-year timeline for the Shingles vaccine, which speaks to the technology's ability to be quickly leveraged for new and emerging infectious diseases.

The COVID-19 pandemic showcased how rapidly and effectively mRNA-based vaccine technology can be deployed. The mRNA vaccines by **Pfizer/BioNTech** and **Moderna** were developed and approved for use within 10 months (with full approval 8 months later). This is substantially faster than even the relatively speedy ~5-year timeline for an Ebola vaccine and the ~9-year timeline for the Shingles vaccine, which speaks to the technology's ability to be quickly leveraged for new and emerging infectious diseases. Beyond COVID-19, we see likely next steps for mRNA vaccines as other respiratory viruses such as flu and RSV, and possibly even chronic diseases such as HIV, where the market may be >\$30B. Key questions remain, particularly in light of growing vaccine skepticism, uncertainty over which adverse events may be class effects and/or require additional monitoring, and the durability of the approach. Nonetheless, we expect these issues are likely to be worked out in the course of future development, and could see vaccines both using mRNA and improved traditional modalities playing a revitalized role in human health span globally – with the recently approved malaria vaccine potentially being the tip of the iceberg. We also sense significant appetite for cure approaches in infectious disease across technologies, with virology players such as **Enanta Pharmaceuticals**, **Vir Biotechnology** and **Gilead** working on small molecules (potentially for combo use) to cure HBV. In the HIV space, we note **Johnson & Johnson**, **Gilead**, and **Moderna** all pursuing cure approaches, with modalities including vaccines, immune activators, broadly neutralizing antibodies, and small molecules.

Conquering cancer – Breakthrough therapies and novel modalities lead the fight

Cancer therapeutics have evolved dramatically over the past five years, progressing from cytotoxic chemotherapies to targeted immune agents, precision oncology approaches, and cell therapies, and we expect progress to continue at a rapid pace. In particular, we see **Gilead** as an innovative driver of new oncology approaches, starting with their leadership in cell therapies, which harness the body's own immune system to fight tumors. This class of drugs has shown impressive results, with **Gilead's** Yescarta showing 44% 4-year survival data in late-line diffuse large B-cell lymphoma (DLBCL), as well as profound survival benefits and a 65%

complete response rate in the second line, which we sense should help CAR-Ts gain increasing usage. We estimate cell therapy sales from Gilead alone could top \$2.5B by 2030, and note a number of new biotechs bringing forward the next generation of cell therapies, including off-the-shelf approaches (**Allogene Therapeutics**, **CRISPR Therapeutics AG**), bispecific approaches, long-lasting armored approaches, or new immune cell types which could offer a superior safety/efficacy balance; Gilead is involved in many of these approach through its KITE business unit, which has recently refocused on addressing hematologic malignancies.

We also see progress across biologic medicines, with traditional monoclonal antibody approaches making way for new modalities such as antibody drug conjugates and bispecifics. Therapeutics such as **Incyte's** Monjuvi offers a long-term maintenance potential in DLBCL, a potentially unique treatment paradigm that may change the way the disease is treated in the frail or elderly. We believe Gilead has executed on a prudent BD strategy in oncology and acquired a number of potentially exciting antibody approaches, including CD47-targeting Ab magrolimab, which targets and blocks a cancer cell-cloaking signal and has optionality in myelodysplastic syndromes (MDS) and acute myelogenous leukemia (AML). KOLs have described it as a potential "home run" for these patients; the drug also has optionality in solid tumors and lymphomas, and we believe Gilead has the potential to be first to market in this increasingly crowded CD47 space. Gilead also has a partnership with **Arcus Biosciences** for their unique anti-TIGIT, which promises a better safety profile while maintaining high efficacy and combinability with other I/O approaches, and we see this class as potentially the next complement to PD-1s. We also believe next-gen antibody approaches like ADCs – of which Gilead's Trodelvy is one – can improve patient outcomes in difficult-to-treat triple-negative breast cancer by two-fold over standard of care, giving patients an extra six months of life; other ADCs such as Daiichi Sankyo and **AstraZeneca's** Enhertu can reduce the risk of disease progression in breast cancer by 72%. In the meantime, bispecific antibodies such as those from **Roche**, **Genmab** and **Regeneron Pharmaceuticals** offer the promise of CAR-T-like efficacy in blood cancers, but with the potential for outpatient administration and significantly reduced safety risks. Among these, we see **IGM Biosciences** as a potential platform company positioning itself for the long term, with not only bispecifics based on its unique IgM antibody platform, but the potential to use the 10–12 binding sites of IgMs to develop unique therapeutics, such as agonists targeting the DR5 apoptotic pathway to kill cancer cells.

Vaccine technology may also be applied to oncology indications, such as with **BioNTech SE's** mRNA approach in melanoma, prostate, and other solid tumors, and T-cell vaccine technology, leveraged by names such as **Vir Biotechnology** and **Hookipa Pharma** to target HIV, CMV, and head and neck cancers. Though cancer remains a major public health issue likely to become even more prominent with the aging population, our efforts to combat it have not shown any signs of slowing down.

Brain health as the next frontier – significant advances coming over the next decade

We note that 2021 saw the first approval of a disease-modifying treatment for Alzheimer's, and despite the controversy surrounding **Biogen's** Aduhelm, we see it as a likely herald of a coming breakthrough in the treatment of Alzheimer's, with new modalities and new targets on the horizon from **Biogen**, **Eli Lilly & Co.**, **Roche**, **Cortexyme**, **Denali Therapeutics** and **Alector** among others. We sense a similar inflection point for Huntington's disease (though perhaps more long term) despite multiple setbacks this year from **Ionis Pharmaceuticals** and **Wave Life Sciences**, with new approaches from **PTC Therapeutics** and **Neubase Therapeutics** that have the potential to address some of the limitations of prior drugs, such as allele specificity and biodistribution. With the 25% increase in anxiety and depression in 2020 in the U.S., COVID-19 has also brought greater focus on mood disorders, where our greater understanding of the

2021 saw the first approval of a disease-modifying treatment for Alzheimer's and we see it as a likely herald of a coming breakthrough in the treatment of Alzheimer's, with new modalities and new targets on the horizon.

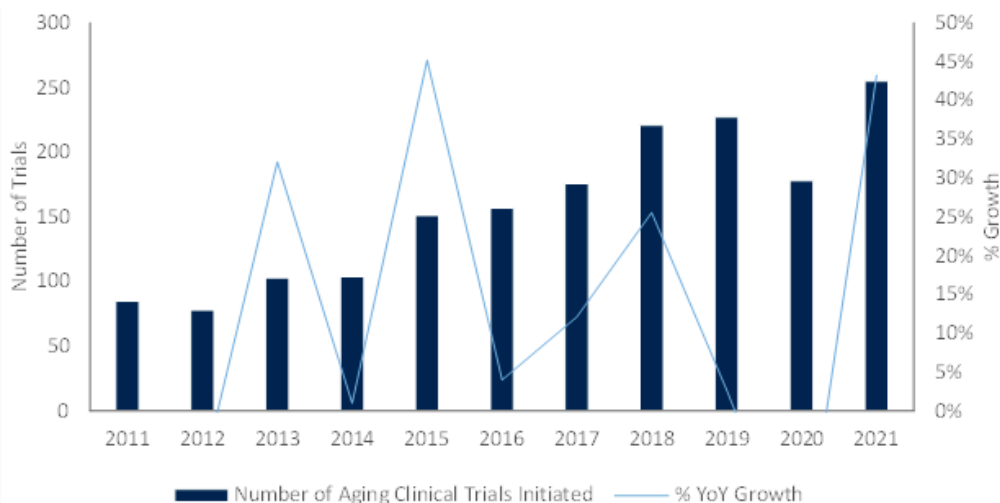
Psychedelic therapy might have the potential to further transform mental health by improving patient outcomes with short-course treatments and a differentiated safety profile to standards of care in treatment-resistance PTSD, depression, or opioid use disorders.

brain's chemistry has led to novel treatments on the verge of approval in depression, schizophrenia, and other disorders. **SAGE Therapeutics'** zuranolone promises to treat depression like an infection, with a short 14-day course to reset and restore the brain's chemistry; **Karuna Therapeutics** offers a drug with first new mechanism in schizophrenia in decades and can enable a combination treatment approach for the disease. Most of all, psychedelic therapy, led by companies such as **ATAI Life Sciences** and **Compass Pathways**, might have the potential to further transform mental health by improving patient outcomes with short-course treatments and a differentiated safety profile to standards of care in treatment-resistance PTSD, depression, or opioid use disorders.

Longevity – The quest has truly begun

While immortality likely remains at the intersection of science fiction and philosophy, we note that some biotechs have begun to approach longevity as a disease, or at least to weave the concept into their mission. A review of U.S. clinical trial listings suggests that the number of trials starting each year since 2011 addressing aging conditions has tripled from 85 to 255, growing at a CAGR of 12%, and outpacing the growth of new trial starts in general (which grow at ~6% annually) (Exhibit 3).

Exhibit 3 - The number of clinical trials addressing "Aging" has grown rapidly since 2011



Source: clinicaltrials.gov

While immortality likely remains at the intersection of science fiction and philosophy, we note that some biotechs have begun to approach longevity as a disease, and the number of trials studying aging conditions is growing rapidly.

About half of these new trials are interventional, suggesting some form of treatment to address the underlying condition, and therefore therapeutic potential. Some companies, like **Unity**, study anti-aging therapies with a focus on ophthalmology, and despite setbacks, we note a growing list of biotech start-ups focusing on longevity including BioAge, Life Biosciences, Google-backed Calico, a number of anti-aging focused funds such as The Longevity Fund and SENS, and even a \$200M longevity SPAC. While disease specific approaches are an important step towards addressing the human lifespan, we believe certain drugs may have broader applicability in improving overall conditions, such as **SAGE's** '718, which can improve cognition in healthy volunteers without amphetamine-like effects, **89bio's** FGF21, which can broadly improve metabolic health, and **Intra-Cellular's** '214, which can potentially reduce neural inflammation and improve cardiac function. These and other medicines could serve as potential starting points to guide future anti-aging approaches. Though immortality is unlikely to be addressed in this decade, we believe current work has the potential to lay the groundwork for identifying potential causes, mechanisms, and eventually solutions, to human aging.

Life science real estate: Collaboration drives innovation

Life science real estate clusters in major research markets play a crucial role in creating a collaborative eco-system that helps drive greater innovation – further accelerating life science development on the Quest for Immortality. These markets generally have leading research institutions (creates partnerships & talent pool), high-quality healthcare systems with a teaching slant, as well as major biotechnology companies and other key service providers. Life science clusters are difficult to create, but once established, success breeds success as more firms look to build a presence to benefit from the ecosystem.

The need for next-generation drug manufacturing represents a new, growing real estate demand driver.

The uptick in laboratory real estate demand, in part driven by the pandemic, is mainly being funneled into a handful of top clusters such as Boston, San Diego, and San Francisco, but demand is solid in other secondary clusters too. Additionally, the need for next-generation drug manufacturing represents a new, growing real estate demand driver. These manufacturing sites are generally being located near the top cluster markets today, but over time, we could see these requirements flowing to secondary clusters with a highly educated workforce and a lower cost of living such as Research Triangle in North Carolina or suburban Maryland. Overall, we believe this backdrop should continue to spur laboratory demand, pushing vacancy rates lower, rents higher, and creating development opportunities with attractive risk-adjusted returns.

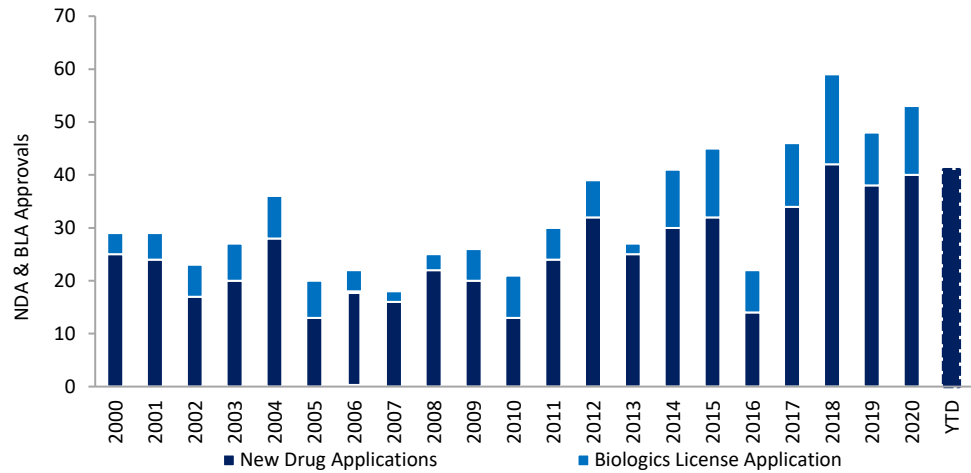
Medical advancements in drug research have led to exciting breakthroughs in gene therapy, gene editing, and biologics, but the manufacturing of these complex drugs is much more difficult than traditional small molecule drugs.

Next-generation manufacturing growing real estate demand driver

The need for next-generation drug manufacturing represents a new real estate demand driver, and plays a critical role in the Quest for Immortality in terms of drug development. Medical advancements in drug research have led to exciting breakthroughs in gene therapy, gene editing, and biologics. However, the manufacturing of these complex drugs such as biologics (large molecule) is much more difficult than traditional small molecule drugs. For example, the development of biologic treatment options depends on cultures of living cells and viruses that require particular environments to grow and remain viable. This process is highly specialized and is generally overseen by PhD/MD individuals that were involved in the research and development process. The end product is more fragile and needs to be transported through a sophisticated supply chain from the production facility to the end user.

Life science companies generally locate production sites, particularly early in the development stage, closer to the top cluster markets so key personnel can oversee the process. However, as the product is commercialized some companies may elect to build large manufacturing sites in markets with a lower cost of living and/or diversify production by outsourcing to a contract manufacturing organization (CDMO). These sites still need to be located in markets with a highly educated workforce that has this specific manufacturing expertise. A few of the secondary cluster markets represent a great base that can support this need such as Research Triangle in North Carolina or suburban Maryland.

Exhibit 4 - Biologics have comprised a large portion of approved treatments over the past few years



Source: U.S. Food and Drug Administration (FDA) and RBC Capital Markets Note: Reflects Center for Drug Evaluation and Research (CDER) data

Home Healthcare: The emerging value proposition

We view the near-term issues of COVID-related staffing pressure as transitory, and believe over the long term, these short-term issues are outweighed by powerful demographics, consumer preference for care at home, the expansion of capabilities and offerings at home, and the value proposition availed to both public and private sector payors.

The home health industry has a multitude of powerful secular tailwinds. We view the near-term issues of COVID-related staffing pressure as transitory, and believe they will improve. Over the long term, these short-term issues are outweighed by powerful demographics, consumer preference for care at home, the expansion of capabilities and offerings at home, and the value proposition availed to both public and private sector payors, all of which are driving an expanding total addressable market. We see both attractive organic growth as well as consolidation opportunities in this highly fragmented industry. Long-term investors should have exposure to the home health sector. The following further explains why.

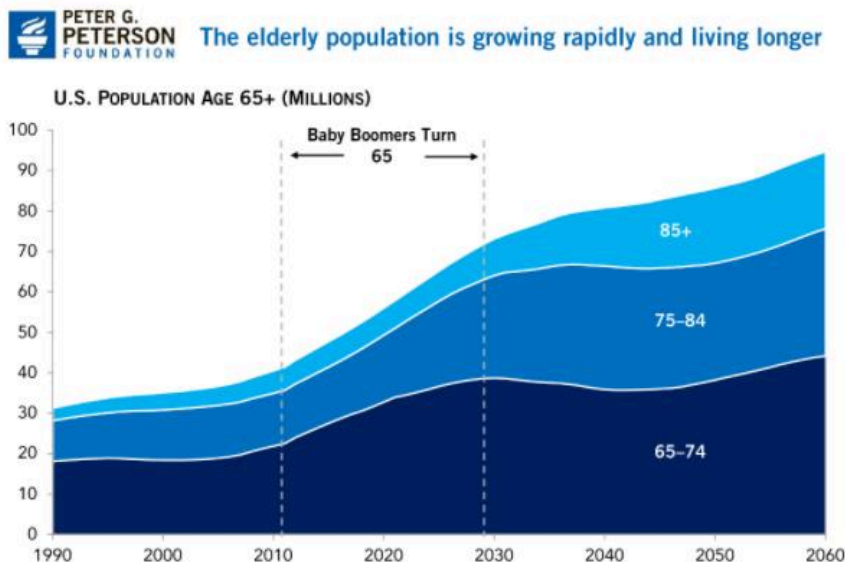
According to a MedPAC analysis of the CMS database, Home Health is a \$32.4B market involving the delivery of skilled nursing, physical therapy, occupational therapy, speech therapy, aide services, and medical social work primarily provided to Medicare beneficiaries in their homes, after a physician makes a referral from either a hospital or physician's office. Fee-for-service (FFS) Medicare spent \$17.8B on home health services for 3.3 million beneficiaries using the service, and this is expected to increase to \$35.1B by 2028. Medicare Advantage (MA), the other large payor, covers approximately 40% of the total Medicare-eligible population, and accounted for 31.2% of home health episodes of care.

There are other ancillary home-based services included in the broader market sizing, including Hospice, a \$22.7B market that covers support services for beneficiaries who are terminally ill with a life expectancy of less than six months. This service is primarily covered under FFS Medicare, and is forecasted to grow to \$45B by 2028. The final home-based service model is Personal Care, a \$15.1B market. Personal care is a home- and community-based service that provides non-medical services, including assistance with activities of daily living (ADLs) primarily for the elderly with physical and/or intellectual disabilities. Medicaid or other state-funded programs are the primary payors for these services as Medicare and MA generally do not cover services.

We see multiple industry tailwinds for home-care-based services

The U.S. population continues to grow older and live longer, increasing the need for both Home Health and Hospice. The number of Americans 65 years and older is expected to increase at a 2.7% CAGR through 2030, with 10,000 Americans turning 65 every day for the next 10 years.

Exhibit 5 - Demographic trends are compelling for the age cohort needing home health care services



Source: U.S. Census Bureau, National Intercensal Estimates: 2016 Population Estimates, June 2017; 2017 National Population Projections, September 2018; and "The Fiscal & Economic Challenge," Peter G. Peterson Foundation

Home Health is significantly less expensive than most post-acute care setting. Home Health is 90% less expensive than SNFs and 97% less expensive than LTACHs. Hospice is 65% less expensive than SNFs and 95% less expensive than acute-care hospitals where many elderly people pass away.

Exhibit 6 - Home Health is one of the lowest cost/ highest value settings for post-acute care

Post-acute Care	Annual Medicare Spending	Average Medicare Cost
Acute-Care Hospital	\$189.0 billion	\$3,250/treatment
Inpatient Rehab Facilities (IRFs)	\$8.1 billion	\$1,584/day
Long-Term Acute-Care Hospitals (LTACHs)	\$4.1 billion	\$1,507/day
Skilled Nursing Facilities (SNFs)	\$27.8 billion	\$485/day
Hospice	\$20.9 billion	\$172/day
Home Health	\$17.8 billion	\$49/day

Source: MedPAC analysis of the Common Medicare Enrollment file and the Medicare Beneficiary Database from CMS. (March 2021)

The home health and hospice industries are highly fragmented and ripe for industry consolidation.

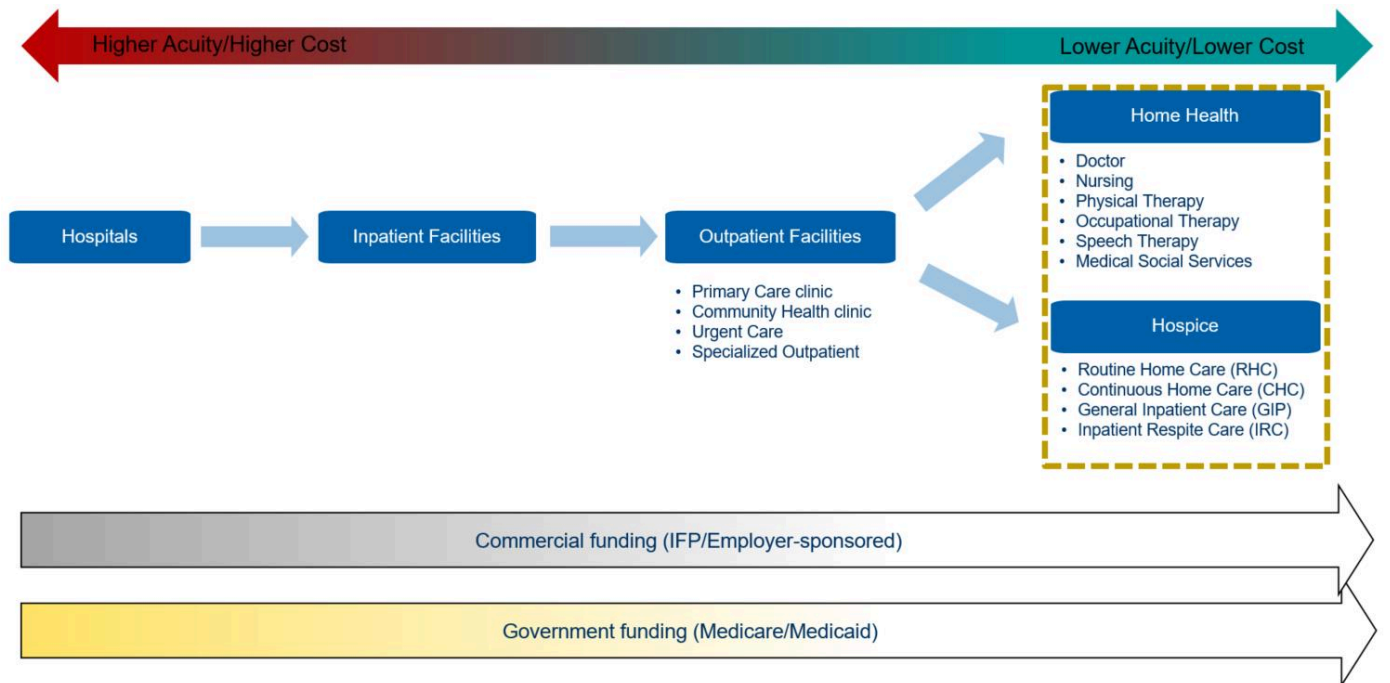
The home health and hospice industries are highly fragmented and ripe for industry consolidation. There are more than 11,300 home health agencies and 4,800 hospice service providers, with the largest public operators collectively accounting for only 20% of the industry. While the January 2020 transition of home health reimbursement to the new Patient Driven Groupings Model (PDGM), which included the elimination of Request for Advance Payment, was to be a major catalyst for industry consolidation, federal relief programs under the CARES Act provided near-term liquidity for operators. With CARES Act grants exhausted and recoupment of

advanced payments now underway, we expect to see financial strains that could likely renew interest (and necessity) for consolidation of the smaller mom-and-pop operators.

Accountable Care/Value-based policy movement and payment models play well into the hands of home-based care providers. To address increasing healthcare costs, both government and commercial payors' care models offer reimbursement that encourages and rewards the best patient outcome for the lowest cost (high value). Specifically, episodic or "bundled" payment models provide a single lump sum payment for all healthcare services utilized for the treatment of a specific medical diagnosis (similar to a "prix fixe" menu versus ordering à la carte). These models will encourage the use of the highest-value (lowest cost, with best outcome) setting for the delivery of post-acute care once a Medicare patient is discharged from the acute care hospital.

We believe home health is a natural beneficiary in this process.

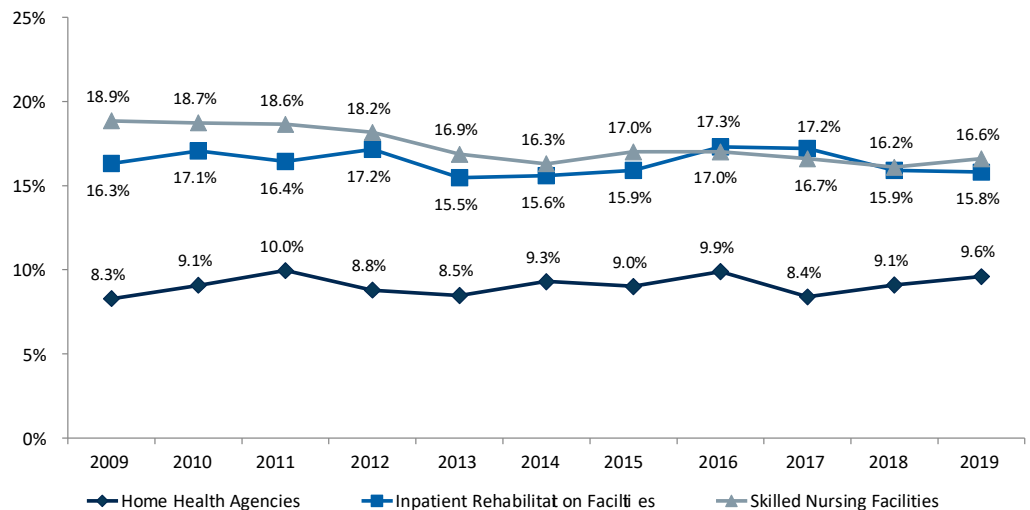
Exhibit 7 - Home health is a natural beneficiary as commercial and government payors push for more care into high value post-acute care



Source: RBC Capital Markets

Home health can be a viable alternative to other traditional post-acute settings in many cases. In fact, a recent demonstration project by CMS highlighted Home Health's high-value alternative versus other settings for certain diagnosis. The chart below illustrates the lower hospital readmissions rates for major joint replacement rehabilitation.

Exhibit 8 - In addition to lower cost, Home health also produces attractive quality outcomes for the post-acute population



Source: AHHQI 2020 Home Health Chartbook, Avalere analysis of the Medicare Standard Analytic Files 2009-2019

Expanding care programs to serve higher acuity, chronically ill Medicare cohorts could potentially expand the total addressable market for home health by as much as \$30B.

Policy momentum from both public and private-sector payors are driving further expansion of capabilities and offerings in the home setting, such as “Hospital at Home” and “SNF at-Home.” Expanding care programs to serve higher acuity, chronically ill Medicare cohorts could potentially expand the total addressable market for home health by as much as \$30B. No doubt, the capabilities of the home health industry were further highlighted by the global pandemic. Hospital at home replaces inpatient-level services with short-term acute home nursing as well as telehealth-driven physician rounding. Hospital at home is suitable for certain chronic patients within specific clinical categories like COPD and CHF that would otherwise present at the Emergency Department, typically being admitted to the hospital for 2–3 days, at a significantly higher cost.

Potential legislation could provide further momentum to the policy movement impacting the sector. The bipartisan Choose Home Act was introduced on July 29, 2021; if signed into law, it would allow clinically appropriate Medicare beneficiaries the option of receiving post-acute treatment at home rather than in a more costly skilled nursing center. Choose Home has significant bipartisan support with co-sponsorship by four senators from each party, as well as lead sponsorship from the Chair of the Senate Finance Health Subcommittee and the Chair of the Senate Aging committee. Similar bipartisan support now exists in the House. The legislation would guarantee Medicare savings of at least 20% for beneficiaries opting for home versus SNF treatment. The legislation would cap payments at 80% of the cost of an SNF stay and limit the benefit to a 30-day episode of care, which together would effectively lock in the 20% savings. Economics firm Dobson DaVanzo expects the bill to drive \$1.6–2.8B of Medicare savings over the next 10 years, although the official scoring from CBO is pending. Assuming a successful scoring by CBO, we would expect the best chances of an acceptable legislation through an “extender bill” later in the year.

Telecom: The 5G health factor

The overall improvement in the accessibility of the healthcare system due to 5G applications provides an opportunity to bridge the divide between rural, urban and suburban geographies worldwide.

A more reliable and faster connected world will be a safer one. The COVID-19 pandemic accelerated telemedicine initiatives globally in order to keep patients and doctors safe. Looking further into the future, telemedicine will continue to evolve to provide more comprehensive and effective healthcare coverage with the development of 5G and associated applications – treating illnesses and saving lives.

5G connections will have an outsized impact on rural communities. These areas, which have been without a reliable broadband connection for years, will be able to experience a similar level of connectivity when compared to urban areas with the buildout of 5G infrastructure. Telemedicine will be particularly important as there is a shortage of doctors in rural regions. The increased bandwidth and low latency of 5G will allow for higher resolution video and images, allowing doctors to treat patients more effectively from anywhere. Additionally, healthcare systems using 5G would be able to provide patients with specialists that they could not otherwise access due to geography constraints. The improvement in the quality of virtual visits will allow for a more holistic implementation of augmented and virtual reality, which will improve a doctor's ability to deliver innovative treatments with high accuracy.

Connected devices and AI technology will further improve healthcare for patients through better health forecasts and real-time monitoring. AI will have more access to data through the increased usage of wearables, which will require a 5G connection. The higher capacity and lower latency associated with a 5G connection will allow for real-time monitoring of a patient's well-being. Data collected by the device would be analyzed by AI in order to make predictions on a patient's recovery, diagnose a condition or provide a notice for medical attention. The data tracked by the device could be sent to doctors in real time to provide the best care to patients. In rural areas, this would reduce the time spent getting to or in the doctor's office, while simultaneously improving preventative care, thus reducing the need to see a doctor. The overall improvement in the accessibility of the healthcare system due to 5G applications provides an opportunity to bridge the divide between rural, urban and suburban geographies worldwide.

Remote telesurgery is the future of medical device surgery

Remote surgery has made a rapid comeback as an aftermath of COVID-19. There are several industry trends that have emerged in the aftermath of the COVID-19 pandemic, which had the most severe impact in 1H'20. These trends include the rapid growth in home healthcare, remote patient monitoring, remote and robotic-assisted surgery, and build-out of the smart city infrastructure. The concept of remote surgery is not new as it was the original intent of the da Vinci platform in the 1980s to provide battlefield surgery for the U.S. army. That said, the timing is only now right given advancements in network speeds such as 4G LTE and 5G. As such, we expect a rapid adoption in remote surgical capabilities in the decades ahead.

Remote surgery capabilities allow for case support today, but AI-driven decision making is the future. Remote surgery capabilities include a range of solutions to make surgery more accessible. This includes digital case support platforms that connect medical device teams to providers and allows them to remotely share best practices and collaborate in real time during a live procedure. It essentially allows doctors to 'scrub in' to any OR or Cath lab from anywhere in the world to participate in real time. We believe the technology will evolve over time to integrate best practices and optimal techniques across the user base and utilize artificial intelligence (AI) to aid the surgeon in decision making during procedures.

Remote surgery capabilities are being adopted by a wide range of users. Remote surgery capabilities in its current form is being embraced by medical device companies to drive adoption of technologies and products; by doctors to facilitate training, real-time guidance, and/or second

Robotic telesurgery could provide accessibility to world-class surgeons and/or capabilities in rural locations, battlefields, spacecrafts, and other locales where medical access is unavailable or severely limited.

opinion, and case sharing; and by hospitals to track surgeon performance, understand product usage, and optimize rating to reduce variability across the hospital system.

Remote telesurgery is the future of medical device surgery. Robotic telesurgery goes beyond simple case support as it utilizes wireless networking and robotic technology to allow surgeons to operate on patients that may be located in distant geographies. The benefits are substantial as it would: (1) provide accessibility to world-class surgeons and/or capabilities in rural locations, battlefields, spacecrafts, and other locales where medical access is unavailable or severely limited; (2) eliminate the need for travel and save substantial time that may be utilized to treat new patients; and (3) allow for surgical collaboration at different medical centers in real time, including second opinions during live cases. We believe today's technology with the 5G network and 3D display makes it easier to enable such surgeries more widely, but there are some challenges such as latency (i.e., the time gap to transfer auditory, visual, and even tactile feedback between locations).

Remote stroke intervention is the 'holy grail' for remote surgery. Remote stroke intervention is the most notable clinical application for remote surgery. Stroke occurs when the blood supply to a part of the brain is interrupted or reduced preventing brain tissue from getting oxygen and nutrients. Stroke patients lose two million brain cells per minute, and the damage can be severe after just 10 minutes. The longer the patient waits to be treated, the greater the chance of brain damage. Stroke is a severely undertreated condition and in many instances patients lose valuable time in getting to a stroke center (even if available, it is inaccessible to most patients around the world).

Exhibit 9 - Remote surgery in China



Source: Design World.

Continue reading more about virtual health in [Hybrid Living – Virtual Health is the Future](#)

Autos: An accident-free world

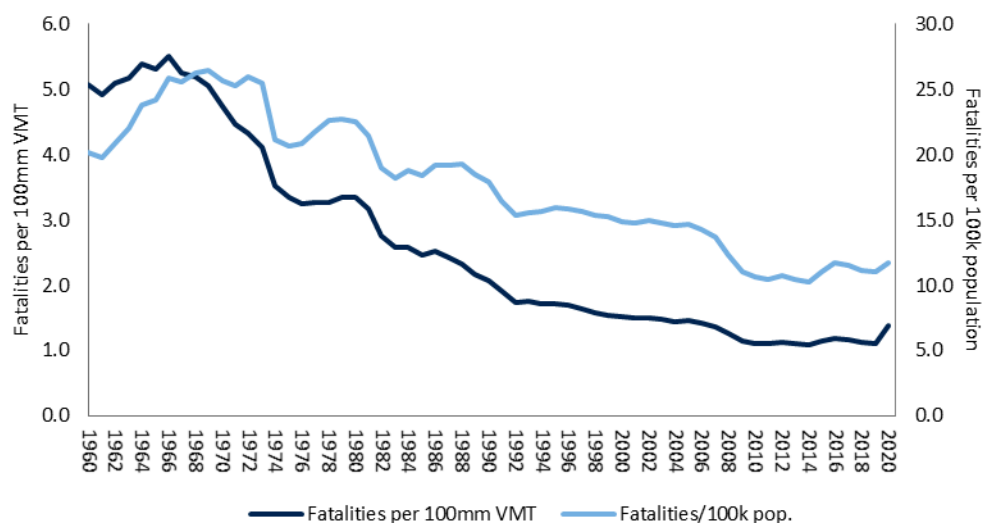
According to the World Health Organization, crash injuries are estimated to be the eighth leading cause of death globally for all age groups and the leading cause of death for people aged 5–29 years.

Automated vehicles can reduce fatalities and increase productivity, but may also widen demographic divides

According to the World Health Organization, each year ~1.35 million people are killed on roadways around the world. That's 3,700 people/day. Per WHO, crash injuries are estimated to be the eighth leading cause of death globally for all age groups and the leading cause of death for people aged 5–29 years. Further, the U.S. CDC highlighted that fatal and nonfatal crash injuries will cost the world economy an estimated \$1.8T dollars (in 2010 USD) from 2015–2030 – equivalent to an annual tax of 0.12% on global GDP.

In the U.S., there were 38.7k traffic deaths in 2020. When we look at fatalities scaled for 100 million vehicle miles travelled (VMT) or per 100k in population, we can see that the rate of improvement slowed significantly in the 1990s, flattened out in the 2010s and actually increased in 2020 (in a year when VMT was down significantly, -12%, during COVID-19). This is despite more and more driver assistance technology in vehicles.

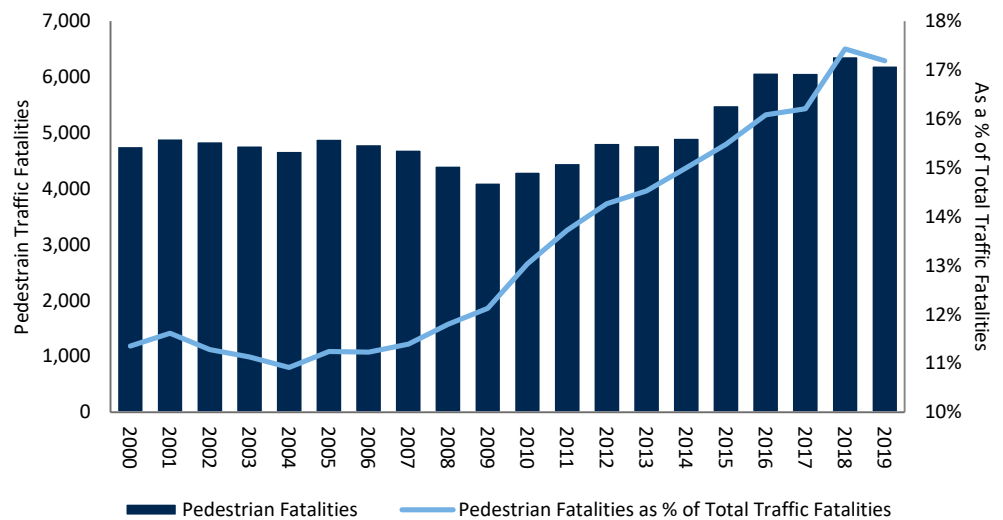
Exhibit 10 - U.S. traffic fatalities per 100 million VMT and per 100k population



Source: NHTSA, FHWA, U.S. Census

Pedestrian deaths (which are included in the U.S. fatalities above) are on the rise, likely due to larger vehicles (more pickups and SUV/CUVs) but also more smartphone distraction.

Exhibit 11 - U.S. pedestrian traffic fatalities



Source: NHTSA FARS

According to NHTSA, 94% of serious crashes are due to human error - automated vehicles have the potential to be better than human drivers and could reduce the risk of serious crashes over the long term.

So a step change in technology may be needed for further improvement in vehicle safety. Enter the promise of autonomous vehicles. According to NHTSA, 94% of serious crashes are due to human error. Automated vehicles have the potential to be better than human drivers. We believe that over the coming 5–10 years, with advancements in artificial intelligence and robotics we will begin to see Level 4 automated vehicles (defined as a vehicles that can operate within a defined operational design domain) hit the road. This will likely be in the form of automated ride-hailing services or “robo-taxis,” automated package delivery and highway freight. We do not believe Level 5 (all and any conditions) will happen anytime soon.


Exhibit 12 - SAE levels of driving automation

		SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?		You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver's seat”		
		You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
Copyright © 2021 SAE International.							
		These are driver support features			These are automated driving features		
What do these features do?		These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
	Example Features	<ul style="list-style-type: none">• automatic emergency braking• blind spot warning• lane departure warning	<ul style="list-style-type: none">• lane centering OR• adaptive cruise control	<ul style="list-style-type: none">• lane centering AND• adaptive cruise control at the same time	<ul style="list-style-type: none">• traffic jam chauffeur	<ul style="list-style-type: none">• local driverless taxi• pedals/steering wheel may or may not be installed	<ul style="list-style-type: none">• same as level 4, but feature can drive everywhere in all conditions

Source: SAE International

Dan Ammann, CEO of General Motors subsidiary Cruise, recently noted that their vehicles, which have been testing in downtown San Francisco, recently approached human driver capability. However, it is important to note that from 2016 until today, the system has improved exponentially – 1,000x. That improvement may have gotten Cruise to a minimal viable product, but the exponential improvement suggests that soon, the system will be significantly safer than a human driver. Cruise is one of only three companies to receive a California DMV driverless deployment permit for paid rides along with Waymo and Nuro (does package delivery). Only one hurdle remains towards regulatory launch (CPUC driverless deployment, paid).

Exhibit 13 - Regulatory progress towards SF driverless ride hail launch



Received	Date	Permit	Permits Issued
✓	Jun 2015	DMV Drivered Test	>50
✓	Feb 2020	CPUC Drivered Test (unpaid)	9
✓	Oct 2020	DMV Driverless Test (unpaid)	8
✓	Jun 2021	CPUC Driverless Test (unpaid)	1
✓	Sep 2021	DMV Driverless Deployment (paid)	3*
—	To Come	CPUC Driverless Deployment (paid)	-

Source: General Motors, Cruise

NHTSA estimates that motor vehicle crashes in 2010 cost \$242B in economic activity and \$594B due to loss of life or decreased quality of life from injuries. In 2014, Americans spent 6.9 billion hours in traffic delays.

Low- and middle-income countries have significantly higher crash death rates – estimated to be three times higher than high-income countries.

In our view, the robo-taxis will likely be in urban areas. This may also lower pedestrian deaths, as there tends to be more pedestrians on city streets than highways. However, progress is also being made on highways with autonomous freight trucks. TuSimple expects to pilot autonomous (driver-out) freight runs with a customer later this year.

Aside from the morality of saving lives, there are economic and societal benefits. NHTSA estimates that motor vehicle crashes in 2010 cost \$242B in economic activity (including \$57.6B in lost workplace productivity) and \$594B due to loss of life or decreased quality of life from injuries. Fewer crashes could increase economic benefits. Further, more automated vehicles on the road could reduce traffic congestion increasing productivity. In 2014, Americans spent 6.9 billion hours in traffic delays. Automated vehicles can also provide more mobility options to those who cannot operate a vehicle, because of either disability or age.

We do note that automated vehicles are likely to evolve differently in different geographies. Again, we believe robo-taxis will start in more urban areas. This could do little to affect more rural traffic fatalities. Larger cities also tend to have higher population incomes. Globally, low- and middle-income countries have significantly higher crash death rates – estimated to be three times higher vs. high-income countries according to the WHO. Initial deployment of more automated vehicles is likely to start in high-income countries, doing little to affect those countries where safety is a larger issue and likely increasing the divide.

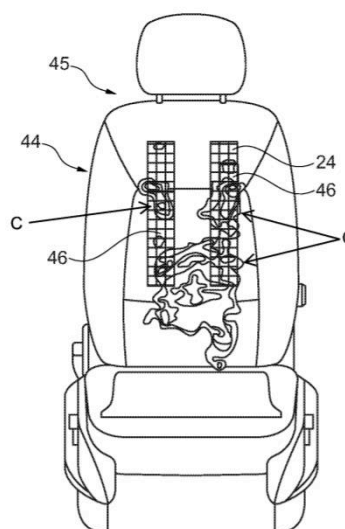
The vehicle as a health sensor

Vehicles today already generate a significant amount of data including geolocation, vehicle health/performance, and driver behavior, among others. But the architecture of a vehicle is changing to allow for more sensors, and computer- and software-enabled features and services. As the architecture of the vehicle continues to adapt, the data sources and data sets are likely to get even larger. Vehicles will have more compute power, more bandwidth, and more over-the-air capabilities (for sharing data back and forth).

As driver assistance features continue to proliferate in vehicles, so too will driver-monitoring systems (DMS) to make sure the driver is attentive and able to take over control of the vehicle if necessary. But it could also be possible to build off hardware already in place for DMS to look to the driver's holistic state of well-being. Toyota has shown this in their LQ concept car, which can identify not only inattentiveness or drowsiness but also emotional states like anxiety or boredom. The system then may blast music or AC to create a safer driving state.

Another area could be increased use of biometrics. For instance, could we see a heart monitor in the driver's seat? While they have since scrapped the project, over the last decade Ford was working on an electrocardiography (ECG) reader that is integrated into the seat.

[Exhibit 14 - U.S. patent application 20150054495](#)



Source: U.S. Patent & Trademark Office

Companies are working on the ability to track resting heart rates, respiratory rates and other vitals in the car.

In the future world, such a feature, or features that track other vitals (think glucose monitoring for diabetics) may be reintroduced. Companies are working on the ability to track resting heart rates, respiratory rates and other vitals in the car. For instance, we've seen different types of sensors that use AI and can track in-cabin body temperature, respiration and heart rate. At CES, Veoneer's test vehicle was able to detect certain vitals for passengers. Eyeris showed an AI software portfolio architecture that can accurately detect the number of occupants in the car, their activities, cognitive state (e.g., driver distraction), heartbeat, body temperature, estimated upper-body size (e.g., for dynamic airbag deployment), etc. Gentex is working on developing systems that can monitor passenger activity and well-being along with vehicle hygiene and air quality.

We can imagine that in a post-COVID-19 world, there may be a desire to be able to monitor driver/passenger temperatures with thermal imaging (especially in a shared transportation modality). However, extending this thought and imagining other capabilities from the sensor suite, we wonder if the vehicle of the future could become an important tool to enable telemedicine. Instead of visiting the doctor in person, can the vehicle – already equipped with cameras and connectivity – also have sensors to detect vital signs to send to a doctor for consultation?

Multi-Industry: Indoor air quality and healthy buildings

The COVID-19 experience sparked a megatrend in indoor air quality, which we expect to fundamentally change the way air filtration and disinfection systems operate in the future to improve health.

The COVID-19 pandemic is a wakeup call to safeguard our indoor environments against the spread of future contagions, as a means of improving and prolonging health and quality of life. The public awareness on indoor air quality and its associated potential health risks are expected to fundamentally change the way building air filtration and disinfection systems operate. Gone are the days of building owners/tenants accepting last-generation stale office building air circulation and the associated “petri dish” of worries. The COVID-19 experience has sparked an entire megatrend in Indoor Air Quality/Healthy Buildings. We now expect building occupants, whether in offices, schools, restaurants, or their own homes, to be hyper-focused on knowing the air quality of their environments in real time. The need to monitor air quality will likely manifest in the deployment of networked sensors throughout a building, measuring against regulatory/set standards and updated on accessible websites and eventually smart phones. Further, there is still much uncertainty regarding the office workplace post-COVID. Many employees may opt to permanently work from home. That said, lower density offices may actually lead to higher commercial building demand. Further, more office capacity will likely be needed in the suburbs. What is clear is that HVAC systems upgrades will be needed to handle higher air exchange capacity, partly driven by new standards for indoor air quality. We also anticipate higher demand for touchless technologies, especially for credential verification and access control. Finally, the widespread adoption of working from home should spur more demand for resi HVAC, likely making this sub-sector a beneficiary of this “work from home/stay at home” trend.

IAQ still in the “first inning”

Indoor Air Quality remains in its nascent stages. Carrier has sized the incremental global market at roughly \$10B, which could add 1–2pp to annual sales growth over the next decade. Similarly, peer Trane Technologies has noted that the opportunity should provide an incremental 1–2pp revenue tailwind over the next decade. Finally, Johnson Controls has cited a \$10–\$15B market growing double-digits.

Demise of the office and other commercial buildings?

Offices have been a key debate item with the potential for working from home to take on a larger role moving forward. An April 2020 University of Chicago paper predicted that 37% of jobs in the U.S. could be performed entirely at home, providing some calibration on how much less office space might be needed. Prior to the pandemic, only a single-digit percent of employees in the U.S. regularly worked from home, with about 4% working from home at least half of the time, according to Global Workplace Analytics. The same firm predicts that within several years, 30% of people could work from home multiple days per week.

HVAC systems likely need to be run harder

It is still unclear what the net effect will be on long-term commercial building demand given the cross-currents of a higher number of employees opting to work from home, lower density requirements for buildings (at least in the near term), and more office building demand in the suburbs. While this remains a worry, we note how there are several natural offsets: (1) We expect higher demand for powerful air handling and filtration systems. Specifically, commercial building HVAC systems will need to power more air circulation to produce more air changes per hour. Prior to COVID-19, most commercial buildings had air changes per hour (ACH) of 6–12, with many as low as three. There also could be a step up in recommended air filters including upgrading to High-Efficiency Particulate Air (HEPA) filters that have Minimum Efficiency Reporting Values (MERV) of 13 or higher. (2) We also see the need to revamp building entry and credential verification systems to become entirely touchless (e.g., using smart phone apps and retina scanners). (3) For other building control upgrades, look for changes to elevator protocols and the management of lobby traffic.

Prior to the pandemic, only a single-digit percent of employees in the U.S. regularly worked from home, with about 4% working from home at least half of the time; this number could increase to 30% of people working from home multiple days per week.

Considering the hygienic issues with some legacy access control systems (e.g., fingerprint scanners), we believe many buildings will be forced to adapt with touchless systems.

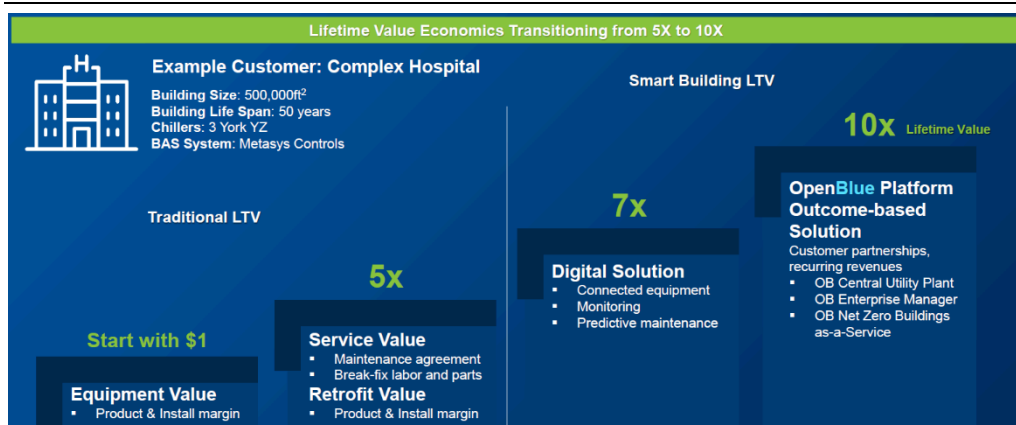
Rethinking building security systems

Considering the hygienic issues with some legacy access control systems, such as fingerprint scanners, many buildings will be forced to adapt with touchless systems. These could include touchless biometrics (ex. retina), near-field communication devices such as a keycard or key fob, or Bluetooth with mobile phones, or combinations of the systems. Even devices like coffeemakers, water dispensers, and copiers could all be upgraded to be touchless and controlled by smartphones. Carrier has noted that most buildings have 8–10 touchpoints as you move from your car to your desk, and that it believes its touchless access systems can eliminate roughly 80% of these contacts.

Evolution to connected buildings and SaaS

The move from legacy break/fix to more digital-linked services and predictive analytics should dramatically increase lifetime value economics of projects. For example, we were impressed with Johnson Controls' example at its 2021 analyst meeting of the much better project economics once its digital offering OpenBlue and services are included. In the old world, \$1 in initial equipment value installed correlated with 5x that value in service and retrofit over time. Once digital solutions were layered in, that increased to 7x, and with the next layer of outcome-based solutions using OpenBlue, it can be 10x. We expect that HVAC and building controls competitors can glean similar outcomes with new digital and connected offerings.

Exhibit 15 - Johnson Controls' lifetime value economics including digital offerings



Source: Johnson Controls Company reports

We expect HVAC companies to play a key role in achieving carbon neutrality, as HVAC systems account for roughly 40% of a building's energy usage.

Residential HVAC supported by “work from home”

Dovetailing with the trend of potentially less need for office space is an increase in working from home. As a result, we expect to see investments in upgrading resi HVAC systems. Further, there should be a spurt in services as a result of the systems being run for longer periods of time, including potentially all day when certain employees were previously located at offices. That said, we are cognizant that HVAC systems can be costly, though we would argue that in certain warmer regions it is not really a discretionary purchase.

Helping customers meet ambitious carbon neutrality targets

With seemingly every public company announcing goals for carbon neutrality in their operations (often 2030, 2040, 2050, etc.), in our view the HVAC players are all in ideal positions. We expect them to help these customers reach their targets by optimizing their HVAC systems, which account for roughly 40% of a building's energy usage. Note that it is our understanding that the targets are often set without a clear roadmap to getting there, and improving one's HVAC system should be a great starting point.

Healthcare services: Putting employee health first

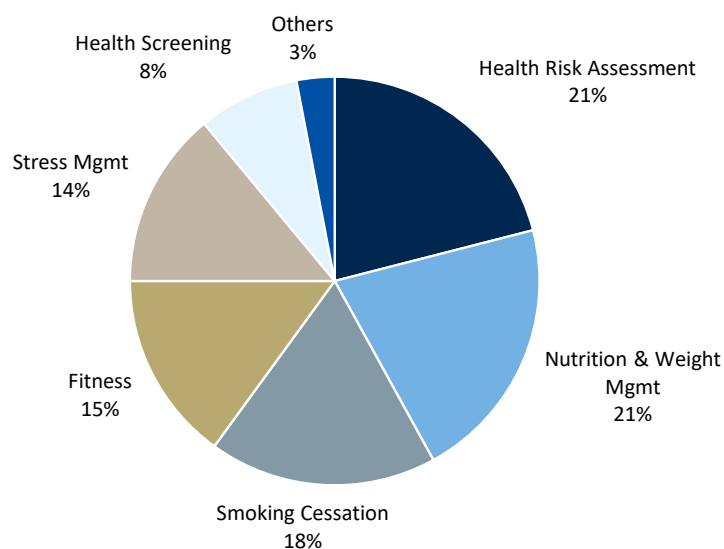
While remote working delivers improved productivity, it may also inadvertently intensify mental health and other health challenges for some employees.

This is leading to a re-evaluation of existing corporate well-being initiatives and an acceleration in the deployment of new corporate well-being technologies.

Employee health is a key corporate priority in the post-COVID world. COVID-19–related lockdowns and other restrictions on in-person physical activities have significantly disrupted businesses across the globe, and have led to significant increases in remote work environments. This shift appears permanent, with many organizations appearing to support remote work or hybrid work environments beyond restrictions related to COVID-19. While remote working delivers improved productivity, it may also inadvertently intensify mental health and other health challenges for some employees. Moreover, the ability for organizations to deliver solutions for employee health is more challenging in virtual and hybrid environments. For example, many organizations provide on-site fitness facilities, nutritious meals, and dry-cleaning services to their employees, which are not available in virtual environments. Additionally, in-office consulting and support for employees is more difficult in a virtual environment. In light of the significant impact that employee health has on employee productivity, absenteeism, employee turnover, and direct health costs, organizations are increasingly prioritizing strategies and technologies to maximize the health of their employees in both virtual and in-person environments. This is leading to a reevaluation of existing corporate well-being initiatives and an acceleration in the deployment of new corporate well-being technologies.

Corporate well-being programs are diverse. Corporate well-being initiatives have expanded beyond just simply offering fitness club memberships to employees or subsidized healthy lunches. Well-designed programs include categories such as health risk assessment, fitness, smoking cessation, health screening, nutrition & weight management, stress management, and others. Based on our research, we believe health-risk assessment and nutrition & weight management are the two largest segments, each representing 21% of the global spending on corporate well-being. The next largest segments are smoking cessation (18%), fitness (15.5%), stress management (13.5%), and health screening (8%).

Exhibit 16 - Corporate well-being solutions address six major categories

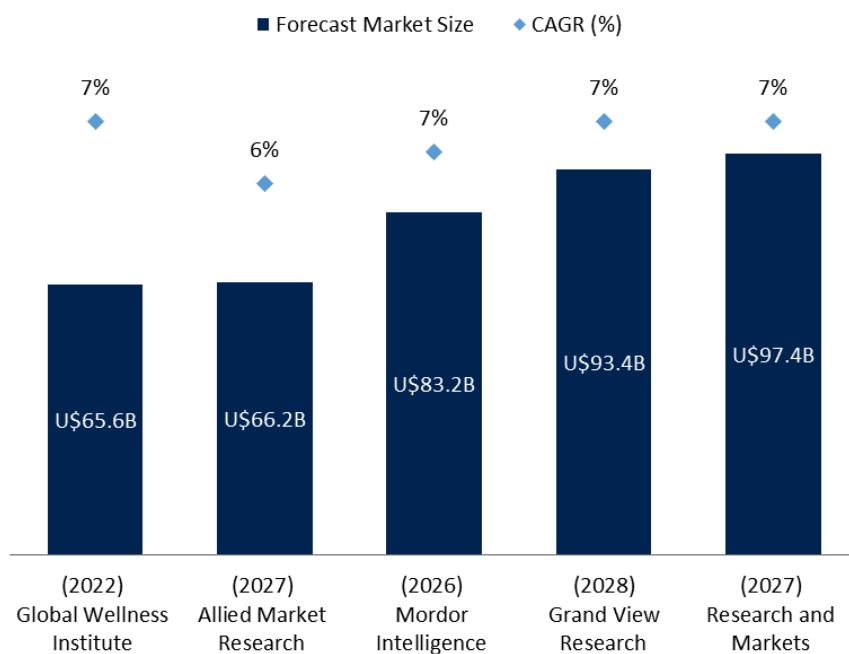


Source: RBC Capital Markets estimates, Grand View Research

While estimates vary, numerous market research firms estimate that the global corporate well-being market will expand at a 6–7% CAGR over the next several years

The global corporate well-being market is expanding at 6–7% CAGR. While the size of the corporate well-being market varies, numerous market research firms estimate that the market is likely to grow between 6% and 7% per annum over the next several years. According to GWI, the global corporate well-being market will expand to \$66B by 2022, up 7% CAGR from \$47.5B in 2018. GWI attributes the growth to rising global prosperity, population aging, increasing prevalence of chronic disease, and a growing understanding and adoption of well-being as a holistic concept. Other market research companies point to similar or larger sizes for the corporate well-being market. For example, market research firm Allied Market Research expects the workplace/corporate wellness market to reach \$66.2B by 2027, which represents a 6% CAGR from \$49.8B in 2020. In comparison, Mordor Intelligence forecasts the corporate wellness market rises to \$83.2B by 2026 from \$57.0B in 2020. According to Grand View Research, the corporate well-being market will grow to \$93.4B (7% CAGR) by 2028. Lastly, a corporate wellness market report by Research and Markets published in February 2020 expects the market to reach \$97.4B by 2027, growing at 7% per annum.

Exhibit 17 - Corporate well-being market is forecast to grow between 6% and 7% per annum



Source: RBC Capital Markets, Company reports, Allied Market Research, Mordor Intelligence, Research and Markets, Grand View Research

Corporate well-being becomes commonplace. According to PwC's CEO Panel Survey in June/July 2020 regarding business priorities following the COVID-19 pandemic, the 699 respondents in the survey ranked employee-related initiatives related to remote work and employee wellness programs as the third- and fourth-highest priorities, respectively, behind only digitalizing core business operations and adding digital products and services. Specifically, 15% of respondents ranked increasing remote work as their first priority, with 11% ranking employee-oriented wellness programs as their first priority. Notably, these employee-related initiatives ranked above automation, lowering carbon footprints, reducing real estate footprints, and M&A.

High ROI from corporate well-being investments is likely to sustain demand. Along with heightened awareness of corporate well-being, there is now data to quantify the financial return to corporations on investments in employee well-being. According to a publically available study performed by Forrester, corporations yielded an ROI of 162% over three years

from solutions provided by corporate well-being company Virgin Pulse. Forrester conducted interviews with four of Virgin Pulse's customers ranging in size from 7,500 to 160,000 employees that have been using the platform for 5 to 10+ years. The report considers quantifiable benefits such as reduced employee attrition, reduced healthcare costs, broad-based productivity increases, decreased administration and communication costs, and reduced costs of fatigue-related mistakes. Moreover, the study also highlights unquantifiable benefits such as more interest in high-deductible health plans, increased participation in preventative care, and improved employee experiences.

Exhibit 18 - Forrester estimates ROI of 162% over 3 years for Virgin Pulse's well-being solution

Cash Flow Analysis (risk-adjusted estimates)

	Initial	Year 1	Year 2	Year 3	Total	Present Value
Total costs	(\$718,200)	(\$4,462,500)	(\$4,462,500)	(\$4,462,500)	(\$14,105,700)	(\$11,815,777)
Total benefits	\$0	\$10,640,981	\$12,517,618	\$14,553,844	\$37,712,443	\$30,953,277
Net benefits	(\$818,200)	\$6,178,481	\$8,055,118	\$10,091,344	\$23,606,743	\$19,137,500
ROI						162%
Payback period (months)						<3

Source: Forrester

Consumer: The rising trend of self-care

We believe consumers will increasingly want to manage their own health and wellbeing, and we expect consumer companies to increasingly offer products and services in this category.

One of the key drivers that led to the consumer trend towards self-care has been the rise of healthcare costs, particularly in the United States – ~66.5% of all U.S. bankruptcies are tied to medical issues.

Rising healthcare costs and an aging population are driving a change in consumers' habits towards self-care, a trend that was accelerated during the COVID-19 pandemic. The WHO defines self-care as "the ability of individuals, families and communities to promote health, prevent disease, maintain health, and to cope with illness and disability with or without the support of a healthcare provider," and the International Self-Care Foundation developed the seven pillars of self-care: (1) knowledge and health literacy, (2) mental wellbeing, (3) physical activity, (4) healthy eating, (5) risk avoidance, (6) good hygiene, (7) rational use of products and services. Self-care has manifested in several different ways across the consumer landscape: the consumer trend towards fitness and a healthier lifestyle, consumers' demand for telehealth options, consumers' desire for healthier food and beverage options, and consumers' needs for self-medications. We believe consumers will increasingly want to manage their own health and wellbeing, and we expect consumer companies to increasingly offer products and services in this category.

One of the key drivers that led to the consumer trend towards self-care has been the rise of healthcare costs, particularly in the United States. The Consumer Price Index (CPI) for Medical Care increased by ~31% over the last 10 years, compared to the total U.S. CPI increase of ~21%, with U.S. national health spending projected to grow at an average annual rate of ~5.4% through 2028, reaching \$6.2T by 2028. This rapid increase in healthcare cost has become a concern for many U.S. consumers, is causing increasing financial pressure, with ~66.5% of all U.S. bankruptcies tied to medical issues (high healthcare costs and/or time out of work). This has led many U.S. consumers to take their health decisions and healthcare in their own hands, a trend even more pronounced among younger consumers with 47% of millennials and 41% of Gen X consumers making every effort to avoid visiting the doctor, according to a 2018 survey by IRI. Overall, nearly nine out of ten Americans actively practice self-care regularly, and one-third of consumers have increased their self-care behavior during the past year.

The COVID-19 pandemic has even accelerated the self-care trend. Restrictions on access to healthcare facilities for non-life-threatening cases increased the demand for telehealth, and increased consumers' attention to their health and well-being, given fears of getting sick during the pandemic. According to a January 2021 IRI survey, ~27% of surveyed U.S. consumers will focus more on health in the future as a result of the COVID-19 pandemic, and 17% will buy more products that support immunity as a result of the pandemic. We believe some of the pandemic-driven behavioral changes will be long lasting. According to the same IRI survey, 49% of U.S. consumers surveyed say they will wash hands more frequently even post the pandemic, 35% say they will use hand sanitizers more often, 33% say they will wear mask in public during flu season, and 27% say they will focus more on their health. The increased use of vitamins and supplements during the pandemic was a clear example of the increased focus on healthcare. According to IRI, the average U.S. household penetration of vitamins and supplements increased by 5% during the pandemic, from 53% (March to December 2019) to 58% (March to December 2020). Furthermore, the number of vitamin and supplement consumers in the 18–34 age demographic also increased year-over-year by 18% in 2020, reflecting the broadened demographic reach of nutrition products. In addition to increasing immunity, other highly sought after benefits included energy, weight loss, gut health, heart health, bone health, sleep, brain function, and stress reduction.

The pre-pandemic trend towards self-care coupled with the behavioral changes during the pandemic generated a large market opportunity for consumer companies, with IRI sizing the self-care market as a \$450B opportunity. The self-care market opportunity is very broad, with products and services ranging from OTC medicines, vitamins and supplements, and natural

and organic home remedies to better-for-you food and beverages, health and wearable devices, and fitness-related products. Consumers are clearly taking a 360-degree approach towards their health and wellness so we would expect the further emergence of self-care will lead to a blurring of the lines between traditional consumer staples categories, consumer discretionary, and tech-enabled categories. Ultimately, we would expect consumer companies to increasingly offer products and services that will allow consumers to manage their health and wellness with less reliance on the healthcare system.

Advances in science and technology have allowed the emergence of a brand-new class of devices that allow consumers to monitor their health without the need of a physician or healthcare professional.

We expect consumer demand for self-care will result in the development of several new self-care consumer products over the next decade.

Advances in science and technology have allowed the emergence of a brand-new class of devices that allow consumers to monitor their health without the need of a physician or healthcare professional. Take for example the finger pulse oximeter, which measures blood oxygen saturation. The technology for this was developed in the 1930s, originally measuring at the ear, with the first finger pulse oximeter not commercialized until the 1970s in Japan, and the 1980s in the U.S. Pulse oximeters have been staples in hospitals for decades. Developed to meet the demand for measuring oxygen during surgery once the use of ventilators during anesthesia became ever more common, they revolutionized the work of anesthesiologists. In certain wearables, features such as pulse ox monitoring are already available, such as in the Apple and Samsung smart watches. While there are notes on caution about the accuracy and reliability of these tracking and data (which we expect to improve over time), we expect similar evolutions to take certain products and categories away from being exclusive to the medical realm and into the area of general consumer health, wellness, and personal care. Continuous glucose monitors are another great case study of the consumerism of healthcare. Today, consumers can get a real-time read on their blood glucose levels and manage their diets and lifestyles accordingly (obviously useful for diabetics but also people looking to manage their weight). Other devices and diagnostics are currently being developed in labs around the world that we believe will provide even more “data” for consumers to use to manage their health and wellness.

We expect that the combination of consumer demand for self-care, their desire to know more about their health and their bodies and technological advances will result in the development of several new self-care consumer products over the next decade. For example, oral care is seeing several developments with the introduction of smart toothbrushes to help consumers brush more effectively, and future concepts, such as a sensor developed at Tufts that could be attached to a tooth, tracking items eaten by a user and collecting data from the mouth. Another example is Viome Bioinformatics, which uses AI to unveil which foods and supplements are ideal for you, your cellular health and gut microbiome. We’d expect many more of these products and services to enter the market in the next decade.

Plant-based foods: The great win-win

“What I was experiencing was more than a clever meat substitute.

It was a taste of the future of food.”

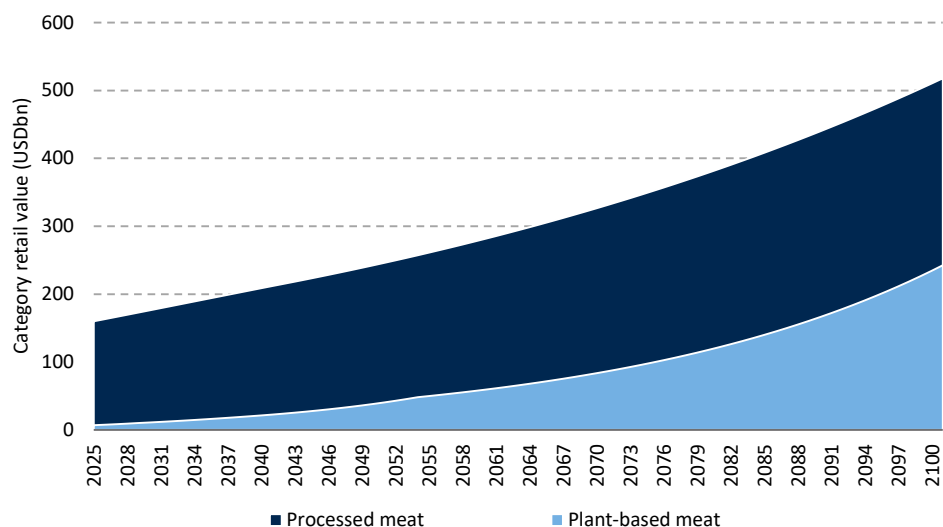
Bill Gates, 2013 after eating the Beyond Burger

Plant-based food and beverages meet rising consumer demand for more environmentally friendly products – one popular choice, the Beyond Meat burger, takes 99% less water, 93% less land, 90% fewer greenhouse gas emissions and 46% less energy to produce than a typical animal burger.

Healthier diets is a key element in consumers’ quest for immortality. Danone found 47% of younger generations are eating healthier and 30% are willing to actually pay a premium for that. The plant-based segment correlates closely with this trend – meat and dairy look-a-like products made from plant-based proteins such as soy, pea, fermented mycoproteins and oat are often lower calorie with more fibre and less fat. They also don’t include lactose (found in dairy) to which a significant proportion of the population is intolerant, nor the chemical compounds in meat that have been linked to cancer. It’s therefore unsurprising that consumers are increasingly becoming ‘flexitarians’ – a 2019 survey by Euromonitor found 46% of respondents globally were restricting their consumption of animal products. The plant-based space is growing fast around the world – in Western Europe it has had a 5-year CAGR of over 10%.

Plant-based food and beverages also meet rising consumer demand for more environmentally friendly products as well. For example, the Beyond Meat burger takes 99% less water, 93% less land, 90% fewer greenhouse gas emissions and 46% less energy to produce than a typical animal burger. Dairy too – one study found the creation of soya milk only had a fraction of the environmental impact of dairy milk. With environmental concerns likely to remain prominent, and given Unilever found that diet is one of the areas 18- to 24-year-olds are most willing to change for the benefit of the planet, we expect the plant-based space to continue to grow in size and penetration of the meat and dairy categories. Our blue sky scenario for the plant-based meat category forecasts it reaching 30% penetration by 2100 (global, ex-APAC). It currently sits at about 3%. You can read more about our view of the category in our RBC Imagine-branded report [Uprooting tradition: What plant-based alternatives mean for the future of protein.](#)

Exhibit 19 - Our blue sky scenario for traditional meat alternative category



Sources: Euromonitor, RBC Capital Markets estimates

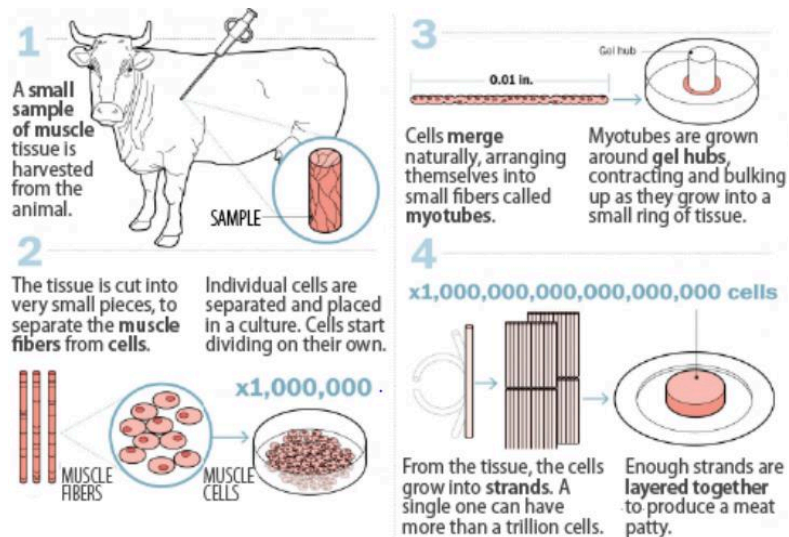
The quoted food sector is making a significant push towards plant-based food and beverages in response to consumers' wish for more healthy alternatives amid escalating environmental concerns. The phrase 'in response to consumers' is important. Branded consumer businesses typically spend five to seven times as much on marketing as they do on research and development. They can be relied upon to provide the funding and encourage this trend (Nestlé, for example, is spending 10% of its R&D budget on plant-based alternatives) but readers should remember that they are marketing companies, not scientific ones. They will not get too far ahead of consumers' preferences and they will want to see a clear path to profitability. Thought leadership will be left to the start-ups of the food industry.

Indeed, many start-ups are moving beyond plant-based and onto other protein alternatives already. Animal product alternatives (not ticking the animal welfare or health box, but these products offer serious health and environmental benefits) are being developed using insects and grown in labs – we call this 'cultivated' or 'cell-based' meat and dairy. The latter is grown using animal cells therefore bypassing the environmental and animal welfare costs of farming. It is yet to reach scale or commercialization, but major milestones have been reached – earlier this year, Singapore became the first country to give regulatory approval to a cell-based product. There's also two publicly listed companies involved in the space – Meat Tech 3D and Biomilk, both listed in Tel Aviv. We expect the quoted food and beverage sector to get involved when consumer acceptance of a lab-grown product is understood more fully and when scale improves cost structures.

We anticipate the future food aisle will include an array of products – plant-based, animal (and insect)-based and cell-based – to meet consumers' unstoppable appetite for healthier and more sustainable products.

We anticipate the future food aisle will include an array of products – plant-based, animal (and insect)-based and cell-based – to meet consumers' unstoppable appetite for healthier and more sustainable products.

Exhibit 20 - How cell-based meat is made in a lab



Source: Regulation of Cell-Cultured Meat, Congressional Research Service, Federation of American Scientists. (25 Oct 2018)

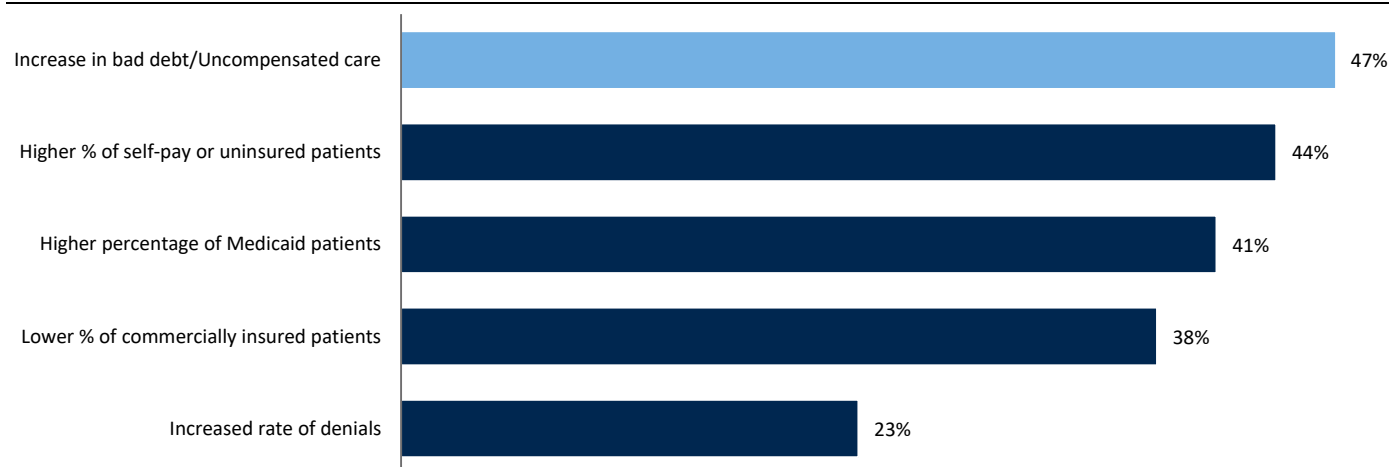
Buy Now, Pay Later (BNPL): The healthcare edition

Given the recent success in the Buy Now, Pay Later movement, we believe similarly structured products will spill over into consumer healthcare (and, more specifically, post insurance payments).

While the quest for immortality may be therapeutically making progress, consumer's ability to finance this noble quest is far more cryptic and adding to the ever-widening wealth/health gap. Thus the need for a more consumer friendly and flexible way to pay. Given the recent success in the Buy Now, Pay Later movement, we believe similarly structured products will spill over into consumer healthcare and more specifically post insurance payments. As in retail, transparency in the cost of goods and services and the corresponding payment tend to correlate with higher acceptance/conversion rates. We foresee a world whereby installment lending, based on a credit profile, capacity to pay, and insurance plan, will be used to offer individuals specific payment plans in advance of procedures, much in the same way a consumer is offered a 0% APR to buy a Peloton. This type of innovation could be coupled with a consumer's digital health records in a health tracking app (think Apple Health), as a means to determine the insurance algorithm. This would effectively work as a rewards system – the more you work out and maintain a healthy diet/lifestyle, the higher your rewards, lower your insurance, and lower the APR on your financed medical procedure, creating a flywheel effect.

It is estimated that the total global addressable market for post insurance-related healthcare payments in is ~\$500B, according to Flywire, with only a small segment being serviced today. In addition, in a recent survey conducted by Kaufman, Hall & Associates on the State of Healthcare Performance, nearly half of all respondents (hospitals & health systems) indicated that bad debt and uncompensated care had increased, suggesting a need for more flexible and tailored payment programs, such as a BNPL solution.

Exhibit 21 - Impacts on the revenue cycle (% respondents seeing an increase in these categories)



Source: Kaufman, Hall & Associates, RBC Capital Markets

Seniors Housing: Adapting to accommodate shifting needs

Advances in medicine, healthcare delivery and access, and healthier lifestyles have extended the lifespans of seniors across the world. Based on data from the OECD, the average life expectancy of 65-year-old American women and men has risen by 21 years and 18 years, respectively, up from 16 and 13 years, respectively, in 1960. As new medical and scientific breakthroughs emerge over the next decade, we believe the form of seniors housing and services offered will further evolve to meet the shifting needs of an older resident population.

New revenue streams to emerge as demand for additional services grows

We believe longer lifespans among seniors will accelerate demand for more à-la-carte services, expanding the opportunity set for revenue generation among operators. As observed over the last decade-plus, seniors entering housing communities at older ages often require more services, particularly assistance with daily living. While services today range from dressing and bathing, to exercise and assistance with medications (among others), we expect the suite of services offered will broaden further, including more physical therapy and wellness programs. Indeed, the pandemic has reinforced the importance of access to in-house services for seniors, particularly amid access restrictions for outside visitors. As well, we believe seniors with the financial ability will be willing to pay a premium for programs and services that allow them to age in-place and cater to their evolving physical, emotional, and intellectual needs.

Operators will increasingly leverage technology to improve resident quality of life

We expect advances in technology will continue to improve access to and the quality of care. We believe telemedicine will play an expanding role in the decade ahead, reducing the need for seniors to travel for routine medical appointments, particularly for more frail seniors. Rising availability and adoption of wearable technology, along with new in-suite smart devices (e.g., in kitchens, washrooms, bedrooms), should also improve health monitoring and the delivery of timely care. Beyond physical health needs, we expect seniors housing operators will also leverage technology to offer more online and virtual learning educational programs. Advances in robotics and artificial intelligence, coupled with a continued shortfall in qualified labor, may lead to an increased use of robots for therapeutic purposes and social interaction, particularly for elderly residents with dementia or during periods of required self-isolation.

We believe scale and the financial capacity to invest in these technology initiatives will be key differentiators among seniors housing owners and operators, particularly with our expectation for labor shortages to persist. The use of data analytics to better understand and predict the needs of aging residents will also prove critical as competition from new supply accelerates.

Applying lessons learned today to inform the design of tomorrow's seniors housing

Lessons learned over the course of the COVID-19 pandemic have prompted seniors housing owners and operators to re-evaluate the form and layout of congregate living. Over the next decade, we believe properties may increasingly incorporate smaller resident clusters that offer essential services for daily living and varying levels of care, but also allow residents to shelter in-place in the event of viral outbreaks. More comprehensive amenities can remain available for use in centralized buildings, in the absence of social restrictions. These more decentralized structures may result in higher operating costs, but we believe select seniors are prepared to pay for the added safety benefits. Demand for larger suites and access to more outdoor space may also rise, as seniors increasingly consider the potential for extended periods of isolation.

We expect the prevalence of mixed-use, inter-generational properties that incorporate seniors housing will also rise over the next 10 years. Specifically, seniors with more active lifestyles are increasingly seeking the benefits of communities that offer access to a variety of retail, cultural and entertainment experiences, a varied mix of age groups, and other healthcare providers.

We believe longer lifespans among seniors will accelerate demand for more à-la-carte services, expanding the opportunity set for revenue generation among operators.

We expect seniors housing owners and operators to increasingly invest in telemedicine, as well as health monitoring and educational technology.

Energy: Longer life = massive implications for emerging markets oil demand

This excerpt was written by Commodity Strategist Michael Tran and Brian Leisen (Associate) from RBC Capital Markets, LLC's Global Commodity Strategy team.

For Required Commodity Strategy and MENA Research Conflicts Disclosures, please see page 261.

In OECD countries, we believe extended lifespans will elongate the tapering tail end of the oil demand curve (an individual tends to use less energy in their later years – but an extension of these years correspondingly increases demand).

As the life expectancy of individuals in emerging markets improves, so too does the associated energy consumption – as lifestyles improve, there is a correlation with greater energy intensity.

The past decade saw the overwhelming majority of oil demand growth stem from the Emerging Markets. To be more accurate, 60–70% of annualized global oil demand growth was concentrated in Emerging Asia. Growth in Organisation for Economic Co-Operation and Development (OECD) countries (a group of 38 countries committed to economic progress and free trade) was largely catatonic outside of the United States. Peak OECD oil demand was achieved over a decade ago, topping out prior to the Great Financial Crisis, leaving the Emerging Market countries to dictate the degree and direction of oil demand.

The conversation around peak oil demand has been focused largely on developed OECD countries, where oil demand growth has sputtered out, with the oil intensity per capita peaking pre-financial crisis and trending lower since. Over that same time period, going back to the 2004 OECD per capita peak through 2019, Emerging Market nations have increased their oil footprint per capita by 30% while growing their population by over 20%, more than twice as fast as OECD countries. EM countries now comprise 83% of today's global population. To add, oil demand has grown by 40 mb/d over the past 35 years, with more than 75% of the growth stemming from Non-OECD nations with aggregate demand surpassing that of OECD countries in 2014.

The shape of the oil demand lifecycle per individual is a left-skewed bell curve. Naturally, consumption ascends as a child grows – continuing to increase throughout the teenage years and peaking as an adult with hauling kids on minivan road trips during the weekend and business travel during the week. Per capita demand begins to taper leading into retirement, downsizing of housing, less discretionary travel and extracurricular activities. This blueprint is true for much of the developed world. The concept of immortality does not change the shape of the demand curve, but elongates the tapering tail end of the curve. In other words, energy intensity per person continues to gear down in the event of the average OECD lifespan elongated by an extra five years. This is particularly the case if the additional years are spent in group senior housing facilities with notably less discretionary driving and travel.

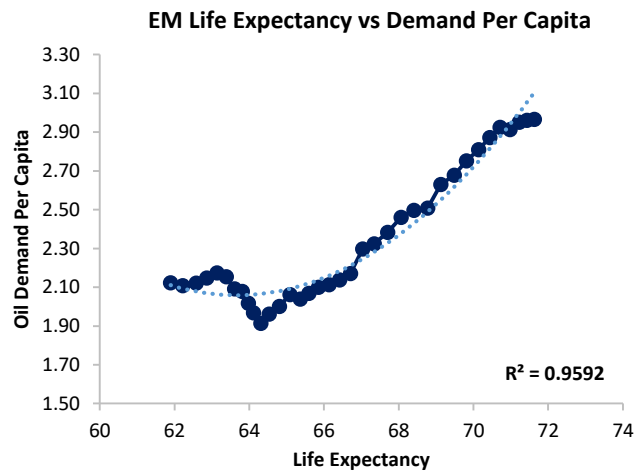
The emerging markets part of the world is different. Energy intensity is in some part a function of development regardless of the specific energy needs of a single nation. Life expectancy historically has a high correlation with energy demand in the emerging world. The rationale being that as a country develops, its population's quality of life increases, which implies an increase in public needs (e.g., access to improved safety, basic necessities, improved air quality, infrastructure, and healthcare). These public needs – all of which have a reflexive relationship with industry and economic development – all require increased energy consumption. This is why increasing the longevity of the average EM lifespan yields a different picture from an energy intensity perspective than in OECD nations. In short, it is because lifestyles have improved.

Despite these staggering numbers, the per capita oil demand of non-OECD countries remains a mere 2.97 barrels vs the 13.29 OECD average. This implies that if closing the per capita gap, emerging market demand would alone jump to ~230 mb/d with the current population. Even if the current emerging markets population were to increase demand three-fold, or an implied ~150 mb/d of non-OECD oil demand, the aggregate oil demand per capita would still be less than Denmark or Sweden.

When looking at the historical regression, if emerging markets were to increase to the current life expectancy of the average OECD nation, 72 to 80, the implied oil demand per capita more than doubles from 2.97 to 6.57 barrels. Though there are biological ceilings as well as industrial

development decisions that disjoint the relationship over time, energy intensity inevitably increases as a country moves up the developmental curve, especially at its infancy when fundamental energy security to provide basic necessities to the entire population is the primary objective.

Exhibit 22 - Emerging market life expectancy vs oil demand per capita



Source: World Bank, EIA, RBC Capital Markets

Energy & Utilities: The hydrogen power solution

As we live longer and energy demands increase, we will need evolving energy solutions, with hydrogen power offering a broad-based set of applications and likely declining in cost over time.

While we expect the transition to take decades, and that fossil fuels will remain a prevalent energy source, we believe hydrogen provides midstream companies with medium- to long-term growth opportunities.

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As we live longer and energy demands increase, we will need evolving energy solutions with hydrogen, among others, very well being an answer given its particularly broad-based set of applications and likely declining cost over time. With greater emphasis on climate change globally and especially as countries strive to meet Paris Agreement and COP26 goals and/or to reach carbon neutrality by 2050 (European Union), hydrogen has regained significant attention as a potential part of the longer-term decarbonization solution. Specifically, hydrogen has high energy density (by mass), is storable, and generates no carbon emissions. In addition, hydrogen can be a source of energy across several industries including transportation/mobility, refining, ammonia, methanol, and steel production, among others. Hydrogen can also provide storage and grid stability for renewable power generation.

Recently, several countries and companies have announced plans to advance hydrogen technology. Notably, hydrogen is a core technology in the European Union's Green Deal. In addition, Japan and Australia signed a hydrogen agreement earlier this year to advance the deployment of hydrogen as a clean energy. In the U.S., NextEra plans to build its first green hydrogen power plant in Florida and Entergy proposed a power plant in Texas with the option to use 30% hydrogen. The IEA estimates ~50 targets, mandates and policy initiatives to support hydrogen, with most focused on transport.

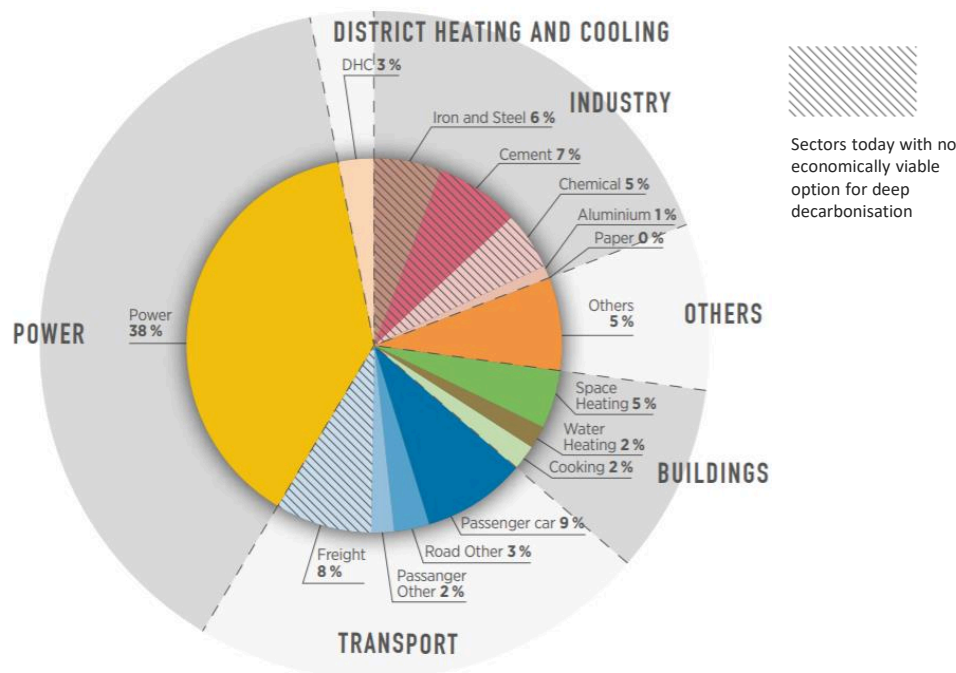
Global demand for hydrogen stands at ~70 million metric tons (pure hydrogen) plus ~45 million metric tons of hydrogen mixture, according to McKinsey. Current demand for hydrogen in the U.S. stands at ~11 million metric tons. Depending on policy, McKinsey estimates hydrogen demand in the U.S. could grow to ~17 million metric tons by the end of 2030 and ~63 million metric tons exiting 2050 (or ~14% of energy demand excluding industrial feedstock demand).

While we expect the transition to take decades, and that fossil fuels will remain a prevalent energy source, we believe hydrogen provides midstream companies with medium- to long-term growth opportunities and, more importantly, participation in the energy transition. As we discuss in the report, midstream companies should benefit from the storage and transportation of hydrogen as well as from carbon capture and storage (CCS) in the generation of blue hydrogen. We expect the natural gas focused midstream companies to benefit initially as existing natural gas pipelines and storage facilities can accommodate some level of hydrogen with minimal, if any, modification. Longer term, midstream companies could repurpose existing pipelines to hydrogen or build networks of hydrogen pipelines given their pipeline expertise.

Applications for hydrogen

Currently, hydrogen's main use is for industrial purposes (i.e., ammonia, methanol, steel production, etc.) with virtually all of that hydrogen production from fossil fuels (less than 0.1% of dedicated hydrogen production comes from water electrolysis). That said, hydrogen has wide applicability, which falling renewable electricity prices and falling costs of electrolysis can enable. Hydrogen can store energy, which allows it to function as a battery to complement renewable electricity. It also has potential to help decarbonize areas in which electricity has limitations such as heavy trucking, long-range road transport, aviation, and industrial processes such as steel making. In this report, we will examine applications for mobility, industrial, grid balancing and energy storage, and heating.

Exhibit 23 - Breakdown of global energy-related CO₂ emissions by sector, 2015



Source: IRENA

Mobility

Aviation, ships, rail, trucks, passenger cars, and industrial vehicles (e.g., forklifts) can use hydrogen as an energy source. Given the nascence of the technology and specific implications of each mode of transport (e.g., flammability and pressure issues in aviation), we focus on mobility applications with the most research, that are most prominent, and appear to be most promising (at least initially).

Trucking: Our autos team believes both battery electric and hydrogen (fuel cells) have use cases within trucking. Battery electric technology is better developed and suited for use in shorter-haul routes where trucks make their runs and then return to a central charging depot overnight. Best-use cases for battery electric vehicles (BEVs) include refuse, garbage, buses, etc. (adoption of which has already begun especially in places like China). However, over larger distances, batteries may not be as suitable for the following reasons:

- Batteries degrade (limits performance and range over time), which begins to impact the economics of the truck and truck route (replacing a battery can also be very expensive).
- Batteries are heavier than the weight associated with fuel cells (could be a ~3–5k pound difference), which in turn limits payload and hauling capacity and thus impacts the potential revenue a truck can generate.
- Charging time (can take several hours to charge battery electric trucks fully vs ~15 minutes for fuel cell trucks, on par with diesel).

Considering these factors, when thinking about medium-haul and long-haul transport, hydrogen makes sense given its higher energy density, faster charge times, etc. However, RBC's auto team caveats that the hydrogen fuel cell technology is more nascent and unproven

For trucking, battery electric technology is better developed and suited for use in shorter-haul routes, whereas hydrogen, with its higher energy density and faster charge times, is better used for medium and long-haul transport.

We believe that blue and green hydrogen production growth may require government support in a number of industries in order to scale.

than batteries and the fueling structure is very limited, which is likely to weigh on the adoption timelines of fuel-cell Class 8 trucks.

Forklifts: Fuel cell (hydrogen) and electric forklifts already outcompete diesel-powered forklifts under optimal conditions. The Hydrogen Council expects the costs of fuel cell forklifts to decline 20% through 2030 (and become cheaper than electric forklifts in 2023), driven by savings in hydrogen production costs and fuel cell technology. McKinsey estimates hydrogen demand of ~360,000 metric tons for forklifts by 2030.

Industrial

Around 76% of hydrogen demand today comes from industrial applications, which include oil refining (33%), chemical production (40%), and steelmaking (3%), with fossil fuels as the feedstock for the hydrogen. Both immediate and longer-term hydrogen demand growth opportunities from industrial applications exists, in our view, although blue and green hydrogen production growth may require government support in order to scale. In this report, we focus on oil refining, chemical production and steelmaking as these appear the most promising use cases for hydrogen in the industrial sector.

Oil refining: Hydrotreatment and hydrocracking are the primary uses for hydrogen in refining and will likely see increased usage, which in turn will likely drive hydrogen demand even without hydrogen-specific government policies. Hydrotreatment refers to the removal of impurities (in particular Sulphur) from crude oil. Refineries currently remove ~70% of Sulphur from crude oil; although increasingly stringent regulations to remove Sulphur content in oil products will likely drive more hydrotreatment. Hydrocracking refers to the upgrade of heavy oils, which have also seen growing demand over the years. The IEA estimates Hydrogen demand from oil refining will grow by 3 million metric tons by 2030. While hydrogen demand will likely grow on its own, we note that fossil-fuel based hydrogen (with no CCS) currently accounts for 20% of refining emissions and emits 230 million metric tons of CO₂ (MtCO₂). Policy support will likely be necessary to accelerate cleaner hydrogen demand.

Currently, the IEA estimates enough refinery capacity exists to meet future refining needs, which eliminates the need for new refineries. In the U.S., existing refineries can supply ~60% of their hydrogen needs, with ~40% from byproducts and 20% from on-site SMR. Since refineries already have SMR units and there is no need for new refineries, blue hydrogen appears to be the clearer pathway to supply clean hydrogen to refineries vs electrolysis (green hydrogen). The IEA estimates CCS would increase costs by \$0.25–0.50/bbl, thus governments may need to enact policies such as a carbon tax, or low-carbon fuel standards similar to those in place in some U.S. states, Canada, and Europe.

Chemical production: Ammonia accounts for 67% of hydrogen demand from chemicals (31 million metric tons of hydrogen per year), methanol accounts for 26% (12 million metric tons of hydrogen per year), and various other applications account for the remaining 7%. Within ammonia, fertilizers represent 80% of hydrogen demand. Consequently, growing global populations may provide a tailwind for ammonia demand (and hydrogen), with the IEA estimating hydrogen demand growth of ~7 million metric tons (~22%) by 2030.

However, the choice between blue and green hydrogen in chemicals is not as clear-cut as with oil refining. The choice will depend on electricity prices, and we suspect will likely be a combination of the two. At electricity prices of \$15–50/MWh, using electrolysis to produce ammonia becomes competitive with blue hydrogen, and at \$10–40/MWh, electrolysis becomes competitive with natural gas without CCS (for reference, in 2019 the global weighted-average levelized cost of electricity (LCOE) from utility scale offshore wind was \$53/MWh and

from solar photovoltaic was \$68/MWh). Scaling the technologies in accordance with the goals of the Paris Climate Agreement creates challenges for both blue and green hydrogen.

- **Blue hydrogen:** Decarbonization of both ammonia and methanol production using natural gas with CCS would require 11,405 Bcf of natural gas by 2030 (equivalent to 10% global gas demand today), an 87% increase vs current natural gas consumption of 6,038 Bcf. Ammonia and methanol demand growth and the phase-out of coal use drives the increase in natural gas use. Decarbonization would also require the capture of 450 MtCO₂/year by 2030. Based on the size of the biggest current CCS facilities (1 million metric tons of annual CO₂ capture, according to the IEA) blue hydrogen would require an additional 450 CCS projects (or ~48/year).
- **Green hydrogen:** Satisfying energy demand for methane and ammonia with green hydrogen would require 3,020 TWh/year of electricity (11% of today's global electricity generation) and 350–450 GW of electrolyser capacity. Based on current electrolyzer designs of 100 MW, green hydrogen production for methane and ammonia would require 3,500–4,500 electrolyzers – roughly one electrolyzer built daily through 2030.

Steelmaking: The two main methods to produce steel include blast furnace-basic oxygen furnace (BOF) and direct reduction of iron-electric arc furnace (DRI), which account for ~90% and ~7% of production, respectively. BOF is cheaper and does not need dedicated hydrogen (though it produces hydrogen as a byproduct), while DRI uses hydrogen as a reducing agent in the production of steel. Worldwide, hydrogen production for DRI totals 4MtH₂, with 75% produced with natural gas and 25% produced with coal. To produce all virgin steel with DRI, hydrogen demand would be 57MtH₂ (though producing this much hydrogen would require as much electricity as India, Japan, and Korea consume today combined).

Currently, virgin steel accounts for more than ~75% of steel production, with the remaining 25% coming from recycled steel. Accordingly, hydrogen demand from steelmaking depends on the growth of recycled steel, and the growth of DRI in the production of new steel. In any scenario, DRI is unlikely to make significant inroads in the short term, as BOF is cheaper and the industry currently has overcapacity at a time when many BOF plants are only 10–20 years old. Consequently, DRI's best opportunity to make inroads will come in the next investment cycle, or will need strong government support, in our view.

With that said, DRI use has been growing (it does benefit from being less capital intensive than BOF), and if it continues to grow at its current pace, it could account for 14% of steel production (based on IEA estimates), which would double steelmaking hydrogen demand. In a scenario more aligned with the Paris Climate Agreement, both recycled steel and virgin steel produced through DRI will grow even more rapidly. Depending on the cost of electricity and natural gas, electrolysis could produce green hydrogen, or SMR could produce blue hydrogen. However, as is the case with other industrial applications, low-carbon hydrogen production may require government support.

Space: To eternity and beyond

Long the domain of governments for national security and scientific purposes, a commercial space market is rapidly emerging. As humanity continues to live longer (and potentially expands its geographic footprint outwards), we believe space will become increasingly relevant. The key drivers of this market development include substantial reductions in the costs to access space, on-satellite capacity and capability expansion, and the opportunity space presents for greater human exploration.

There are currently four primary space markets we are tracking:

- Space tourism
- Earth observation
- Communications
- Space infrastructure and exploration

Near term, increased access to space provides many advantages for medical research. The Microgravity environment in space, for example, allows cells to grow differently (slower and in more of a 3D pattern) than on earth, which allows for a longer culture process. The International Space Station (ISS) is a very good environment for protein crystal experiments. These protein crystals are used in many pharmaceutical drugs, and can be important to understand when looking at different diseases.

As costs for space access continue to decline, there are many companies that are building private space stations, which will significantly expand research opportunities in space. These efforts are not limited to medical applications, but space will also support advanced research in areas of energy, materials and transportation.

As capital continues to flow into private space ventures, infrastructure is getting built that will eventually allow for much greater access to the moon and beyond.

Longer term, many believe humans will eventually look to colonize parts of the moon, or even other planets, such as Mars. For example, Elon Musk has been very vocal that one of the objectives of SpaceX is to allow humans to one day live beyond planet Earth. Space can represent an opportunity for a fresh start, or a way for those with the resources to one day leave earth, which will reflect divisions among the global population. For now, those with the means are limited to a ~5-minute ride into space on either a Virgin Galactic or Blue Origin spacecraft. However, as capital continues to flow into private space ventures, the infrastructure is getting built that will eventually allow for much greater access to the moon and beyond.

Exhibit 24 - SpaceX Starship rocket



Source: SpaceX

Space, however, is a long-cycle business. The primary consideration for human access to space will remain safety, which will limit the pace of cost reductions and human space flight capacity. Moreover, the capital requirements for the industry are substantial. While re-usability on the rockets – which is key to the cost reductions – is important, the industrialization of the supply chain and manufacturing capacity will take several years. SpaceX is at the forefront of rocket development, and its Starship (pictured above) is expected to provide high-volume lift capacity to the moon and other space destinations.

Many firms today are building private space stations. These will serve as a launching pad for greater human access to space for both tourism and exploration objectives. The demand for launch services is expected to see substantial growth, and the number of satellites orbiting the earth will expand exponentially as low-earth orbit (LEO) constellations expand. As we think towards the greater commercialization of space, space vacations and tourism, and eventually colonizing portions of the moon, the demand for space infrastructure will be substantial, as the potential for permanent life beyond planet Earth becomes closer to reality.

The Individual Revolution

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The Individual Revolution – Introduction

Social media, immense amounts of personal content and consumer-first applications are shifting the balance of power away from traditional institutions and into the hands of individuals.

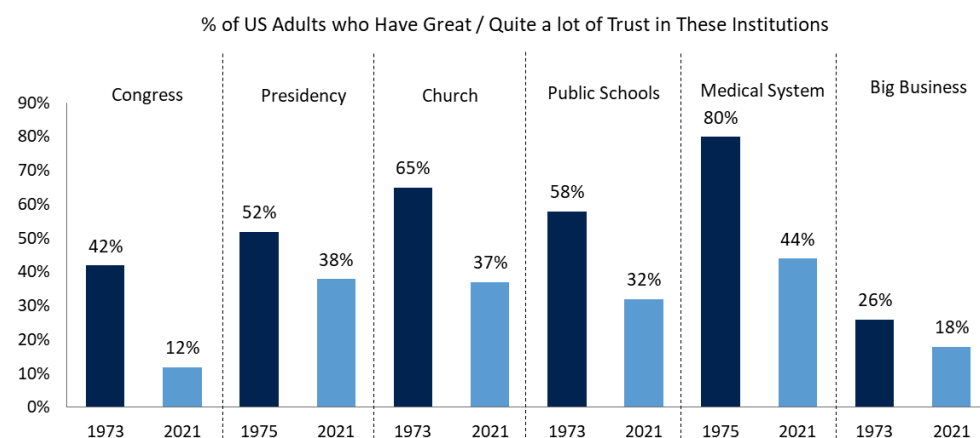
The Individual Revolution: Social media, immense amounts of personal content and consumer-first applications are shifting the balance of power away from traditional institutions and into the hands of individuals. This will create a new world order in every aspect of the global economy and will likely be the single biggest disruptive force to existing centers of power. In addition, it could create new economies such as the monetization of personal data (and the associated parameters around that data ownership). Consequently, as power shifts away from institutions towards individuals, global societies will deal with both the positives and negatives.

What is driving The Individual Revolution

The shifting balance of power from institutions to the individual has been catalyzed by several drivers, including general declines in trust of key institutions, advancements in communications technology that enable individuals to align around a common set of beliefs, as well as advances in science and technology, which allow consumers to collect significant data about themselves and their bodies.

Perhaps the biggest driver of The Individual Revolution is the general decline in trust for the most established institutions (governments, education, healthcare, and even large corporations). As shown below, based on Gallup survey data, the percentage of U.S. adults having “great” or “quite a lot of trust” in major US institutions (i.e., congress, the presidency, the church or organized religion, public schools, the medical system, and big business) has declined significantly since the 1970s for all institutions. Importantly none of these institutions has more than 50% of respondents having “great” or “quite a lot of trust” in them. Trust in traditional institutions is even lower among Gen Z and millennial groups, as shown by a study by Morning Consult. The data is clear and the problem is getting worse – which is motivating consumers to take matters into their own hands.

Exhibit 25 - Trust for major American institutions has declined significantly since the 1970s



Source: Gallup, RBC Capital Markets

In addition to rejection of government, we also see rejection of corporations as a major risk of unrest and instability. From the United States to South Korea, in 2021, waves of labor unrest began rippling globally. Within the span of three months, union workers across three major food companies (Mondelez, PepsiCo, Kellogg's) engaged in massive workforce strikes; similar strikes happened across industries, with 10,000 workers going on strike at John Deere, 24,000



Progress in genetic medicine will tackle several genetic diseases in the not too distant future, improving lives for millions of patients worldwide.

healthcare workers at Kaiser Permanente authorizing a strike, and ~80,000 union members in South Korea rallied across over a dozen cities, while half a million walked off jobs as part of a general strike in late October. Major themes across strikes have been a rejection of attempts to impose two-tier classes of workers, demands for better working conditions, and increased and equal pay at a time of gender inequality.

Additionally, advances in science and technology have allowed individuals to collect more data about themselves and their bodies and allowed pharmaceutical companies to make significant progress on personalized therapeutics. Progress in genetic medicine will tackle several genetic diseases in the not too distant future, improving lives for millions of patients worldwide. The mRNA vaccines for COVID-19 are probably the epitome of what genetic medicine can do for both humanity and the companies developing the drug or vaccine.

Advancements in science and technology have also enabled the movement of devices to retail shelves that were once exclusive to hospitals, allowing consumers to track a large amount of data on their bodies. Take for example the finger pulse oximeter, which measures blood oxygen saturation. The technology for this was developed in the 1930s, originally measuring via the ear, with the first finger pulse oximeter not commercialized until the 1970s in Japan, and the 1980s in the U.S. Pulse oximeters have been staples in hospitals for decades. Developed to meet the demand for measuring oxygen during surgery once the use of ventilators during anesthesia became ever more common, they revolutionized the work of anesthesiologists. In certain wearables, features such as pulse ox monitoring are already available, such as in the Apple and Samsung smart watches. With further technological developments, we'd expect current wearable devices to increase the number of health data they can track (e.g., glucose levels) and we'd expect new devices to be introduced increasing the amount of information consumers can obtain on themselves.

How The Individual Revolution is manifesting

Bucking traditional lifestyles, employment

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 cycle through more than a dozen jobs in their working years, either by desire or necessity. 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 are doing, when they work, and the environment in which they work.

The onset of the COVID-19 pandemic that drove a mass and sudden shift to working from home has also shocked the labor force. This more recent labor-driven change has spurred growth of the "gig" economy, 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).

The appeal of a traditional 9-to-5 long-term job with a single employer has diminished. 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), Upwork (a professional freelancer marketplace), 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 “Independent Work: Choice, Necessity, and the Gig Economy” from October 2016, 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, having more desire to understand the motivations of their employer, and be contributing to an organization that is doing 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.

Along with changing preferences in employment, we also see a global shift in attitudes towards marriage, children, and family. Delaying marriage and children are trends seen both in the US and abroad and we see a trend of the milestone of having a child increasingly replaced with pet ownership.

Bucking traditional lifestyles, marriage and children

Along with changing preferences in employment, we also see a global shift in attitudes towards marriage, children, and family. Delaying marriage and children are trends seen both in the U.S. and abroad; we also see a trend of the milestone of having a child increasingly replaced with pet ownership. Both the age of marriage and age of first child are trending higher with more people spending more of their 20s and 30s single; in the mid-90s the share of the unmarried population aged 22–35 surpassed the married population and continued rising to the present. Around 1988, when the U.S. share of pet-owning households was 56%, around 45% of 22–35-year-olds were single; by 2015, the share of the 22–35 population without a spouse was over 65%. Family size is also shrinking, with Americans having fewer children. In 1976, the share of women aged 40–44 who had 3+ children was 65%; in 2014 this had shrunk to 38%.

These are not phenomena limited to the U.S. The mean age of first marriage for all OECD countries has been rising year over year, and the number of marriages per 1,000 people has been declining over time for the vast majority as well. We believe these trends are the natural result of the higher educational attainment and labor force participation of women over time, and has been further exacerbated by recessions and austerity measures that keep young people from moving forward with marriage and parenthood. In China, a country with a more collective vs individual societal structure, marriage rates have also been dropping for at least six years in a row. In 2019, the country’s marriage rate reached its lowest level in 14 years. The marriage rate has continued to fall despite the country lifting its one-child policy. Similar to other countries, in China, women have started outnumbering men in both undergraduate and postgraduate programs.

We also believe some of the motivation behind the rejection of the institution of marriage ties to inequality. Across the globe, women are still expected to carry out more of the child-rearing and household duties – a phenomena that persists even in dual-income households, households where both partners earn the same, and in households where women make more. The Bureau of Labor Statistics’ American Time Use Survey showed that women aged 25–34 spend more than 50% more time on housework than men in the same age ranges; while the gap is smaller for women who work, they still spend almost 25% more time on housework than men. In a Gallup survey of housework, in no combination of questions were men more likely to be doing a greater share of the housework than women (though the difference is less severe in partnerships where the woman is the higher earner).

The data and personalization exchange

The Industrial Revolution of the late 1700s and the introduction of assembly lines and mass production in the 1900s paved the way to the modern economy and society, largely based on standardization of products and services to reach broader audiences and consumers. Henry Ford's famous quote "any customer can have a car painted any color that he wants so long as it is black," when the Ford Model T was introduced in 1909 summarizes this concept. This economic model puts significant power in the hands of institutions and companies, who are the provider of the standardized goods and services, thus, directly and indirectly, influencing individual behaviors and choices. While this economic model will certainly remain the basis of modern societies, we expect the next decade will see the rise of another revolution: The Individual Revolution, which we expect will start to shift the power back towards individuals and their personal choices.

Over the last decade, the rise of social media and several other technological advances (e.g., smartphones, smart devices, wearables, etc.) have led to an enormous amount of data collected on individuals.

At the same time, companies and individuals are now realizing the power and value of this information, and challenging existing sharing agreements.

Over the last decade, the rise of social media and several other technological advances – such as the adoption of smartphones, smart devices, and wearables – has led to an enormous amount of data being collected on individual habits, health, consumption, and preferences. At the same time, companies realized the power of this information as a way to maximize value for each customer by offering targeted products and services. As consumers see more targeted offerings they are starting to demand even more personalized products and services and are willing to pay a premium for them.

In Latin literature, Appius Claudius Caecus uses the sentence "*homo faber suae quisque fortunae*," meaning "every man is the maker of his own destiny." We believe this will be a key way of living for most consumers over the next decade. Consumers will want to bring the decision making back into their own hands and away from mass-influenced decisions and trends. Within Consumer, we believe this will lead to a demand for personalized products that better align with individual's preferences as well as marketing messages concentrated on individual choices rather than mass products and messages. We also see the disruptive technologies such as blockchain and non-fungible tokens (NFTs) as ways to enhance consumer personalization and promote exclusivity. Similarly, in telecommunications, it will lead to even more personalized content from social media to news and entertainment.

In healthcare the influx of capital, combined with some critical scientific breakthroughs, led to advances in genetic medicines and vaccines that are changing the lives of patients worldwide. These breakthroughs combined with the large amount of health data collected with existing wearable devices (as well as patented technologies not yet launched) will lead to personalized therapeutics on a much larger scale over the next decade. We'd also expect more customized services and solutions in financials and insurance, as well as individual demand for open investment platforms where consumers can make transactions of their own choice in a simpler and more cost-effective way.

We see the battle over data, in terms of data protection and data monetization, as a key part of the Individual Revolution, as consumers and governments are increasingly realizing the power of consumer data. Ultimately, we believe data protection regulations will make it harder for companies to access consumer data and we see the evolution of business models centered on data monetization. We also see geopolitical tension rising among sovereign countries over the control of individual data, as demonstrated by the U.S.–China tension over the control of social media site TikTok.

Financials: What am “I” worth? How to play the self-monetization economy

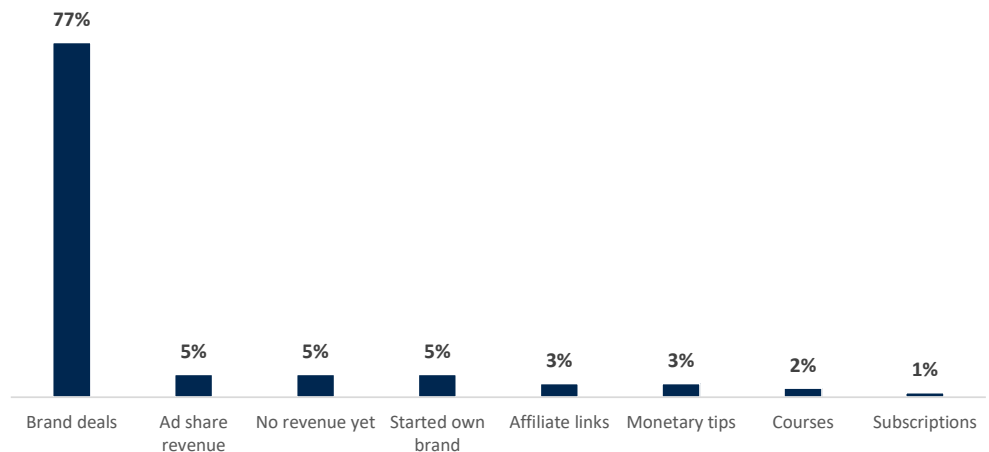
We believe companies’ ability to extract vast amounts of data freely from consumers is coming to an end.

We also we believe there needs to be a mechanism to exchange value from companies who do collect and use information back to their consumers.

As consumers increasingly recognize that they are the product as it pertains to consumption of social media, we believe companies’ ability to extract vast amounts of data freely from consumers is coming to an end. As a result, we believe there needs to be a mechanism to exchange value to consumers from social media companies (and others), such that consumers can be rewarded (or paid) for the use of their personal data, which is a concept we refer to as self-monetization. Digital tokens are well equipped as a means to monetize personal data as specific companies can create their own digital tokens, which can easily be transferred to a consumers’ digital wallet or potentially directly linked into the social network’s platform. In many ways, we could begin to think of this as the ultimate distributed and variable workforce, whereby millions of individuals would be (at the individual’s choosing) tethered to specific organizations that rely on aggregation of mass data. As the proliferation of AI, Machine Learning and Quantum computing evolves, the ability to predict or even steer consumer behavior will increase, which will ultimately beg the question of “free will” and who truly is in control.

Not unlike the creator economy, whereby large technology platforms utilize creators to drive engagement (similar to influencers), we believe tech platforms who monetize our data for free will have to create a similar direct monetization channel. If we look to the creator economy, also in its early days, as a guidepost for the self-monetization economy, we believe the opportunity could prove very large and disruptive, as corporate brands are expected to spend ~\$15B on influencer marketing by 2022, according to Mediakix.

Exhibit 26 - Sources of revenues by surveyed creators (%) n = 2,000



Source: CB Insights, RBC Capital Markets

Blockchain: An engine of the Individual Revolution?

To start, it's important to understand what blockchain is as there is often a lot of confusion. Blockchain is a type of distributed ledger, and in simplified terms, blockchain is simply a decentralized database with the following unique characteristics:

- Decentralized: no one entity controls the database
- Distributed: everyone has a copy of the database
- Immutable: records cannot be changed, only amended

Because blockchain is decentralized, it tends to be less efficient as a whole compared to a centralized database. Typically, several validators and other resources (such as additional energy) need to be involved for each transaction on a blockchain, whereas a centralized database requires minimal resources to enter transactions. Many believe that these inefficiencies are outweighed by benefits derived from the three characteristics listed above (decentralized, distributed, and immutable).

Some quick background

Though blockchain technology has been around for quite some time, we believe the technology had not matured to a level that was suitable for banking and the financial markets in terms of scale, speed, flexibility, and autonomy. Though different markets, products, services, and activities will have different requirements, the technology itself appears to have evolved enough since the Ethereum launch in 2015 to meet the general critical demands of at least certain segments in the banking and financial markets. One of the most critical advancements in terms of scaling and speed was the change in the consensus mechanism to validate transactions from the original energy intensive Proof of Work (PoW) mechanism that is still being used today by the Bitcoin and current Ethereum protocols to a general overall adoption of a more energy efficient Proof of Stake (PoS) mechanism currently used by the majority of other blockchain protocols (Ethereum will transition to PoS likely by 2023). The transition to PoS is a key step in reducing the energy intensity of the crypto space.

Another critical transformation in the technology was an increasingly accepted view of a multiple blockchain universe with interoperable blockchain protocols. This opened the door for development of more specialized blockchains that not only enhanced scale and speed, but also provided increasing flexibility and autonomy. A flurry of smart contract platform blockchains (blockchains that act as computers to run programs for others) have been developed the last few years, but one of the most interesting, yet less known is the Cosmos protocol, which is a sovereign blockchain on its own, but also part of the overall Cosmos Network, a network of sovereign and interoperable blockchains. Aside from being interoperable, what's also interesting about these blockchains on the Cosmos network is that they were built using the Cosmos SDK a software development kit (SDK) to build application-specific blockchains. Why is this significant? Essentially, the Cosmos SDK lowers the barrier to entry for blockchain development, allowing for the business side of the house to drive development instead of the developer side of the house driving development.

From an architectural perspective, there are three general layers of blockchain development:

- 1) **Consensus layer:** This is the layer where the consensus mechanism resides to determine the validity of transactions.
- 2) **Networking layer:** This layer is responsible for the propagation of transactions and consensus-related messages between different validators.
- 3) **Application layer:** This is where the application program resides.

Though blockchain technology has been around for quite some time, it has only recently matured to a level that is suitable for banking and the financial markets in terms of scale, speed, flexibility, and autonomy.

Previously, if an entrepreneur wanted to build a blockchain, the entrepreneur would need to build all three layers from the ground up, despite only being interested and having expertise in the application layer. The Cosmos SDK essentially “packages the networking and consensus layers of a blockchain into a generic engine, allowing developers to focus on application development as opposed to the complex underlying protocol.” This allows for start-ups to focus on the business-use case and value propositions of blockchain and less on the technology.

We think the ability to create a blockchain from scratch to a broader group has meaningful implications in the banking and financial markets:

- First, developers can customize a blockchain to natively embed certain programs and features as opposed to having these programs and features being executed at the smart contract level. We believe this has the potential to greatly enhance scaling, speed, efficiency, and usability.
- Second, developers have greater flexibility in meeting regulatory compliance requirements that range from handling confidential and private information on a public blockchain to meeting KYC/AML requirements.
- Third, in being a sovereign blockchain, blockchain applications can better meet the necessary requirements in a fluid regulatory landscape. As an example, an application running on the Ethereum blockchain must work within the Ethereum governance framework. What this means is that any bug fixes or new features must receive approval from the Ethereum platform itself before any changes can be adopted. A sovereign blockchain would allow developers full control to make changes as needed when needed.

Regulation needed to catch up

The regulatory landscape is very fluid as blockchain development has been rapid, presenting to regulators novel business and financing paradigms that do not appear to fit neatly into current legal and regulatory definitions. Though a separate and exhaustive report is needed to properly cover the current pressing regulatory issues, we do want to highlight one key change that we think has been impactful to the banking industry. In a January 4, 2021 [interpretive letter](#), the OCC approved the use of stablecoins by commercial banks for banking transactions, among other things. We find this to be interesting with the following thoughts:

- First, this interpretive letter clarifies the issuance and use of stablecoins as permissible bank activities by national banks, and therefore, banks do not need to apply securities laws to bank-issued stablecoins.
- Second, banks can now onboard traditional financial transactions in fiat dollars to stablecoins on a blockchain.
- Third, regulators are increasingly requiring crypto companies to follow KYC/AML guidelines. Banks already have an expertise in KYC/AML compliance and the use of blockchain could make the process even more compliant.
- Fourth, we believe bank stablecoins will likely hold true 1:1 exchange rates, since the stablecoins will likely be backed 100% by bank deposits.
- Fifth, because banks are highly regulated and insured by the FDIC, bank stablecoins have essentially zero counterparty risk, which is not the case with third-party non-bank stablecoins.

The OCC interpretive letter was a critical step in a [September 13th transaction](#) where NYCB facilitated the payment process through the minting and burning of stablecoins between buyers and sellers in the secondary trading of Figure’s privately-held shares on the Provenance blockchain. To our knowledge, NYCB became the first U.S. bank to mint a stablecoin on a

The regulatory landscape is very fluid as blockchain development has been rapid, presenting to regulators novel business and financing paradigms that do not appear to fit neatly into current legal and regulatory definitions.

blockchain backed by fiat deposits. This stablecoin, known as USDF, is led by a consortium that includes several community banks to develop standards and practices for the stablecoin.

Understanding the value propositions of blockchain

Because it is decentralized, distributed, and immutable, blockchain offers distinct value propositions, particularly as it relates to banking and the financial markets in general:

- Displacing trust with truth
- Real-time bilateral settlement
- Real-time servicing reports
- Enhanced security
- Automation
- 24/7/365

Displacing trust with truth: Since transactions are immutable on a blockchain when digitally native (i.e., transactions are entered directly onto the blockchain), there is no need to trust third parties for custody or attestation in many situations. The blockchain allows everyone to know in certainty that an asset is in fact what is being represented.

Real-time bilateral transaction settlement: By acting as a transaction ledger, custody platform, and legal ownership registry, blockchain is able to offer real-time bilateral transaction settlement by eliminating traditional intermediaries and processes. This ultimately eliminates counterparty and settlement risk. Typical settlement time for traditional exchanges is T+2 days with brokerages and clearinghouses, like the DTCC, acting as intermediaries. This elimination of counterparty and settlement risk could reduce regulatory capital requirements for banks, in our view.

Real-time servicing reports: Since transactions settle in real-time and recorded on the blockchain, it becomes possible to provide real-time servicing and performance reports on loans that are digitally native to the blockchain. As an example, it could be possible to provide real-time remittance reports on RMBS securities down to the underlying loans rather than the typical 30+-day remittance reporting cycle. We believe this higher level of transparency could lead to improved trading liquidity in the primary and secondary markets.

Enhanced security: Because blockchain is decentralized (no one entity has control over it) and distributed (many entities have copies of it), there is no single point of attack. That being said, online platforms of any type remain vulnerable to certain types of attacks, such as distributed denial of service (DDoS) attacks.

Automation: One of the key benefits of blockchain is automation. This is largely done through the use of smart contracts, which are programs stored on a blockchain that run when predetermined conditions are met. Examples of smart contract automation include credit auditing for loans, KYC/AML compliance, trade settlement procedures, loan servicing procedures, certain due diligence procedures, custodian functions, and many more.

24/7/365: Another key benefit of blockchain is the ability to execute transactions 24 hours a day, 7 days a week, and 365 days a year, which may ultimately push the financial exchanges into doing the same.

The approach to realizing the full value proposition of blockchain

A key observation to comprehending the value of blockchain is understanding the full life cycle of a financial asset and recognizing that current value chains are comprised of specialized,

Blockchain offers distinct value propositions: displacing trust with truth; real-time bilateral settlements, real-time servicing; enhanced security; automation; the ability to operate 24/7/365.

We believe blockchain projects will need to focus on the full life cycle of a financial asset and encompass the entire value chain, converting to an overall end-to-end value platform where specialized business models can plug in and offer their expertise.

Likewise, blockchain projects that focus solely on a specific specialized business process will offer a lower value proposition and have a higher degree of failure, in our view.

discrete business processes. A certain level of friction exists within the linkages of each specialized, discrete business process. To recognize the full potential of blockchain and deliver compelling value, we believe blockchain projects will need to focus on the full life cycle of a financial asset and encompass the entire value chain, converting to an overall end-to-end value platform where specialized business models can plug in and offer their expertise. Likewise, blockchain projects that focus solely on a specific specialized business process will offer a lower value proposition and have a higher degree of failure, in our view.

The last few years has seen a flurry of blockchain projects. Many of these blockchain projects are developer led and generic, allowing for multiple use cases in multiple industries and businesses. This approach may work for many industries, but may be more difficult to penetrate in the highly regulated and entrenched traditional banking and financial markets. These markets are very complicated and mature, surrounded by an entire ecosystem of industries providing systems and services with defined processes. The inertia of the ecosystem is very strong, and blockchain projects entering these markets would need to provide compelling value to disrupt the ecosystem. In order to do this, a blockchain project would likely need to look at the full life cycle of a financial asset and be tailored to that life cycle as best as possible. Additionally, it may be difficult for entrenched businesses to see beyond their silos and their current processes to realize the full value proposition of a blockchain in the life cycle of a financial asset. This is why we find the Cosmos SDK so interesting. It allows for a financial start-up with a full understanding of the life cycle of a financial asset and no legacy infrastructure to deal with to rapidly build and deploy a specialized end-to-end financial platform blockchain. We believe this is where blockchain can deliver compelling value with high value propositions. One of the key takeaways that we've seen with the rise of the retail trading platform, Robinhood Markets, is that if the value proposition is high enough, business models and entrenched businesses will have to adjust.

Markets with high potential for disruption in the near term

Questions to ask

To understand the markets that we believe may have a high potential for disruption from blockchain, we list the following questions to ask in light of the valuation propositions discussed:

- **Do the underlying assets trade?** Every time an asset trades, there is usually a certain level of friction, such as third-party vendors like custodians, vaulting services, etc. One of the key benefits of blockchain is that it greatly reduces, and sometimes eliminates, this friction.
- **Is there a lot of trading volume?** The more an asset trades, the higher the level of friction, and the higher the value proposition of blockchain.
- **Does settlement time matter?** If a transaction does not settle instantly, then is there a cost to this, such as higher liquidity, collateral, or capital requirements?
- **Does it require a lot of recycled diligence work?** Sometimes on asset pool trade, the buyer will have a team of lawyers and auditors checking on the reps and warranties of the seller's team of lawyers and auditors. But as we highlighted earlier, one of the key value propositions of blockchain is that it displaces trust with truth, allowing one to know in certainty that an asset is in fact what is being represented.
- **Are real-time performance reports of underlying assets valuable and to whom?** The more buyers, investors, and regulators find value in the real-time performance of the underlying assets, the higher the value proposition of blockchain.
- **Is there an inefficient process?** An inefficient process is not necessarily related to blockchain value propositions, but may provide more leverage in changing how current processes are done. Often times in the financial industry, there are archaic processes that

have been kluged together resulting in inefficient processes that have an infrastructure and inertia that is often hard to break unless there is compelling value to the change.

- **Is the process long and complicated with various internal and external parties?** With the use of smart contracts, blockchain could automate the workflow process between various parties and provide increased transparency for each party.
- **Are there voluminous datasets to work with that are well defined, consistent, relevant and used often in processes?** Assets that have voluminous datasets that are well-defined, consistent, relevant and used often in processes are ripe for smart contract automation and filtering.
- **Does the activity involve dealing with federal, state, and local governments?** Generally, we view the higher the level of government involvement in a process, the harder it is to achieve meaningful change, which may be slow if achieved.

Markets with high potential for disruption: We believe the asset-backed securities (ABS) markets including MBS have a high potential for disruption from blockchain that includes the following underlying assets: mortgage loans, auto loans, student loans, credit card receivables, and equipment leases. The mortgage market appears to offer the highest potential for disruption given the origination volumes, level of securitization and secondary market trading, required degree of diligence work, the voluminous structure-friendly datasets to work with, and an overall process that many consider sub-optimally efficient. Within these high disruption markets, certain businesses, such as lawyers, auditors, custodians, and others, could see varying degrees of impact.

In addition, we believe there could be potential for spillover into the more traditional fixed income and equities securities markets. As noted earlier, NYCB facilitated the secondary trading of Figure's privately held shares. In a subsequent press release Figure completed its secondary offering, noting that its Marketplace trading platform "is the first of its kind and allows for real-time, bilateral trading and immediate settlement of private company shares. This represents a significant improvement from the current 60+ day process to trade equity in private companies." Figure also noted that the platform saved over 90% of the traditional fees associated with the secondary trading. The value propositions appear very compelling, and we imagine this could add pressure to the debt and equities ecosystem, though it remains too early to tell.

Blockchain and banking – A closer look

Though it remains to be seen if the overall number of blockchains increases or declines, in highly specialized and regulated markets like banking and finance, we currently expect to see an increasing number of specialized blockchains that have an expertise in a specific area in the next 1–3 years with some dominating and others dwindling. In a 3–5 year timeframe, we expect the market to firm up with the dominant blockchains holding most of the market share of activity in their respective fields with interoperability between blockchains to some extent and dependent on business use case. Ultimately, we expect these blockchains to change the business models of some businesses within their respective ecosystems. Some businesses will be more impacted than others, with some thriving from new or enhanced value propositions, while others face continual structural pressures.

With the OCC giving banks approval to issue stablecoins for banking transactions, it could be possible for different banking stablecoins to emerge with the potential for one taking dominance over the next two years. The stablecoins would be used to on-ramp financial transactions on a blockchain, but could also potentially be used as a form of real-time gross settlement. Bank stablecoins are still in the very early stages and remains to be seen the level of adoption and usage.

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We've also noticed a trend of sorts over the past two years between fintechs and SMID-cap banks. Both appear to have incentives that are somewhat aligned and capabilities that the other party does not have. Fintechs are quick, nimble, have zero legacy infrastructure to weigh them down, come in with fresh eyes capable of seeing through various silos, and have an expertise in understanding the capabilities that technology can provide, but lack the capabilities that a banking license provides. On the other side, SMID-cap banks are hungry for loans, fee income, deposits, and ways to manage expenses lower. Though they have regulation and more infrastructure to keep in mind than fintechs, SMID-cap banks have much more flexibility than large cap and super regional banks. In the last 10+ years, large cap and super regional banks have invested heavily in tech spend, and that has shown through in terms of improvements in digital statistics in both the consumer and wholesale banking. Given all the regulations, investments, and legacy infrastructure that large cap and super regional banks must factor in, blockchain could provide an opportunity for SMID-cap banks to leap frog larger banks and take a leadership role in certain areas.

Blockchain: NFTs enhancing the customer journey

We see an opportunity for new and disruptive technologies such as blockchain and non-fungible tokens (NFTs), to enhance the customer journey and levels of personalisation beyond simply knowing the consumer. In time, this should serve to encourage increased spending from the most high-value customers. We expect businesses to look to segment their customer base and thereby reward customers with whom they interact more frequently.

- **The next step in the customer relationship journey.** In time, we expect the adoption of technologies such as blockchain and tokenization to be the next step to allow for efficient personalisation and deeper customer relationships. NFTs allow for the creation of ‘digital twins’ to high-value physical products, the likes of which are already being used by some luxury retailers. This then fosters exclusivity and allows for the sharing of provenance details and simplifies customer support processes (e.g., repair and maintenance, lost and stolen, authenticity, proof of ownership).
- **Rewarding high value customers.** We see the use of NFTs moving forward to loyalty reward schemes, such as private sales events or exclusive merchandise for the most valuable customers. For example, a retailer could program an NFT to grant or revoke exclusive access to a lounge or restricted area of the store based on prior purchases or brand engagement. This would then act as an incentive to buy more, helping retailers to increase their share of the consumer’s wallet.
- **Driving the growth of rental/resale.** We think that the use of blockchain for seamless, instantaneous transactions, without the requirement for human intervention, could make rental processes safer, more efficient and cheaper. This, in turn, should help to support the growth of the rental/resale market, thereby also helping consumers to be more sustainable in future.
- **Positives for the public health sector.** In time, we expect the development of a connected system with centralized patient information that is accessible by multiple healthcare providers and patients alike. We anticipate that the expenditures will ultimately be satisfied by grocers, pharmacies, and others with an economic interest in the platform. This should ultimately lead to consumer benefits such as personalized preferences, nutritionally appropriate menus and digitally pre-populated, ready-to-order baskets available for click and collect or home delivery.

By the same token

Bridging digital and physical realms with tokenization

Over time, wide scale adoption of emerging technologies like tokenization could become integral to efficiently satisfying evolving individual and societal preferences.

From mass to me

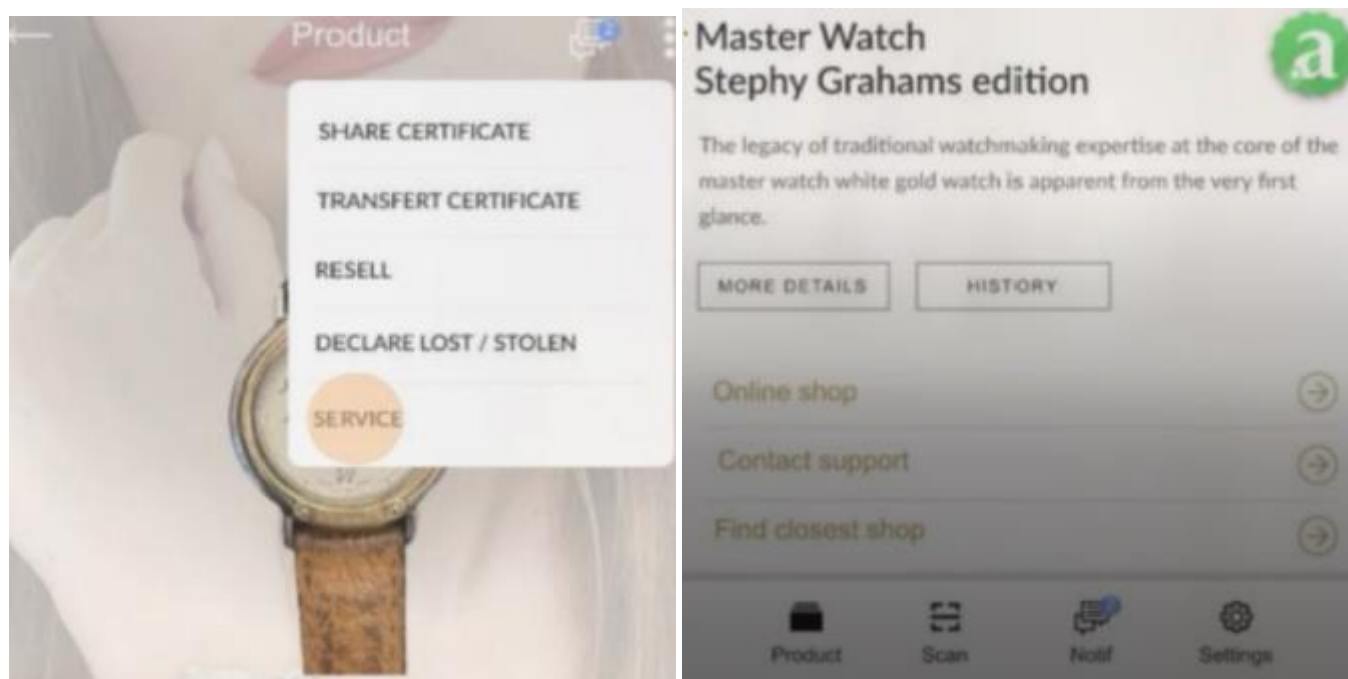
Over the next decade, it should become increasingly possible to satisfy individual preferences through data generation & tracking, and the ensuing collective knowledge produced. And no discussion about hyper-personalization would be complete without highlighting the emerging role of NFTs—unique (as in irreplicable), blockchain-derived digital assets that marketers can use to bridge the physical and digital experience and deepen customer relationships.

Forward-looking luxury retailers and fashion houses are already leveraging NFTs by creating digital twins to high-value physical products to promote exclusivity, share provenance details, serve as repository for repair or maintenance history, help declare the physical good lost or stolen, and facilitate transfer by assuring authenticity and proof of ownership. NFTs create a perpetual, non-replicable, transferable and programmable link to the customer.

In our vision of the future, programmable NFT certificates could deepen brand–customer relationships by unlocking certain features to reward consumers based on the depth of interactions with the brand.

In our vision of the future, programmable NFT certificates could deepen brand–customer relationships by unlocking certain features to reward consumers based on the depth of interactions with the brand. Examples include selectively unlocking access to private sales events or exclusive merchandise for emerging high-value customers based on brand interaction through their social media channels; or concert tickets augmented with a digital backstage pass unlocked for certain individuals to incentivize and reward based on engagement, prior concert attendance, album and merchandise purchases, and digital music downloads.

Exhibit 27 - NFT-based digital passports deepen brand–customer relationships, and can serve as proof of ownership and authenticity



Source: Arianee

We envision a future where consumers leverage NFTs for status and self-expression in virtual ecosystems—for instance, purchasing one of a kind, personalized luxury sneakers and owning the digital twin online. NFTs would provide digital proof of ownership and authenticity of a unique physical product, enable transactions, and could program a royalty stream remitted to both the retailer and original-owner every time the asset is transacted. Scarcity and authenticity beget value. In our view, NFT-based digital assets are poised to become the pillar of one-to-one relationships between brands and creators and their communities of fans and customers.

Insurance: Just for you

Technology gives companies new ways to evaluate and price risk and, accordingly, new ways to customize coverage.

The bottom line is a customized product can be marketed as a way to give customers more of what they want (and less of what they don't want) while saving them money in the process.

Insurance has always been about matching premiums to expected risk. Technology gives companies new ways to evaluate and price risk and, accordingly, new ways to customize coverage to address individual needs. Anything that can be measured becomes a vector for repackaging insurance risk. This can include anything from human behaviors and geospatial characteristics to time compression and the human genome. While customized risk assessment can be a boon for “good” risks, it has a dark side too as some risks that are currently socialized become either more expensive to insure or are simply deemed uninsurable.

Tailored coverages: We have already seen a number of tailored type coverages offered across the insurance industry as companies look to attract and entice customers with coverages that are appealing and the right fit for them. Increasingly, consumers and businesses are looking to buy plans and other related coverage items on an ad-hoc basis and buyers want more say on everything they buy (including insurance coverage) and don't want to necessarily buy one-size-fits all items.

In the future, we think customers will want even more choice on the types of insurance coverage that they buy. These can include coverage amounts, deductibles, limits, policy length, etc. We see no end in sight to the significant capital levels flowing into the insurance sector to fund Insurtech start-ups (many of whom offer tailored coverage) while incumbent carriers continue to adapt and do whatever is necessary to offer choice and keep customers satisfied. The bottom line is a customized product can be marketed as a way to give people more of what they want (and less of what they don't want) while saving them money in the process.

Exhibit 28 - Summary of customized coverage

- Customizable policies with more options is the future
- Pay by the mile and telematics have room to expand in the years ahead
- Companies will offer more on-demand insurance via direct & phone
- We expect increased innovation & creativity in the insurance buying process
- Effective use of data & analytics, AI, and predictive modeling will be key to profitability

Source: RBC Capital Markets Research

Pay by the mile & telematics: Personal auto coverage is already highly customized and only getting more so. Pay by the mile or usage based pricing is now starting to catch on and makes sense for some customers particularly for city drivers or those that don't drive much.

Telematics are also becoming an increasingly important variable and allows insurers to monitor driving behavior for the insured (either through a device or smartphone) for a certain period of time. The use of telematics enables companies to better assess individual drivers and price risk accordingly. Allied Market Research estimated that telematics was a \$2.37B market in 2020 and they forecast this to reach \$13.78B by 2030 (nearly a 20% CAGR).

While companies are quick to highlight how much good drivers can save, it also helps the companies identify less attractive drivers that they can quickly price out of their book of business.

Most major companies (Allstate, Progressive, GEICO) have offered telematics for a while but we think all companies will need to have a telematics option especially as some state regulators crack down on banning the usage of variables like credit scores in setting rates. We

also think that homeowners coverages could be tailored more in the future with insurers asking more questions and taking a harder look at each homeowners risk on a more case-by-case basis. We think things like Ring doorbells, home monitoring, and other preventative emerging technologies will be encouraged and rewarded by homeowners' insurers.

Exhibit 29 - Telematics basic description



Source: Confused.com

Utilizing tracking chips, the Internet of Things and wearables, we imagine the possibility of point-in-time coverage on literally any item or situation to the extent that a customer is willing to pay a premium and there are tools to measure risk.

We think that carriers should be able to offer and price these new customized products more efficiently in the future based on better use of data and analytics.

On-demand insurance: We think consumers will expect to have their say on what items are insured individually and what is blanket covered. One-off coverage on certain items such as insuring laptops, smartphones, or events or trips is already coverage that can be uniquely obtained and priced down to increasingly shorter periods. Companies such as Trov and Slice do this now, and more will likely do this in the future.

Utilizing tracking chips, the Internet of Things and wearables, we imagine the possibility of obtaining point-in-time coverage on literally any item or situation to the extent that a customer is willing to pay a premium and there are tools to measure risk.

Workers in the gig economy are now using on-demand insurance and we think that usage should grow materially in the years ahead. The best examples now are Uber and Lyft drivers where auto coverage is activated when they sign on to the app and deactivated when they sign off.

This type of coverage can be extended to a range of entrepreneurs running various types of businesses that need coverage some identifiable unit of time. To the extent tracking is allowed certain risks such as workers comp could be extended to the individual level charging more when a worker is engaged in physical acts and less when they are sedentary.

Customers want coverage in real time (at the click of a button) and are now looking to buy coverage at their fingertips without having to fill out large forms – and we think that will happen. We believe that the days of long-term commitments or contracts to buy coverage are over. That said, we think that insurers will still need to be careful to make sure that they know who is buying, that fraudulent behavior can be detected, and the product is priced appropriately.

Data and analytics should help with profitability: We think that carriers should be able to offer and price these newer products more efficiently in the future based on better use of data and analytics. We expect companies to make further advances on adopting things like artificial intelligence, Blockchain, robotics, data and analytics, and predictive modeling to appropriately assess risk and price different product lines. We expect companies to make further

investments in data and analytics and big data as this is no longer a nice thing to have but because it is necessary to survive and thrive in the years ahead.

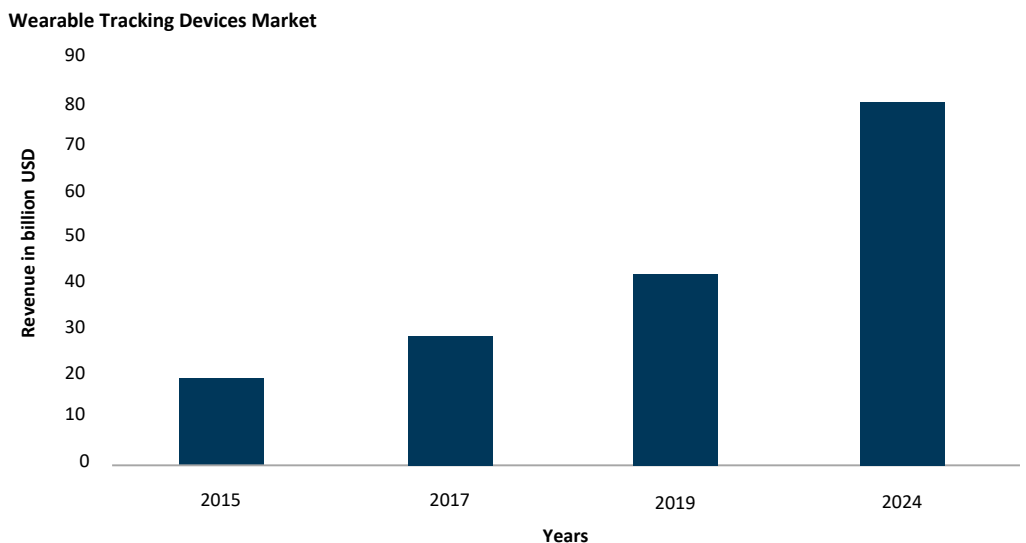
Beside risk assessment, companies are using technology and AI for loss prevention and mitigation. Cameras, sensors, sprinkler system, and the Internet of Things can help detect losses early on and have loss mitigation measures. Big data and AI can also help tally and predict what areas or product lines are most prone to claims, and employ loss-mitigation techniques for those risks.

Worker's compensation & trackable monitoring: We think that the way that workers' compensation is priced now could change and give more recognition to the industry being served and risks involved. For example, a worker at a construction or job site has a much greater probability of being hurt at work compared to a worker sitting at their desk.

Wearable devices could identify when workers are on a jobsite and in dangerous areas as compared to safe areas and when they are involved in activities that give rise to losses rather than engaged in low risk activities. Premiums could then be tuned to specific employees rather than generalized based on payroll and job code.

AIG noted a few years ago their use of wearables for construction workers to track their movements and have a better handle on the perceived risks. While not popular with workers, we expect the use of trackable technology to be further utilized in the years ahead. Below is a table predicting that the wearable tracking device market will hit \$80B by 2024 vs. just over \$40B in 2020.

Exhibit 30 - Wearable tracking devices market is expected to show growth (\$B)



Source: profsharemarketresearch.com

DNA or genetic testing: Life insurers are looking at utilizing biology and medical science to apply genetic testing and genome mapping. A PartnerRe report examines three types of genetic testing that are in three different stages of development and implementation. The first type is single gene analysis, which is the most accurate and usable method of existing testing. It tests single genes to find specific results related to a single outcome (Huntington's, Alzheimer's, etc.). The tests are typically reimbursed by healthcare insurers and have prices in

the \$100s. The adverse selection risk is currently low because these tests are designed for rare diseases with 1%–2% population exposures.

Exhibit 31 - Genetic testing maps

Genetic test	Description	Quality	Main providers and owners of the date	Approximate cost of a test	Risk of adverse selection
Single gene analysis	Identified 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, primary to analyze and better target treatments for cancers	USD 1,000 within the next few years	Now: Low , data processing requirements 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

Table 1: Summary of the three main types of genetic testing and their impact (adverse selection risk) on Life and Health insurance. The 'low' and 'high' categories are presented as a simplification and for comparison purposes only.

Source: PartnerRe

Whole genome sequencing is the second testing methodology available. It involves, as the name suggests, the mapping of the entire human genome. It is more expensive, and less developed, but is moving from the lab to hospitals in the testing for cancer and other diseases. As of now, this poses a small risk to life insurers from an adverse selection standpoint but in the longer view could be a high risk as these tests become more accurate for diseases that are more common than those tested by simple gene analysis and to the extent pricing comes down.

Finally, there is direct to consumer genetic testing. These tests have low accuracy and involve no medical professionals and pose little risk to insurers on a near-term basis. As the tests develop and become more accurate, they could pose a higher risk, but the lack of medical professionals' involvement would limit the ability of a customer to form an information edge on the insurers.

We see genetic testing as a key opportunity for insurers that can allow for more accurate risk profiling of potential customers and improved profitability. Ultimately, what DNA or genetic testing will be allowed from a regulatory perspective is still unclear, and could depend on the states or countries involved.

How we buy insurance? The way that customers buy on-demand insurance is likely to continue to evolve with some consumers now more comfortable buying on a "direct" no-contact basis either online or via a smartphone. The NAIC recently noted that millennials are twice as likely to purchase their policies online or through a smartphone (rather than an agent) and we expect future generations could be even higher. In the case of life insurance, consumers have been lobbying for easier ways to buy life insurance coverage without having to take blood tests, provide samples, or fill out time-consuming applications and that is starting to come to fruition.

We expect the use of chatbots to become more common as the next generation of younger buyers prefers this option, especially for straightforward transactions. At the same time, we

We see genetic testing as a key opportunity for insurers that can allow for more accurate risk profiling; ultimately, what DNA or genetic testing will be allowed from a regulatory perspective is still unclear.

anticipate that companies will still offer the ability to interact with agents to run through certain topics and subject matters. We expect increased innovation and creativity in the insurance buying process as money continues to flow into the Insurtech space and incumbent companies spend on innovation.

The ethics of individual insurance

Insurance works on the principal of socializing common risks. The more we can measure about risk the less need there is for risk sharing and the more accurate premiums can be matched to loss expectations. Effectively, we stop relying on actuarial tables and the law of large numbers and start relying on algorithms and loss prediction.

Moral hazard is an insurance concept that suggests the risk taker (policyholder) knows more about their propensity for loss than the insured does and will avoid insurers who fully price for risk and instead adversely select against insurers who do not fully appreciate their risk profile. The good news for insurers is that information helps level the playing field. The bad news for policyholders is that they may be less able or unable to find coverage at an affordable price.

Take for example an auto owner in a high-crime neighborhood. This person's driving skill may be just as good or even better than a similar driver in a low-crime area, but they may still pay more because their auto may be more at risk for theft, vandalism or uninsured motorist risk. None of these are factors inherent to the operator but are factors in the overall loss profile. A fully customized risk needs to weigh both the positive factors (being a good driver) and the negative factors (living in a high-crime area).

Full customization of insurance will inevitably help some buyers and harm others, perhaps leading to a more bifurcated distribution of premiums.

As a society, we will need to weigh all the risk factors of offering customized insurance, and determine whether they are worth it.

Likewise, while genetic testing and genome mapping could be useful for life insurers, should they be able to use this? We think this creates somewhat of a moral dilemma, has privacy issues, and can cause selection issues. Said differently, those with the "right" genes might easily obtain low-cost coverage while those with the "wrong" genome might pay a much higher rate or be denied altogether.

For example, it is already the case that life insurance companies differentiate between men and women based on observed differences in longevity. Genetic testing might exacerbate some of these differences. There could be racial or ethnic segmentation as well based not just on already observable social factors but potentially genetic differences as well.

Full customization of insurance, whatever the product, will inevitably help some buyers and harm others, perhaps leading to a more bifurcated distribution of premiums whereas broader risk sharing (as is currently the case) tends to allow more policyholders to pay near the average. As a society, we will need to weigh all the risk factors that go into offering customized insurance and determine whether they are worth it.

Media & Telecom: Personalized content

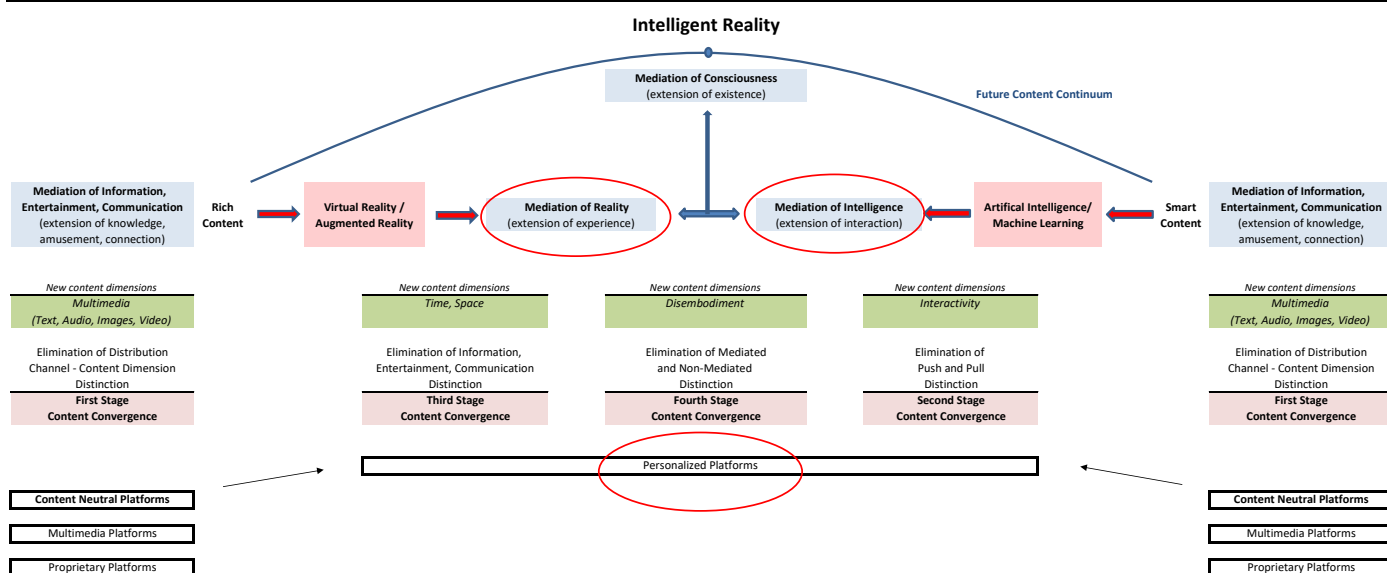
The rise of personalized platforms

In our 2002 report *“Scaling Interactivity”* we developed a digital content aggregation thesis where, in an interactive digital environment, we proposed that: (1) traditional media platforms would evolve from proprietary content platforms to multimedia content platforms; (2) with interactivity, these multimedia content platforms would then evolve into content neutral platforms; and (3) with personalization, these content neutral platforms would then evolve into personalized platforms (bottom of Exhibit 32). Almost 20 years later, we believe our digital content aggregation thesis has stood the test of time with the traditional media platforms evolving into multimedia platforms through the 2000s, the large, concentrated consumer platforms (Google, Facebook, Amazon, Apple, Netflix) emerging as the dominant content neutral platforms through the 2010s, and with these content neutral platforms (among others) now racing to develop personalized platforms.

In our June 2018 RBC Telecom Scenario Report entitled *“Intelligent Reality and the Inflection Period for Content,”* we identified a potential mid-2020s content inflection period that could accelerate the emergence of personalized platforms. With VR/AR/MR and AI underpinned by an increasingly powerful technology stack, we believe these platforms will be capable of delivering exponentially greater personal “presence” and “relevance” at scale, resulting in the mediation of both reality and intelligence (middle of Exhibit 32).

A potential mid-2020s content inflection period could accelerate the emergence of personalized platforms, which we believe will be capable of delivering exponentially greater personal “presence” and “relevance” at scale.

Exhibit 32 - The rise of personalized platforms



Sources: RBC Capital Markets report “Intelligent Reality and the Inflection Period for Content”

The rise of the “data-industrial complex”

In our view, one of the key (if not most important) components of the value chains underpinning personalized platforms will be the ‘data-industrial complex’ – a reference by Apple CEO Tim Cook for today’s consumer data ecosystem. Under the first iteration of the Internet over the past 20 years, consumers have largely voluntarily entered into what are effectively barter arrangements with the large, concentrated consumer platforms (“walled gardens”) as well as websites and apps (the “open Internet”) exchanging consumer information for some form of network access and/or online service. These barter

Under the second iteration of the Internet (the “Metaverse”), we expect the data-industrial complex to take its first real leap forward with significantly greater consumer data ownership, portability and protections.

We believe that an advanced data-industrial complex represents the single greatest “infrastructure” opportunity over the next half century.

arrangements, catalyzed by third-party data providers and third-party cookies have enabled both walled gardens and the open Internet at virtually zero cost of sales to monetize consumer information with advertisers. Not surprisingly, with only minor regulatory oversight, powerful “winner take all” network effects, active horizontal integration, and limited consumer data ownership rights, portability and protections have emerged: (1) walled gardens have not only grown in size and influence, but have become exceptionally profitable and highly valued while enjoying rising barriers to entry; and at the same time (2) the open Internet continues to steadily encroach on consumer privacy.

Under the second iteration of the Internet (often referred to as the “Metaverse”), we expect the data-industrial complex to take its first real leap forward with significantly greater consumer data ownership, portability and protections. While the General Data Protection Regulation (GDPR), the California Consumer Privacy Act (CCPA) and Google and Apple’s discontinuation of third-party cookies in the Chrome browser, along with related changes by Apple are collectively a step forward in giving consumers more transparency, choice and control, we believe this regulation only scratches the surface of what will be required of this complex to support personalized platforms. More broadly, a more highly evolved data-industrial complex with sophisticated consumer data ownership, fungible portability and enterprise-grade protections would exponentially expand the pool of anonymously and non-anonymously aggregated consumer information – the impact of which would be nothing short of transformative and akin to what the banking industry, by facilitating the flow of capital, did for capitalism, market efficiency and the global economy. In fact, we believe that an advanced data-industrial complex represents the single greatest “infrastructure” opportunity over the next half century with wide-ranging economic, social, cultural, political, environmental and national security implications.

In our view, an advanced data-industrial complex could:

- Unleash an unprecedented step-up in market efficiency across all sectors of the economy driven by superior information exchange;
- Impact all elements of public policy resulting in vast improvements, for example in healthcare (unprecedented sharing of medical records), education (unprecedented immersive and specialized learning environments) and government administration;
- Provide the necessary consumer privacy and security safeguards for powerful AI and VR-driven personalized platforms;
- Be a massive consumer data resource for private and public sector AI initiatives;
- Be the common data depository for public 5G-drive IoT use cases across smart cities, connected cars and other public infrastructure;
- Incorporate blockchain technology within a consumer-owned, digital locker construct as one mechanism to protect against unauthorized access and use of personal information;
- Institutionalize consumer information as a fully tradeable asset class with established fair market value mechanisms, enabling consumers to generate actual cash returns on their information (establishing the “time value of information”);
- With an ability to generate cash returns, be a contributor to any universal basic income (UBI) program; and
- Become a more objective arbiter in establishing a “common set of facts” required to sustain healthier political discourse in a democracy.

Consumer: Power to the people

We expect the reams of consumer data being accumulated through ecommerce and retailer loyalty programs will be the cornerstone for a new era in retail: the Personalization Period, powered by mass customization.

Since the emergence of the retail shop as we know it, power has largely been in the hands of the brands and the retailers: retailers chose the products and brands to stock in their shops, and consumer choice was limited to those products and brands. With the emergence of ecommerce, products and brands are now free to interact directly with their consumers, without the friction and limitations that ensue when the retailer acts as intermediary.

Although much of retail remains mass-oriented and relatively undifferentiated, the reams of customer data that is being accumulated through online browsing and shopping and retailer loyalty programs will be the cornerstone for a new era in retail: the *Personalization Period*, powered by mass customization.

As it stands today, personalization is the attempt to provide shoppers with unique experiences across all interactions and channels, using data accumulated during previous interactions, updated and iterated in real time. The objective: to provide anticipatory and proactive interactions that stimulate demand, deepen loyalty and drive revenues.

The simplest iteration would be the customization of an online customer interface to reflect historical customer purchasing patterns and onsite behavior, adapted to seasonal shifts based on input from weather data in the customer's region, and augmented by a virtual styling assistant for high-value customers. So, when Customer A, living in Montreal, logs into her personalized shopping portal on a blustery day in November, the welcoming image is of the customer wearing a yellow (her favorite color) rain slicker with jeans, blue and white striped (she likes to pair these two together) sweater and rain boots, all in her size, all available at the click of a mouse, and delivered to her home via drone within two hours.

Elements of this type of highly adaptive/proactive approach are already available, Nike introduced early elements of mass customization in 1999 with NikeiD, and both Dr. Scholl's and adidas offer customized shoe inserts. Luxury brands from Louis Vuitton to Baume offer buyers the option of customization across a range of options, but these are all consumer-initiated, and lack the proactive, anticipatory, quickly available element that will one day typify the shopping experience.

Advantages to the retailer or brand include heightened loyalty, as customers value the unique goods/services being offered; reduced waste, as unpopular items are simply not produced (turns out Customer A really likes yellow, but not in a rain slicker); and often, higher revenues, as studies have found that more than half of consumers are willing to pay a premium for products customized to their individual taste/style.

From me to the masses

Optimizing resources & improving societal outcomes through the creation of a truly circular customer relationship. The combination of emerging technologies should enable broad-based monetization of customer assets, whether digital, material or physical.

Digital: Monetizing your own data or bandwidth. The "monetization of self" through data control and sharing with selected entities, whether private or governmental could meaningfully disrupt incumbents in the advertising space. It is also conducive to the proliferation of businesses such as Filecoin, which encourages data storage/sharing through tokenized incentivizes (Filecoins).

Material: Making optimal & efficient use of existing resources while satisfying the "ownership vs. service" dilemma or preference by attracting products from the sidelines.

The advent of technologies such as tokenization and innovative payment solutions could enable practically “anything-as-a-service” by benefitting both owners and renters, and in some cases society at large. Traditionally, ownership appeal has centered primarily on lower total cost of ownership (TCO) that improves with asset utilization, but sourcing convenience, product availability, and seamless transaction / authentication / payment remain critical to maximizing the collective asset base. As new technologies mature and as models of asset rights evolve, in our view, myriad use cases exist to leverage NFT programmability, proof of authenticity and transferability.

How it might look? A retailer could program an NFT to grant or revoke exclusive access to a lounge or restricted area of the store based on prior purchases or brand engagement—a token that could be transferable for a fee and thus have value. NFT certificates could also be used to unlock doors. A homeowner or car owner in a remote location could transfer their unique NFT-enabled certificate through a smartphone app, granting another person access to the connected physical asset. Customers could have self-sovereign IDs stored in a public blockchain, allowing for seamless transactions, instantaneously, without any need for human intervention, with payments approved and processed through smart-contracts also running on blockchain. This would render the process of renting out assets much more safe and efficient, for the benefit of all involved, with less hassle and lower TCO for owners, more products available for renters at a lower cost, and improved outcomes for the planet on a more robust/fulsome utilization of existing resources.

Taking the individual rental example a step further, mass adoption of tokenization-based car renting combined with “vehicle-to-grid” or “vehicle-to-building” (V2G/VBI) technology integrated with battery-powered electric vehicles could have a significant impact on society. Combining emerging software and AI capabilities with what is essentially a distributed energy storage solution in the rapidly growing BEV car fleet, could drive vastly improved societal outcomes from the tokenization and subsequent monetization of hard assets. While not in use, benefits would accrue to asset owners by providing grid services in exchange for a monetary (potentially tokenized) incentive lowering the car’s TCO, while benefiting society at large by powering & regulating/stabilizing the grid, or a specific building for that matter.

Physical: Building on the earlier telemedicine and public health monitoring discussion, it seems inevitable that we are heading towards a “connected healthcare & wellness” ecosystem, with the individual at the center of it all. In time, we should witness the creation of a connected system with centralized patient information (medical records, genetic tests, biomarkers...) accessible by multiple healthcare providers (doctors, pharmacists, dieticians, physical trainers...) and patients alike, with related expenditures ultimately satisfied by grocers, pharmacies, and others with an economic interest in the platform.

In addition to receiving valuable health and lifestyle recommendations from physicians and other stakeholders, individuals could also reap tokenized government-subsidized rewards based on voluntary disclosure of medical records on the public blockchain, healthy food purchases, activity levels tracked by wearable devices, and improvements in biomarkers. All of this assuming that we can get to a place where accurate determination and fair distribution of tokens can be satisfied. But at the very least, we envision a future in which patients willing to self-disclose could benefit from a range of nutritionally appropriate menus to suit individual palates, preferences and medical requirements, with digitally pre-populated, ready-to-order baskets available for store pickup, home delivery (likely via drone) or any other convenient last-mile solution.

We envision a future in which patients willing to self-disclose could benefit from a range of nutritionally appropriate menus to suit individual palates, preferences and medical requirements.

Internet: Gig economy

Bucking traditional lifestyles, employment

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 cycle through more than a dozen jobs in their working years, either by desire or necessity. 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 are doing, when they do that work, and the environment in which they work.

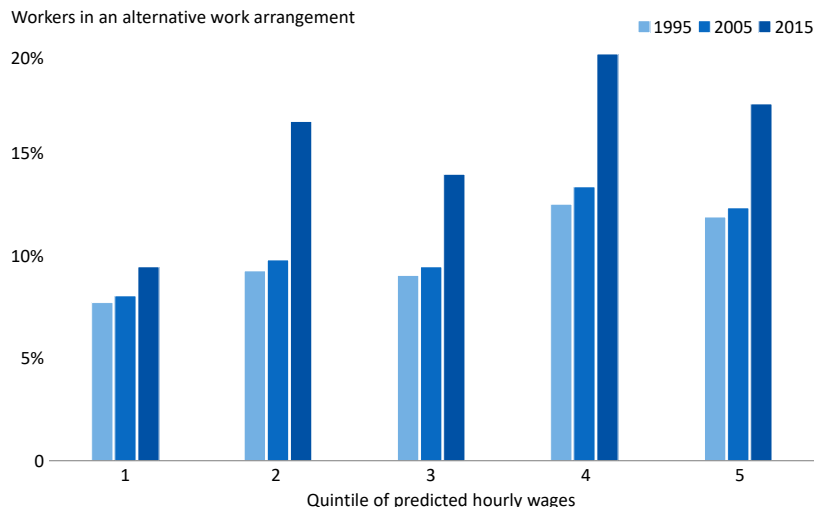
The days of lifetime employment with a single company that provides a pension and retirement health insurance are long gone for most workers.

The onset of the COVID-19 pandemic that drove a mass and sudden shift to working from home has also shocked the labor force. This more recent labor-driven change has spurred growth of the “gig” economy, or 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, as well as 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 an 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.

The appeal of a traditional 9 to 5 long-term job with a single employer has diminished. 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?

Exhibit 33 - Alternative work arrangements on the rise across income levels



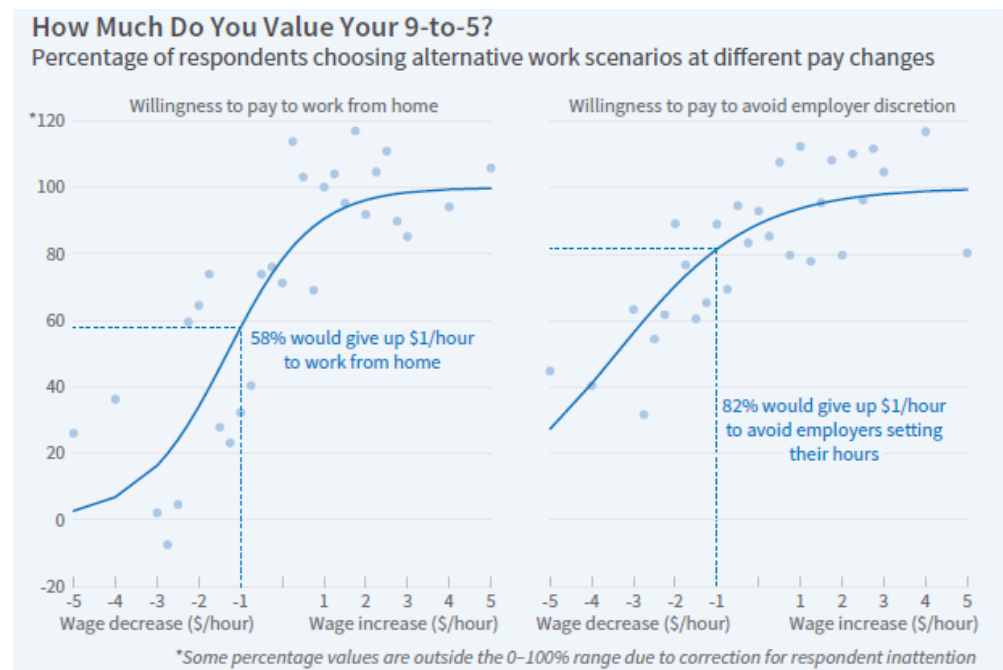
Source: National Bureau of Economic Research article, “Putting Price Tags on Alternative Work Arrangements” (December 2016)

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), Upwork (a professional freelancer marketplace), 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, *Independent Work: Choice, Necessity, and the Gig Economy* from October 2016, 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, having more desire to understand the motivations of their employer and to be contributing to an organization that is doing 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. Exhibit 34 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.

We see a growing desire across generations 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.

Exhibit 34 - 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)

Internet: “Marketplace theory”

Digital marketplaces – disruption unlikely to go unnoticed

Among our most bullish views for value creation over the much longer term, we often speak about the emergence of digital marketplaces across almost any vertical that could benefit from additional marketplace liquidity (which is essentially every end-market, marketplace, etc.). With that said, one of the key, long-term friction points we are monitoring is our view that digital marketplaces, in some cases, will likely invite greater-than-average regulatory scrutiny for two primary reasons:

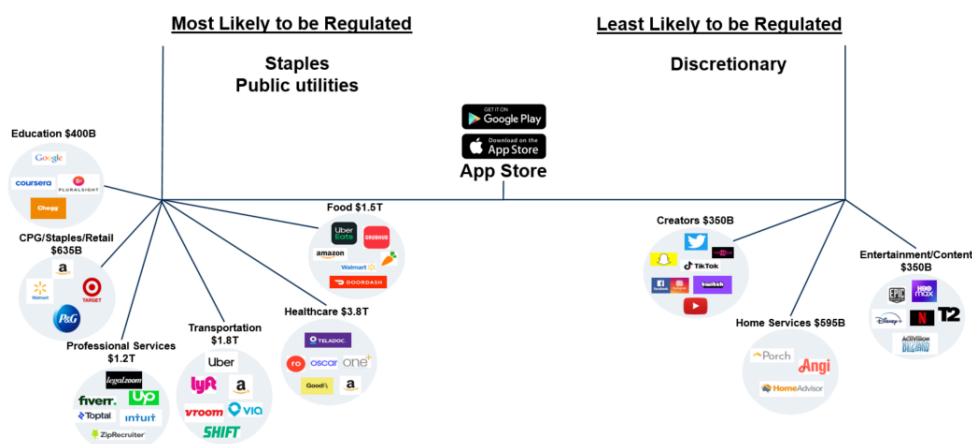
- 1) They tend, in many cases, to capture value from long-standing, legacy industries, which often perceive that value capture as unjust or even something approaching nefarious; and
- 2) Due to the inherent network effects that accompany any growing digital marketplace, market share tends to become more concentrated than legacy industries, which allows the marketplaces to extract disproportionate economics that in some cases, can challenge the underlying sustainability of the end-market’s business model or even existence.

As such, over the next decade, we believe that certain digital marketplaces could be indicted in the court of public opinion as accelerating the widening wealth gap akin to the historical bourgeoisie/proletariat socio-economic class divergence and a continuation of the same, well-known modern trend that has been visible for decades. As such, we believe regulators will likely take ongoing issue with and seek policy that aims to address the blurring of a socio-economic lines of demarcation between those that make their living from digital marketplaces and those that do not. Given the extraordinary value creation of these marketplaces since the emergence of the smartphone in 2007, and the relative marginalization of end-market earnings power as a result of this emergence, we believe this friction is only likely to increase over time.

In terms of how to assess the dynamic risks laid out above in our coverage universe, we believe the key determinant is where end-markets fall in the staples vs discretionary spectrum. The more vital an end-market is to basic society, the more likely digital marketplace’s disproportionate value capture is unlikely to be tolerated by regulators, in our view, whereas for other discretionary areas, we’d see regulator intervention as less likely.

We believe that certain digital marketplaces could be indicted in the court of public opinion as accelerating the widening wealth gap and that regulators will likely take ongoing issue with and seek policy that aims to address the blurring of a socioeconomic lines.

Exhibit 35 - We believe marketplace regulation will likely focus on Staples/Utilities/Public Goods



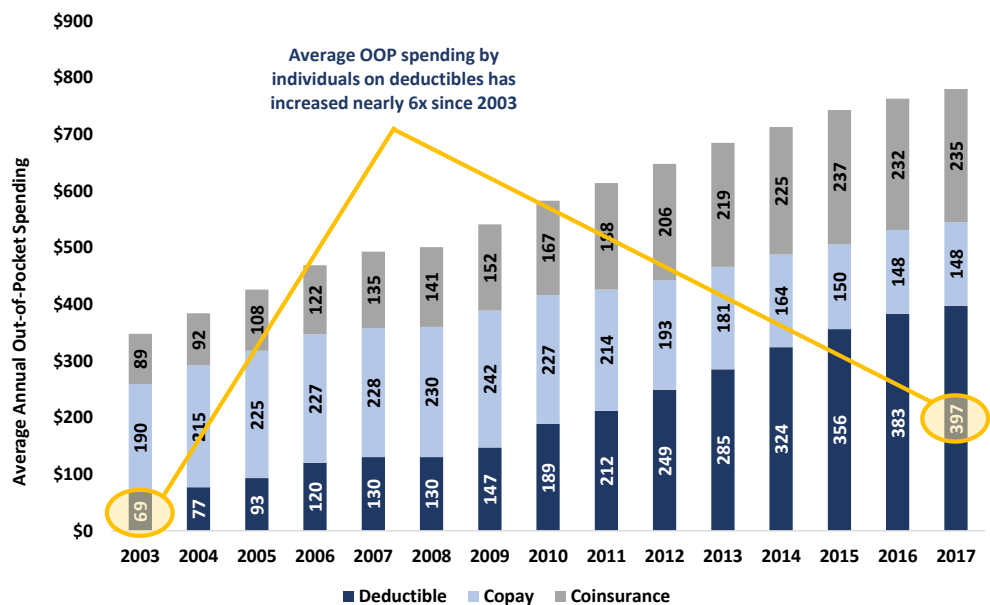
Source: Company reports, U.S. Census Bureau, UStravel.org, RBC Capital Markets estimates

Healthcare services: The rise of the U.S. healthcare consumer

Historically, individuals have been able to consume healthcare with little regard for the cost since the vast majority was covered/paid for by their insurer. Beyond the premium, individuals rarely ever had to pay anything out of their own pockets, so have never had any incentive to ration or “shop” for services. This has resulted in a system where patients consume healthcare without any economic constraint. Another unintended consequence of this includes a market that now marginalizes the consumer, since they have never really had any individual control over healthcare purchasing decisions.

Notably though, change is underway here as well – we are seeing more evidence that an increasingly empowered and incentivized consumer is beginning to emerge.

Exhibit 36 - Individual OOP spending on deductibles has increased nearly 6x since 2003



Source: Kaiser Family Foundation and RBC Capital Markets

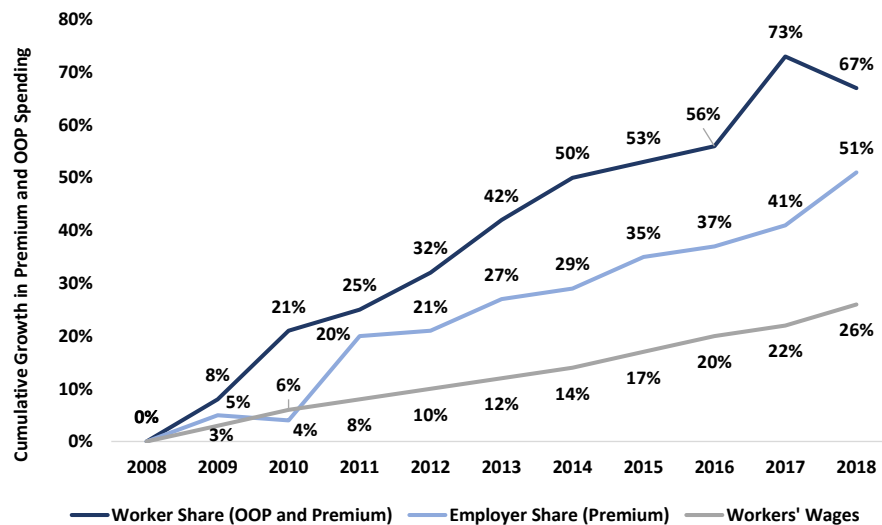
As employers have wrestled with rapidly inflating healthcare costs, they are passing an increasing share of the cost on to their employees in the form of higher premiums, deductibles and coinsurance.

As a result, there is an increasing emphasis on empowering patients and making them more active participants in achieving their own health goals.

Two forces are propelling change

There two forces that are propelling this consumerization/“retailization”: (1) as employers have wrestled with rapidly inflating healthcare costs, they are passing an increasing share of the cost on to their employees in the form of higher premiums, deductibles and coinsurance. This is helping fuel a “consumerization” of healthcare as individuals are increasingly responsible for the “first dollars” of their care via the higher deductibles—individuals now have more of a vested interest in seeking lower cost options. Along these same lines, it is also driving a “retailization” of healthcare, as a variety of cheaper and more convenient healthcare sites and services are popping up to meet this new consumer demand. And (2) there is an increasing emphasis on empowering patients and making them more active participants in achieving their own health goals. Many of the new payment models discussed above are recognizing and emphasizing the benefits of placing patients at the “center” of their own care plans.

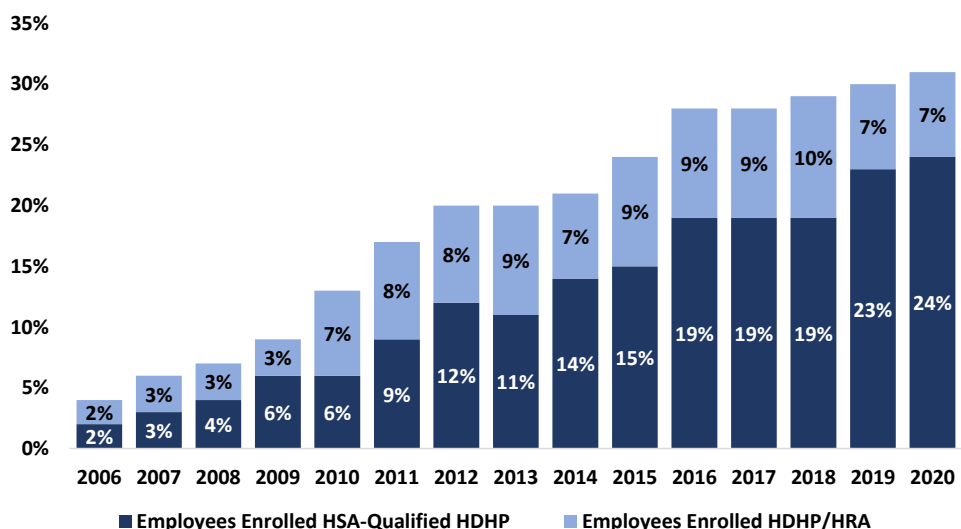
Exhibit 37 - Cumulative growth in healthcare spending for families with employer coverage



Source: Kaiser Family Foundation and RBC Capital Markets

More specifically, an increasing effort is being made to engage individuals in a manner that matches their needs, capacities and preferences. These strategies range from providing incentives to individuals who better manage their chronic diseases or choose high-value providers, to giving patients access to data and tools that enable them to better understand their conditions and treatment options (including the benefits, risks and costs of each).

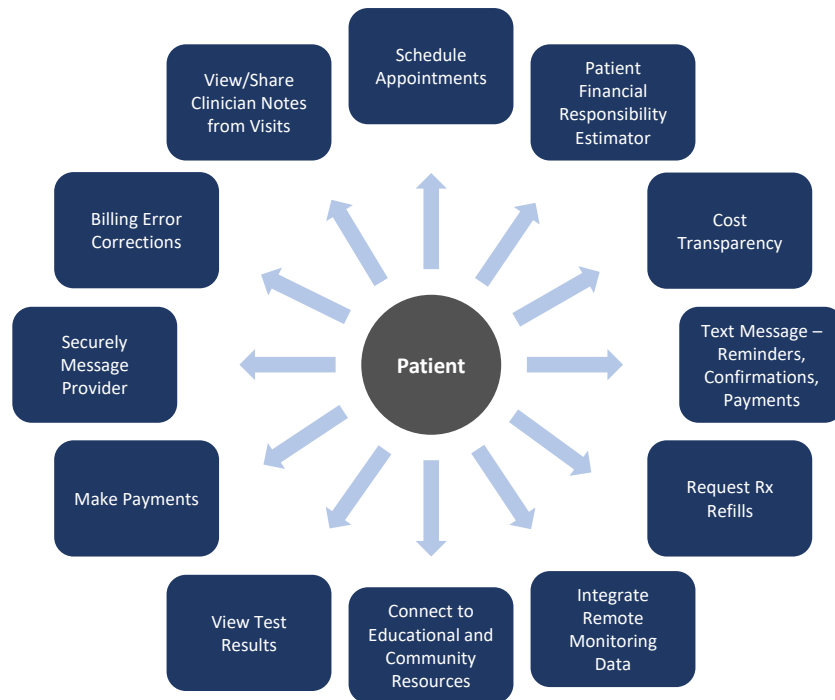
Exhibit 38 - Proportion of individuals enrolled in a HDHP continues to grow



Source: Kaiser Family Foundation and RBC Capital Markets

We expect these consumer forces to strengthen over the coming years as: (1) the number of individuals covered under alternative payment models (APMs) increases; and (2) the proportion of individuals enrolled in high-deductible health plans (HDHP) continues to grow.

Exhibit 39 - Elements of an Effective Patient Engagement solution



Source: U.S. Department of Health & Human Services and RBC Capital Markets

New capabilities needed to better serve customers

With the newly empowered consumer increasingly sitting at the center of healthcare purchasing decisions and care plans, individuals, payors and providers will all require new tools and capabilities to manage effectively in the new paradigm.

- Individuals will need solutions to help understand both the cost and quality of available treatment options, as well as tools to better manage benefits (including health savings accounts) and technologies to better manage their own health (i.e., monitoring devices, medication management, and educational material and wellness information).
- Providers will need tools to make their practices more consumer-friendly, including solutions that help patients more easily communicate with their care team, schedule appointments, transparently understand costs and make payments, and deliver relevant educational material to patients to help more effectively engage them in their own treatment plan. Providers will also benefit from tools that help them better monitor and engage their patients from afar.
- Payors will need tools to help members better understand and manage their benefits, make more-informed cost decisions and deliver pertinent educational material.

Power: The rise of resilient prosumers

A producer and consumer, or a “prosumer,” can self-supply electricity or sell it into the grid, such as those with rooftop solar panels or electric vehicles.

The significant reduction in solar PV costs and technological improvements have resulted in PV installations (and battery storage systems in some cases) in numerous homes and buildings. As a result, the traditional consumer has transitioned into a producer as well. A producer and consumer, or a “prosumer,” can self-supply electricity (also known as distributed generation) or sell it into the grid. Prosumers particularly at the commercial and industrial level can also provide demand response services (reduce energy usage) to the grid during peak periods. At the residential level, it could simply be a home with rooftop solar PV panels. At the commercial and industrial level, it could include a combination of rooftop solar PV panels (or another form of generation), a battery storage system, and a flexible load that could provide demand response services. We also see electric vehicles (essentially battery storage on wheels) potentially playing a large role in the grid as EV adoption rates increase.

Prosumers also benefit from improved energy resiliency. The increased frequency of power outages in the U.S. has challenged conventional wisdom around centralized power. Over time, we believe residential rooftop solar plus storage adoption will increase as homeowners desire greater resiliency. While the early adopters of residential rooftop solar were homeowners with excess disposable income interested in combatting climate change, as solar system costs have declined, and various government incentives as well as various financing methods (loans, PPAs, etc.) have expanded, adoption has increased among homeowners of different economic classes. We see resiliency as one of the key factors driving the next leg of adoption as homeowners become increasingly frustrated with power outages.

Number of prosumers set to accelerate

Retail and commercial prosumers have emerged over the past decade as the cost and efficiency of rooftop solar (and battery storage) systems continue to improve. In our view, there are a number of factors that support an acceleration in the growth of prosumers, including continued cost improvements for solar and battery systems, increased demand for electricity (electrification of heating and mobility), higher EV adoption, and a larger social focus to decarbonize the grid. In the near term, we believe that elevated merchant power prices over the next year further improves the economics of rooftop solar systems for prosumers.

With various tailwinds supporting the growth in prosumers, we expect prosumers to play a larger role in the electrical grid with respect to supplying power and/or the provision of demand response services. Providers of generation, metering and software applications (e.g., rooftop solar procurement companies) are well-positioned to benefit. With respect to regulated utilities, we believe that the growth in prosumers can be a threat for utilities that maintain a traditional role (generate and distribute), while offering opportunities for utilities that are flexible and revise their business model to adapt to the changing environment.

North America

Prosumers have flourished in the U.S. as there is good penetration in the residential solar rooftop segment, particularly in California. Homeowners are often able to produce power at a levelized cost (after incentives and tax credits) that is lower than the local utility's residential electricity rate, and the excess power generated during the day can be sold into the grid. The arrangement enables prosumers to green their energy consumption, improve their electricity security and reliability, and reduce overall electricity costs. Community solar has also grown in popularity in the U.S. for residents who rent, live in multi-tenant buildings or have roofs that do not support a solar system. Community solar refers to local solar facilities (typically ground-mounted) that are shared by multiple subscribers who receive credit on their electricity bills for their share of power produced. Currently, in the U.S., residential/community/commercial

solar facilities make up ~36% (39 GW) of the installed solar capacity, according to the Solar Energy Industries Association (SEIA).

According to Wood Mackenzie's Q2 2021 update, residential rooftop solar installations totaled 905 MW in 1Q21 (+11% Y/Y), which represented the largest ever first quarter installations. For 2021, Wood Mackenzie forecasts 19% year-over-year growth for residential solar. Wood Mackenzie estimates that residential solar penetration will increase from ~4% currently to ~13% in 2030. We believe the penetration level to be achievable as we note that penetration has reached ~32% in Hawaii and ~15% in California.

Europe

Prosumer numbers in Europe are fast increasing, but still from a low base. According to a report from SolarPower Europe, 90% of Europe's roof surfaces remain unused, but this is expected to change with European rooftop solar capacity expected to grow from 90 GW at present to 570 GW by 2030. SmartEn provided a prosumer map in 2020 with the current situation and prospects for prosumers in the various European countries: Germany is at the forefront of solar PV rooftop installations, but regulatory and technical barriers limit the participation of aggregation. Great Britain offers one of the largest selections of prosumer technologies in Europe and provides financial incentives together with allowing prosumers to make the best use of their assets through aggregators. France has a strong penetration in rooftop installations of over 5 GW in 2019 that according to the French NECP is going to increase by 1.2 GW annually (0.9 GW of large rooftop and 0.3 GW of small and medium rooftop capacity) up to 14.5 GW–19 GW in 2030. Nevertheless, interaction with the grid could be improved, and there are barriers to monetize flexibility. Italy shows a significant development of various technologies for consumers such as rooftop solar PV, which accounts for around half of the solar PV installations in the country. Combined heat & power (CHP) for residential customers and commercial areas and battery storage have started to show significant growth. Spanish prosumers are starting to play a more important role in the energy transition after a slow start due to the Sun tax, which has since been abolished, but further regulatory changes are still required to enable the monetization of flexibility.

Significant cost reductions drive rooftop solar adoption

According to SEIA and Wood Mackenzie, solar installation costs have decreased by ~70% over the past 10 years, with residential solar system costs declining by ~50%. SEIA notes that in 4Q20, an average size residential solar system cost ~\$20,000, pre-incentive, vs. \$40,000 in 2010. On a per watt basis, according to SEIA and Wood Mackenzie, since 2014, residential rooftop solar hardware costs have declined by ~37% (from \$1.52/watt in 2014 to \$0.96/watt in 2020) and other costs (labor, permitting, customer acquisition, overhead, etc.) have declined by ~12% (from \$2.14/watt to \$1.89/watt). While the pandemic-related shortages and supply chain issues have driven price increases in certain materials, we believe the longer-term trajectory will be continued cost reductions.

While battery costs may be high, we note on a dollar per kilowatt-hour basis, lithium ion battery costs have declined ~85% from 2010 through 2019 (from > \$1,350/kWh to < \$350/kWh). Given likely further declines in solar PV and battery costs, and potential increases of retail electricity bills, the case for an expansion in the number of prosumers is likely even without Government financial support. The economic benefit of prosumers increases with a higher percentage of self-consumption. Residential prosumers with rooftop solar PV self-consume only 30%, but this could increase up to 65–75% due to demand side response and batteries, and it could be 50%–80% for some industries. Other prosumer solutions such as demand side response might be even more appealing in countries with a high take-up of smart meters, as less investment is required to achieve the benefits. Lower electricity bills might be

Solar installation costs have decreased by ~70% over the past 10 years, with residential solar system costs declining by ~50%.

The appeals of becoming a prosumer could include lower electricity bills, greater energy independence and reliability, and renewable energy goals.

one of the main appeals of becoming a prosumer, but greater energy independence and reliability could be important factors to consider. If properly managed, this might contribute to a reduced need for large transmission lines and support renewable goals.

Power outages drive demand for resiliency

Weather-related power outages in the U.S. have increased in frequency in the past decade. According to Climate Central, in the U.S., weather-related power outages totaled 990 from 2010 through 2019, which is a 77% increase from the 558 weather-related power outages from 2000 through 2009. The Northeast saw a 159% increase in weather-related power outages (+159% from 127 in 2000–2009 to 329 in 2010–2019).

Specific storms driving significant power outages include winter storm Uri, which according to PowerOutage.us, left ~4.4 million homes without power for a period of days, and Hurricane Isaias in August of 2020 that caused power outages at ~3.8 million locations across New Jersey, New York, Connecticut and Pennsylvania. In addition, in California, utilities implemented rolling blackouts to reduce wildfire risk during the heatwave in the summer of 2020 (to avoid power lines from causing fires).

As the pandemic forced more individuals to work from home, we suspect individuals have become more acutely aware of their power needs and less tolerant of power outages, even short duration ones that can disrupt work. We have already seen increased adoption of residential rooftop solar in states with less irradiation (New Jersey) and in states that do not have net metering (Texas), which we attribute in part to resiliency demand. In addition, battery attachment rates with residential solar systems continue to grow (Sunnova battery attachment rate on origination was ~30% in 3Q21) as does backup power generator demand.

Technological improvements and public policy are supportive

Large-scale prosumers have been in place for many years, self-supplying electricity in some energy intensive industries (e.g. pulp mills, mining, and aluminum smelting). However, technological improvements, particularly in solar PV, have made it possible for power generation at a much smaller scale (e.g., residential rooftops). The evolution of smart meters, net metering, and software that can control and manage the energy consumption down to individual appliances, have made it possible for consumers to be prosumers.

Looking into the horizon, we believe other technologies that can play a significant role in the growth of prosumers include the adoption of electric vehicles (significant battery storage and energy management potential for the grid), and improvements in hydrogen electrolyzer and hydrogen fuel cell technology (which could eventually increase the number of prosumers at the commercial and industrial levels).

Another key enabler of prosumers is policy and legislation. For example, supportive net metering policies enable prosumers to sell excess power into the grid. In the U.S., federal investment tax credits (ITCs) and some state-level incentives for solar systems subsidize a significant portion of the cost of renewable energy. Finally, a growing number of countries and organizations have adopted carbon net zero targets for 2050 or sooner, which should increase the adoption of renewable energy, including rooftop solar and batteries. California's building code currently requires new construction homes to have solar PV systems, and the requirements are under consideration in additional states and regions.

Utilizing idle EVs: V2G

The next time you go to your neighborhood electric vehicle (EV) dealership, you might be buying more than just a car. Your new EV could hold more power than you need for more than

Technological improvements such as the evolution of smart meters, net metering, and software that can control and manage energy consumption have made prosumers possible.

In the future, we believe the adoption of electric vehicles and improvements in hydrogen electrolyzer and fuel cell technology could increase the number of prosumers.



When stationary, an EV battery is a small-scale energy storage system. In large numbers, EV batteries are a form of distributed energy storage resource. We imagine a future where vehicles can help manage grids and create customer savings.

The accelerated development of virtual power plants and microgrids could work alongside or displace centralized grids.

Longer term, we could see the development of the home as a microgrid.

90% of the time and you might wonder what else it could be doing other than idling in the garage. Excess power could be used to power homes, appliances, and even the electric grid. When stationary, an EV battery is a small-scale energy storage system. In large numbers (think a parking lot full of cars), EV batteries are a form of distributed energy storage resource. Technology is a challenge but does not seem to be prohibitive; utilities have conducted pilot projects that show that a fleet of electric buses can help manage grids while creating customer savings. This begs the question: when can commercialization be achieved? We think that it is unlikely to occur in the first half of this decade as EV penetration remains low in the next several years; we expect the focus for energy storage resources will in stand-alone in utility-scale systems. However, expectations for EVs to dominate new vehicle sales, more charging infrastructure, and increased data on EV usage patterns should increase traction for vehicle-to-grid (V2G) use in the latter half of the decade.

The electric grid is undergoing a fundamental transformation to accommodate higher levels of intermittent resources and necessitates more energy storage assets. Utility-scale projects will provide the baseline for bulk electric needs, but a secular shift towards more nimble microgrids create demand for decentralized assets. According to Bloomberg New Energy Finance (BNEF), the behind-the-meter battery market is growing at 30–40% annually across the globe, driven by new residential and commercial batteries. EVs now provide a convenient alternative and can be incremental to the total addressable market.

The primary benefit of V2G is the ability to lower the total cost of EV ownership. V2G services allow consumers to arbitrage power prices by selling excess power during times of shortages and charging during times when power is plentiful. An onboard battery management system will share data with the grid operator and optimize battery capacity automatically without the consumer having to exert any work. Arbitrage payments could offset the cost of EV ownership, or be counted as a rebate on utility bills for providing capacity to the grid. In the future, the consumer could also participate in ancillary services for the grid with the proper compensation, assuming regulators implement the right market pricing mechanisms.

Rethinking power distribution

While most consumers currently receive most of their power supply from a centralized grid, resiliency demand could drive a fundamental shift in power distribution. We see two potential outcomes. First, the accelerated development of virtual power plants and microgrids could work alongside or displace centralized grids. Second, longer term we could see the development of the home as a microgrid.

A virtual power plant aggregates the capacities from different distributed energy resources (residential rooftop solar and batteries, solar farms, wind farms, etc.) into a network that can dispatch power. Virtual power plants connect to the grid, generally target wholesale markets and have aggregation software that functions similarly to a traditional power plant. In September 2020, the U.S. Federal Energy Regulatory Commission (FERC) Order 2222 removed barriers that prevented distributed energy resources, such as rooftop solar, from participating in power capacity auctions and that distributed energy resources can participate through aggregation to satisfy minimum sizes and performance requirements. Companies such as Sunrun and Sunnova have secured contracts to deliver power from their aggregated systems. As residential battery storage penetration increases, we expect growth in virtual power plants.

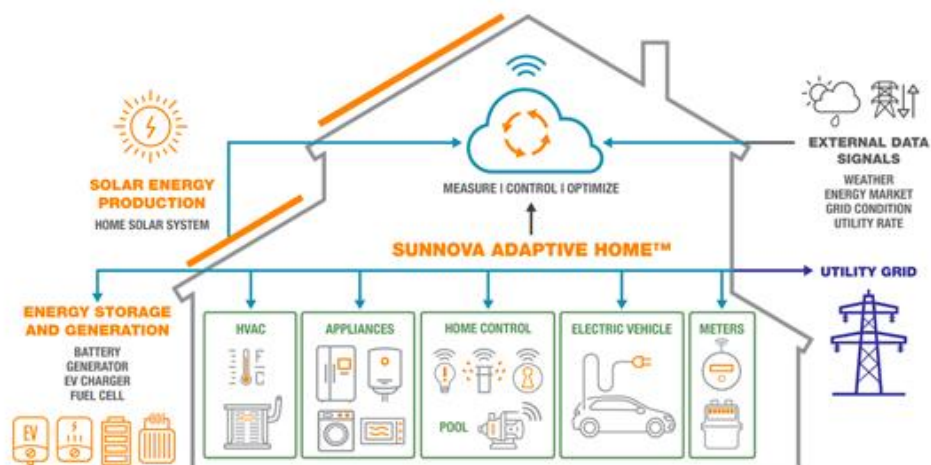
A microgrid is an energy system with control technology that covers a certain geographic footprint (such as a housing community), which may or may not connect to a centralized grid. If connected to a centralized grid, microgrids can be “islanded” and continue to work in the event of a disruption in the centralized grid. The microgrid would provide electricity through the aggregation of solar power from rooftop panels and battery storage within the community,

and the community could have a rate plan under the microgrid. Microgrids currently exist in the U.S. including college campuses, medical centers and communities.

Currently, in the U.S., homes connect into the grid, even if homeowners have installed rooftop solar panels. Longer term, with continued improvements in technology and ongoing cost reductions, we believe homeowners could in theory completely move off the grid and resiliently power their homes. The combination of micro-inverters that can provide backup power without a battery, the proliferation of lower-cost battery storage, EVs with bi-directional inverters (can provide power to the home), traditional backup power generators and smart appliances that can self-regulate power needs could technically convert the home into a microgrid.

In practice, we see several challenges to the home as a microgrid under the current utility regulatory environment. Some homes, given their location, may not be suited for solar power. If more homes move off the grid, then utilities would have fewer homes over which to spread utility costs. That said, over time, we suspect centralized and distributed energy resources can work together to more efficiently and resiliently provide power.

Exhibit 40 - Sunnova Adaptive Home vision – integrates solar/storage/EV/energy control



Source: Sunnova Company reports

We believe utilities might offer customers self-consumption or demand side response solutions in which ownership structures of the self-generation installations differ between the utilities and customers, with utilities even providing financing of some installations.

Utilities need to be flexible

Traditional utilities need to adapt to this new world of increasing prosumer numbers and new business models. If the definition of a traditional utility is to generate, distribute and supply energy, sales of these activities are likely going to fall, but new businesses are starting to emerge. We believe utilities might offer customers self-consumption or demand side response solutions in which ownership structures of the self-generation installations differ between the utilities and customers, with utilities even providing financing of some installations. In these scenarios, the capital structures of the utilities will differ and we believe successful utilities will need to be increasingly flexible in the future. The European Electricity Federation (Eurelectric) has called for and sees the removal of barriers to prosumers as a possible business opportunity such as forecasting, balancing, backup or aggregation to prosumers. Eurelectric also wants to expose prosumers to market signals.

The adoption of EVs and the electrification of the transportation sector can be positive for utilities. Higher levels of grid usage, more infrastructure spending opportunities, and the

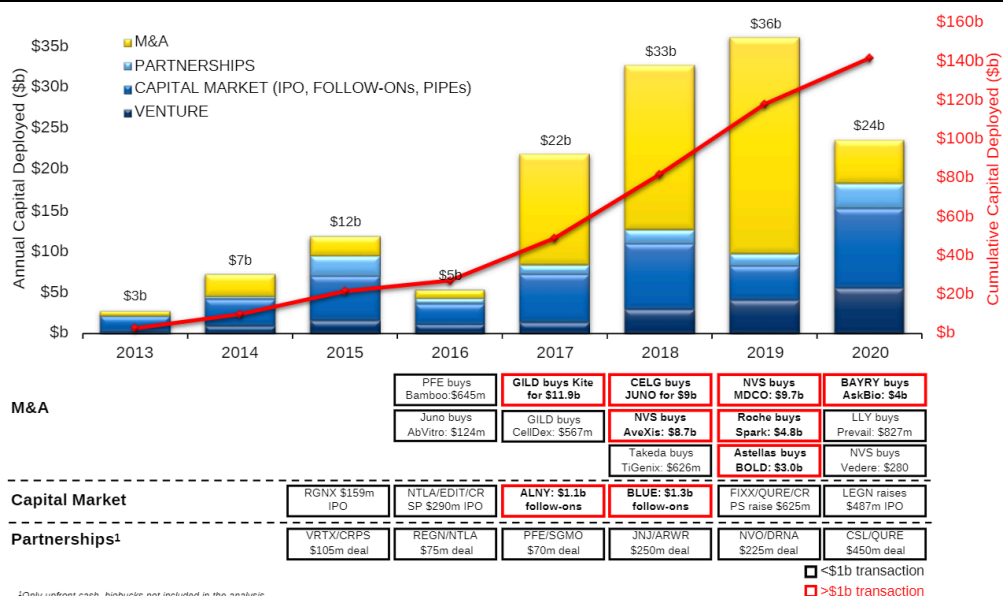


acceleration of decarbonization will encourage utilities to try to incorporate more V2G usage. The greatest opportunities could come from transmission and distribution upgrades, especially if more fast-charging stations necessitate higher voltage distribution lines.

Genetic medicine: The next frontier of personalized therapeutics

As the Individual Revolution plays out over the years to come, it arguably does not get more personal than our very own, unique genetic makeup. Genetic defects leading to diseases do happen. There are an estimated 5,000–8,000 monogenic diseases (conditions that arise from a single gene) and many more that are polygenic (conditions arising from multiple genes). The good news is that we have a growing medicinal toolbox to tackle these diseases and the capital is just pouring in. We estimate ~\$150B deployed over the last few years across venture, equity market, partnerships and M&A (Exhibit 41).

Exhibit 41 - Capital deployed to genetic medicine companies



Source: Companies 10K/Q And Alliance For Regenerative Medicine (ARM), RBC Capital Markets estimates

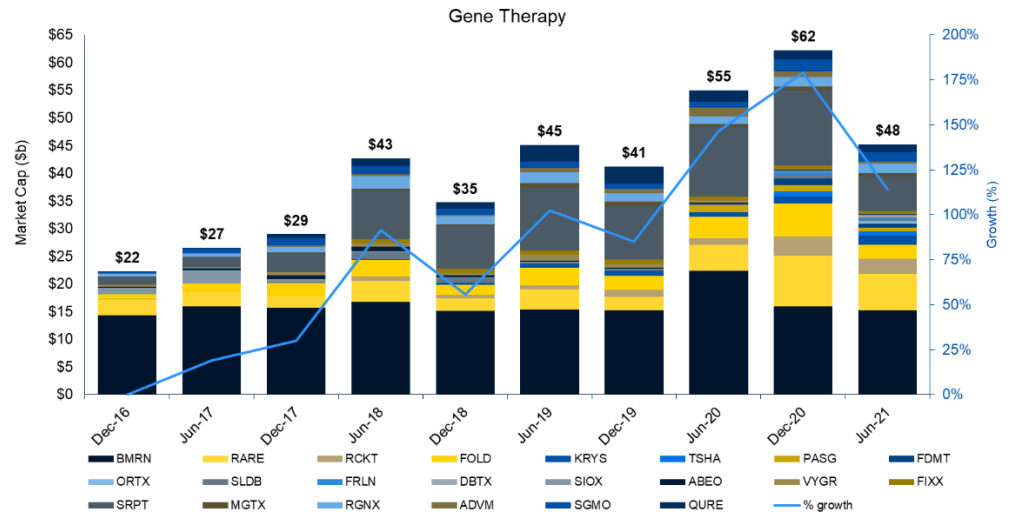
We believe that genetic medicine will tackle most genetic diseases in the not too distant future given we now have ways to dial-down gene issues, add genes, remove genes, or correct genes.

This influx of capital, combined with some critical scientific breakthroughs, has led to the approval of multiple genetic medicines (like Spinraza, Zolgensma, Kymriah and Onpatro) that are changing the lives of patients worldwide. We think this could be just the tip of the iceberg given that there are more than 1,000 clinical trials underway, preclinical companies are raising record-breaking capital and multiple academic labs are working on the latest iteration of the technology. Importantly, while the first few drugs were approved for rare diseases (such as spinal muscular atrophy, inherited retinal diseases, familial hypertriglyceridemia), the CDC has now approved two COVID-19 vaccines (mRNA based) in the U.S., and multiple drugs in late-stage development for more prevalent diseases in cardiology, neurology, oncology and autoimmunity. Overall, we believe that genetic medicine will tackle most genetic diseases in the not too distant future given we now have ways to dial-down gene issues (RNAi/ASOs), add genes (gene therapy, mRNA), remove (gene editing) or correct (base editing) genes. The mRNA vaccines for COVID-19 are probably the epitome of what genetic medicine can do for both humanity ([a recent study from Yale](#) suggest the vaccine has saved 279,000 lives and 1.25 million from hospitalization) and shareholders (Pfizer and Moderna combined revenues for the year are estimated at \$50B+).

We see four general categories within genetic medicine: gene therapy, RNAi/ASO, cell therapy and gene editing. Gene therapy is the ability to deliver genes in patients with genetic defects, RNAi/ASO is the ability to turn off the expression of genes, cell therapy uses cells (most often

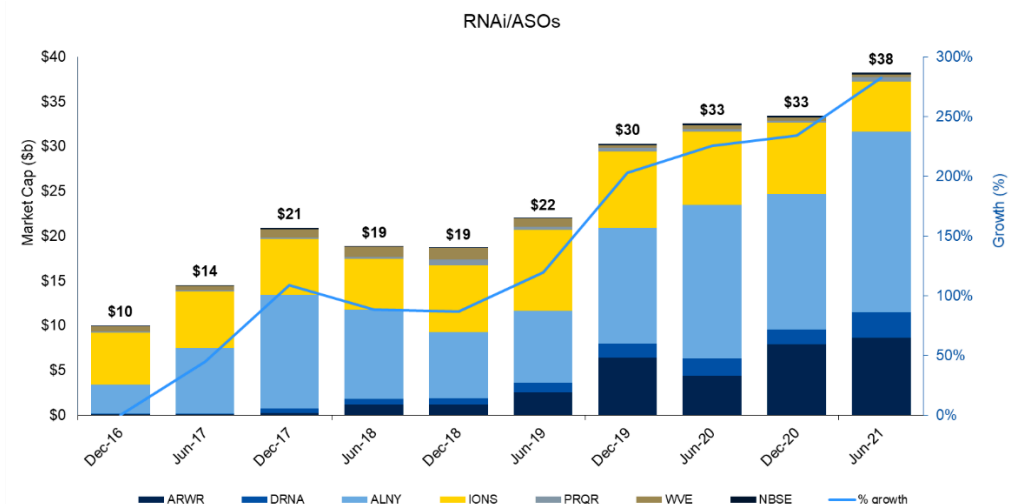
manipulated in the lab) as a therapeutic and gene editing is the ability to edit the molecular code of life (either DNA or RNA). The graphs below represent the value that the leading public companies in each category have unlocked over the last five years. Numbers are impressive with gene therapy moving from \$22B in cumulative market cap to \$48B (Exhibit 42), RNAi/ASO from \$10B to \$38B (Exhibit 43), cell therapy from \$3B to \$31B (Exhibit 44) and gene editing from \$2B to \$40B (Exhibit 45).

Exhibit 42 - Gene therapy market growth



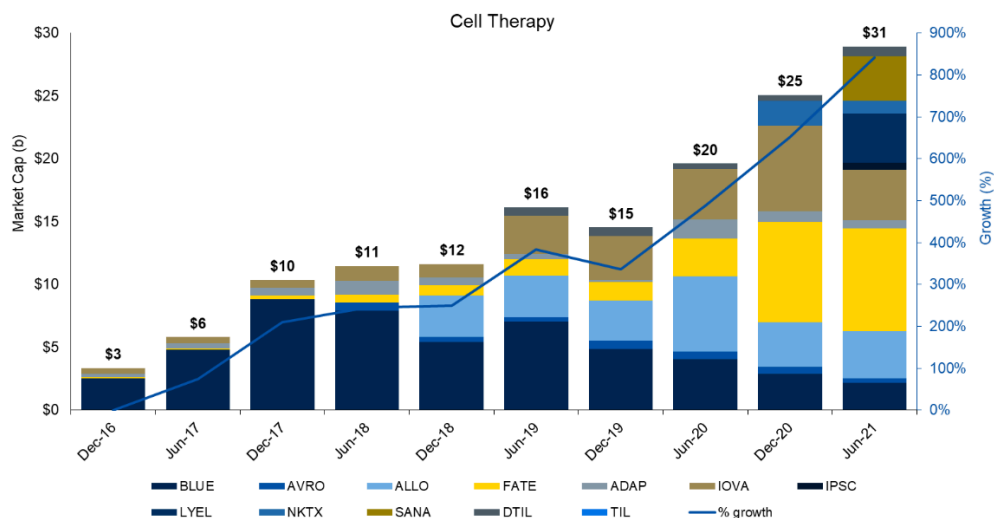
Source: FactSet, RBC Capital Markets

Exhibit 43 - RNAi/ASO market growth



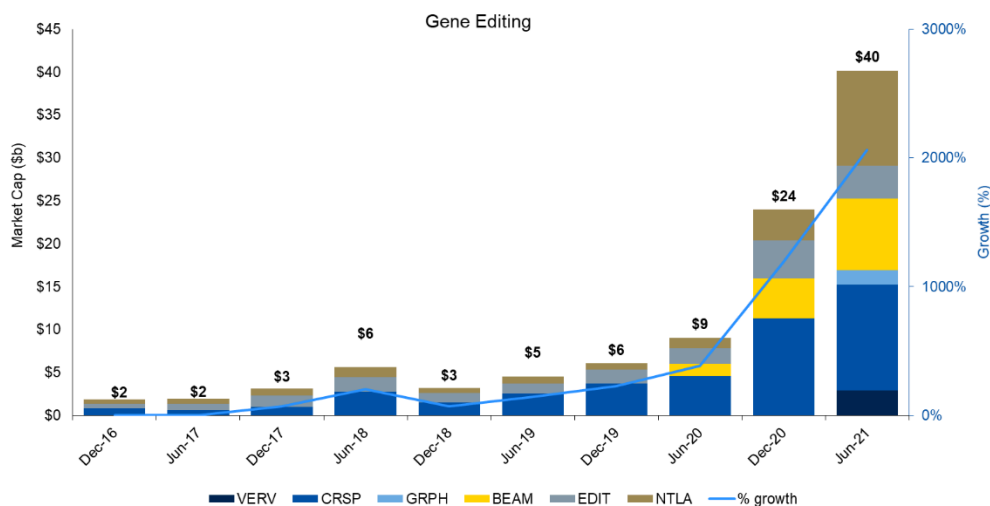
Source: FactSet, RBC Capital Markets

Exhibit 44 - Cell therapy market growth



Source: FactSet, RBC Capital Markets

Exhibit 45 - Gene editing market growth



Source: FactSet, RBC Capital Markets

Despite all the success, innovation has not been a straight line and investors need to weigh the promise of these breakthroughs against potential safety and regulatory risks.

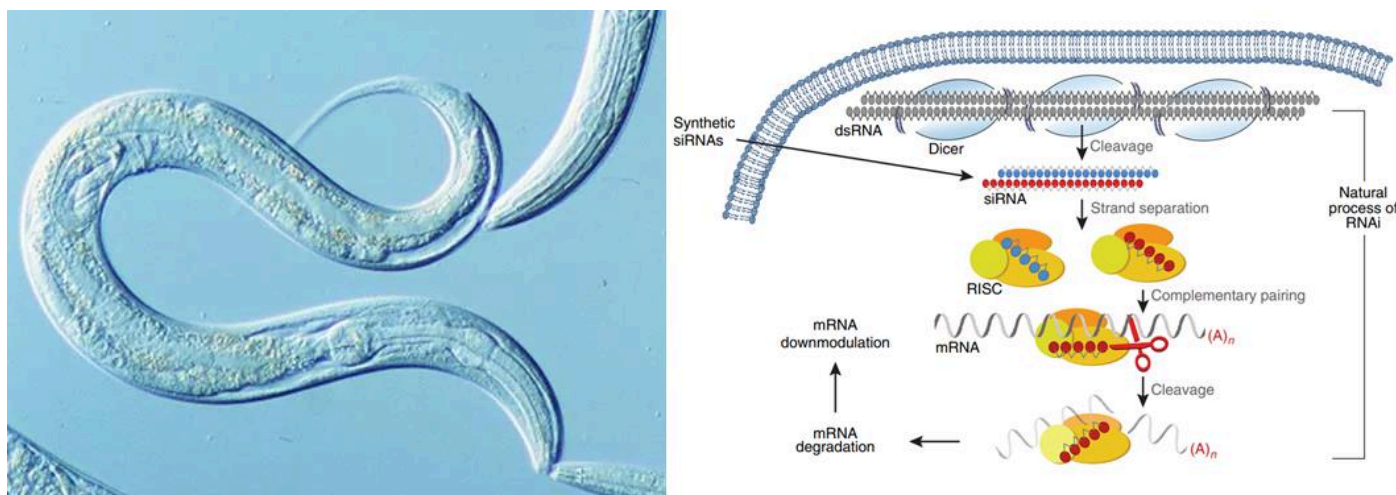
We now have multiple drugs approved in each of the categories including RNAi (Alnylam has four commercial products, IONS has three), cell therapies (Yescarta, Kymriah, Abecma, Breyanzi), and gene therapy (Luxturna and Zolgensma). There are no approved drugs yet for gene editing but we believe Intellia Therapeutics has shown over the summer a clinical signal in TTR-polyneuropathy that is likely to translate into an approvable drug.

Despite all the success, innovation has not been a straight line and investors need to weigh the promise of these breakthroughs against potential safety and regulatory risks. We review here where the four key categories within genetic medicine are in the innovation cycle and where we think they will go from here.

RNAi – From turning off genes in worms, to a \$40B market making an impact for patients

RNAi was first discovered in *C. elegans* (tiny transparent worms about 1 mm in length that live in the soil). Craig Mello (University of Massachusetts) and Andrew Fire (Carnegie Institution of Washington) discovered that small pieces of RNA can be used to prevent mRNA translation, effectively turning off the expression of individual genes in these worms (Exhibit 46). The work started in 1998 and the two professors won the Nobel Prize in 2006. In a 20-plus year journey with plenty of ups and downs, that foundational discovery in worms has now lead to a \$40B market and the approval of multiple drugs. We think the technology is now refined, safe and effective and the \$40B market could just be the tip of the iceberg as the approach will now be used for much larger indications and possibly for new tissues beyond the liver.

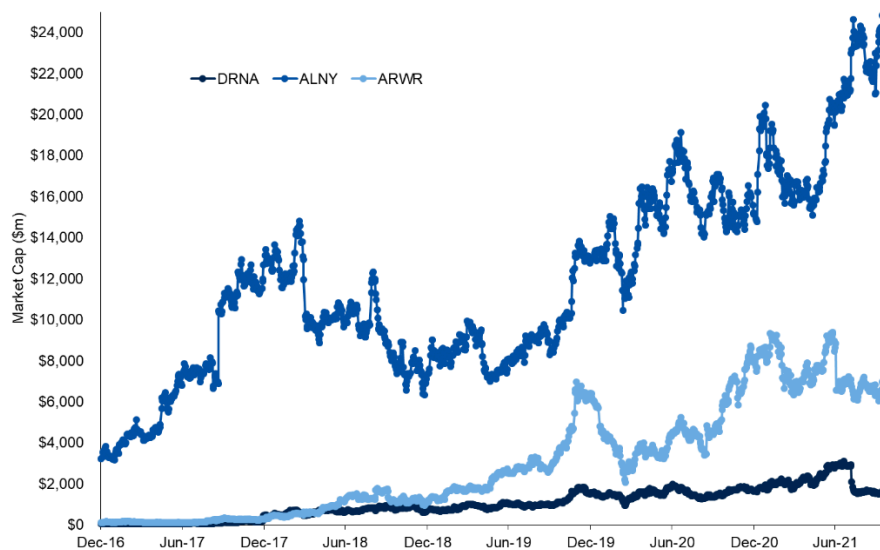
Exhibit 46 - RNAi mechanism of action



Source: Bumcrot, D., et al. 2006, Nat. Chem. Biol., Society for Mucosal Immunology

After the pioneering work in *C. elegans* by Mello and Fire, funding started to pour in after Mark Kay at Stanford University demonstrated that the molecular trick could also be replicated to turn off genes in mice. VC-backed Biotechs were quickly formed, and upon early proof-of-concept in eye or lung, Pharma started to either collaborate with them or buy them outright. By the late 2000s, TAK and RHHBY had \$1–2B deals with Alnylam, Novartis took a 20% equity stake in Alnylam, Merck bought Sirna Therapeutics for \$1.1B in cash and Abbott and Pfizer had independent, early programs in development. However, by the early 2010s, things quickly soured. Delivery became an issue as disguising the molecule from the human immune system/enzymatic degradation became difficult. By the mid-2010s, Merck gave up on Sirna and sold it to Alnylam at a \$925M loss (\$175M). Alnylam went through two rounds of layoffs and was struggling to rationalize why there was a mortality imbalance in its molecule revusiran (13% vs 3% for placebo), Arrowhead cut its workforce by 30% after discontinuing its lead program for Hepatitis-B (NHP data showed increased mortality) and DRNA traded at cash after its early program for oncology was discontinued (MYC-1). Most investors gave up on the space, but the few that did not, have been handsomely rewarded. Since January 2017: Alnylam unlocked ~\$22B in value and is up ~7x, ARWR unlocked ~\$7B in value and is up ~59x and Dicerna unlocked \$1.5B in value and is up ~27x (Exhibit 47).

Exhibit 47 - Market growth Of RNAi leaders Alnylam Pharmaceuticals, Inc., Arrowhead Pharmaceuticals Inc., and Dicerna Pharmaceuticals Inc.



Source: FactSet, RBC Capital Markets

So how did the field turn the story around? Well, chemistry is the answer. Companies developed chemical modification that allowed siRNA to be more stable to enzymatic degradation, less recognizable by the immune system and more targeted to the liver via LNPs. ALNY got the first molecule over the finish line (Onpattro) for TTR-polyneuropathy and all companies are now moving to an even better delivery system called GalNAc. In contrast with LNPs, which require IV administration, GalNAc can be administered subQ, is easier to manufacture and has a broader therapeutic index. ALNY has three additional drugs approved in the U.S./EU using GalNAc (Givlaari for acute hepatic porphyria, Oxlumo for primary hyperoxaluria and Leqvio for hypercholesterolemia) and the company now has visibility to cash flow profitability, despite trading at cash not too long ago.

We think RNA technology is now refined, safe and effective and the \$40B market could just be the tip of the iceberg as the approach will now be used for much larger indications and possibly for new tissues beyond the liver.

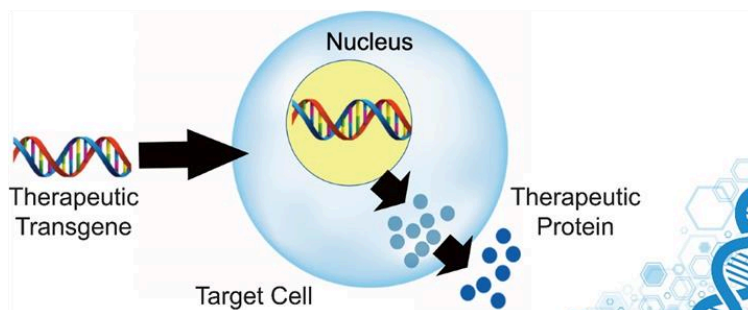
Overall, we believe that this could be just the tip of the iceberg as we see several molecules from companies in the space poised to garner approval in other indications for cardio metabolic diseases (cardiomyopathy, hypertriglyceridemia, hypercholesterolemia, hypertension, NASH, Lpa), genetic diseases (alpha-1 antitrypsin, hemophilia) and infectious diseases (Hepatitis B). Importantly, we think these indications have a relatively high probability of success given they are all targeting the liver and use an established platform like GalNAc. A testament to the promise is that Pharma is back with Eli Lilly, Novo Resources Corp., Regeneron Pharmaceuticals, Amgen Inc., and Johnson & Johnson, and Boehringer Ingelheim all signing deals with siRNA companies.

Barring any unforeseen circumstances, we think the field of siRNA will continue to grow as indications going after liver targets are fairly de-risked at this point and we could be looking at a totally different field should companies be able to deliver siRNA to tissue beyond liver like CNS, lung, muscle or kidney.

In vivo gene therapy: Tough few months with multiple setbacks, but innovation continues to make progress

In vivo gene therapy delivers a missing gene through the use of a viral vector directly to the patient, which is subsequently able to transfect the patient's cells and begin producing the missing protein (Exhibit 48).

Exhibit 48 - In vivo gene therapy



Source: Gene Therapy in Hemophilia, ISTH.org

Two gene therapies have been approved by the FDA, RHHBY's Luxturna for RPE65 (an inherited form of blindness) and NVS/RGNX's Zolgensma for SMA (a genetic neuromuscular disease). Both therapies are making an impact for patients, with Luxturna's treated patients gaining enough vision to navigate a maze-like course, and Zolgensma-treated babies (otherwise dying/permanent ventilation within two years of age) achieving key motor function milestones (including sitting) and extended survival.

Despite all the enthusiasm and the recent approvals, safety and durability have been an issue. On safety, the dark days of Jesse Gelsinger (one of the first patients treated with a gene therapy who died in a clinical trial, UPenn/Nation Children ultimately agreed to settle for \$1M+ with the DOJ) were thought to be behind us with new knowledge about viral vectors, but multiple setbacks have been reported in the recent months nonetheless. Among the most prominent, we note: 1) four deaths due to liver toxicity in the Audentes/Astellas trials for X-linked myotubular myopathy, 2) complement activation in the SLDB's trial for Duchenne's muscular dystrophy, 3) MRI abnormalities in the VYGR/NBIX's Parkinson's disease trial post intracerebral injection, and 4) dorsal root ganglion inflammation in primates for NVS/RGNX's Zolgensma. On durability, it has been undeniably shorter than originally hoped and the FDA has requested longer follow-up to both BMRN and QURE for two different types of hemophilia. These setbacks, combined with some manufacturing issues have led to a string of clinical holds, complete response letters and delays. Overall, we estimate that these setbacks have pulled back the cumulative market cap in gene therapy by ~\$15B YTD.

However, VC funding continues to fuel the pipeline of private companies and with 2,600 gene therapy trials currently ongoing, we think the field could be today where RNAi was in 2015 or so. We actually think this is a great time to look into gene therapy with much of the hype removed, but innovation continuing to make steady progress in a wide variety of rare diseases (hemophilia, Duchenne, Fabry, Dannon, Huntington's, PKU, MPS, etc.), and prevalent indications for the eye (macular degeneration/diabetic retinopathy), heart (cardiomyopathy) and CNS (Alzheimer's). Going forward, we think the combination of new vectors, new prophylactic regimens and more rational indication prioritization focused on local delivery for diseases with high unmet need will create value for patients and shareholders.

We think now is a great time to look into gene therapy with much of the hype removed, but innovation continuing to make steady progress in a wide variety of rare diseases and prevalent indications for the eye, heart and CNS.

Cell therapies are the most personalized out of any of the genetic medicines since they typically are created by taking a patient's own cells, modifying them outside of the body (a.k.a. ex vivo) and re-infusing them back to the patient.

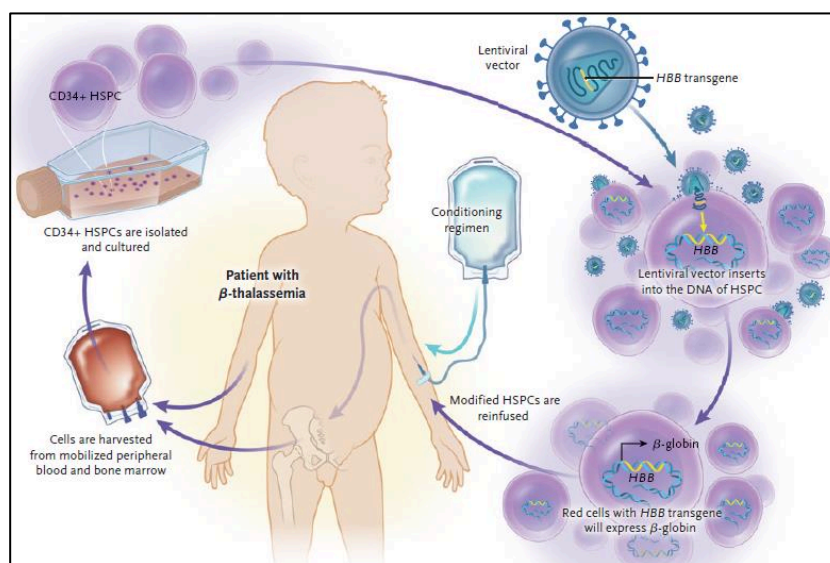
To improve durability, we think new viral vectors are key. Next-generation AAV vectors are driving higher expression ([link](#)) and alternative tissue tropism (current vectors have strong affinity for the liver). AAV will continue to transduce genes episomally, but higher expression levels will extend durability (starting at a higher level should help mitigate any waning activity over time). On alternative tropism, being able to reach tissues outside of the liver (heart [link](#), peripheral nervous system [link](#), bone marrow, [link](#)) would materially broaden the potential indications which can be treated by gene therapy.

On safety, many current approaches exclude patients with an immune system primed to attack the viral vector, and include prophylactic steroid regimens to limit immune responses. One step further could include the use of B-cell depletion agents like rituximab. In gene therapy studies where patients received rituximab as an add-on to steroids, the immune response was greatly attenuated ([link](#)). In addition to safety, prophylactic B-cell depletion may allow re-dosing, something not doable today. This method has not been widely explored in clinical trials yet, but we think could gain traction in the next few years as it is a clever solution to both safety and re-dosing.

Ex vivo gene therapies – A highly personalized gene therapy approach for rare disease

Cell therapies are the most personalized out of any of the genetic medicines since they typically are created by taking a patient's own cells, modifying them outside of the body (a.k.a. ex vivo) and re-infusing them back to the patient (Exhibit 49). Other types of cell therapies which use a patient's stem cells are in development for a wide range of rare, genetic diseases (bluebird bio Inc.'s Zynteglo for beta-thalassemia is already approved in the EU with pending approval for sickle cell disease, AvroBio's Fabry disease program is currently in Phase I/II). Much like gene therapy, this type of cell therapy is also gene-additive, and since the therapy derives from a patient's own stem cells that engraft in the bone marrow, they may have longer lasting effects vs AAV-based *in vivo* gene therapies, but limitations related to safety and toxic pre-conditioning regimens are areas in need of improvement.

Exhibit 49 - Ex vivo gene therapy



Source: High, K., et al. 2019. NEJM.

Going forward, we think the use of less-toxic and more precise antibody-based pre-conditioning regimens will help to make ex vivo cell therapies more appealing to patients and physicians.

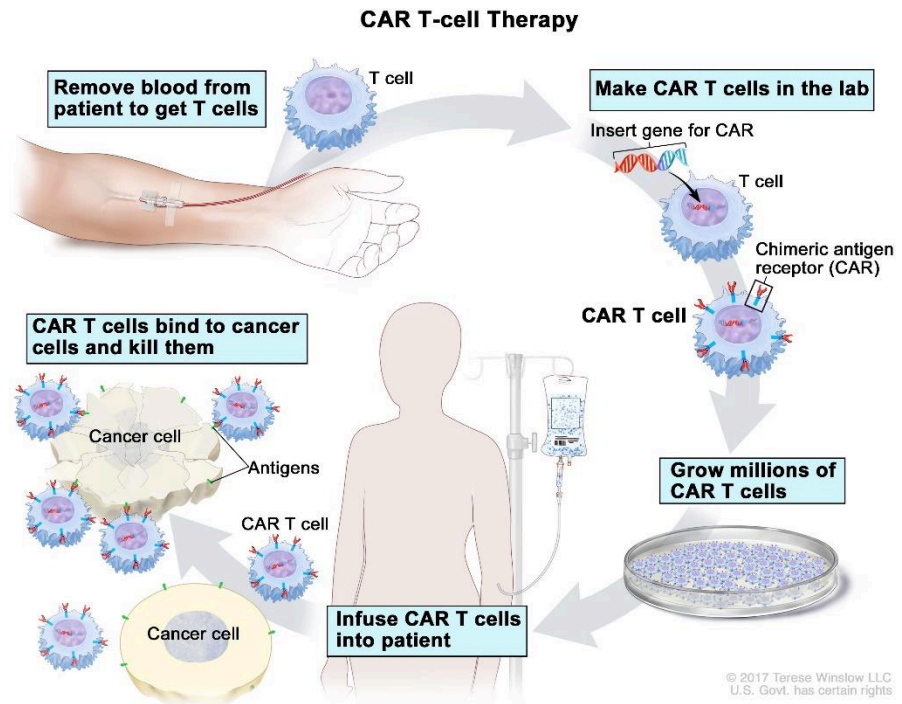
To expand the field, *ex vivo* hematopoietic stem cell therapies will need to include less toxic preconditioning regimens

The biggest limitation of *ex vivo* cell therapies for genetic diseases is the pre-conditioning regimen the patients must endure before receiving the treatment. The benefit of these cell therapies is potentially lifelong since they use patient-derived stem cells, add in the missing gene, and reinfuse the cells back into the same patient where they will engraft into the bone marrow and continually produce the new protein. For the bone marrow engraftment to succeed, the old bone marrow must be removed with the pre-conditioning agent busulfan. Busulfan is a non-specific alkylating agent which can break or cross-link strands of DNA causing a wide range of side effects including: 1) risk of severe infection (the patient's immune system is ablated during treatment), 2) infertility, and 3) increased cancer risk in some patient populations (bluebird bio reported 2 cases of AML/MDS in sickle cell patients after receiving Zynteglo). Going forward, we think the use of less-toxic and more precise antibody-based pre-conditioning regimens will help to make *ex vivo* cell therapies more appealing to patients and physicians. Magenta Therapeutics, Jasper Therapeutics, and Forty Seven (acquired by Gilead in 2020 for \$4.9B) all have conditioning agents in development that target receptors specific to hematopoietic stem cells in order to clear them from the bone marrow. The enhanced specificity of a monoclonal antibody approach vs a non-specific small molecule approach like busulfan, could help to limit any off-target effects. These programs are early in development, but we think highly specific antibody conditioning agents will eventually replace toxic busulfan for *ex vivo* cell therapies.

CAR T-cell therapies – A patient-centric approach to blood cancers

Autologous (or obtained from the same individual) CARTs (chimeric antigen receptor T-cell) are derived from a patient's T-cells and modified in order to form a highly specified attack on certain forms of blood cancers (Exhibit 50). Currently, there are five CARTs that are FDA approved (Gilead's Yescarta & Tecartus, Novartis AG's Kymriah, Bristol-Myers Squibb's Breyanzi, Bristol-Myers/bluebird bio's Abecma), all for specific forms of blood cancers (Non-Hodgkin's Lymphoma, acute lymphocytic leukemia, mantle cell lymphoma, and multiple myeloma). Thus far, cell-derived therapeutics have shown some pretty impressive results in relapsed/refractory cancer patients with few remaining options (Yescarta has a 72%/51% overall response/complete response rate in relapsed/refractory LBCL patients, and Abecma has a 72% response rate in patients with relapsed/refractory multiple myeloma).

Exhibit 50 - CAR T-cell therapy



Source: NCI, cancer.gov

Future of CART is allogeneic – One donor, many patients

Autologous CART (same patient-derived) therapies for oncology have been shown to be very effective, however they come with limitations, including safety (severe immune responses called cytokine release syndrome are common) and complex logistics (cells need to be taken from the patient, flown to a facility to modify the cells, and then flown back to be reinfused to the patient). This has spurred the need for an off-the-shelf alternative known as allogeneic CART. Allogeneic CART programs aim to derive T-cells from a healthy donor, which are modified to not only attack tumors, but also limit the risk of graft-vs-host disease when they are given to sick patients. Since the cells are donor derived, this limits the complex logistics and potential manufacturing failure associated with patient-derived CART, and allows for potential re-dosing. Allogeneic approaches are now possible to explore since the donor-derived T-cells can be modified with gene editing approaches so that the risk graft-versus-host disease is almost eliminated.

Several companies have allogeneic approaches in development (Allogene Therapeutics, Crispr Therapeutics, Intellia Therapeutics, Caribou Biosciences, Beam Therapeutics), and have shown some promising early results on safety (Allogene and Crispr both reported fewer rates of severe Cytokine Release Syndrome than autologous), efficacy (Allogene and Crispr both reported efficacy data within same range as autologous), and the benefits of redosing (Allogene and Crispr have both seen improved efficacy with two doses). Allogeneic programs are still early in development and have faced some recent challenges (ALLO's clinical programs are on a clinical hold after a chromosomal abnormality was found in the CART cells of one follicular lymphoma patient, and CRSP response rates do not appear to be as durable as most other autologous CARTs), but we think these issues can be overcome with time and allogeneic will become the preferred cell therapy for blood cancers as the whole field is moving in this direction.

CRISPR is such an exciting innovation due to its high level of on-target specificity, high level of editing efficiency, and versatility to be used both ex vivo or in vivo, or as a gene reduction, gene correction, or gene insertion approach.

Gene editing excitement has been brewing in 2021, but where do we go from here?

Gene editing refers to any molecular biology tools that are able to permanently knock out, correct, or insert a gene at a highly specified area of the genome (Exhibit 51). Gene editing tools such as TALENs (Allogene), and Zinc-Finger Nucleases (Sangamo Therapeutics), have been around for some time, but it was the discovery of the CRISPR/Cas9 system by Jennifer Doudna and Emmanuelle Charpentier (who ultimately were awarded the Nobel Prize in 2020 for their discovery) which has truly revolutionized the field. CRISPR is so exciting due to its high level of on-target specificity, high level of editing efficiency, and versatility to be used both *ex vivo* or *in vivo*, or as a gene reduction, gene correction, or gene insertion approach. As a result of the Nobel Prize win, media attention, interest from some high-profile investors, and promising early clinical data from Crispr and Intellia Therapeutics, CRISPR-based biotechs have attracted significant attention recently. Clinical data has really fueled the value of these programs. For instance: 1) Crispr demonstrated CRISPR can work in an *ex vivo* approach to treat sickle cell disease/beta-thalassemia (program spurred an additional \$900M investment for an extra 10% ownership from partner Vertex in 2021), and 2) Intellia reported game changing initial results that showed CRISPR components can be delivered *in vivo* by a lipid nanoparticle to safely and effectively lower levels of abnormal TTR protein better than current therapies (data from six patients resulted in an initial stock price increase of 50%, plus a substantial over-subscribed follow-on offering of \$690M). Overall, 2021 has been an unforgettable year so far for CRISPR-based gene editing.

Exhibit 51 - Gene editing stands as a core healthcare theme of the Individual Revolution



Source: Burgio, G., 2019. BioTechniques

Where does CRISPR go from here? Time for base editing to drop

Crispr and Intellia's initial clinical programs both rely on the first generation CRISPR/Cas9 system. CRISPR 1.0 is excellent at knocking out genes, but it is unable to perform gene-correction where one mutant nucleotide is changed for the correct base pair. Thus, in order to benefit patients who have single disease causing mutations (sickle cell disease, A1AT, etc.), a more precise approach – base editing – is needed. Base editing is being pioneered by Beam Therapeutics, Intellia, and Verve Therapeutics, and offers several advantages: 1) it can swap-out single nucleotides in a highly precise manner (A to G or C to T transitions), 2) it is versatile

and can be used for gene knockouts or gene correction, both *ex vivo* or *in vivo*, 3) it avoids double stranded breaks in DNA which could limit potential off-target edits or genetic translocations (gene traveling from one area of the genome to another), and 4) it can be used for multiplex editing (multiple edits simultaneously) to make highly specialized CARTs for blood cancers and potentially solid tumors. There are no base editing programs in the clinic yet, but we think this approach will drive the future of gene editing due to its increased level of specificity and versatility.

Genetic medicines are in their infancy with rare diseases, but will transition to more common indications as the field grows

Considering the very first commercialized medicine, Aspirin, a small molecule derived from the bark of the willow tree, was first made available to the mass market in 1915 ([link](#)), the field of drug development has made almost unbelievable advances in a relatively short period of human history. In just over a century, we have gone from relying on non-specific, plant-based derivatives with limited knowledge as to how they worked as our main source of medications, to a wide range of therapeutic modalities with increasing levels of specificity and personalization, including: monoclonal antibodies, bispecifics, antibody-drug conjugates, RNAi/ASOs, mRNA, gene therapies, cell therapies and gene editing.

Genetic medicines are still in their infancy (first ASO ever approved was Novartis/ Ionis Pharmaceuticals' Vitravene in 1998, first gene therapy ever commercialized was Gendicine in China in 2003, first CART ever approved was Novartis' Kymriah in 2017, Roche's Luxturna was the first gene therapy ever approved by the FDA in 2017, and the first RNAi approved was Alnylam Pharmaceuticals' Onpattro in 2018), and are mainly focused on rare diseases. However, as the field understands more about how best to use these molecular tools, and improves upon their safety and efficacy, the future of these treatments will be for more common indications.

We have already seen the use of genetic medicines in the larger population with the mRNA based COVID-19 vaccines from Moderna and Pfizer/ BioNTech SE, and recent reports from Pfizer suggest that an mRNA-based flu vaccine is also in development, which could mean even more mRNA will make its way into people's arms across the world. Other common cardiovascular indications like high blood pressure (Ionis Pharmaceuticals and Alnylam Pharmaceuticals both have programs in the clinic), high cholesterol (Novartis/ Alnylam have an RNAi therapeutic, Leqvio targeting PCSK9 which is EMA-approved/pending FDA approval), and dyslipidemia/hypertriglyceridemia (Arrowhead/IONS both have multiple RNAi/ASO based programs) are all currently in development. Even more interesting, base editing company Verve, is also targeting common cardiovascular disease indications, aiming to offer potentially life-long, one-time treatments for high cholesterol. Diabetes is also another area where genetic medicines hope to relieve patients of their frequent insulin injections – Crispr and partner ViaCyte have an allogeneic stem-cell derived therapy in early stage development for type 1 diabetes, and Kriya (private) has an AAV-based gene therapy in the works as well. Thus, the future of genetic medicine will not be limited to a small portion of the population, but could eventually become the treatment of choice for the majority of illnesses or diseases, leading to a world where people are spared from the omnipresent threat of infectious disease, and are free from the constant health burden of chronic diseases.

The future of genetic medicine will not be limited to a small portion of the population, but could eventually become the treatment of choice for the majority of illnesses or diseases, leading to a world where people are spared from the omnipresent threat of infectious disease, and are free from the constant health burden of chronic diseases.

Artificial Intelligence Activated

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Artificial Intelligence Activated – Introduction

Today, an increasing portion of our digital experience is powered by AI that gets smarter with more usage and with more data. We believe that, over time, technology will evolve from AI-enabled applications to true general purpose AI, which we view as the fifth industrial revolution.

Artificial Intelligence Activated: While we are some time away from general purpose artificial intelligence that science fiction cautions us about, AI is becoming a critical component to all aspects of business. The battleground for AI is now migrating from understanding its potential and acquiring capabilities to putting the concept into action. And while AI brings plenty of benefits (solutions that learn and improve over time, more powerful software to automate mundane tasks, etc.), it also brings with it many risks, including security concerns and the potential for unprecedented job displacement/transition.

We see every company becoming a digitally enabled company over time and expect to see more and more of our daily interactions powered by technology. We've already seen traditional interactions completely changed with technology: Work has changed with video conferencing, travel and leisure has changed with ride sharing and homestays, entertainment has changed with over-the-top (OTT), and even dating and marriage has changed with online dating applications.

The next leg is artificial intelligence (AI), which has already made the leap from theory to reality. Today, an increasing portion of our digital experience is powered by AI that gets smarter with more usage and with more data (e.g., social media that provides more relevant content based on your profile, but also uses that data for increasingly specific advertising). We believe that, over time, technology will evolve from AI-enabled applications (on both the consumer and industrial side) to true general purpose AI, which we view as the fifth industrial revolution.

We see a number of key debates with the rise of general purpose AI:

Automation and jobs. Most AI today is designed to work with people and make them more effective, versus outright replacing them, but that could change over time. While society has always seen jobs replaced by automation, general purpose AI could lead to an accelerated rate of job replacement. Importantly, the nature of those jobs will be very different than in centuries past, as we could start to see white-collar jobs replaced by digital processes – jobs like reviewing legal documents, reading and analyzing x-rays, and reconciling accounting could one day be replaced by software. The important question is does society adapt to this accelerated automation and create new jobs (as has traditionally happened during prior industrial revolutions) or will society have to adapt to a massive amount of permanently unemployed/underemployed people?

Privacy. As noted, AI works best with the more data it aggregates and society provides literally zettabytes (one trillion gigabytes) of data. We expect to see more societal pushback around ownership of data, but also wonder if society is willing to give up premium “free” offerings (including social media and email) in exchange for data privacy.

Fairness and equity. We see emerging debates around the fairness of AI applications. For example, AI can lead to pricing discrimination, such as lower healthcare premiums for physically active people (data provided through phones and fitness trackers) or lower automobile insurance premiums for “safe” drivers (data provided through connected cars). In addition, AI, facial recognition, and sentiment analysis can already be used to filter candidates for interviews, but over time, we wonder if these tools can be used for law enforcement or negotiations. We also believe access to AI won't be equitable and wonder if those with access to AI systems will increase the wealth disparity versus those without direct access. Finally, as alluded to in the first point, accelerated automation of jobs could lead to a massive wealth disparity between those with “AI-proof” jobs and those without.



Security. Not only are there worries around potential data breaches with the massive amounts of data being collected and stored, but artificial intelligence creates additional security risks. For example, with seemingly every device being “connected” (debatable how necessary that may be), hackers have greater entry points into the lives of individuals and businesses, and physical devices can be misused. In addition, we believe there is potential for general purpose AI to be misused by nefarious actors and even expect AI could become the next “arms race.”

Can artificial intelligence exceed human intelligence? To us, this is the critical long-term debate on general purpose AI: is there a true ceiling to how “smart” AI can get? We wonder if, over time, AI systems learn to not just emulate human processes learned from human behavior, but instead evolve to teach themselves. Or, perhaps the greater worry, what happens when AI systems begin talking to one another and potentially exceed human intelligence?

Information Services: Data, the crystal ball to predict the future

Artificial Intelligence (AI), Machine Learning (ML), and the Cloud are enabling Information Services to deliver predictive actionable insights. Cloud has minimized the barriers to capture alternate datasets, store and analyze big data, and distribute data at scale using APIs and a Cloud distribution platform. Natural Language Processing (NLP) has enabled analysis of unstructured data while Entity Linking has facilitated programmatic linking of disparate datasets. AI/ML made it possible to generate insights and predictions, which has been transformative.

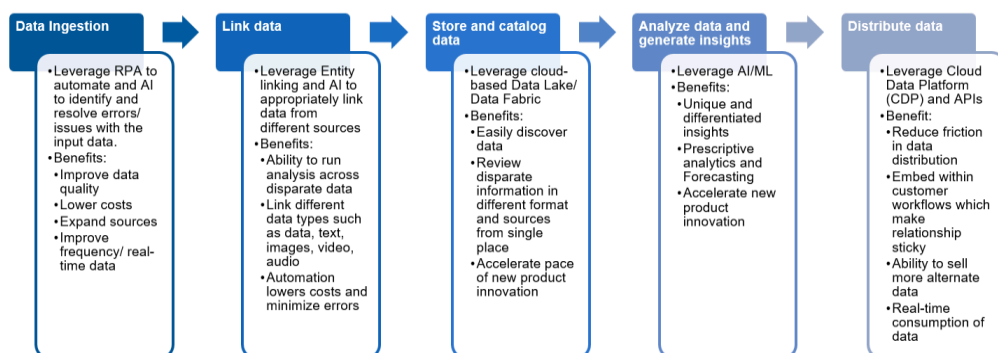
Data Lake/Data Fabric implemented using the Cloud infrastructure has enabled aggregation and analysis of disparate structured (numbers) and unstructured (text, images, audio, video) data. In addition, data cataloging is making it easier to discover content. RPA (Robotic Process Automation) and AI have streamlined data ingestion by automating manual data entry. Cloud Distribution Platforms (CDP) and APIs have made it easier to distribute data and deepen the integration with the customers' workflow creating an upward spiral for alternate data.

The confluence of secular trends, namely Digitalization and the focus on ESG, accelerated by COVID-19, along with the democratization of Cloud and AI/ML, has accelerated the demand for industry-specific proprietary data.

The confluence of secular trends, namely Digitalization and the focus on ESG, accelerated by COVID-19, along with the democratization of Cloud and AI/ML, has accelerated the demand for industry-specific proprietary data. Cloud, along with the adoption of AI/ML/Deep Learning, has also accelerated the demand for data. As a result, Information Services companies with access to industry-specific proprietary data and domain expertise can capitalize on the secular trends, which enables them to deliver accelerated revenue growth with strong barriers to entry.

Transformation of the data lifecycle using Cloud, AI/ML, and RPA has resulted in improving quality, depth, and breadth of data. In addition, it has expanded Alternate Data from diverse sources, including Internet of Things (IoT). Data accuracy has improved with real-time updates. AI is generating predictive insights while minimizing friction in distributing data. This has resulted in driving revenue growth from improved customer experience and greater demand for data while lowering expenses of gathering, analyzing, and distributing data.

Exhibit 52 - Transforming data lifecycle leveraging Cloud and AI/ML

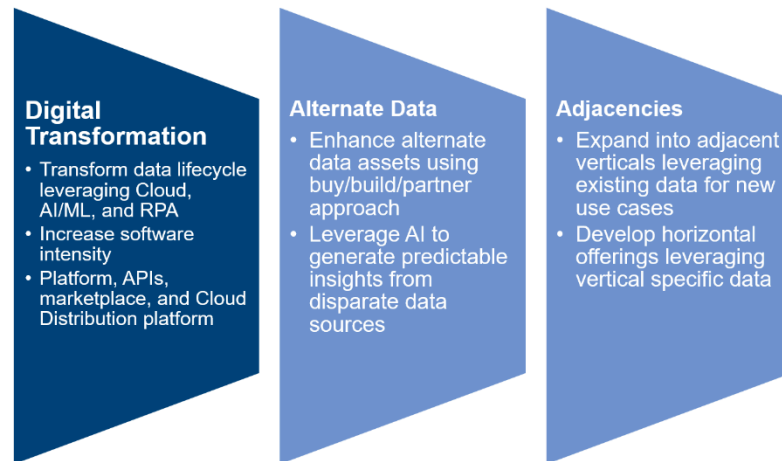


Source: Company reports, RBC Capital Markets

Information Services companies have expanded analytics and workflow software tools to deeply integrate into customers' workflow. For example, MSCI's Analytics solution leverages strength in Indices and ESG. Verisk Analytics acquired FAST, a provider of policy administration software for the life insurance and annuity sectors. Verisk also acquired Sequel, provider of commercial, and specialty insurance software. Moody's Software serves as a Chassis for

Integrated Risk Assessments and combined curated data with analytics to help customers make better decisions.

Exhibit 53 - Multi-pronged transformation and growth strategy



Source: Company reports, RBC Capital Markets

Information Services companies are using Alternate Data and expanding into adjacent verticals and new horizontal offerings, which has led to expansion of the overall pie. Alternate Data has helped improve, streamline, and automate decision-making driving a better consumer experience, faster turnaround, higher quality results while lowering expenses as well as the overall risk profile. For example, alternate data such as employment and income data, utility, and rent payments have improved consumer credit decisions by providing access to consumers with thin or no traditional credit files. Lenders are looking at data over a period (trended data) rather than a point-in-time snapshot to obtain a better perspective on consumers' credit behavior. The demand for Alternate and Trended Data has driven accelerated growth for the Credit Bureaus (TransUnion/Equifax).

Information Services companies are leveraging their existing data sets for new uses outside the core verticals. Credit Bureaus have leveraged their core strength among traditional lenders to expand in FinTech, Insurance, Healthcare, Public Sector, and Gaming/Gambling. Credit Bureaus are also leveraging consumer information to expand into Identity and Fraud Solutions, as well as Digital Marketing.

Exhibit 54 - Data is the new oil

Quality of the data
assets

- Proprietary vs. commoditized
- Alternate data
- Breadth and depth of the data
- Frequency of data refresh - real-time vs. dated

Technology
transformation

- Cloud migration
- Adoption of AI/ML for linking data and generating predictive insights
- Data lake/ Data fabric
- Cloud Data Platform
- APIs

End market
dynamics

- Defensive vs. cyclical
- Strong secular trends
- Value proposition in the evolving landscape

Source: Company reports, RBC Capital Markets

Software: Automation in practice

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Looking out over the next 10 years, we believe automation will become a necessity for filling the global talent shortage, ultimately leading to increased adoption, and a reshaping of the enterprise.

In our view, this will lead to an increased focus on creativity and problem solving in jobs for workers solving.

We feel that automation will become an increasingly important supplement for shortages in skilled human capital as “human tasks” move up the value chain with manual repetitive tasks increasingly being accomplished by machines.

Wants and needs; looking to the future of automation

Within the software industry, automation can refer to many different things including simple job scheduling or workflow to low-code and no-code tools, robotic process automation (RPA) as well as machine learning and artificial intelligence. At its core, automation improves the quality, consistency, and quantity of work that can be delivered by practitioners through the supplemental use of software. This has become increasingly important as the network topology continues to expand with cloud growth, hybrid-work is the new normal and there are fewer skilled workers. Overall, we believe automation tool usage will increase dramatically over the next 10 years.

The earliest utilization of automation often came from job scheduling, orchestration and leveraging simple workflows. While these technologies have been around for decades, they continue to be instrumental in the elimination of repetitive tasks and increasing the efficiency of scarce resources. Orchestration and workflow allow teams to leverage best practices to replicate previous work into new areas. This remains one of the purest forms of automation, using software for repetitious tasks. From here, the use cases and capabilities of automation have grown considerably, continuing to increase the efficiency of the workforce to help deal with a severe shortage in skilled talent, increasing the value of human capital by making workers more efficient. Much of the recent forms of automation have come from leveraging robotic process automation (RPA) as well as AI and (ML).

Looking out over the next 10 years, we view automation as both a want and a need. While currently there are concerns around automation replacing workers, our view is that in the future, we need to leverage automation at an increasing rate. We believe automation will become a necessity for filling the global talent shortage, ultimately leading to increased adoption, and a reshaping of the enterprise. As the capabilities for automation continue to expand, the bar will be raised for what is considered “human work” leading to more fulfilling jobs for workers focusing on creativity and problem solving and not the repetitive tasks that can be more efficiently accomplished through automation.

As part of Korn Ferry’s “Future of Work” series, they estimate that the global talent shortage for all markets will be roughly 85 million people by 2030, resulting in \$8.5T unrealized annual revenue. We believe automation will be required to fill this gap but is also expected to create more jobs than it makes redundant, with our interpretation of Gartner (“Predicts 2019: AI and the Future of Work,” Helen Poitevin, Moutusi Sau, Svetlana Sicular, Eric Hunter, Cindi Howson, Kanae Maita, December 13, 2018) indicating that in 2020, AI would become a positive net job motivator, creating 2.3 million jobs while only eliminating 1.8 million jobs.

This is not to say that there will not be growing pains in terms of retraining and reallocating resources. We feel companies will look at automation as a balance of wants and needs, with the largest and earliest investments to supplement human capital and make them more efficient, with the replacement of workers not being a priority compared to reallocating them to focus on high-value tasks.

Looking at cybersecurity as an example, according to a 2020 annual Cyber Security Workforce Study by (ISC)², the gap in cybersecurity talent has reached a shortage of ~3.12 million in the United States alone and there are ~897,000 cybersecurity professionals with another ~359,000

unfilled positions. When looking at graduation rates in computer science, we've seen relatively stable trends at 3–4% of bachelor's degrees over the past decade. Given these trends, we feel it is unlikely more human resources are the answer in the near term.

This skilled labor gap was exacerbated by the pandemic as work environments continue to grow and become more complex. There is no human solution in the short term, although increasingly there are steps being taken to fill the gap, including addressing the gender gap as only 25% of cybersecurity professionals are women, with an increased focus on diversity, equity, and inclusion. Additionally, based on our interpretation of Gartner ("Predicts 2020: AI and the Future of Work," Helen Poitevin, Svetlana Sicular, Sam Grinter, December 6, 2019) which highlighted other positive aspects of automation noting that by 2023, the number of people with disabilities employed will triple due to AI and emerging technologies reducing barriers to access. Currently, according to the same (ISC)² report, the labor gap is expected to grow by 20–30% annually over the next several years.

Key components of an automation strategy to help fill the skilled labor gap





The key to filling this skilled labor gap with software is maximizing the efficiency of workers. Outside of basic job scheduling or orchestration, the four main ways we look to automation to solve this is through:

- 1) **Low-code/no-code:** Low-code/no-code solutions can help to lower the bar for coding, application creation, and creating automated processes for citizen developers. This has a two-fold benefit, allowing business users who are actually using the applications or processes to have an active role in their creation and lowering the burden on scarce developer resources by enabling simpler tasks to be off-boarded. Once created, these automated processes can remove remedial tasks from workers allowing them to increase their efficiency by focusing on higher-value work.
- 2) **RPA:** This includes the automation or augmentation of manual repetitive tasks to improve user productivity. Traditionally, RPA thrived in environments that mimic the actions of an end-user using rule-based logic. RPA intercepts instructions between an application and the operating system and reroutes the task to an RPA bot for execution. RPA bots are either attended or unattended, where an end-user or the commencement of a workflow must trigger attended bots. Unattended bots execute routine tasks that do not require user interaction. Generally, these bots are accessed by multiple workstations/clients and can complete tasks across several devices. More advanced forms of RPA now have robots that emulate human behavior and are adaptable to evolving external variables. This leads to a more intuitive process for customers on how to utilize and interact with robots as well as the ability to utilize robots for both simple and complex use cases. The idea is to enable workers to interact with robots the same way they would with a human. A key to both low-code/no-code solutions and RPA is the ability for lower-skilled workers to be involved in the creation of tools to make their own work more efficient. This has led to the rise of citizen developers, who are able to create solutions to their own problems, without taxing developer resources.

The skilled labor gap is expected to grow by 20–30% annually over the next several years – closing this gap will require maximizing the efficiency of workers as well as retraining and reallocating resources.

Exhibit 55 - Citizen Developer use cases

Anyone Can Be a Developer

	Citizen Developer (End-User)	Citizen Developer (Power User)	Business-Led Pro Developer	Enterprise IT Pro Developer
				
Full-Time Developer	No	No	Yes	Yes
Preferred Tools	"No-code" (configuration)	Low-code	Low-code and Pro-code	Pro-code
Typical Apps	Individual and Workgroup	Workgroup	Departmental	Enterprise

Source: Gartner, "The Importance of Citizen Development and Citizen IT" Jason Wong, October 10, 2019

Consistent with Moore's law, which states that the number of transistors on a microchip doubles every two years, we continue to see exponential data growth as the world becomes increasingly connected.

- 3) **Machine learning and augmented intelligence:** Machine learning is utilized to separate the news from the noise. Consistent with Moore's law, we continue to see exponential data growth as the world becomes increasingly connected. While we have access to increasing volumes of data, the aggregation of data or logging has largely been commoditized. There is now a greater focus on how to make sense of that data, which is where machine learning and increasingly specific algorithms have become more impactful. Augmented intelligence is the process of combining the skills of both computers and humans, utilizing machines to generate relevant actionable information while humans can focus on leveraging context, creativity, and industry expertise to efficiently make decisions. A prime example is in security alerts; generating alerts for anomalous behavior in a large enterprise often leads to alert fatigue where thin cybersecurity resources are trying to find the "needle in a needle stack." Machine learning allows alerts to be prioritized based on metadata to create scoring that takes into account how likely the alert is malicious and how impactful it might become. This allows the handoff to the human counterpart to be much further down the line than if the person is left to decipher the threat level on their own.
- 4) **True artificial intelligence:** True artificial intelligence is utilized to replace worker tasks, but we think it is important to emphasize, as noted earlier, that this is not the same as replacing workers. While machine learning and artificial intelligence typically go hand in hand, the difference is in decision making. Machine learning is utilized to improve artificial intelligence, becoming more adept at decision making as data volumes grow by gaining additional context. In general, AI is utilized to replace mundane tasks that cannot be accomplished efficiently by humans. In this way, AI is not taking away jobs, but increasing their value, by leaving humans to the core competency of natural intelligence, allowing them to be complex contextual decision makers. As capabilities around AI grow, the threshold for what types of decisions can be made will continue to rise, with the long-term goal of AI replicating or improving upon the thought process of human workers.

The rise of DevSecOps, due in part to automation

At its core, AI and ML create speed and efficiency. One area where we have seen this highlighted is in development with a focus on agile development and continuous release cycles being enabled by ML, AI, and low-code/no-code tools. These efficiencies allow for rapid development with applications going from ideation to production in record times, which has created an increased need for interoperability between developers, security, and IT operations. This has resulted in a convergence of the three groups as well as their budgets to the idea of DevSecOps, but also the need for common data sets and automation tools that are aware of one another.

The reason we view this market as likely to converge is the data. Security, IT, and DevOps teams have common goals and often utilize common data sets. The idea that their tools are not communicating is not sustainable, in our opinion. While SIEM and SOAR solutions have primary goals around identifying and responding to security events, anomaly detection is a close cousin to identifying performance issues in applications. All can use UEBA to discover insider threats or performance issues used for security but also to manage user experience. The core to all of these technologies is machine learning and artificial intelligence. We view this as inevitable, in part, due to the labor shortage previously discussed across developers, cybersecurity, and IT operations. The efficiency gains of keeping these teams uniform as well as the ability to supplement overburdened parts of the development life cycle helps to eliminate choke points and increase overall production. With security inherent in the application development life cycle, speed can safely be unleashed, with less worry about launching a vulnerable application into production.

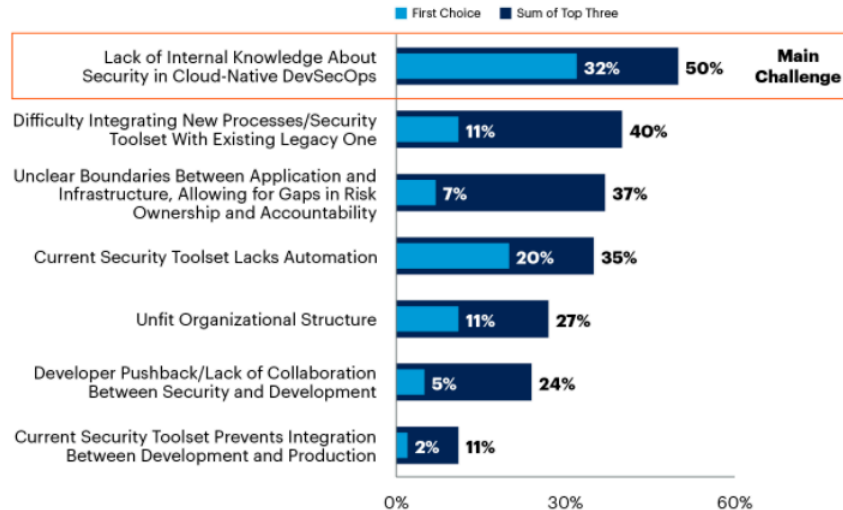
We feel vendors in security, monitoring, and DevOps will continue to add automation to make their integrations feel seamless to the end-user, allowing common data resources to be shared for efficiency as well as preventing information asymmetry. We believe vendors who fail to meet these challenges will be at a significant disadvantage as the pressing needs for automation to support expanding environments increasingly weigh on decision-makers who are taking a more holistic view of IT spend. As seen in the Exhibit below, based on our interpretation of Gartner ("Survey Analysis: Enabling Cloud-Native DevSecOps" by Dionisio Zumerle, September 13, 2021), the number two response in terms of "first choice" challenges for adopting DevSecOps is that the current security toolset lacks automation.

We believe that security, IT, and DevOps teams will continue (and need) to converge, as they have common goals and utilize common data sets; the idea that their tools are not communicating is not sustainable, in our opinion.

Exhibit 56 - Challenges in DevSecOps

Top 7 Security Challenges in DevSecOps Pipeline

Percentage of Respondents



Source: Gartner "Survey Analysis: Enabling Cloud-Native DevSecOps" by Dionisio Zumerle, September 13, 2021

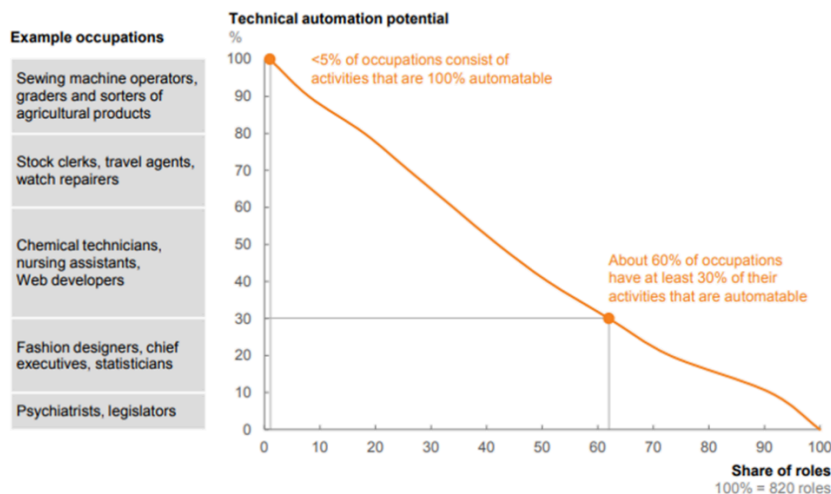
What are the benefits?

We believe the culmination of these trends should make companies vastly more efficient over the next decade, helping solve the global talent shortage and creating more meaningful, fulfilling jobs for people so they can focus on creativity and problem solving. As seen below, the McKinsey report "A Future that Works: Automation, Employment, and Productivity" noted that 60% of all occupations have at least 30% technically automatable activities.

Exhibit 57 - Percentage of jobs that could be fully or partially automated

While few occupations are fully automatable, 60 percent of all occupations have at least 30 percent technically automatable activities

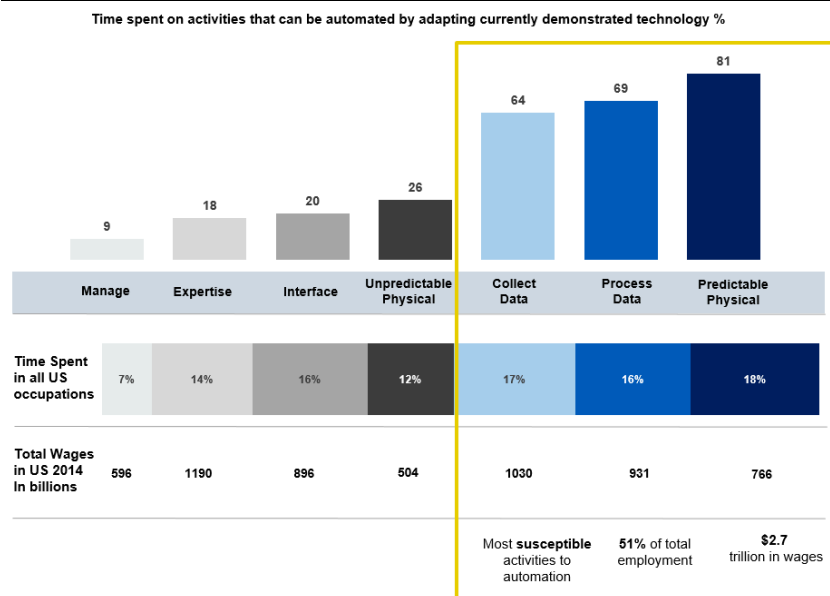
Automation potential based on demonstrated technology of occupation titles in the United States (cumulative)¹



Source: McKinsey Global Institute analysis

When thinking through the ROI, this equates to \$2.7T in wages, which we feel will further propel extensive investments in automation across the global economy.

Exhibit 58 - Wage impact of automation



Source: McKinsey Global Institute analysis

Autos: Software-enabled vehicles transform many industries

While electrification in transportation gets a lot of attention and certainly will continue to inflect, we would argue this is widely appreciated. Further, while we do not mean to diminish the benefits from electrification – decarbonization, lower cost to own/operate, a better driving experience – ultimately, it is a change in what powers the vehicle from point A to point B. In and of itself, electrification does not change the industry business model much – automakers are still selling a unit. That is why we see a much larger potential change to the automotive and ancillary industries from the software-enabled vehicle and unlocking the value from the data such a vehicle can provide. Connected, software enabled vehicles can provide a better, more personalized experience for the customer, but also have tangible economic benefits to automakers, suppliers, dealers, insurance companies, tech players and other industries.

While electrification in transportation is an important and topical theme, we see a much larger potential change to the automotive and ancillary industries from the software-enabled vehicle and unlocking the value from the data such a vehicle can provide.

For example, automakers with access to richer data than insurance companies could potentially offer an improved insurance product.

From a consumer perspective, the vehicle becomes an updatable device, much like smartphones today versus the current static experience consumers have in legacy vehicles. Using over-the-air (OTA) updates, new and more advanced safety features can be pushed to the vehicle. The consumer can choose customized digital “skins” for the displays or select certain vehicle performance upgrades – imagine a software controlled modulation to get more horsepower or torque from the electric powertrain for that trip up to the mountains.

From an automaker perspective, this enables a shift from selling units to being able to sell more SaaS like, recurring revenue, higher margin services. Software based enhancements are zero marginal cost. Further, the connectivity with the customer moves beyond just the initial unit sale to one that could be over the life of the vehicle. This creates a larger life-cycle monetization opportunity for automakers. An increasing part of their revenue and profits could be tied to the size of the connected fleet, which should be ever growing, not just the unit sales in any given year that is more subject to economic cycles.

Having access to rich data could enable an improved insurance product. We believe this could allow some automakers (General Motors and Tesla for instance) to get into insurance. It’s possible that the automaker could get significantly richer data from the vehicles than the insurers considering they can use AI to analyze data from all the sensors (likely >100) on the vehicle vs. insurance companies who only get cell phone or OBD port data, which is much more limited. For instance, currently an insurance company may use cell phone data and figure out a driver’s speed or braking tendencies and may interpret that as a “bad driver” data point. But, using all the data on the vehicles, they may be able to interpret that as the safe driver decision or a hard brake wasn’t their fault, and “reward” the consumer for safer driving. Likewise, they can offer discounts for taking a higher-end active safety product or even offer dynamic pricing based on driving behavior and usage. They can get better, quicker and more accurate crash data.

The data on vehicles can also be very beneficial to fleets. Imagine how large logistic companies can increase the efficiency of their operations interpreting the data that comes off vehicles. Today, fleets buy third-party devices that provide limited data. If the vehicle is connected and sensors and software are embedded and integrated, the data becomes much more valuable. Now, they may know if automatic emergency braking (AEB) activated. However, with a more connected embedded vehicle they will also know if it did not execute and an accident occurred how close the system did come to activating. That can lead to system refinement, enhanced safety and lower cost. The system will also be able to monitor battery degradation on electric vehicles, which can guide usage cycles and lead to maintenance savings.

Autonomous vehicles would open up a whole new realm of data and monetization opportunities

Autonomous vehicles will process incredible amounts of data relating to both the environment and the consumer. From the environment perspective, remember the vehicle has a full and rich sensor suite that is processing, in real time, the world around it. Information the vehicles pick up about traffic, road conditions (need to repair) and curbside activity can be extraordinarily valuable to many constituents including local municipalities. From a consumer perspective, the autonomous vehicles will know a lot about the occupants – where they are going and where they are coming from. You can imagine that this could lead to targeted ads or even a store paying for your ride to their establishment – a relatively effective customer acquisition cost. Autonomous vehicles can also free up time. There is no longer the need for a driver to pay attention to the road. This could increase work productivity (think of a morning work commute) but in many instances this could mean an emerging opportunity for media. Passengers may want to spend time virtually socializing with friends or family (usage or engagement on social media can rise).

We envision a future where a consumer could trade the information the vehicle is gathering on the environment and its passengers in return for a lower cost for that vehicle.

The average vehicle trip time in the U.S. appears to be between 22 and 27 minutes (depending on the source). That appears to be a good time for the average 30-minute show (ex-commercials) but it is also possible new forms of entertainment and shows could emerge for this channel, similar to how media specific for the smartphone emerged. In a shared trip environment, this can even be social with the operator pairing up passengers who are watching the same show. In a more personally owned autonomous experience or in a longer autonomous ride-hail ride, movies would be a possibility. What is especially intriguing is using the vehicle to make the media more engaging and enhancing the experience (using augmented reality or for instance “rocking” the car to simulate a vehicle chase scene). The vehicle could also recommend or show specific, thematic entertainment based on the vehicle destination or even serve as a “tour guide” during site seeing. Think of the vehicle as the ultimate Disney ride for the real world.

The onus of course will be on figuring out the right data, the signal from the noise, and thinking of ways to monetize that information. At the extreme, think about how a consumer could trade the information the vehicle is gathering on the environment and its passengers in return for a lower cost for that vehicle. While this likely still has a ways to go given the large upfront cost of manufacturing a vehicle and the timeline of the return on that data, it could become more of a reality over time.

Aerospace & Defense: There's a new class in Top Gun

We believe we are at a threshold when it comes to the military's use of drones and robotic systems. The marriage of artificial intelligence (AI) and unmanned technology is opening up new opportunities while creating new challenges. One example of this is the opportunity to use drones as loyal wingman in support of manned aircraft. There are several programs today looking to incorporate drones into missions in support of manned aircraft, especially fighter aircraft. A second example involves swarming technology.

The loyal wingman opportunity is actively pursued in the U.S. by both the U.S. Air Force and the U.S. Navy. One of the more visible programs in the U.S. is the Skyborg program, one of three Vanguard programs managed by the Air Force. As part of the Skyborg program, contracts have been awarded to Boeing (BA), General Atomics (private), and Kratos Defense & Security. Boeing is developing the Boeing Autonomous Teaming System (BATS) aircraft in Australia, while Kratos is offering its Valkyrie aircraft. These unmanned aircraft are intended to support a range of missions, and the ability to “partner” with 5th generation manned aircraft, such as the F-35, is dependent on the AI technology these unmanned systems will be able to deploy. The image below shows a Kratos XQ-58A Valkyrie aircraft flying in formation with the F-22 and the F-35 aircraft.

[Exhibit 59 - Loyal wingman test flight with fighter aircraft](#)



Source: U.S. Air Force Research Labs

In Europe, the U.K. is funding loyal wingman development efforts through its Future Combat Air Systems Technology Initiative (FCAS IT), which has provided a development contract to the project Mosquito team, which is led by Northrop Grumman (NOC) and Spirit AeroSystems (SPR). There are similar efforts underway in other European countries and with the Russian and Chinese militaries as well.

There is also significant effort on unmanned swarming systems, which are made possible through the use of AI. Swarming drone systems refer to multiple systems deployed with the objective to autonomously alter their behavior based on communication with one another, independent of human interaction. The fact that the “swarm” will be able to communicate and then alter its behavior implies a degree of artificial intelligence that is unique in today's defense systems. There are a number of swarming programs in the U.S., including the Air Force's Golder Horde program and the DARPA Gremlins program. Swarming technology can be applied to very small drones or to larger systems.

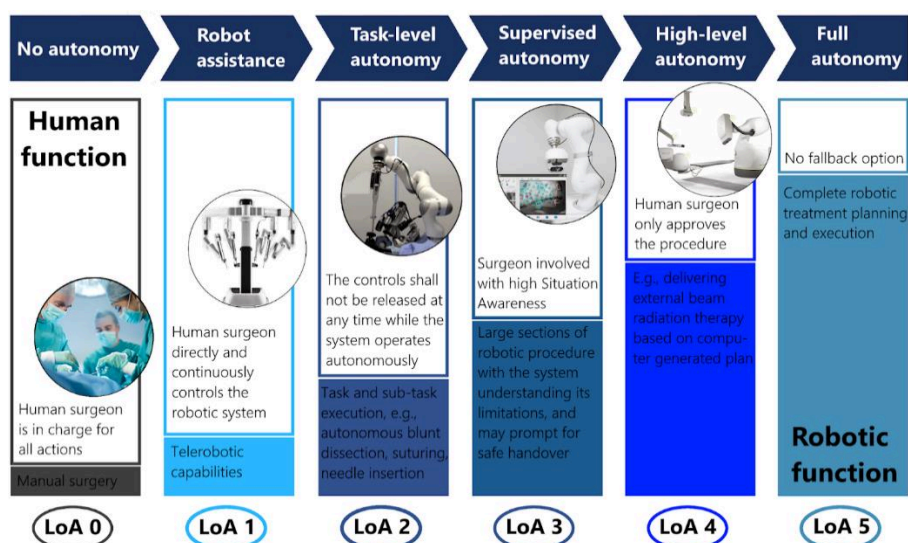
Med Devices: Artificial Intelligence & Autonomous Robotics

Surgical robotics is still in its infancy with respect to scale and scope; we believe surgeries will eventually be done by autonomous robots controlled by artificial intelligence (AI) algorithms that receive input from an array of visual and haptic sensors.

Artificial Intelligence and autonomous robotics is the future of surgery. One of the most significant innovations in medical devices has been the advent of robotics. The field is not new as the da Vinci Surgical System became the first surgical robotic platform in 2000 to be commercially available in the United States indicated for use in general laparoscopic surgery. Despite that, robotics is still in its infancy with respect to the scale and scope. It appears to be a moonshoot opportunity today, but eventually we believe surgeries will be done by autonomous robots controlled by artificial intelligence (AI) algorithms that receive input from an array of visual and haptic sensors. In fact in 2016, Shademan, et al. reported complete in vivo, autonomous robotic anastomosis of porcine intestine using the Smart Tissue Autonomous Robot (STAR). The procedure was conducted in a highly controlled experimental setting, but outperformed human surgeons in a series of ex vivo and in vivo surgical tasks. Notably, it demonstrated the clinical viability of autonomous soft-tissue surgical robotics for the first time.

The autonomous level of healthcare robotics is in its infancy, with much room to grow. Autonomy refers to the ability to perform an intended task without human intervention. There are six levels of autonomy in surgical robotics that vary based on the degree of human intervention the system is able to trade. For example, da Vinci is the most widely used system globally, but is a handler-agent robot that is completely dependent on human control. Robotic-assisted surgery or RAS (LoA1) is utilized across several specialties today – urology, gynecology, and general surgery. That said, there is significant room for adoption as penetration remains significantly low at less than 2% globally. RAS is accompanied by enabling technologies such as tool and eye tracking, tissue sensing, augmented reality (AR), and haptics. We believe there has been progress made in task-level autonomy (LoA2) such as suturing, which involves needle insertion and knot typing, but it is not widely commercial yet. The most notable supervised suturing has been STAR, which has a KUKA LBR arm with seven degrees of freedom and a custom suturing tool.

Exhibit 60 - Level of Autonomy (LoA) in Healthcare Robotics



Source: IEEE Robotics & Automation Society

Robotic surgery has advantages that should minimize surgical variations and make it the standard of care over time. Robotic surgery is minimally invasive and has significant benefits

We believe robotics will standardize surgery across care settings and surgeon capabilities.

over open surgery, which include shorter hospitalizations, reduced pain and discomfort, faster recovery time and return to normal activities, smaller incisions that may result in reduced risk of infection, reduced blood loss and transfusions, as well as minimal scarring. For the surgeon, robotic surgery has the benefit of greater visualization of the surgical field, enhanced dexterity that eliminates issues such as hand tremors, and surgical precision that is unmatched by human capability. Due to these benefits, we believe robotics will standardize surgery across care settings and surgeon capabilities.

Robotic surgery is at an inflection, but there is a multi-year runway for growth aided by technology advancements. By our estimate, 1.5–2.0 million surgical robotic procedures are performed annually and +9 million have been performed since 2010 alone. The current addressable market for surgical robotics is 6 million procedures, which represents those that can be addressed with existing technology. Industry leaders such as Intuitive Surgical expect the addressable market to expand to 20 million procedures over the next few years, but we would expect the market to expand further over time aided by technological advancements.

The field of robotics will continue to expand beyond soft-tissue surgery. Robotic surgery is being adopted not only in soft-tissue surgery, but also in hard-bone surgeries such as in knees, hips, and spine. Companies operating in the former are Intuitive Surgical Inc., Medtronic PLC, and CMR Surgical to name a few, while those operating in the latter include Stryker Corporation, Zimmer Biomet Holdings Inc., Smith & Nephew PLC and Globus Medical Inc.. Industry reports and recent checks suggest that demand has strengthened in recent quarters suggesting that we are at an 'inflection' point in procedures that the technology is currently indicated for. We have also seen applications benign prostatic hyperplasia (BPH) or enlarged prostate (Procept Biorobotics), and diagnostic areas such as bronchoscopy (Intuitive Surgical, Johnson & Johnson).

Healthcare: Accelerating drug discovery

We are seeing greater integration between tech and biopharma, and despite the growing proliferation of AI to guide drug discovery, we note most compounds remain in early stages of preclinical or clinical work.

We also remain cognizant that the actual advantages AI may bring may be more incremental than in other fields.

Expect collaborations between tech and biopharma to continue into the next decade. With both tech and biopharma as prominent high-growth industries, we are seeing greater integration of the two, particularly in the world of AI – something we expect will continue in the coming years. Investment in AI drug development has steadily increased, with \$2.1B in capital raises in 1H21, and a total of over \$11.8B in total invested capital, which we believe points to an area of continued focus for investors, and one that we would expect to grow. Large biopharma players are also deploying resources towards this trend, with **Gilead** being among the first to sign an AI drug discovery deal in 2019 with a three-year, potentially \$1B partnership in NASH with Insitro; other large-caps to pen deals include **Pfizer**, **Bristol-Myers**, **Bayer**, and Roche/Genentech. Big tech names are getting involved too, with **Microsoft** and **Novartis** collaborating since 2019, and NVIDIA Corporation working with AstraZeneca and Schrodinger Inc. on molecular optimization and reaction prediction for novel molecule synthesis.

There are high expectations for AI-based drug development, though validation likely years away. Despite the growing proliferation of AI to guide drug discovery, we note most compounds remain in early stages of preclinical or clinical work. Even work speeded by AI, such as a kinase inhibitor developed jointly by **Bristol-Myers** and **Exscientia PLC** (which has 3 molecules in ph.I), still took 11 months to be identified, and though impressive vs the ~3 years we estimate the average process may take, it must still go through the traditional and rigorous drug development pathway (which could take the better part of a decade). We also remain cognizant that the actual advantages AI may bring may be more incremental than in other fields, where drug discovery screens already leverage automation and fairly advanced computational biology to maximize hits. Further, bleeding-edge technologies such as ASO, gene therapy, or gene editing technologies will likely benefit less from advancements in AI than more traditional small molecule approaches, which have typically faced a throughput bottleneck.

Clinical stage AI can also lead to missteps, such as Epic System's sepsis AI algorithm potentially worsening patient outcomes. We estimate that a year saved during preclinical development could save biopharmas in the order of \$1–3M per program, along with any competitive advantage they gain. That being said, we note there are potential AI solutions across drug development, with companies such as Deep Lens working with **Lantern Pharma Inc.** to accelerate clinical trial enrollment and patient matching with advanced AI algorithms; a year at the clinical stage may cut costs by \$20–100M per program. Ultimately, we believe further collaboration between tech and biopharma is worth pursuing, but caveat that biological systems are complex and difficult to model, and we look to the late 2020s to benchmark the true impact of AI-fueled drug development, as today's early stage compounds would be approaching pivotal readouts.

Healthcare Technology: Improving financial health with a digital workforce

Approximately 5–10% of individuals employed by health systems are tied to the revenue cycle process, which includes all of the steps doctors and hospitals have to take to get paid for their work. Steps range from collecting a patient's insurance information before the visit all the way to final billing and collections. This is not a simple process; there is a wide range of healthcare services and a vast network of payors, including both patients and insurers, with different and dynamic policies and reimbursement rates. As a result, this tends to be a very labor-intensive and often redundant process that providers historically have been poor at managing themselves (which results in providers chronically spending too much to collect too little). These issues are further compounded by tight labor markets in the U.S. and rising wage inflation.

An increasing number of provider systems have invested in both automation and patient experience – the goal being to not only reduce the cost of performing the various revenue cycle functions, but also to improve the customer experience. Early investments included robotic process automation (RPA), which is used to address simple tasks. Now, more health systems are deploying additional technologies like artificial intelligence, machine learning, optical character recognition and natural language processing – the combination of which is helping to automate much more complex processes, enabling organizations to further reduce their reliance on labor.

We believe AI could materially improve the efficiency of the healthcare system; approximately 5–10% of individuals employed by health systems are tied to the administratively heavy revenue cycle process, which includes all of the steps doctors and hospitals have to take to get paid for their work.

Pre healthcare visit – Where are some opportunities for automation?

- **Scheduling.** An effective way to streamline the scheduling process is to enable patient self-scheduling. Facilitated by RPA on the back end, patients can reserve a spot on a provider's calendar that updates in real time. In many cases, providers are unable to see each other's schedules, which means there can be a fair amount of manual effort to coordinate a referral appointment. By having an integrated platform or RPA that can speak to different systems, the scheduling can largely be automated to accommodate the patient's schedule.
- **Registration.** While the entire registration process can be automated from the provider standpoint, the automation starts at the sub-process level. For example, registering a patient requires gathering data from disparate sources and populating a registration template. Each part of the retrieval process can be completed via RPA.
- **Eligibility verification / Determination of patient financial responsibility.** Similar to the Medicaid example, this often requires searching a payor website and/or reaching out directly to the payor to verify eligibility for benefits/coverage. RPA can be used to scan Medicare and Medicaid eligibility websites to determine eligibility on behalf of the patient. For example, RCM vendor nThrive claims that its software is able to save providers an average of 1.8–3.0 full-time employees (FTEs) worth of effort. With a clear explanation of what will be covered, the providers can then provide patients with accurate cost projections.

Post healthcare visit – Where are some opportunities for automation?

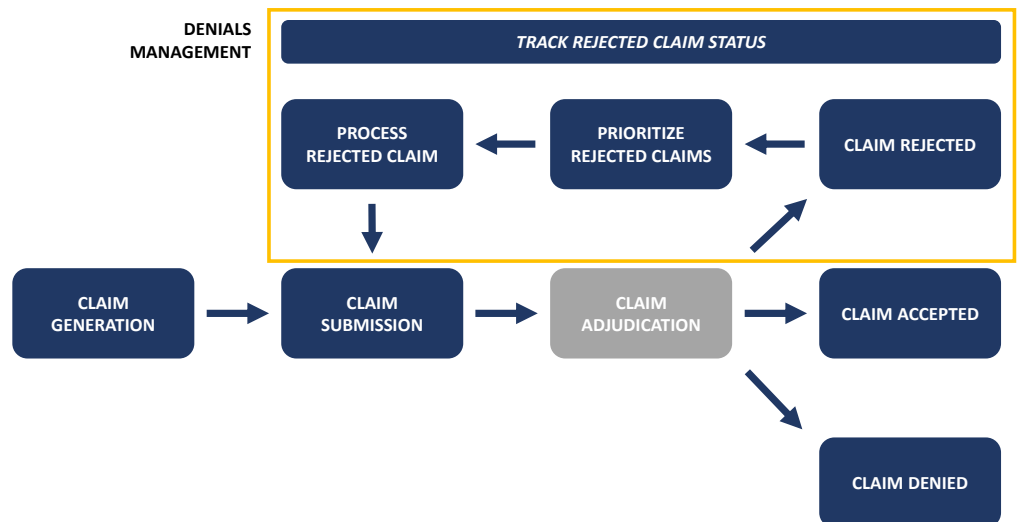
- **Coding.** Following a visit, a medical coder will create a 'superbill' that involves the assembly of both provider and patient information as well as procedure and diagnoses codes specific to the visit. There are tens of thousands of codes that might apply to each component of the visit. Coders have historically used actual code books or searched for applicable codes in a database, which is a very manual process (and does require some knowledge to account for the nuance of each visit). Intelligent automation can help review text and make coding recommendations that coders can sign off on. Essentially, this is a way to augment the coding capacity of a human employee.

- **Pre-submission claim generation and auditing.** The superbill becomes the foundation for generating a medical claim. It contains much of the same data, but must be formatted to meet the appropriate payor billing requirements. Automation can be used in sub-processes requiring data assembly while ML can help audit the final claim for coding/billing compliance and address any gaps in data, inaccuracies, potential ineligibility or even duplicate filings. This final scan before submission is a critical part of minimizing claims denials.
- **Prior authorization (PA).** When a physician orders medication, additional testing or procedures, the physician's office immediately begins the PA process to find out whether the payor will pay for it. As previously noted, this is a highly manual process that can take more than week for the payor to reject or approve the course of treatment. If denied, the appeals cycle can take more than a month. Intelligent automation can help initiate the PA process, assemble relevant forms and documents in the proper format based on historical data, and track authorization to completion.

After claim submission – Where are some opportunities for automation?

- **Billing statement preparation.** Once the insurer's payment responsibility has been determined, the provider can prepare the patient's billing statement. This typically includes an itemized cost of each service and the portion that is covered by insurance. Assembling the proper data from each source and delivering the bill primarily consists of routine sub-tasks that are prime candidates for automation.
- **Patient communications.** After a bill is released to the patient, there is often follow-up correspondence that takes place. Patients tend to ignore the first bill, so there are additional copies that are typically sent. Further, patients may call or e-mail with questions, comments or complaints. Re-sending digital or hard copy bills can be easily automated, but some follow-up customer service items can be addressed with ML and natural language processing that can read emails or direct calls efficiently to the appropriate channels.
- **Denials management.** When a payor denies a medical claim, there are two feasible next steps: (1) spend time figuring out why and if there is an easy fix, then resubmit; or (2) move on and take the loss. While there are some steps in the process that can be automated in terms of the tracking process, much of the opportunity lies in the ability to effectively optimize the balance between potential revenue recovery and cost of re-submission. ML can be used to help providers manage/prioritize those denials and utilize manual resources more efficiently.

Exhibit 61 - Simplified denials management workflow



Source: RBC Capital Markets

Why is this so meaningful for providers?

We estimate 5–10% of health system employees are tied to the revenue cycle process, which means that a significant investment in time and money is required to recruit, train, and retain talent. Therefore, maximizing efficiency of these processes can have a meaningful impact on the profitability of a health system, which more often than not operates on very thin margins. Further, with tight labor markets, health system vaccine mandates leading to staffing shortages / rising wages, and increasing competition for patients leading to more focus on creating more consumer-friendly experiences, the value that providers can derive from a well-managed revenue cycle continues to grow.

It is also important to note that automation is most often not about eliminating employees, but getting better leverage off an existing employee base and avoiding additional hiring. This applies to outsourced vendors such as R1, who estimates it has avoided the cost of 1,200–1,500 more FTEs, as well as institutions like the Moffitt Cancer Center that (per a recent company presentation) has automated the equivalent of 200 full-time employees. This is substantial compared to the 500 FTEs currently in a revenue cycle function and the ~7,000 across the system. We expect to see more hospitals, health systems, and revenue cycle vendors accelerate adoption of these technologies as software costs come down and billing complexity/labor costs continue to rise.

We expect to see more hospitals, health systems, and revenue cycle vendors accelerate adoption of these AI technologies as software costs come down and billing complexity/labor costs continue to rise.

Energy & Utilities: Digitization and AI in oilfield services

The benefits of digitization and AI in oilfield services are becoming clear

Digitization drives efficiencies, which should increase E&P productivity and facilitate emissions reductions. We believe AI capabilities will be needed to reduce emissions in oil and gas operations. For example, remote operations mean fewer trips required to the wellsite to check valves, monitor production levels, and perform routine maintenance.

- **Margin enhancement:** Today, digital product offerings provide an opportunity to differentiate from asset-heavy segments of oilfield services while expanding margins through high-value offerings and reducing costs. Tomorrow, AI should play a role in improving economics of new energy sources and drive the next leg of the energy transition.
- **Labor management:** The oilfield service segment has traditionally added personnel during upcycles and shed personnel during down cycles. The increasingly fast nature of oil and gas cycles has left many workers scarred from frequent layoffs with the result that many have exited the industry. Efficiency of personnel will reduce the risk of labor shortages and the cost of severance during down cycles.

Current and future uses for artificial intelligence in oilfield services

Oilfield service providers are continuously rolling out technology offerings. Many of these initiatives are direct partnerships with producers and technology firms.

Exhibit 62 - Service providers ramping up on AI and digitization efforts

Category	AI enablement	
	Today	Future
Data Analytics	<ul style="list-style-type: none"> Oil & gas operations are remote, some connected with satellite, LTE Connections can be expensive and spotty in less-established regions Cloud enablement increasing, but remains relatively early-stage 	<ul style="list-style-type: none"> Advancements in communications can bring equipment on-line to a centralized location Increased well-accuracy and proficiency with analytical software Remote operations centres support operations and diagnostic capability
Hard assets automation & utilization (equipment)	<ul style="list-style-type: none"> Rig systems increasingly perform repetitive rig tasks Automated rig prototypes can automate pipe tasks, personnel still required on rig 	<ul style="list-style-type: none"> Increased asset automation reduces the number of personnel required on-site
Maintenance management	<ul style="list-style-type: none"> Maintenance activities are highly weighted to reactive & time-scheduled versus predictive 	<ul style="list-style-type: none"> Equipment health monitoring and analytics shifts the balance to highly predictive, improving asset utilization, reducing downtime & saving costs

Source: Company reports, RBC Capital Markets

In the future, we expect continued advances in data analytics, increased asset automation, and enhanced equipment health monitoring, reducing labor management considerations and driving efficiency and margin improvements for oilfield services.

AI partnerships and data analytics

Increased connectivity should underpin enhanced oil and gas value. McKinsey & Co. recently estimated advanced connectivity could result in an additional \$250B of upstream value by 2030. Improvements are projected to come from a mix of existing infrastructure and proliferation of low-earth orbit satellites and 5G networks. Increased connectivity allows service providers to improve remote offerings, data collection, and enhanced analysis.

Technology partnerships to drive next leg of AI capability. Baker Hughes, Shell, C3 AI and Microsoft have launched the Open AI Energy Initiative (OAI). The OAI provides a framework for energy operators, service providers, and independent software vendors to offer interoperable solutions including AI and physics-based models, monitoring, and prescriptive actions. Baker Hughes' BHC3 AI suite has several applications for increased productivity across upstream applications designed to reduce asset downtime, maximize performance, and improve supply chain efficiency.

Hard assets enabled by AI

Equipment is getting smarter. Schlumberger sees autonomous drilling as a journey with five stages, ranging from assisted operation to full autonomy. Many drilling operations today rely on some degree of assisted operation or automation, though many applications still require feedback loops to/from directional drillers. In an offshore environment, the company recently drilled a section of a fully automated orchestration of both surface and downhole equipment enabled by its digital platform. Offshore technology typically leads onshore technology and we expect to see enhanced automation to onshore rigs in the coming years.

Exhibit 63 - Automated drilling rigs require robust data and system support



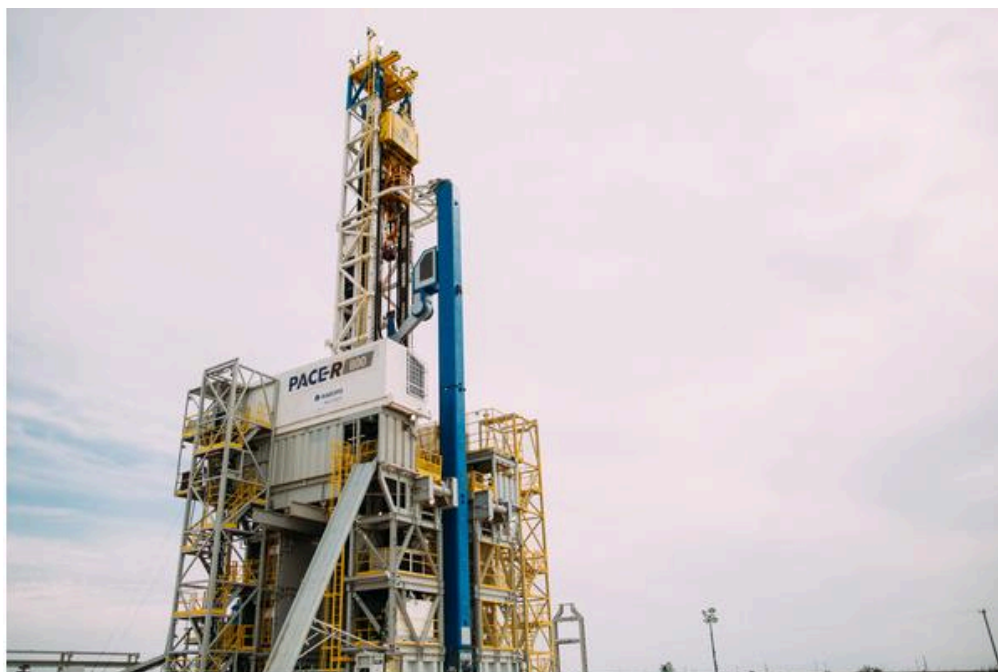
Source: Schlumberger

Rigs now automated, further advances likely to increase efficiency. Nabors has built the world's first automated drilling rig, the PACE®-R801. The system has robotic pipe-handling capability, which removes personnel from the most dangerous part of the rig floor, known as the "red zone." The rig is enabled by a network of control systems, which help keep the well on target and manage several key drilling metrics including weight on bit and rate of penetration. The rig still requires the same amount of personnel as a normal rig, but the duties change. In the future, we see further AI development reducing the personnel required in the field, including remote operations.

Offshore technology typically leads onshore technology and we expect to see enhanced automation to onshore rigs in the coming years.

We also see further AI development reducing the personnel required in the field, including remote operations.

Exhibit 64 - Automated drilling rigs require robust data and system support

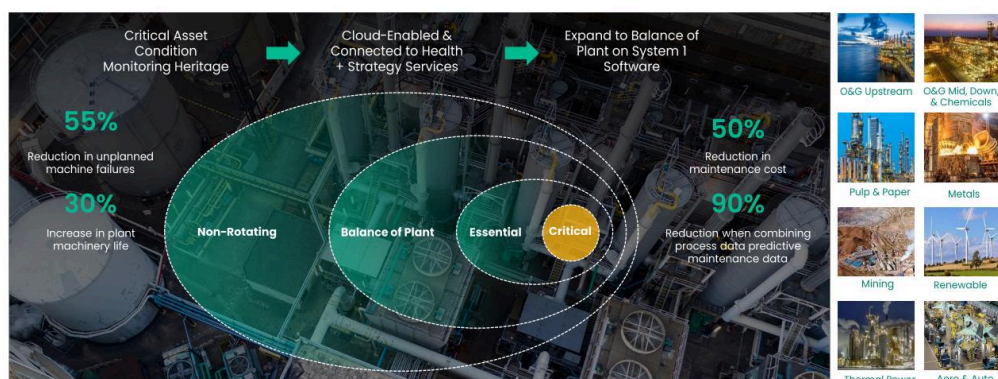


Source: Company reports

Maintenance management – less reactive, more predictive

OFS is helping energy and non-energy firms be more proactive and less reactive. Non-productive time is one of the largest sources of inefficiencies in the oilfield services industry. On the other hand, hours-based maintenance may result in over-capitalization of assets. Increasing predictive maintenance across the oil and gas value chain will be accretive to service provider margins through better asset utilization. Baker Hughes is building out its strategic investment in Asset Performance Solutions (APM) including critical asset monitoring and has recently expanded its reach to Balance of Plant with an investment and strategic partnership with Augury. Baker Hughes sees the APM market growing at a 10.1% CAGR through 2026, making it a significant growth opportunity.

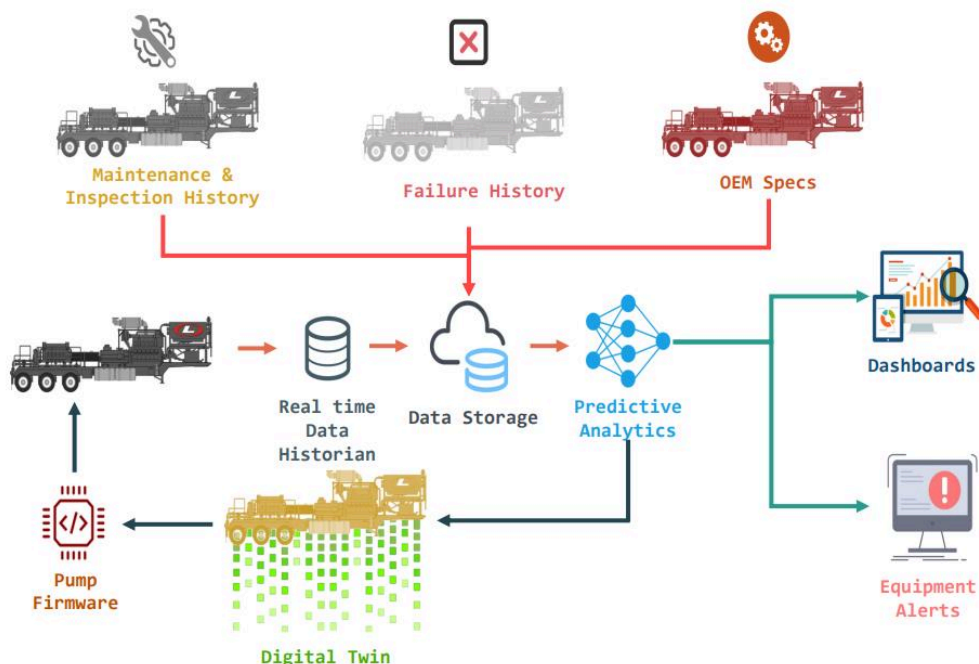
Exhibit 65 - Baker Hughes sees condition monitoring in industrial settings as a key growth area



Source: Baker Hughes

Predictive analytics are like an equipment ECG. Historically, maintenance inspection and failure history would be tracked manually, sometimes by individual mechanics. Pressure Pumper, Liberty Oilfield Services is digitizing its operational data through condition-based sensors, using predictive analytics to improve equipment reliability and reduce maintenance costs. The company's cost modeling represents a 2–3% cost-avoidance reduction in opex. Predictive maintenance modeling is gaining traction across the industry, but we believe is in relatively early stages.

Exhibit 66 - Pressure Pumping firms are using predictive analytics to better monitor assets



Source: Liberty Oilfield Services, RBC Capital Markets

Risks and potential issues

Partner risk: Oilfield services firms seeking to partner with incumbent technology companies to build out AI offerings may need to demonstrate both commitment to tangible greenhouse gas emissions reductions and progress towards the energy transition. We believe firms have made strides towards both, though progress timelines may need to be accelerated.

Slow adoption by customers: Capital scarcity may deter oil and gas services companies from investing in new technology.

Government regulation: Government regulation may play a role in slowing adoption and reducing benefits of AI. Specifically, potential taxation to compensate for potential job losses could slow overall adoption of AI initiatives.

Mining: “Intelligent mining” – AI and machine learning

Technological advances by major mining companies – via joint research studies with universities, original equipment manufacturers, and in-house development – have focused on robotics, big data management, AI and machine learning. This has been labelled in broad terms as “intelligent mining.”

Mining companies make decisions that impact production, safety and profitability every day. These decisions involve trade-offs, and given the scale usually involved in mining operations, sub-optimal decisions can have a large impact – be it positive or negative. Machine learning has been used to provide industry valuable insights through the whole value chain (from mine to port) in real time, using algorithms that learn and generate desirable behaviors and recognize patterns from input data containing relevant examples. We expect these uses to become of increasing importance for the mining industry over the years to come.

The mining industry’s cost base has been facing upward pressure due to various headwinds; we expect AI and machine learning to become increasingly important tools to boost productivity over the years to come.

Generally speaking, the mining industry’s cost base has been facing headwinds, including energy costs, higher strip ratios, more difficult ore bodies, lower grades and more complex lithology, increasing labor costs, input costs, higher government take/royalties, longer haul distances, and frontier regions for exploration (to name a few). These challenges have led mining companies to focus heavily on productivity (without losing flexibility); specifically, the performance of mines, processing plants, transportation, and exploration. Below, we provide an overview of some of these key areas of focus for future advancement.

Autonomous vehicles and transportation

One of the largest and most evident industry leading initiatives has been autonomous or semi-autonomous vehicles and transportation. At the mine site, autonomous and semi-autonomous vehicles (loaders and trucks) have improved fuel consumption, improved driver behavior, reduced performance variance, all impacting the volume of material moved and the cost of doing it. For a select few miners, who own their port and rail, this is now being applied to all parts of the chain.

Specifically for blasting, companies have been able to assess the strength and characteristics of orebodies/rocks while drilling, and subsequently test, apply and tailor different drill hole patterns, explosive types and blast design to ensure reliable and efficient rock fragmentation. The increasing ability to apply such learnings and systems to complex and diverse commodities and operations has also reduced manual mining and blasting, which is considered to be higher risk and lower efficiency.

Remote operation

Another key initiative is remote control centers, which allow trained staff to operate mine equipment, vehicles and systems remotely from town centers, from hundreds to thousands of kilometers away. The benefits of the continuous mining system while operating remotely has resulted in reduced operating costs and better productivity, as well as better quality of working life. This reinforces the notion that intelligent mining can respond to the challenges that the mining industry wishes to address.

Processing enhancements

With big data and intelligent mining came predictive maintenance. Algorithms are used to identify and highlight indications of failure (be it change in wear patterns, sound, heat generated during production, previous observed failures, historical maintenance, and weather). These algorithms would detect failures ahead of time, allowing mining companies to re-schedule and plan maintenance, order / stocking of parts, change ore feed and any other

inputs as needed. This has resulted in higher utilization rates and hence increased throughput and reduced the impact of planned maintenance, a trend we expect to continue as adoption increases across the industry.

Tools such as AI and optical ore sorting are being put to work already at companies like **Anglo American**, which has started using AI and optical sorting to pre-sort low-grade ore from going into the plant and is currently rolling this out at multiple operations. With processing, similar to predictive maintenance, the measuring and assessment of key variables across processing plants (be it a simple dry screening operation for iron ore or a complicated poly metallic processing) has led to optimization of yield by tinkering and changing physical or chemical variables. Higher yield equals to higher output and lower unit costs. Recently, there has also been the use of small pilot plants, which use machine learning to try to address specific processing problems at a small scale prior to moving to commercial volumes. These have led to more efficient deployment of capital and less downtime, once again pushing the boundaries of plant efficiency and uptime.

Exploration

Exploration is also increasingly utilizing machine learning and AI. A key example of this is the reclassification of millions (if not billions) of geographical data points to groups, and the use of machine learning to highlight signatures from existing mines and discoveries, which is then used to predict and highlight where to explore next. This has allowed more targeted exploration programs and reduced time in the field.

New technology is being used and rolled out in the mining industry all the time, with innovative ideas central to modern mining. We have also seen this manifest in soft skills, with more and more jobs becoming increasingly tech-focused. Not only have new roles been created, but also new crossover hybrid positions between the traditional mining roles such as mining engineering & geology and data science & software developers. As technology continues to increase its influence in the mining sector, we see a future with increased specialization in such fields.

Overall, through the whole mining value chain, machine learning, AI and innovation is becoming more integral to help miners improve and hone their competitive advantages (be it block caving, running infrastructure, low cost positions, exploration, innovative processing, etc.). Given that most structural cost headwinds that we referred to earlier continue to strengthen, we expect technology innovation and use of machine learning will be of increasing importance over the years to come.

As technology continues to increase its influence in the mining sector, we expect more jobs to become increasingly tech-focused, including more crossover between traditional mining roles such as engineers and geologists, data scientists and software developers.

Datacenters: The AI data storage conundrum

The computing needs of AI will drive solutions for data storage, security and sovereignty, while requiring a large buildout of compute and storage infrastructure. Companies are exploring the possibilities of edge compute in order to provide high-quality connections closer to the end user, ensuring better performance. However, to make this vision a reality, companies need to invest in edge data centers and other infrastructure that allows them to manage large quantities of data.

Big data and the use of AI to recognize trends will require additional capacity for data storage. The largest issues with data storage are cost and sovereignty. Companies will often discard data because of the high costs associated with keeping and transferring the data once stored, while governments debate over which jurisdictions own and have access to data.

In order to solve the cost problem, companies are increasingly focused on hybrid solutions, including a mix of cloud and on-premises storage for data. The increasing prevalence of sensors and compute and storage solutions that have lower costs and require less power will allow edge to serve a more crucial role in processing and storing data locally. In order to meet the demand required, companies will need to continuously build out more capacity for storage.

Edge will also play a pivotal role in resolving issues with data sovereignty. Data exists in a highly mobile state, which makes it difficult to determine who owns the rights to the data. With edge compute and storage, a company can make definitive claims regarding where the data exists and how it was collected. This will reduce data sovereignty issues as companies and governments will be able to understand when the data is shared and the source of the data.

Edge will also help from a safety perspective, as data is less exposed to cyberattacks when it stays within a certain storage unit. Less travel and better defined boundaries will allow companies to pinpoint the source of a cyberattack as well as reduce the frequency of cyberattacks through less travel.

Hybrid Living

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Hybrid Living – Introduction

As the lines between the physical and digital world continue to blur, we expect significant changes in societal interaction, workplace productivity, and opportunities to engage consumers, serving as a catalyst for entirely new business models.

Hybrid Living: Our environment is increasingly becoming inclusive of our physical space as well as our digital world. As augmented and virtual reality continue to become more user friendly and easier to access, the lines between the physical and digital will continue to blur. This will have significant implications on how we interact as a society, accelerate workplace productivity, create new opportunities to engage consumers and customers, as well as become the catalyst for entirely new business models.

In 2017, IBM made headlines for ending its decades-long remote work policy, and calling back into the office the 40% of its 386,000 employees who were working under that policy. Around the same time, other major employers, including Aetna and Yahoo, had also ended remote work policies that had enabled the companies to save money on office space, in the interest of better collaboration. Fast forward to March 2021 and IBM's CEO has publicly stated that 80% of the company's employees will work in hybrid remote roles after the pandemic. The pendulum of how we live and work has swung in different directions throughout time – from agrarian and rural to industrial and urban to now in the technology age. The ubiquity of technology and its adoption across age groups has ushered in an era of hybrid living.

What is driving this acceptance and uptake of hybrid living? Was this an inevitable change that the COVID-19 pandemic accelerated like other trends? Looking at the percentage of U.S. adults who say they use the Internet, broken out by age, in 2020, the 18–29 cohort is at 99%, the 30–49 cohort is at 98%, and the 50–64 cohort is at 96% – lagging behind them is the 65+ group at 75%. Except for the 18–29 age group, all groups saw an uptick of usage between +10–30pts since 2010.

Millennials were the first generation to grow up both in and out of the Internet age; their generation and the generations thereafter are extremely comfortable with technology as a part of everyday life, rather than as something separate and apart from real life. In fact, some studies have shown that technology is now so ingrained in daily life that the smartphone rivals the home as the most important place for consumers. In fact, by 2017 more than one-third of Americans lived in a household with three or more smartphones according to Pew Research. By 2020, U.S. households had, on average, ~10 connected devices in the home.

A survey conducted by Strategy Analytics in 2019 found that more than 54% of households own at least one smart home device (speakers, thermometers, security, light bulbs, etc.). These frequent and repeated interactions with technology on a daily basis have made consumers more comfortable than ever with technology, blurring the line between online and offline.

Younger generations today are already more comfortable creating online communities and living a significant portion of their social lives online. An area where this is most prominent is in the gaming community. Fortnite, an online video game created and launched by Epic Games in 2017, had over 125 million players in less than a year, and had more than doubled this by May 2020 to over 350 million players.

It is possible this comfort with socializing online was part of the driving force behind millennials' rejection of nightlife culture in the 2010s. The phenomenon of "cocooning" has been observed across multiple survey results; in a 2016 survey, YPulse found that more than 70% of millennials and teens would rather stay home than go out on the weekend. In fact, across all age groups, a majority of respondents said they would rather stay home than go out on a Saturday night. The same survey found that over **80% of 21–33-year-olds would rather give up drinking for a week than give up their phones.**



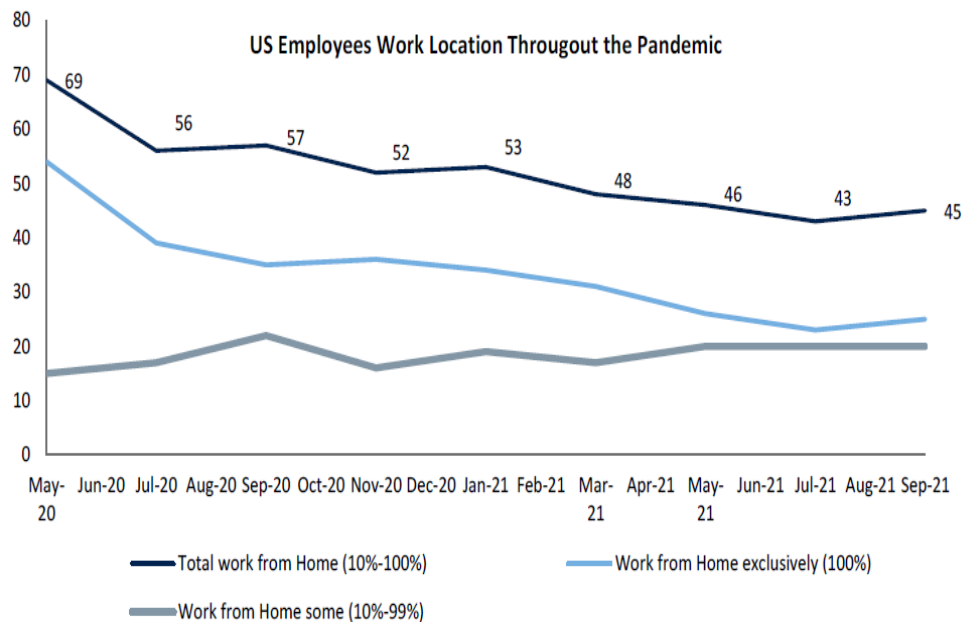
The COVID-19 pandemic only accelerated these trends, which were already quite prominent. Following more than a year of spending more time at home (and investing in their homes) and adapting to a virtual environment, consumers are more comfortable than ever living a hybrid life. In a 2020 survey, 70% of consumers said they would prefer to see a first-run movie as a digital rental at home than in a theater if both were available at the same time for the same price.

The hybrid lifestyle has also taken a stronghold with daily life beyond just entertainment. At-home exercise equipment must be not just functional but interactive, engaging, and provide an online community of support. The success of Peloton has been the company's interface, which "gamifies" use of the bike, providing "badges" for various accomplishments and milestones (streaks of use, number of classes, trying to new classes, themed classes). The company also boasts a strong online community, with groups forming and finding each other via hashtags and large online communities; one such community centered around strength classes on Peloton's app "hardcore on the floor" boasts almost 250,000 members online. We see similar dynamics with other modern products that build a community around them, including Traeger, a grill company.

Software: The future of work

Of course, we cannot talk about the hybrid lifestyle without discussing hybrid work and its implications. Prior to the COVID-19 pandemic, only about a quarter of U.S. workers worked from home with regularity. Data shows those workers tended to be more senior and in managerial positions. At the peak of the pandemic, nearly 70% of the workforce was working from home (as were the vast majority of the school age children, learning from home)—a number that Gallup estimates at ~100 million remote employees.

Exhibit 67 - During the peak of the pandemic, ~70% of the U.S. workforce was doing some level of remote work



Source: Gallup. RBC Capital Markets

Similar to the dynamic of consumers sticking to cooking habits they learned during the pandemic, we expect a strong desire for flexible work to continue, especially among white-collar employees.

As the majority of Americans received vaccinations and mobility returned, the number of those working from home exclusively fell, but those with some level of working from home did have some stickiness to it. Similar to the dynamic of consumers sticking to cooking habits they learned during the pandemic, we expect a strong desire for flexible work to continue, especially among white-collar employees.

According to Gallup, over 90% of WFH employees said they want to keep their workplace flexibility post-pandemic, and over half preferred a flexible arrangement. Over 50% of fully remote and nearly 40% of hybrid workers said they were extremely or somewhat likely to leave their jobs over lack of remote working options.

The consequences of remote/hybrid work would have tremendous implications for population centers. While we do not expect all the office workers of New York City and San Francisco to turn to an agrarian lifestyle, the possibility for workers to decouple from coastal cities could slow or reverse over 200+ years of urbanization trends in America.

The implications for such a shift in the United States cannot be underestimated. For example, what happens to electoral politics and the balance of power? What happens to major city centers with large budgets should a large share of the tax base exit? What happens to the value of both personal and commercial property that got its value for being in proximity to

these places? What are the implications for the environment without the daily commute (which has grown ~25% in the past 40 years)?

How we see the future of work playing out from here

We believe the future of work is hybrid but "hybrid work" can manifest in different ways. **We outline three different hybrid work models:**

- 1) **true hybrid work** – employees work in the office 2–3 days per week and remote the remaining 2–3 days;
- 2) **fully remote** – offices exist in this model, but there is no requirement for employees to be in the office consistently; and
- 3) **virtual-first** – most employees should work from home most of the time, but teams are encouraged to use offices for tasks that require in-person collaborative group work.

All these models require businesses to re-imagine operating models for people, places, and processes, and, importantly, the technology required to support these future operating models. Alongside smart speakers, AI-infused webcams, and a number of different hardware devices adapted for hybrid, we believe software plays a critical role in supporting the future of hybrid work.

In our view, virtual meetings are here to stay despite employees who are experiencing "Zoom fatigue," only now businesses need to adapt their video-conferencing solutions for hybrid work scenarios. We see a number of exciting technologies surfacing from video-conferencing vendors (Zoom, Microsoft) in order to enable hybrid meetings, such as interactive whiteboards (Zoom announced at Zoomtopia, joining Microsoft's Miro, among others in the space), Microsoft's fluid components technologies, interactive webinars, and new layout modes catered to hybrid meetings (meaning there are people both physically and digitally attending a meeting simultaneously). Microsoft and Slack are also testing push-to-talk features into their platforms as well as push-to-video (short video-based messages). In addition, we believe business travel will always remain depressed relative to pre-pandemic levels and a significantly greater share of meetings (including internal and external) will be done virtually. We expect there to continue to be new, innovative technologies built for both internal and external communication/collaboration in order to support hybrid work models.

Where could we see the future of virtual meetings? Mixed reality. We believe mixed reality (MR) could drive the next evolution of virtual/hybrid meetings and in general have an imprint on the future of hybrid work in the long term. Microsoft's keynote at Inspire brought mixed reality to the forefront with a demo of Spatial Anchors, an early-stage product for multi-user mixed reality experiences where teams in different geographic regions can collaborate in a shared virtual experience leveraging holoportation, logographic sharing, and visualization. This particular use case of mixed reality remains far from being ready for widespread use case but we think it will be an important market to watch develop with players like Facebook, Apple, Microsoft, and Snapchat all taking the mixed-reality space seriously. We note augmented reality (AR) hardware and software vendor, Magic Leap, spent the last few years re-focusing its business on enterprise use cases after VR struggled to take off on the consumer side (gaming) and in early October raised a \$500M funding round at a \$2B valuation. We note mixed reality's use case extends beyond knowledge worker meetings to first line workers, who are already using augmented reality glasses and headsets in industrial settings for worker safety, training, remote assistance, and 3D remote inspections. In addition, mixed reality is serving real-world use cases in 3D visualization for designers, engineers, doctors, and digital twins' use cases.

We expect there to continue to be new, innovative technologies built for both internal and external communication / collaboration in order to support hybrid work models.

Significant investment in customer experience, but how about employee experience?

Businesses were pressured to significantly invest in Customer Experience technologies during the pandemic as physical/in-person storefronts, client meetings, marketing events, and call centers were all shifted to digital. In turn, modern front office software vendors saw an uplift. However, back-office vendors largely underperformed their front-office peers. Although businesses were quick to adopt collaboration and communication tools, such as video conferencing, persistent messaging, and project management software, we believe this came at the expense of potentially modernizing their human capital management (HCM) and enterprise resource planning (ERP) software.

To some extent, we believe the de-prioritization of the broader employee experience has contributed to what has been deemed the "great resignation." In August, a record 4.3M U.S. employees resigned from their jobs, which is the highest level since the Bureau of Labor Statistics began tracking the metric in 2000. In response, we are seeing some companies begin to increase salaries and most at least partially adopt more flexible work models in order to attract and retain talent. We see this as especially true in the technology sector given "cool" physical office spaces don't carry as much weight for a more remote and distributed workforce.

Therefore, we believe current labor dynamics could serve as a potential catalyst for a wave of public and private investment in HCM-related software in order to manage, analyze, and improve the employee experience across the full employee life cycle (from onboarding to talent management to departure). We believe there are many legacy, disjointed tools that go undiscovered by employees despite businesses' investments in them. We see solutions like Microsoft Viva's Employee Experience starting to fill that gap as an interface to bring all those disjointed products into one pane. In addition, there are some businesses gradually making increased investments in nascent technologies like learning experience platforms, "Voice of the Employee" solutions (Qualtrics Employee Experience, Workday's Peakon), and Digital Adoption Platforms (WalkMe, Whatfix). In all these areas, we believe corporate buy-in is still in its very early stages.

Longer term, we observe a number of HR use cases where there is room for innovation. We believe data-driven and AI strategies can still play a much larger role in HR, such as in talent acquisition, employee coaching and mentoring, self-service chatbots, and employee experience analytics. In our view, analytics is still very underdeveloped in HR use cases. We believe employee engagement tools could be an interesting area too (e.g., solutions to facilitate more frequent and personalized communications between HR or managers and their employees to check in on wellness, track professional development goals, and discuss benefits, etc.).

In our view, analytics is still very underdeveloped in HR use cases. We believe data-driven and AI strategies can still play a much larger role in HR, such as in talent acquisition, employee coaching and mentoring, self-service chatbots, and employee experience analytics.

Education: The early innings of a total transformation

While in the very early innings, we believe the future of edtech is finally here and we expect innovation to continue rapidly over the next 5–10 years.

From K–12, to higher education, to professional education, the way we learn has been evolving in new and exciting ways for years with the COVID-19 pandemic accelerating this path significantly. That said, despite all the changes to the system of learning in 2020/2021, we believe that the transformation of education is still in the very early innings. We have closely followed the edtech landscape for years and it was not until 2021 that edtech truly seemed to be catching up to the hype. In our view, the future of edtech is finally here and we expect innovation to continue rapidly over the next 5–10 years.

Why now? What has changed? We see two catalysts that have driven this advent of edtech transformation. First (and more obvious) is COVID-19, the "grand experiment" for schools that effectively forced educators globally to adopt technology overnight. Teacher adoption of technology is critical and the genie will not be going back in the bottle now that teachers have seen the power of solutions for facilitating in-person education. Similarly, based on our industry checks we believe that administrators/decision makers are now more supportive of using technology to facilitate learning, and are doing so at an increasing rate (as opposed to more back-end use cases). Second, we believe that the technological infrastructure of learning institutions even 3 or 4 years ago was not up to the challenge of making adoption of integrated edtech solutions viable. The steady upgrade of IT systems, the availability of devices for K–12 students, and the adoption of the cloud are all recent changes that we believe finally can give edtech a place to shine at K–12 and universities alike.

How could edtech shape the future of K–12? While we do see a number of exciting tools (e.g., modern display technology like interactive whiteboards) and software (Zoom, Kahoot!) gaining adoption in K–12, we believe these tools are only scratching the surface for how technology can shape learning. For us, the rise of personalized learning tools is the most exciting change in the K–12 landscape and is something that we believe can improve learning outcomes and equity. Over the next 10 years, we expect public and private K–12 schools alike to adopt solutions like analytics that can identify core areas of focus, software with personalized learning tracks, or even the availability of micro-tutoring delivered virtually.

Higher education; an antiquated business model? For years, universities have taken an almost "vertical integration" approach to the campus sprawl, trying to do everything for everyone largely out of a need for physical proximity. The thinking is that providing breadth and depth of products and services in a centralized location would maximize a college's value proposition. The growth of modern campuses (both upwards and outwards) is supported in part by student loans (the average U.S. borrower in 2020 had \$37,000+ of student debt). While questioning the value proposition and business model of higher education is not new, COVID-19 has brought higher education's many shortcomings to the surface. Students are realizing now more than ever that there are more efficient or cost-effective methods of obtaining an education (or even direct employment), and we expect parents and students alike are more likely to balk at the high sticker price of an in-person education (particularly when part of tuition is being used to fund services or facilities that the student will never utilize). We take the view that the advent of cheaper and (often better) education alternatives along with waning demand for traditional (and expensive) education will cause many universities to reevaluate their business models. We believe that tighter integration with online learning platforms like Coursera will be a critical component of this long-term tailwind.

We believe online degrees will increasingly be part of higher education's playbook. Fall 2020 immediate college enrollments declined ~7% Y/Y (National Student Clearinghouse). Balancing this with the economic fallout from extra expenses in 2020 needed to make campuses COVID-19 ready and many colleges were left in a difficult situation; spending money they didn't have

We believe that the advent of cheaper and (often better) education alternatives along with waning demand for traditional (and expensive) education will cause many universities to reevaluate their business models.

In our view, a hybrid work future is the most likely outcome for enterprises, and we expect corporate and consumer learning platforms to play a larger and larger role.

We also believe that the growing “skills gap” in enterprises has been widened by the pandemic and that online learning can be used to help bridge this gap.

in 2020 and then losing tuition. Considering that tuition itself is unprofitable for many colleges before state funding (dorms are often one of the best profit centers for colleges), this decline in enrollment is a significant impact to colleges' financial state that will be felt for years. Because of this, we believe that additional sources of revenue are critical for universities to maintain their financial well-being in the near term and expect to see more universities offer online education options to students by partnering with Online Program Management (OPM) platforms like Coursera. Importantly, after the initial upfront investment required to kick-start one of these programs, OPMs typically take over the marketing costs, providing universities with a low-cost method to retain and expand their student base.

Edtech and the hybrid work future. In our view, a hybrid work future is the most likely outcome for enterprises, something that brings new challenges for educating a company's workforce. We expect corporate and consumer learning platforms to play a larger and larger role in this hybrid work future not just in terms of size and spend, but in determining use cases and ways businesses can leverage education platforms to drive better business outcomes:

Talent acquisition and re-skilling. We believe that the growing “skills gap” (the skills employers want vs. the skills employees have) in enterprises has been widened by the pandemic and that online learning can be used to help bridge this gap. On hiring, we have noticed a growing trend of education platforms branding themselves as talent acquisition tools that can connect employers with learners that have gained the skills needed via learning platforms. Similarly, this use case increases the attractiveness of the learning platform for learners (creating a nice “flywheel” effect) as these platforms can increasingly pivot themselves as a job placement tool with insight into the most hireable and in-demand skills. For existing employees at an organization, learning platforms can be an effective, long-term tool for employers to create learning paths to up-skill their workforce and further bridge the skills gap (a use case that has substantial ROI implications).

Employee retention. With the market for talent (particularly technological) being so competitive, employers are increasingly focused on retention of employees with in-demand talents. Corporate learning platforms, particularly those that provide a track or path to up-skilling or promotion for an employee, can be a nice incentive for employees to remain with an organization.

Tech vendors and education. One of the fastest-growing trends we have seen in online learning content has been the rise of tech vendors providing classes for free or reduced cost. This benefits technology vendors by familiarizing future workers (and potential buyers) on their solutions or by providing a pool of potential workers for the vendor. We expect this to become a larger and larger part of technology companies' playbooks over the years and see potential for tech companies to expand these programs further by partnering more deeply with universities.

Gaming: Let's have some fun

The long arc of human achievement

Author Byron Reese in his book “The Fourth Age” believes humanity is set to embark on a fourth age of robots and AI, superseding a third age that brought writing and wheels, a second age that brought agriculture and cities, and a first age that brought language and fire. Separately, The Atlantic published the “50 Greatest Breakthroughs since the Wheel” using functional categories (provided by Stanford business historian Leslie Berlin) to group these breakthroughs into innovations that:

- **Extend intellect:** The printing press, semiconductors, paper, Internet, personal computer, photography, abacus;
- **Extend life:** Penicillin, optical lenses, vaccination, nitrogen fixation, sanitation, refrigeration, the pill, the green revolution, moldboard plow, Archimedes’ screw, cotton gin, pasteurization, scientific plant breeding, the nail, the lever, the combine harvester;
- **Kill:** Gunpowder and nuclear fission;
- **Extend communication:** The Internet, telephone, telegraph, radio, TV;
- **Extend mobility:** The internal combustion engine, steam engine, airplane, compass, automobile, sextant, sailboat, rocketry;
- **Are organizational:** Alphabetization, the Gregorian calendar, paper money;
- **Are critical physical and operating infrastructure:** Electricity, sanitation, cement, air-conditioning; and
- **Enabled the Industrial Revolution:** The steam engine, steelmaking, oil refining, oil drilling, assembly line.

Our innate quest to transcend time and space

Regardless of how one categorizes human achievement, we believe one unifying theme from media history is our innate quest to transcend time and space (and our interaction therein). While humanity is clearly far from being done on the physical front by transcending “physical space and time” (space exploration being a concrete case in point), like Bryon Reese, we do expect a notable acceleration in the human transcendence of “digital time and space. In our June 2018 RBC Telecom Scenario Report entitled “[Intelligent Reality and the Inflection Period for Content](#),” we created a roadmap by which investors could better understand and track this acceleration, highlighting how, with personalized platforms that integrate VR/AR/MR and AI, the digital boundaries for mediated reality (time and space) and mediated intelligence (interactivity) are virtually infinite, and only restrained by the capabilities of the technology stack.

Even better than the real thing

With the relentless advancement in the technology stack, in our view, it is almost mathematically certain that VR/AR/MR and AI usher in a new era of mediated reality and mediated intelligence that begins to rival that of, and in some instances substitute for, the real world. While there are numerous examples of such substitution already taking place – work-from-home, video conferencing, virtual learning, remote healthcare, online gaming – we believe these examples only scratch the surface of what the full transcendence of digital time and space could represent. Furthermore, hybrid living and the “fusion” of physical and digital time and space is likely to lean on a variety of interfaces from traditional screens and headphones to VR goggles and AR glasses to virtual assistants, holograms and eventually multiple machine-human interfaces. Ultimately, we think the most successful personalized platforms in support of hybrid living will be those best able to fuse physical and digital worlds in the most natural, seamless and holistic ways.

We believe that VR/AR/MR and AI will usher in a new era of mediated reality and mediated intelligence that begins to rival that of, and in some instances substitute for, the real world.

We believe the economic, social, cultural, political and environmental impacts that the second iteration of the Internet (often referred to as the “Metaverse”) will bring will be nothing short of profound.

Sizing up extension versus substitution

The disruption that the first iteration of the Internet is having on several industries (media, retail, real estate, banking etc.) and institutions is well documented. While significant, we believe the economic, social, cultural, political and environmental impacts that the second iteration of the Internet (often referred to as the “Metaverse”) will bring will be nothing short of profound. In grasping the investment implications of an acceleration in the human transcendence of digital time and space within this Metaverse, a critical component will be understanding where digital time and space will be an extension of physical time and space, and where it will be a substitute. Against this backdrop, we caution that the more obvious “extension scenarios” whereby the productivity of industries and institutions are greatly enhanced by VR/AR/MR and AI technology, will need to be carefully sized up against the less obvious but much more profound “substitution scenarios” whereby existing industries and institutions are outright displaced.

In the meantime: It’s all fun and games!

For an early glimpse of what the transcending of digital time and space and hybrid living could look like, we turn to the global gaming ecosystem. Enabled by the advancement of the technology stack, video games are now fully morphing into broader, holistic immersive platforms that converge entertainment, information and communication while embedding powerful social, sport and commercial elements. The amplification of these elements has resulted not only in a much larger gaming ecosystem, but one where we believe the level of engagement is simply unparalleled across mediated content, rivaling that of in-person interaction and even physical sport. Furthermore, there is no doubt in our mind that gaming is already an identity and a lifestyle and at the center of pop culture for Gen Z (ages 6–24) and most millennials (ages 25–40), displacing TV, movies and music that had arguably held this position for the better part of the 20th century.

In our view, characteristics of gaming that position the global gaming ecosystem near or at the forefront of hybrid living include:

- Gaming is addictive as a highly immersive form of entertainment;
- Gaming platforms sit at the frontier of the current technology stack with computer-simulated platforms serving as natural environments for VR/AR/MR and AI;
- Gaming content has a natural head start with respect to the mediation of reality and the mediation of intelligence;
- Gaming is at the center of pop culture at a time when the rate of change in mediated content is set to accelerate through our mid-2020s inflection period;
- Gaming personas naturally have “presence” and are inherently “relevant” providing high degrees of anonymity, freedom of expression and exploration, acceptance, authentication and/or sense of community; and
- Gaming platforms by design look to be a natural precursor to the “Metaverse.”

Internet: Metaverse – The story of the ultimate walled garden

Metaverse is the next stage in the evolution of the Internet

In our view, the metaverse is the most logical next step in the evolution of leveraging the confluence of bandwidth, software and mobility to where those foundational components are now evolved enough to begin integrating aspects of the physical world more immersively into the digital world. With that said, much like those that have been big beneficiaries in the current Internet, we see many of the same determinants of success as companies pursue their relative metaverse strategies, which is likely favorable for a few players in the Internet space.

In line with prior generations of Internet value creation, we think the likely beneficiaries in the emerging Metaverse are companies pursuing some iteration of the walled garden approach, as opposed to those with a blockchain/open-source/disaggregated platform structure.

One of the key debates we see forming is the notion that the metaverse could be colonized by one or just a few ecosystem providers vs a blockchain/open-source/disaggregated platform structure. Obviously, the potential for infrastructure, hardware, software and applications partnerships is enormous. In line with prior generations of Internet value creation, however, we think benefits may accrue to companies pursuing some iteration of the walled garden approach as connectivity's inherent network effects should likely allow for rapid formation of competitive moat, which is virtually impossible to overcome once it has begun.

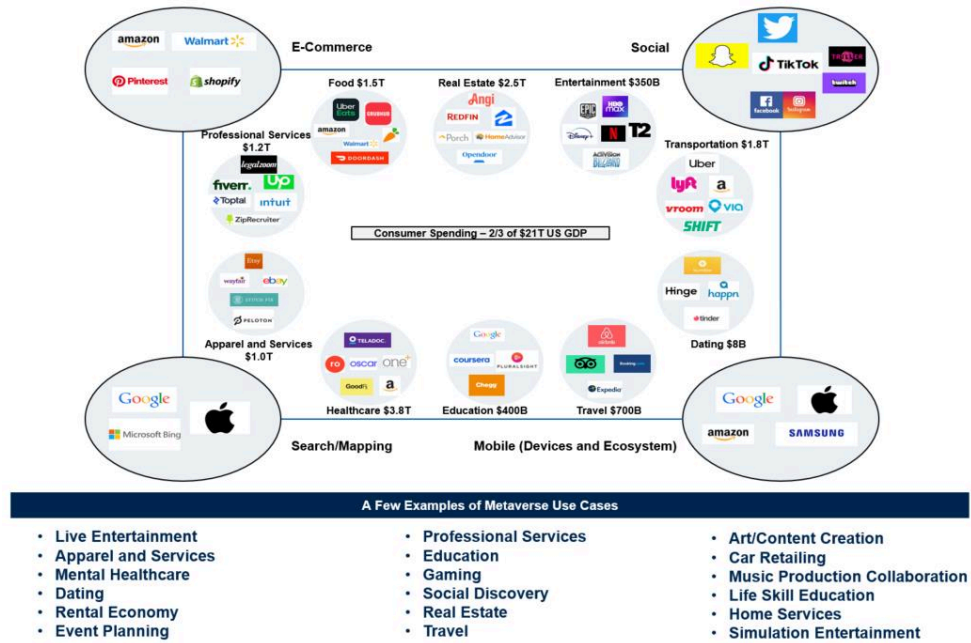
Obviously, we're biased, but we believe the walled garden approach likely carries some significant structural advantages:

- 1) Full ecosystem control leads to tighter integration between hardware, software and the respective ecosystem enabling likely broader innovation and a better, more cohesive user experience.
- 2) The existing possession of the largest audiences should provide meaningful tailwinds to metaverse adoption given that any open-source consortium may encounter initial foundational platform discord that will slow the pace of innovation and adoption.
- 3) The ability to tie data from existing platforms like search and social should favor those seeking vs those that must compel a new user base.
- 4) Expanding ability to manage risk exposure to user privacy and a myriad of potential criminal applications.

In terms of low-hanging fruit verticals for early pursuit within a metaverse environment, we believe they must possess two core characteristics:

- 1) The digital experience must at least somewhat reasonably approach the equivalent physical experience while not reducing the efficiency of the current online equivalent (buying books online vs digitally finding them in the metaverse); and
- 2) There must be some commercial aspect to the activity. Obviously anything around education, gaming and many leisure activities such as any sort of live entertainment likely makes the most sense, but we also think of interesting commercial applications like manufacturing, robotics, real estate, dating, travel, home services, car retailing and many other use cases across other enterprise and professional services applications.

Exhibit 68 - We think metaverse applications make sense across the spectrum of consumer (and this doesn't even include enterprise)

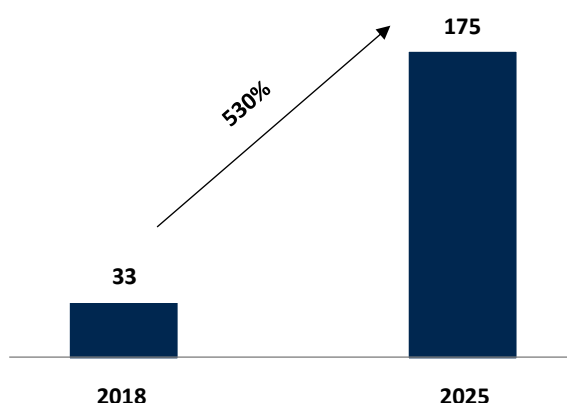


Source: Company reports, U.S. Census Bureau, UStravel.org, RBC Capital Markets estimates

Internet: Policing the online world

Digital content has exploded. The amount of data generated every day has exploded. The World Economic Forum estimates that the volume of data in the world will increase 530% from 33 zettabytes (one billion terabytes) in 2018 to 175 zettabytes by 2025. This is up from 1 zettabyte in 2016. With significant reductions in prices and advances in the quality of sensors, nearly every device generates data that is now stored locally or is uploaded to the cloud. Social media encourages consumers to create and share more digital content. Global smartphone penetration has reached 81%, according to Statista, which means that the vast majority of the population is able to create and share content whenever and wherever.

Exhibit 69 - World Economic Forum expects global data measured in zettabytes to rise another 530% by 2025



Source: RBC Capital Markets, World Economic Forum

According to the European Commission, 85% of criminal investigations involve some form of digital evidence. While the vast majority of digital content is innocuous (like cat videos), a small portion involves criminal activities, provides evidence of criminal activities and involves communications and other metadata to establish relationships between criminals.

The good guys are only going to need more help. Digital forensics software are tools used for the identification, extraction and preservation of digital evidence, which can be used by a court of law. These tools help law enforcement agencies sift through enormous amounts of data to find illicit or suspicious content in an efficient manner. Moreover, these tools analyze digital “artifacts” or traces of data left behind on digital devices. Artifacts help trace the activities and communications of criminals, even when they may try to conceal their activities. Artifacts typically provide clues that help investigators identify additional locations of digital evidence, such as websites or apps that criminals may have used or the timing of certain illicit activities.

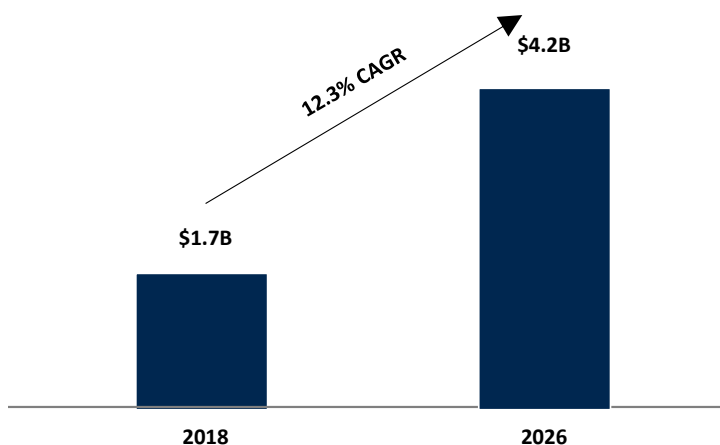
Digital forensics is a niche, yet growing market. Grand View Research forecasts the digital forensics market is set to expand at a 12% CAGR from \$1.7B in 2018 to \$4.2B in 2025. Drivers of growth include increasingly sophisticated criminals using electronic communications, the digitization of data, and the exponential growth in data volume and complexity across numerous applications, devices, and cloud services. Additionally, there is a lack of technical expertise among investigators, which requires advanced software to help efficiently and effectively investigate criminal activities.

The digital forensics market is set to expand at a 12% CAGR from \$1.7B in 2018 to \$4.2B in 2025.

Helping fuel this growth is a lack of technical expertise among investigators (among other factors).

Exhibit 70 - Grand View Research estimates digital forensics is a \$1.7B market, which it forecasts to grow at a 12.3% CAGR

While we believe digital forensics tools are predominately used in the public sector, enterprises are increasingly adopting digital forensics as part of their cybersecurity practices.



Source: Grand View Research; RBC Capital Markets

Digital forensics is crossing over into the corporate market. While we believe digital forensics tools are predominately used in the public sector, enterprises are increasingly adopting digital forensics as part of their cybersecurity practices. The COVID-19 pandemic has raised the need for digital forensics solutions in the corporate market given the elevated level of cybersecurity crimes. According to McAfee, COVID-related cyberattack detections increased 240% Y/Y Q3/CY20 and 114% Y/Y Q4/CY20. In particular, these tools help IT professionals analyze insider threats (e.g., corporate espionage, sharing of trade secrets) and identify exposures from malware and other cybersecurity attacks. Additionally, digital forensics tools are crossing over into adjacent markets like case intelligence & analytics and electronic discovery (e-discovery). Case intelligence & analytics software is used to manage workflows in forensics labs and organize large amounts of digital evidence. E-discovery software involves identifying, collecting, and analyzing electronically stored information in response to a legal dispute or internal investigation.

Monitoring the regulatory front

While the mass of data collected on individuals continues to grow, calls for regulation around personal privacy and data protection will become increasingly important. Privacy regulations regarding consumer data are limited, which allows advertisers and social media companies to sell and use data in order to market their products more effectively. While ads and social media feeds are more targeted to a particular person, and thus, more meaningful, many consumers are worried about the lack of transparency as to what their data is being used for. As a result, debate around regulation and possible legislation of consumer data uses will continue to be prevalent moving forward.

Regulations could broaden to hold Internet companies more accountable for data generated on their platform or misuse of consumer data.

Regulations could broaden to hold Internet companies more accountable for data generated on their platform or misuse of consumer data. Section 230 of the Communications Decency Act currently gives companies protection from liability for user-generated content on their platforms. While this protection has benefitted companies since their inception, consumers are becoming more aware of how their data is being used to shape the online environment around them. In order to prevent misuse of their ever-increasing data footprint, consumers may push for Section 230 to expand its scope. The widened focus could include a provision for social media companies or other Internet companies to meet certain standards regarding transparency and data security to qualify for protection under Section 230.



Additionally, the use of AI ultimately benefits consumers in the form of better ads or a more tailored newsfeed; however, insights gained from the use of AI may provide deeper knowledge into behavior and profiles that consumers may not want to share with a company. Strict privacy standards on what data AI can analyze as well as how it can sell or otherwise use data will need to be regulated in order to keep data private and in the hands of consumers.

Manufacturing: Factories of the future

Using digital tools will increasingly make breakthroughs in the physical world. From a manufacturing standpoint this means more AI/machine learning, 3D printing, robotics, rapid prototyping, etc. The scaling potential of changes to manufacturing with the advent of Industry 4.0, the industrial Internet of Things, is a vast opportunity. This can move well beyond “smart” manufacturing to complete end-to-end connectivity across the supply chain allowing for significantly richer information and flexibility. There will be an increasing focus on the “machine that makes the machine.” So the factory moves from robots that are printers or assemblers or cutters to self-assembly machines that can merge materials and assembly functions. If we think about the amount of IoT devices in factories and throughout the supply chain, it is possible that manufacturing can be on the same cusp of scaling that the Internet saw when it scaled as devices moved from mainframes to computers to smartphones. The recent supply bottlenecks, logistical issues and factory downtime issues post COVID-19 have highlighted the need to strengthen supply chains. Robotics, AI, software and other predictive technologies can help supply chains run more efficiently.

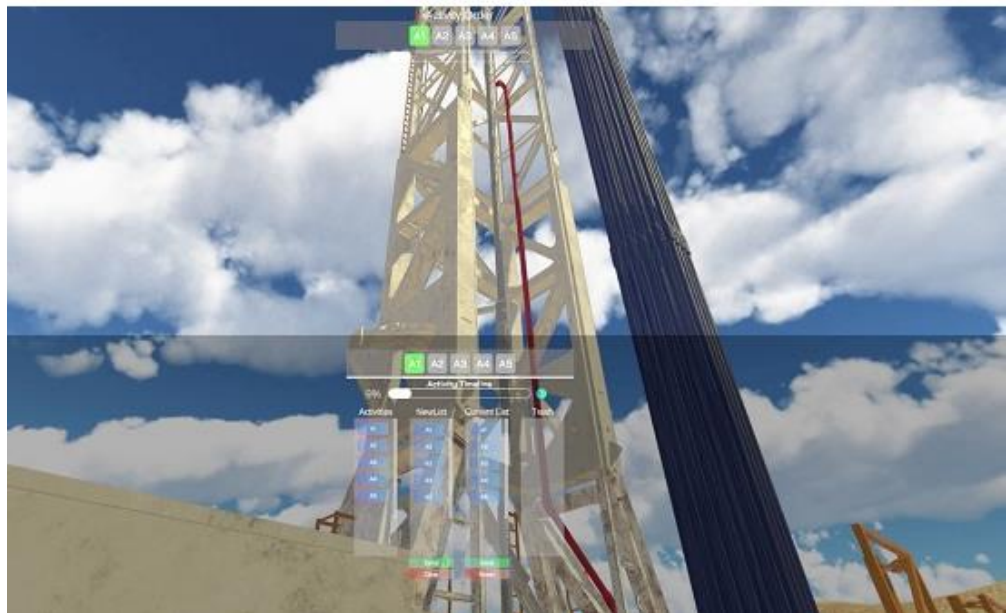
While this will require significant investment and capex, it is not hard to imagine that the payback can be fairly quick given productivity, reduced operation costs in logistics, labor and materials as well as working capital efficiencies.

Energy: Oilfield Services...from home?

Remote operations and enhanced collaboration tools are being increasingly used to complete projects within the oil & gas industry, with adoption partly driven out of pandemic-necessity. Remote monitoring provides enhanced efficiencies, improved safety, and in some instances, may help lower emissions through fewer unnecessary trips to remote well or rig sites. Effective remote operations require enhanced asset monitoring capabilities, communication, and analytics.

The virtual oilfield. Schlumberger is conceptualizing a virtual twin environment where users from multiple organizations can access a virtual project. The software creates a digital rendering of a completions site, rig, or gas processing plant. Users can look at the animated activities and operations sequence and choose to collaborate or make changes in real time. The whole workflow is accompanied with a combination of gaming and real-world features to improve the user experience: 3D avatars, white boards, notes capture, and chat and voice communication. Each of these can be experienced in VR, on a mobile or PC mode. Eventually the virtual environment may be used to conduct simulation analysis.

Exhibit 71 - 3D immersive environment for drilling



Source: Schlumberger

Medical devices: The world of smart implants

The integration of smart implants into daily clinical practice could have significant benefits for the patient, physician, and payor.

We expect the data collected by smart implants to eventually be tied to patient outcomes with the ultimate goal of combining sensor capabilities with artificial intelligence to assess implant fidelity in real time and provide the physician with improved decision-making ability.

Smart implants are the future of the medical device industry. Smart implants are implantable devices that not only provide therapeutic benefit to treat the underlying disease, but also provide diagnostic capabilities. The underlying sensor technology is not new and has been utilized in the medical device industry for decades, such as in cardiology and in wearables. That said, the integration of sensor technology into implants to make them ‘smart’ and capable of diagnosis for potentially decades post-surgery is a significant leap forward, in our view, that leaves no room for patient non-compliance.

There are significant benefits associated with smart implants. The integration of smart implants into daily clinical practice could have significant benefits for the patient, physician, and payor. For the patient, it is likely to drive early detection of deteriorating conditions, such as post-surgery, which could in turn allow for early intervention and treatment of the condition. For the physician, it is likely to drive efficiency in patient treatment as they can spend time treating more severe or higher acuity cases as well as drive additional revenue streams with remote patient monitoring. For the payors, it is likely to drive significant cost savings due to early detection and treatment of the disease, which in turn could drive down revision rates over time.

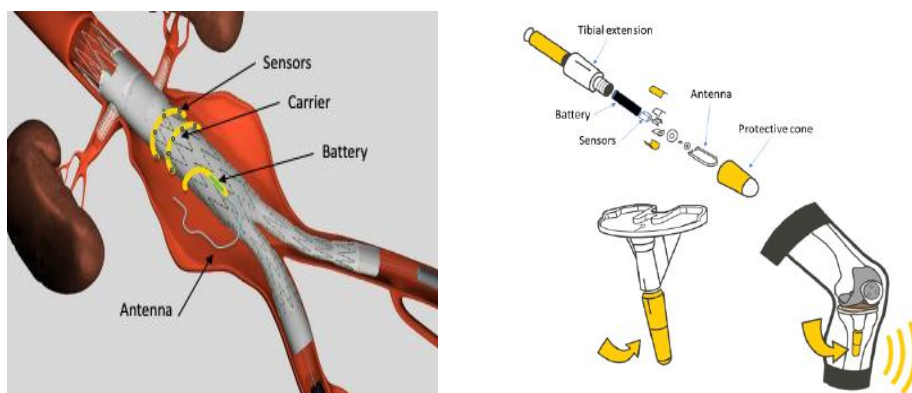
Smart implants are likely to permeate into several medical device sub-markets over time. ‘Smart’ implants have applicability in a range of medical devices. The near-term applications are likely to be in orthopedics such as reconstruction (e.g., knee and hip arthroplasty), spine (e.g., fusion procedures), shoulders (e.g., replacement procedures), and trauma (e.g., fracture fixation among others). The intermediate applications are likely to be in areas such as vascular (e.g., aortic aneurysm and stents), as well as aesthetics (e.g., breast implants). In the long term, we expect ‘smart’ implants to permeate throughout the field of medical devices and become the standard of care.

Smart implants will expand the scope of their diagnostic capabilities over time aided by artificial intelligence. Smart implants are likely to be limited in the scope of their diagnostic capabilities initially as we expect the data capture to measure physiological parameters such as activity and motion in orthopedics (i.e., gait, range of motion, average walking speed, and distance traveled) and pressure and flow in vascular. Subsequently, we expect this data to be tied to patient outcomes with the ultimate goal of combining sensor capabilities with artificial intelligence to assess implant fidelity in real time and provide the physician with improved decision-making ability.

Smart implants could lower revision rates in orthopedics and allow monitoring of brain aneurysms in neuro applications. In orthopedics, sensors measure frequencies in knees or how firmly an implant is integrated into the surrounding bone. As the implant begins to fit more firmly into the surrounding bone post-surgery, the frequency captured should reduce suggesting a successful surgery. If the implant begins to loosen after several years, the frequency captured will begin to increase and be captured by the physician’s monitoring hub for follow-up. This capability can address a major issue of micro-motion or the feeling of instability in knees, which is a major contributor towards a 20% dissatisfaction in knee procedures. The technology could help identify other complications as well such as contracture or restriction in motion, aseptic loosening caused by foreign body reaction to wear debris, and infection. If such conditions can be detected early, it may require a simple change, manipulation, or revision of a component of the implant versus a revision surgery that is costly and has greater implications for the patient. In neurovascular, sensors could be integrated with flow diverters, as an example, for the treatment of brain aneurysms or bulges in blood vessels

or to monitor hemodynamics in a blood vessel (without costly diagnostic procedures required frequently to assess how the vessels are healing post procedure).

Exhibit 72 - Smart implants in Orthopedics and Neurovascular



Source: Canary Medical, Inc.

We believe the device industry is in the in the early innings of driving continuum of care that integrates AI in a way that could drive meaningful decision-making.

Ultimately, we believe smart implants or talking medical devices could be game changing for the industry over time.

Smart implants are likely to become a significant part of the continuum of care. A major trend in the medical device industry is to provide continuum of care to patients in their care journey. This includes pre-operative care (e.g., with wearable sensors), intra-operative care (e.g., with robotics), and post-operative care (e.g., with smart implants). We believe the device industry is in the in the early innings of driving continuum of care that integrates AI in a way that could drive meaningful decision-making. We believe smart implants are likely to play a critical part in closing the gap, especially given that the necessary building blocks are now in place for the industry to drive towards it. This includes reimbursement for remote patient monitoring (see Exhibit 73) as well as miniaturization of the device that allows for less modification to the implant itself.

Exhibit 73 - Established CPT codes for remote patient monitoring

What's covered	CPT Code	Amount
Patient onboarding	99453	\$18.77
Data collection	99454	\$62.44
Data use		
First 20 minutes	99457	\$51.54
Next 20 minutes	99458	\$42.22

Source: Canary Medical, Inc.

Smart implants could drive further innovation in the medical device sector. The data obtained from years of smart implant usage is likely to drive further innovation in the medical device sector, we believe. It could lead to refinements in implant designs, surgical techniques, and strategies for post-operative care as well as rehabilitation. Net-net, we believe smart implants or talking medical devices could be game changing for the industry over time.

Healthcare Technology: Virtual health is the future

We are quickly approaching a point where virtual channels will be the first place people turn for their healthcare needs.

The pandemic has accelerated the proportion of life experienced through a virtual interface. This extends beyond just entertainment as more individuals are conducting business without ever meeting in person. While less intuitive, healthcare services are no exception and are arguably one of the more applicable use-cases for a sustainable, hybrid solution.

We are quickly approaching a point where virtual channels will be the first place people turn for their healthcare needs. These new models are being built around the idea of “stepped care,” where artificial intelligence (AI) is used to guide individuals to the most appropriate resource or site. AI is also being used to automate the addressing of many lower-acuity issues. In higher-acuity situations, virtual care involves remote consultations with physicians and therapists. And in those cases where an in-person visit is needed, it can facilitate remote interactions with specialists and equip doctors with better tools to more continuously (and remotely) monitor patients via a myriad of connected devices.

To be clear, the intention is not necessarily to replace in-person care, rather the aim is to make it more efficient, effective and consumer friendly. Virtualizing care does this by: (1) eliminating geographic barriers; (2) extending a provider or health system’s capabilities; (3) facilitating better collaboration among care teams; and (4) enabling the delivery of more proactive and continuous care.

How does virtual health add value?

A big part of what makes Virtual Health so exciting is the potential it holds. Investments into the space are accelerating – per Rock Health, digital health venture funding broadly totaled \$14.6B in 2020, up 90% YoY, and 76% higher than the previous record set in 2018. Funding in 2021 has already eclipsed the entirety of 2020 (by \$0.1B) in the first half of the year alone. Much of this is being used to fund innovation, which is helping accelerate new technologies and applications that are being deployed to address a rapidly expanding range of use cases.

To help better conceptualize the longer-term applications and opportunities here, we discuss some of the many ways in which we see virtual care adding value...

- Lowering the cost of delivering care** – beyond the savings from shifting an in-person visit to a virtual setting, providing individuals with virtual options can help avoid costly urgent care and emergency department visits in the U.S. Also, recent advances in artificial intelligence (AI) are now enabling many lower acuity issues to be resolved in an automated manner, avoiding the need for a provider at all. This helps increase provider efficiency and ease shortages by enabling them to continually practice at the “top of their licenses.”
 Per the American Hospital Association (AHA), one of its members that established a virtual hospital immediately following the initial COVID-19 outbreak treated 18,000 patients as of August 2020, with only 3% requiring a subsequent transfer to a brick-and-mortar site. The key take here being those virtual capabilities helped avoid a significant number of costly hospitalizations.
- More efficient triaging** – for those individuals that need to be seen “in-person,” an upfront virtual triage – either via a physician or an AI chatbot – can help better direct them to the most appropriate site. The benefits of better navigation include not only getting individuals to the optimal site for their condition, but also determining based on their insurance coverage/provider network, which providers deliver the best value (outcomes vs cost).
- Enabling more proactive care** – recent advancements in technology have given rise to a myriad of new devices that enable more granular/frequent/real-time data gathering from patients (during the times in between physician office visits), that when coupled with

Virtual health lowers the cost of delivering care, results in more efficient triaging, enables more proactive care, improves adherence, all while providing convenience and better access to better care.

advances in data processing and intelligence, are helping facilitate more proactive interventions to catch health issues earlier on and help avoid or minimize acute events. Better coordination tools and virtual consultations also enable more effective and efficient collaboration among care team members.

- **Providing convenience** – not only are the virtual options more convenient for individuals, but they help improve employee productivity/reduce absenteeism, and enhance the patient/consumer experience.
- **Improve adherence** – tangential to this, it has been well established in medical literature that a lack of adherence to treatment plans – including missing or foregoing physician office visits – is one of the biggest drivers of poor health outcomes. Making it more convenient to get healthcare helps reduce missed appointments and improve adherence, which can go a long way in improving an individuals' overall health.
- **Enabling better access to better care** – virtual options help remove the geographic barriers to getting care. Along the lines of convenience, telehealth makes it easier for individuals with mobility issues (either because of a disability or handicap or lack of access to reliable transportation or they live in a rural location) to access care. It also helps individuals access better care – no longer are they limited to the providers in their locality; via these virtual tools, they can just as easily reach some of the most specialized doctors in the country (or world).

Improving the access to care

Virtualizing care delivery

Historically, individuals usually had to leave their home in order to receive any type of healthcare. With recent advances in technology, this is no longer always the case. There are a myriad of companies that offer either virtual health services directly to individuals, or are helping existing providers and payors establish virtual alternatives for their own patients/members.

Exhibit 74 - TytoCare has developed a series of devices that help physicians perform more comprehensive virtual medical examinations



Source: Company Website

Facilitating easier access to specialists / higher-quality providers

When care can be delivered remotely/virtually, it can facilitate access for individuals to options or resources they may not otherwise have locally. Similarly, it can also help supplement or enhance the quality of care they are receiving. Offerings here range from platforms that provide care sites with remote access to networks of specialists who help enhance the quality

of the care being delivered locally, to second opinion services that provide individuals access to some of the highest-quality, most specialized doctors in the world who can take a second look at the diagnoses and treatment plans that their local doctors have laid out for them.

Exhibit 75 - Amwell provides a combination of software and devices that enable providers to connect with both each other and/or patients remotely



Source: Company website

Improving the quality of care

There are almost an infinite number of ways virtual capabilities can (and are) being used to improve the quality of care individuals are receiving.

Beyond helping to improve the access individuals have to care, there are almost an infinite number of ways virtual capabilities can (and are) being used to improve the *quality* of care individuals are receiving. Again, the range of approaches/strategies here is very wide, but some of the more exciting include: (1) remote patient monitoring – using new devices and artificial intelligence to gather and better understand more real-time/higher-quality data from individuals to enable more proactive interventions to help avoid higher-acuity health events; (2) the development of next-generation disease management programs that help individuals better manage their conditions; and (3) improving mental healthcare – there is growing appreciation for (and work being done to address) the significant impact behavioral health issues can have on an individual's overall health.

Remote patient monitoring

Historically, doctors only knew what was going on with their patients when those individuals came into their offices for appointments. This meant there could potentially be significant gaps in the time between those visits during which (and unbeknownst to the doctor) a patients' health could deteriorate and they would wind up in the hospital as a result. Landing in an

emergency department is not only very expensive (in terms of money), but is awful for the patient because it typically means they have suffered some type of acute medical event.

Fueled by recent advancements in technology, there has been a proliferation of new devices that enable more granular/frequent/real-time data gathering from patients (during the times in between physician office visits), that when coupled with advances in data processing and intelligence, are helping facilitate more proactive interventions to catch health issues earlier on and help avoid or minimize acute events. Offerings in this space range from the devices/sensors/wearables used to capture the data, to the tools that enable the aggregation of all relevant data, to the software that helps analyze all of it and determine what is actionable (and which actions should be taken).

Addressing mental / behavioral health (BH)

There is increasing appreciation for the impact a behavioral health condition can have on an individual's overall health. In many cases, the existence of a BH condition can impair a person's ability to effectively manage any chronic medical conditions they may be afflicted with – several recent studies have shown these situations can act as a multiplier on that individuals' medical spending as a result. This has resulted in both health plans (i.e., payors) and providers becoming much more interested in better managing a patient's mental health as a way of better controlling their medical costs. Given the difficulties in doing this effectively and at scale – ranging from a lack of experience/expertise with these types of conditions, a lack of access to a network of behavioral health therapists, and even an inability to accurately identify individuals with BH conditions (i.e., most BH issues are undiagnosed) – a growing number of payors/providers are looking to outsource it. Technology is making a difference by not only helping facilitate easier access for individuals (via video visits with therapists and/or AI-powered chatbots), but also using data to better understand who may be struggling with an undiagnosed condition and modeling out which treatment options would be most effective and efficient.

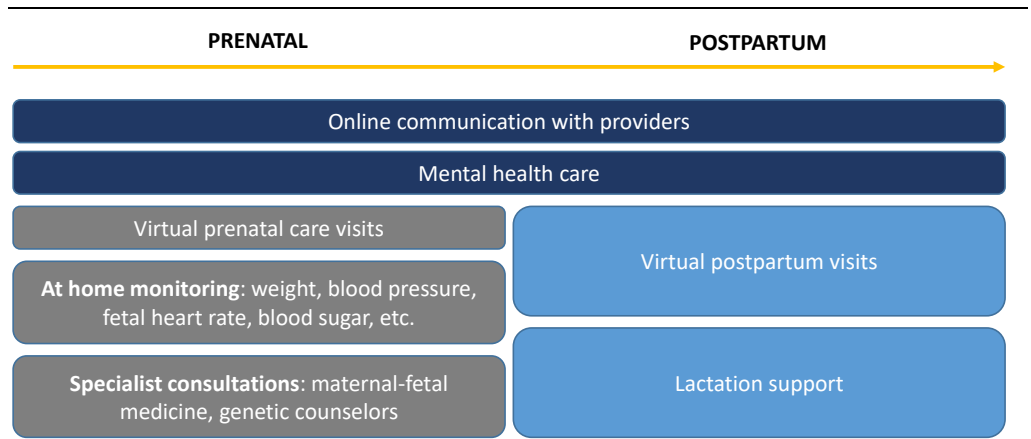
Other novel applications

As technology continues to improve the quality and affordability of telehealth capabilities, so too does the range of appropriate use cases. There are a number of companies including Amwell and SOC Telemed that provide the capabilities to support broader access to specialist care in areas with more complexity such as tele-oncology, -radiology, -pathology, and -cardiology. Further, telehealth is enabling efficient at-home care (post-operative) in skilled nursing facilities, dentist offices, and even in the workplace to treat musculoskeletal injuries. We expect the number of applications to grow significantly as innovation continues.

As technology continues to improve the quality and affordability of telehealth capabilities, so too does the range of appropriate use cases. We expect the number of applications to grow significantly as innovation continues.



Exhibit 76 - Many services can be virtualized during and after pregnancy



Source: Kaiser Family Foundation and RBC Capital Markets

Real telehealth involves much more than just a video connection – much of it centers on the integration of multiple disparate sources of data.

Telehealth is much more than just video conferencing

We still get a lot of questions around the extent to which telehealth is really all that different than just video conferencing. The competitive moats that exist here are not immediately obvious – but they do exist.

While video conferencing was the quick answer for many providers who scrambled to put solutions together in the immediate aftermath of the initial COVID-19 outbreak, it is not a viable long-term solution. Real telehealth involves much more than just a video connection – much of it centers on the integration of multiple disparate sources of data. The most effective telehealth solutions use data in multiple different ways, including:

- **Triaging the situation** – using data and artificial intelligence (AI) upfront to help resolve lower acuity issues and then direct individuals to the most appropriate resource/level of care when needed. This helps increase provider efficiency and ease shortages by enabling them to continually practice at the “top of their licenses.”
- **Simplifying the administrative aspects of the interaction** – integrating into scheduling systems enables appointments to be booked seamlessly. The most effective telehealth solutions will also connect into electronic health record (EHR), e-prescribing and patient accounting/revenue cycle management (RCM) systems to simplify the billing and collecting process and to capture the clinical details of the visit. Simplifying these administrative tasks help minimize friction, making it easier to incorporate telehealth into provider workflows.
- **Delivering better care** – integrating into EHRs, care coordination and decision support systems equips providers with a more complete picture of the patient and access to resources that can help them deliver higher quality and more proactive care. There are also platforms now that enable doctors to control devices on the patient’s end, including digital stethoscopes, remote cameras and other diagnostic devices which can broaden the range of physiological data that can be collected and assessed.
- **Driving engagement** – the pandemic has helped generate more awareness of the virtual options for getting care, but we are still in the very early days of what we believe is the longer-term opportunity. Said differently, there is still a lot of education and behavior change that needs to occur. More sophisticated telehealth/virtual health platforms have tools that help better inform individuals of the options they have available to them. They also have mechanisms that can remind those individuals of what the virtual alternatives are at the moments they are most in need of them.
- **Access to bigger/better/deeper pools of healthcare providers** – in many of these new models that were hastily established following the initial COVID-19 outbreak, video conferencing with a doctor is just simply shifting an in-person visit to a virtual one. Many of the more established virtual health providers have created large networks of specialists and “experts” that not only enable a virtual consultation with a physician, but significantly elevate the quality of care being delivered by facilitating interactions with some of the most specialized / highest-quality doctors in the world.

What are the next big ideas?

Incorporating one or several of the capabilities described above is helping give rise to multiple promising new care delivery models, including Virtual Primary Care, Whole Person Care, Hospital at Home, and ‘Next Generation’ chronic condition management.

Virtual-first plan design

Virtual-first plan design is the structuring of health plan benefits in a manner meant to change how individuals access healthcare – the aim being to incentivize individuals to seek care

Innovation is giving rise to multiple promising new care delivery models, including Virtual Primary Care, Whole Person Care, Hospital at Home, and 'Next Generation' chronic condition management.

through the less costly virtual channels first (i.e., telehealth), thus minimizing the use of the traditional, but more expensive brick-and-mortar 'in-person' settings. Payors have multiple levers they can pull to steer members to virtual channels and can gear them based on how aggressively they want to incent change. Not surprisingly, most of them rely on financial enticements.

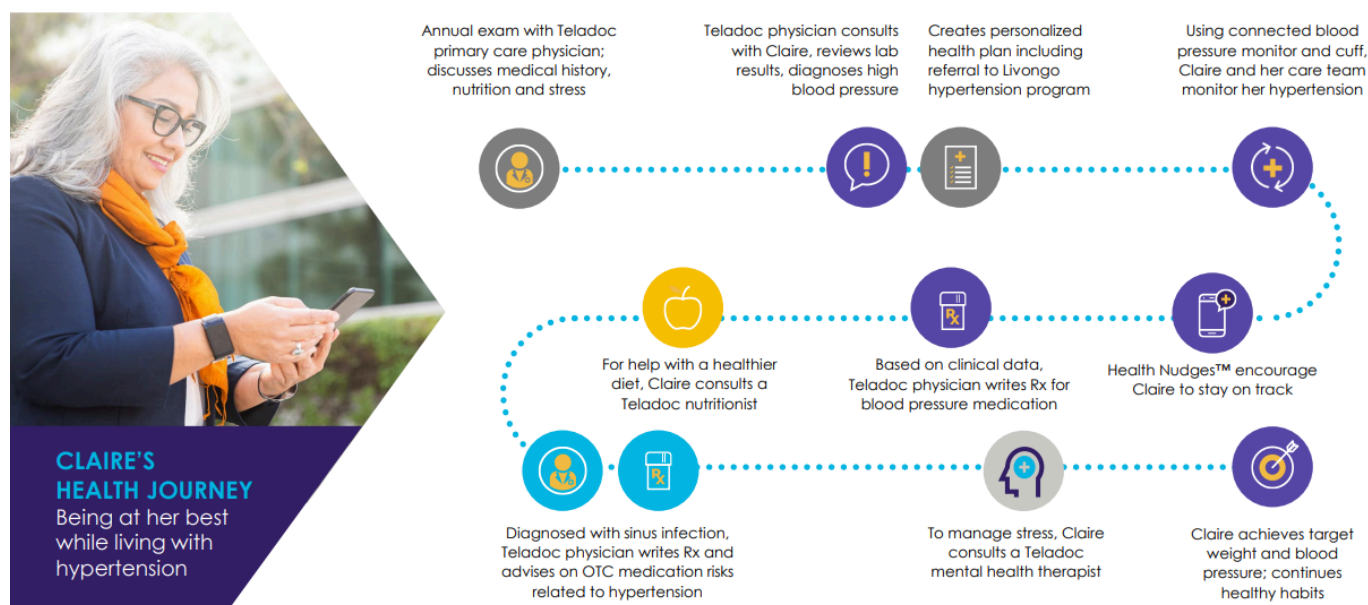
Examples include: (1) changing deductibles and copays – payors can lower members' out-of-pocket costs for virtual health visits while at the same time increasing costs associated with seeing a provider in-person; (2) reducing the cost of specialists – payors could lower the out-of-pocket costs of seeing a specialist for those members referred to them via a virtual visit; (3) lowering prescription costs – payors could offer lower out-of-pocket costs for prescriptions prescribed to members via virtual visits; (4) providing incentives for a second opinion – payors could deposit money into a health savings account (HSA) or provide some other financial enticement for members to seek a second opinion before scheduling a surgery or undergoing particularly costly treatments; and (5) providing an easy-to-use member interface – supplying members with "one front door," or a single, user-friendly interface can also help incentivize the use of virtual options.

Virtual Primary Care

Whereas the "virtual first" concept discussed above uses plan design to incentivize individuals to utilize virtual alternatives, Virtual Primary Care on the other hand involves more of a re-design of how care is actually delivered. Participants in VPC programs have a longitudinal relationship with an individual physician, who is available to them virtually and integrated into a larger team of other providers (health coaches, dieticians, therapists, specialists, etc.) that are able to 'virtually' shepherd individuals through most of their day-to-day healthcare needs. These models, over time will also likely build in more devices and remote monitoring capabilities, helping providers better track and manage patients outside the walls of their practices, enabling the delivery of more proactive care.

Exhibit 77 - Example of "Whole Person Care" enabled by the merging of Teladoc/Livongo's capabilities

Delivering Whole Person Care for Better Health Outcomes



Source: Company presentation

Whole Person Care

We know an individual's health is influenced by a myriad of different factors, with the medical care they receive just being one of them – their emotional/psychological condition can play a big role as can genetics, nutrition and other social determinants. 'Whole Person Care' focuses not only on better integrating and coordinating the medical care they receive (primary, specialty and acute care), but also addressing their behavioral and socioeconomic needs. Put more simply, it brings together all of the parts of the system to treat the whole person.

Hospital at home (HaH)

A hospital is usually one of the most expensive places an individual can go for care, so programs designed to either shorten length-of-stays or avoid them altogether have the potential to save a lot of money. HaH models involve providing hospital-level care to individuals in their homes as a full substitute for acute care. This is enabled by a combination of connected devices that help monitor a patient's health by collecting relevant physiological data (blood oxygen levels, EKG, etc.) along with daily supervision by doctors and/or nurses both in-person and virtually. In response to the pandemic-related shortage of hospital beds, CMS expanded its Acute Hospital Care at Home program, through which Medicare beneficiaries can now receive in-home care for 60+ conditions including asthma, chronic obstructive pulmonary disease, congestive heart failure and pneumonia.

Next-generation chronic condition management

The concept of care management is not new, but up until now has been limited in its effectiveness since, historically, doctors only knew what was going on with their patients when those individuals came into their offices for appointments. This meant there could potentially be significant gaps in the time between visits, during which (and unbeknownst to the doctor) a patient's health could deteriorate and they could wind up in the hospital as a result. Landing in an emergency department can be very expensive, and is a negative outcome for the patient because it typically means they have suffered an acute medical event.

Tailwinds are strengthening

Not only has the pandemic helped accelerate Virtual Health to its tipping point, but we see the longer-term macro tailwinds continuing to strengthen: (1) consumers are increasingly being empowered and placed in control of healthcare decisions; (2) technology is advancing and more money is flowing into the space, helping to further accelerate innovation; (3) there is more data proving the effectiveness and returns linked to these new solutions; and (4) the reimbursement and regulatory landscapes are becoming increasingly supportive.

The opportunity is immense

The delivery of more proactive, effective and convenient care is the goal here – we view these new virtual tools as a key enabler of this – and if done right, it has the potential to both significantly improve overall health and lower costs. Not only are the dollars involved substantial – the U.S. spends ~\$3T annually on chronic conditions alone – but adoption remains low, innovation is accelerating and there are a wide (and rapidly expanding) range of potential use cases.

The broader software industry is in the game

In our view, software that enables telemedicine will remain a sustained beneficiary. We are closely watching technologies that allow existing medical practices with existing books of business (especially those that are part of larger healthcare systems) to become true telemedicine providers.

Virtual tools are key to the delivery of more proactive, effective and convenient care, and if implemented correctly, have the potential to both significantly improve overall health and lower costs.

We are bullish on technologies that allow existing medical practices with existing books of business (especially those that are part of larger healthcare systems) to become true telemedicine providers.

Zoom, in our view, has the best video meeting platform of any software provider, especially in terms of reliability, scalability, and ease of use. Given how ubiquitous Zoom became during the pandemic in both the business and consumer spheres, we believe Zoom has significant mindshare to drive further adoption within telemedicine. In addition, we would note Zoom sells verticalized solutions targeted at healthcare that are fully HIPAA compliant. Beyond this, Zoom also offers robust APIs to integrate those best-in-class video-conferencing capabilities natively within the healthcare provider's applications, meaning the patient and doctor never have to switch applications, while the healthcare provider preserves branding and control. Separately, we note Zoom's video APIs are embedded in Veeva CRM Engage, which allows pharmaceutical sales reps to communicate directly with doctors virtually.

Twilio is an API (application programming interface) company that sells communications tools, including texting, voice, and video for companies to embed in their applications. Twilio's video APIs also saw major adoption during the pandemic, including telemedicine use cases. In fact, we would point out that Epic's telemedicine platform is powered by Twilio's video APIs. Epic is the largest EMR provider and has been able to successfully cross-sell its telemedicine platform into its large install base.

In addition, software on the back end (including software that enables building better mobile applications, payments, bookings, etc.) should see sustained benefits as the rise of greater telemedicine and the push for greater control over healthcare.

Real Estate: Digital emergence could change...everything

Advancements in technology have already changed the way people work, shop and even socialize, and thus, the way they use real estate, creating a new hybrid reality. This trend has implications for the demand for real estate not just in terms of location but also its type, style and the way it is operated.

Urbanisation has been a big theme for real estate over the last few decades, with the biggest global cities appearing to have benefitted most. This trend appears to have largely been driven by improved access to the best jobs and education, which in turn has led to better access to healthcare, retail and entertainment. A virtuous circle of demand from multiple users of property has been created. However, the progress in the digital world has made it possible to access all these activities remotely to varying degrees.

The COVID-19 pandemic highlighted what has already been made possible by technological advances, from working from home to entertainment at home. The benefits are well recognized, not least the savings in terms of time and money from reduced travel. We think the perceptions of such benefits are unlikely to change. In contrast, the increasingly talked about frustrations of the COVID-19 imposed changes, however big or small, seem likely to erode over time due to a combination of further technological advances and demographics/the passage of time.

We believe the temporary “race for space” during COVID-19 lockdowns is likely to be a slow, but steady long-term trend as people do more at home, only partially offset by less need to store as many physical possessions in a digital world.

Similarly, more affordable (and thus often less accessible) locations could potentially increasingly gain favor (assuming digital connectivity is sufficient).

Ongoing improvements in augmented and virtual reality should enhance users’ experience of interacting with others online, whether from a work or entertainment perspective, as well as making it more broadly accessible. At the same time, the proportion of the population more comfortable in the digital world will constantly grow because of demographics. As a result, we think it likely people will become more comfortable at home more of the time, making the nature of the property they live in more important, but the location less important.

Many of the jobs that cannot be done remotely will still most likely follow those who can work more remotely (such as a shift from the cities to the suburbs), to the extent that their jobs are not replaced by technology altogether. The very large differences in real estate prices between the biggest cities and other locations would appear to be a strong catalyst for a slow unwinding of the urbanization trends of the last few decades.

In terms of what it means for real estate, the need for housing is likely to grow at least as fast as populations, in our view. We believe the temporary “race for space” during COVID-19 lockdowns is likely to be a slow, but steady long-term trend as people do more at home, only partially offset by less need to store as many physical possessions in a digital world. Similarly, more affordable (and thus often less accessible) locations could potentially increasingly gain favor (assuming digital connectivity is sufficient). Even concerns about greater difficulties in the delivery of physical goods becomes less relevant if 3D printers become commonplace.

For most other types of real estate, such changes would appear to create more headwinds. For example;

- **Retail property:** the impacts of retailers needing less physical retail space are already clearly evident, though how much less and the best format is still unclear. Conversion to residential is an option, but often with relatively unattractive economics.
- **Offices:** we expect employers to find solutions to issues like less collaboration, difficulty of training junior staff, and culture creation as augmented and virtual reality continue to become more user friendly, greatly reducing their need for office space. The bigger question is the timing and pace of such change. There is already evidence that some office space is going to be converted to residential in big cities such as London.

Property is a long-term investment and once the current flood of money seeking yield in this low interest rate environment dries up, we expect such uncertain long-term prospects to increasingly influence the values of properties that appear most at risk from these trends.

- **Logistics:** the overall headwinds appear less significant, unless one takes into account 3D printing becoming commonplace. However, owning the right type of warehouses in the right locations on the right economic terms may prove challenging. The exceptionally high prices currently paid in some leading global cities do not factor in the potential for a reversal in their population trends in our view.
- **Self-storage:** Fewer possessions in a more digital world risks a gradual decline in demand for self-storage space in the long term. Likewise, less need to move house with jobs in a WFH world would reduce another source of demand to use such space. However, most important will be the shift in where their customers live as proximity has typically been a key driver of customers' decisions.
- **Healthcare:** Demographics in most countries point to a tailwind in tenant demand. Furthermore, while some services will increasingly be provided remotely, most appear likely to continue to require attending in person. We also believe the issues around populations shifting to new locations is less significant given the residential nature of many properties.
- **Student housing:** Given the typically young age of students, the argument for them adopting online learning and avoiding the need to pay for student housing appears strong at first glance. However, we see the appeal of using it as a first step to leaving the family home and gaining independence as enduring.

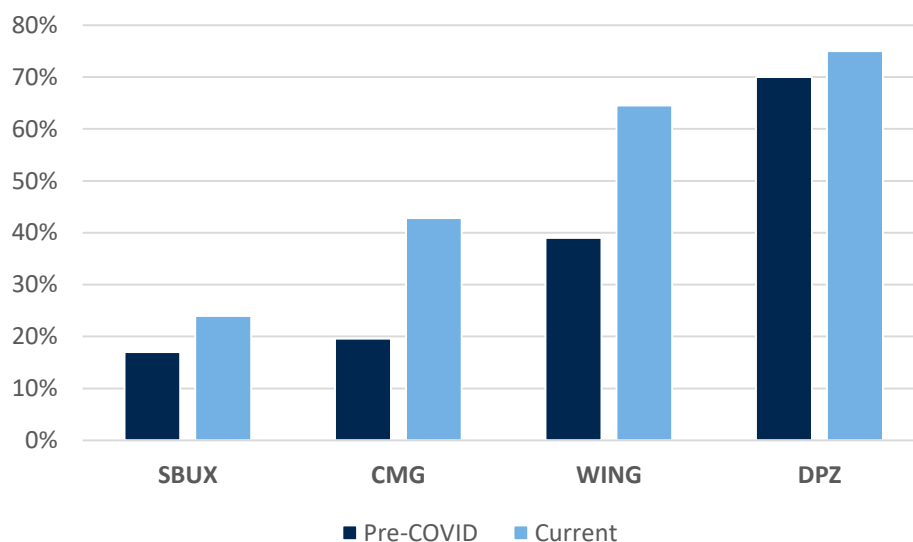
We believe many of these changes will occur gradually, far slower than those in retail properties in the U.S. and U.K. However, property is a long-term investment and once the current flood of money seeking yield in this low interest rate environment dries up, we expect such uncertain long-term prospects to increasingly influence the values of properties that appear most at risk from these trends.

Restaurants: More digital on the menu

Since the onset of the pandemic, digital sales growth has been a key top line enabler for the largest quick service restaurant brands, and the restaurant industry more broadly. COVID-19 accelerated restaurants' digital transformation, as customer demand for convenience – and, in the context of the pandemic, contactless experiences – drove restaurant brands to expand their digital offerings. We observed restaurant companies accelerate their digital capabilities, including enhancements for guests to seamlessly place off-premise orders for pickup or delivery through mobile apps and online. Meanwhile, companies with technology and digital platforms already in place, and in categories that played well to shifting consumer demand amid the pandemic – including Domino's, Chipotle and Wingstop – enjoyed faster recoveries and stronger sales trends in 2020, given their ability to meet off-premise demand, while also benefitting from harvesting customer data and building one-to-one relationships. We view customers' embrace of digital ordering during the pandemic as a meaningful acceleration of long-term structural changes taking place within the restaurant industry. **Over the long term, we expect digital engagement to remain sticky – and grow further – continuing to be a top line driver and enabler for the best-positioned brands.** We believe scale brands that continue to invest heavily in digital and technology will be well-positioned relative to peers with less resources and/or focus in this critical area.

Brands such as Chipotle and Wingstop saw a significant increase in digital engagement, versus just prior to the pandemic.

Exhibit 78 - Digital order mix, by brand for Starbucks, Chipotle, Wingstop, and Domino's (U.S.)



Source: Company reports, RBC Capital Markets estimates; SBUX = Mobile Order Transactions as % of Total Transactions

Benefits of the digital channel

Over the course of the pandemic, digital ordering has been a tailwind for restaurants' average check growth, driven in part by larger order sizes and a higher average number of items per check (also benefitting margins). Restaurants have also used digital-only promotions to increase customer engagement, and as a result, drive higher frequency. Beyond driving sales growth via higher average check, other benefits of digital includes operational efficiencies (e.g., improved speed of service), and the development of key marketing tools. Regarding the latter, in some cases restaurants are now beginning to collect first-party customer data that they previously did not have. With these new forms of data, restaurants are able to create one-to-one personalized marketing messages that aim to drive frequency by: 1) informing customers about promotions; 2) announcing new products; and 3) engaging lapsed customers.

Within our coverage, both **Starbucks** and **Domino's** are among those companies that have historically demonstrated the benefits of strong digital ecosystems (e.g., mobile app, online ordering), including sales growth and higher frequency. Another recent example includes **Chipotle**. Since the onset of the pandemic, Chipotle has seen its digital sales mix increase materially. Since the end of 2019, Chipotle's digital sales mix has grown from approximately 20% to 43% today (as of 3Q21), having peaked at nearly 61% during 2Q20. In our view, digital sales was an important driver of Chipotle's rapid sales recovery during the spring of 2020, as well as a driver of ongoing growth, given that digital ordering reduces frictions historically associated with the brand (e.g., long lines at peak order times), as well as more easily enabling delivery.

Growth of loyalty programs

Some of the restaurant industry's most successful loyalty programs – notable examples include those for Domino's and Starbucks – have not only driven order frequency, but have also provided restaurants with key insight into customer behavior for marketing purposes. Given the recent rapid adoption by customers of restaurants' digital ordering capabilities, additional large, mature fast-food brands have rolled out their own – in some cases, long-awaited – loyalty programs. McDonald's, Wendy's, Taco Bell and other large brands, have each launched or enhanced loyalty programs over the last year-plus. A key initiative for quick-service restaurants going forward will be continued focus on building their loyalty membership bases, and further leveraging the programs to drive sales growth and gain insights.

Impact of digital on restaurant development and reimagining

Given the growth in digital ordering and the resultant impact on restaurants' off-premise sales channels, restaurant prototypes are now evolving towards digitally enabled formats or features, including restaurants with dual drive-thrus, mobile pickup lanes and digital menu boards. Major fast food brands, including quick service and fast casual concepts, have introduced new prototypes that incorporate more technology throughout, highlight takeout and delivery and improve operational efficiency. To name a few, Chipotle began opening mobile order drive-thru lanes (Chipotlanes) pre-pandemic, helping to drive more higher-margin mobile order pick-up transactions. Meanwhile, McDonald's recently announced that it has partnered with IBM to ramp up the development of automated drive-thru order taking at scale, with IBM acquiring McD Tech Labs (formerly Apprente, which was acquired by MCD in late 2019). Longer term, we expect to see greater integration – and utilization – of technology within restaurants, not only on the customer-facing side of the business, but also in the back of the house (e.g., inventory automation, robotics, etc.), which could potentially help offset building labor cost pressures faced by restaurants today.

The emergence of virtual brands and ghost kitchens

In addition to the more widely known digital channels noted above, the prevalence of other digitally-enabled channels – such as ghost kitchens and virtual brands – has also increased recently. The rise of these formats (off-premise-focused channels, with food prepared in central kitchens or existing restaurant kitchens that have excess capacity) ramped up during the pandemic, and in some cases, have rapidly driven meaningful levels of sales. For casual dining brands in particular, given how they are used (i.e. a majority dine-in) and frequency of use (i.e. less habitually used than a QSR brand), virtual brands have been a significant driver of off-premise sales. Most notably, Brinker International (EAT), the owner and operator of the Chili's and Maggiano's brands, launched its first virtual brand concept It's Just Wings in June 2020. In its first year, the It's Just Wings brand generated ~\$170M in total sales, while helping Chili's maintain an off-premise mix above 30% (vs. <20% pre-pandemic). On ghost kitchens, specifically, Wendy's (WEN) recently announced a development commitment by REEF Kitchens to open and operate 700 delivery kitchens over the next five years in the U.S., Canada and the U.K.

The Great Balancing Act

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The Great Balancing Act – Introduction

We believe new forms of warfare – both physical and cyber – and trade conflicts will arise, particularly related to climate change, including the race for critical commodities to fuel the energy transition, agricultural nationalism and climate change targets and policies.

The Great Balancing Act: *An accelerating rate of change on multiple fronts has the potential to create unprecedented instability. Conflicts will arise between countries, among sub-populations and across regions on an increasing number of fronts, as well as behind the scenes. On top of a pickup in cyberterrorism activity, we believe new forms of warfare – both physical and cyber – and trade conflicts will arise, particularly related to climate change, including the race for critical commodities to fuel the energy transition, agricultural nationalism and climate change targets and policies. Even basic systems like democracy and capitalism are set to undergo dramatic change. Even within individual entities themselves, societies, corporations, institutions and even individuals, will face internal tension balancing speed and near-term costs as they strive to make progress in this increasingly complex global context.*

The new fronts

The increase in cyberterrorism activity, whether state-sponsored or otherwise, is an example of the changing landscape of conflict, and looking forward, we believe that the energy transition will spawn a range of new conflicts on new battlegrounds that have the potential to further drive a wedge between countries, regions and demographics (e.g. generational, race, socio-economic). A selection of themes that we see as having a multi-faceted potential for conflict include:

- **Energy transition:** We view the energy transition as driving a wide range of conflicts including neo-colonialism driven by the need to secure critical commodities (e.g. rare earth metals) and civil conflicts resulting from the impact of rising costs associated with paying for energy transition investments.
- **Agricultural nationalism:** Particularly against the backdrop of changing climate patterns, security of the food supply could become an increasing issue, especially when layering on the increasing use of crops as feedstock into the fuel supply. How this burden is shared across society could drive wider instability.
- **Climate change:** Rising trade conflicts stemming from countries that can readily achieve climate change targets (e.g., border adjustment taxes), the plight of climate refugees from a political and socio-economic perspective, and the approach to countries that cannot meet global targets (or worse, are unwilling to meet global targets) are topics that we expect to move to the forefront.
- **Societal transitions:** Aging populations, the fracturing of media and the widest gap in income inequality since before World War I is creating many fault lines. Automation will start to erode our ability to allocate societal resources purely by labor creating potential for new dynamic economic systems, but these will come with friction. With democracies struggling and the power of corporations growing, legislative and legal reforms are set to rise.

Rising tensions on existing battlegrounds

We see many existing areas of conflict intensifying, particularly as it relates to regional and national spheres of influence, cyber-warfare and the socio-economic divide.

- **Spheres of influence:** We see the likelihood of increased conflict between nations and their regional alliances on historical battlegrounds (e.g. east versus west, Middle East).
- **Cyber-warfare:** Although a relatively new front, we have seen the increasing impact and number of instances of cyberterrorism activity, whether it be state-sponsored or otherwise. We expect attacks on critical infrastructure and corporate assets to intensify.
- **Class action:** Socio-economic and racial divides could continue to widen driven by a host of factors including politics and affordability (e.g. food, electricity, healthcare, education). We believe that social media and the notion of the "splinternet" will exacerbate these tensions.

We are all in this together – driving balance, collaboration and harmony

In many cases, we believe the roots of the rising conflicts stem from collective challenges for the human race, and especially in those cases, we see a strong potential for collaboration and balance (at least among segments of society) to come together to solve those problems.

But we also see a strong potential for collaboration and balance (at least among segments of society) to come together to solve these problems.

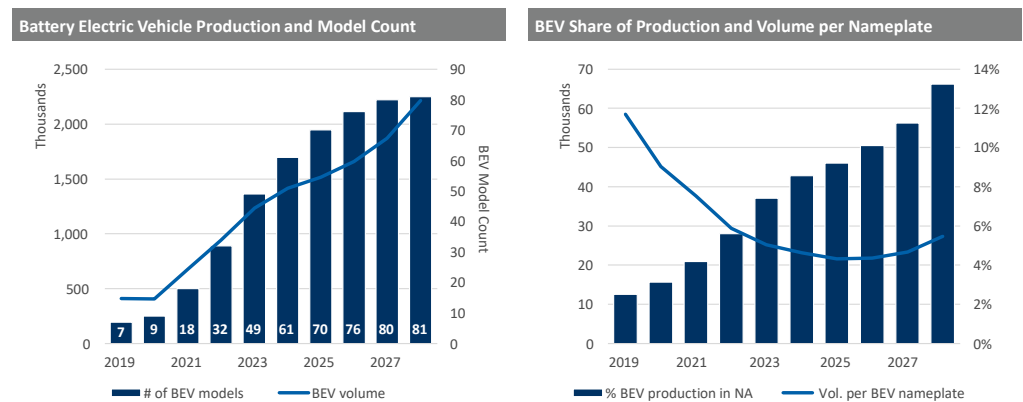
- **Rallying to solve existential risks to society:** As we have seen with the coordination of global resources and relative cooperation to fight COVID-19 (and as an example the speed with which multiple vaccines were developed), we believe similar coordinated action will occur when society is faced with existential risks. In particular, we believe there will be significant advances in the global fight against climate change, which could come in the form of new technologies, more efficient and lower-cost facilities to decarbonize (e.g., reducing the cost of renewable power) and broader societal support for policies to accelerate decarbonization, even if they come at a higher cost for segments of the population (e.g., higher taxes on the wealthy to fund these initiatives that benefit all of society).
- **Technological advancement will continue to be multi-national:** There are numerous instances of technological advancements that have come from research and development located in multiple countries. We believe multi-national private enterprises and the academic community will be key drivers of international cooperation to advance key technologies.
- **Extremism and the drive to the middle:** While extremist views may persist, we have observed numerous instances of the majority of the population rejecting the "radical" right and left to support politicians and policies that straddle the "middle." As we have seen over time, we expect large segments of the population will continue to come together and rally behind issues that benefit society – at a time where the power of individuals has never been greater.

Autos: Electrification and battery demand

While regulatory requirements have been a large driver of battery electric vehicle (BEV) sales thus far, ultimately, an inflection can occur not just when costs come down, but when the consumer has a compelling product for whatever their use case and needs are. This means offering across a wide range of segments and price points. Therefore, while we believe the shift to BEVs is a consensus view, the timing/slope of the inflection will be consumer led. The good news for electrification is more BEVs are coming. North America is, to date, less regulatory driven than Europe or China so it is an interesting case to look at how BEVs may evolve. According to IHS, the BEV model count for NA production will reach 116 in 2030 from 17 today while the share of BEV production in NA will increase from high-single-digit percentage today to over 30% in 2030.

While we believe the shift to BEVs is a consensus view, the timing/slope of the inflection will be consumer led – this will occur not just when costs come down, but when the consumer has a compelling product for varied use cases.

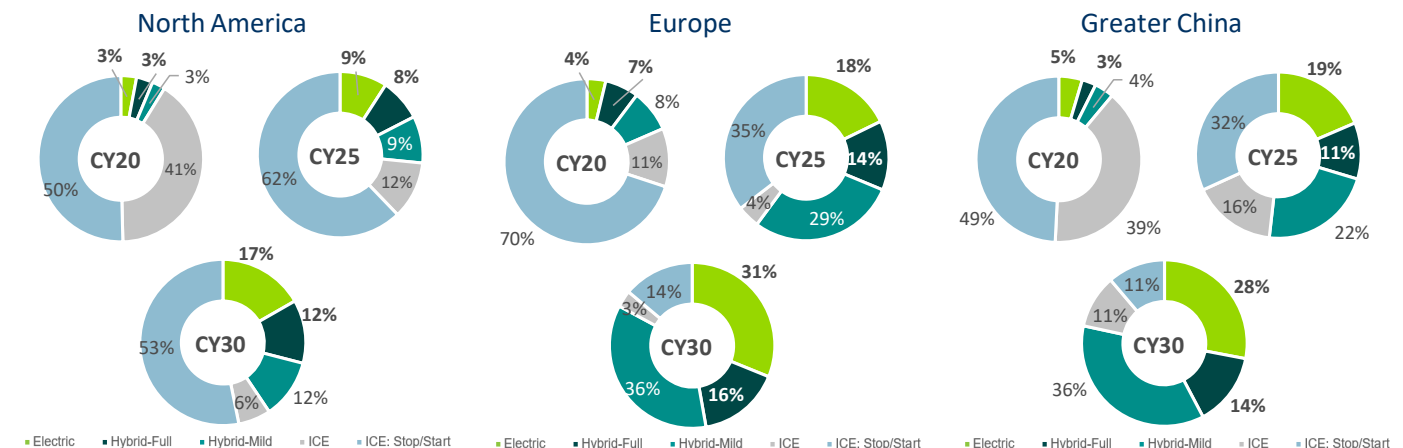
Exhibit 79 - North American battery electric vehicle (BEV) production, 2019–2030E



Source: IHS

Furthermore, IHS expects meaningful penetration in the three major regions for automotive, North America, Europe and China. In the U.S., President Biden has stated a 40–50% BEV goal by 2030. In Europe, under the “Fit for 55” program they are targeting a 55% reduction in CO₂ from 2021 levels and 100% by 2035. Likewise, China (which has supported the “new energy vehicle” market with subsidies to date) is also focused on tightening regulations.

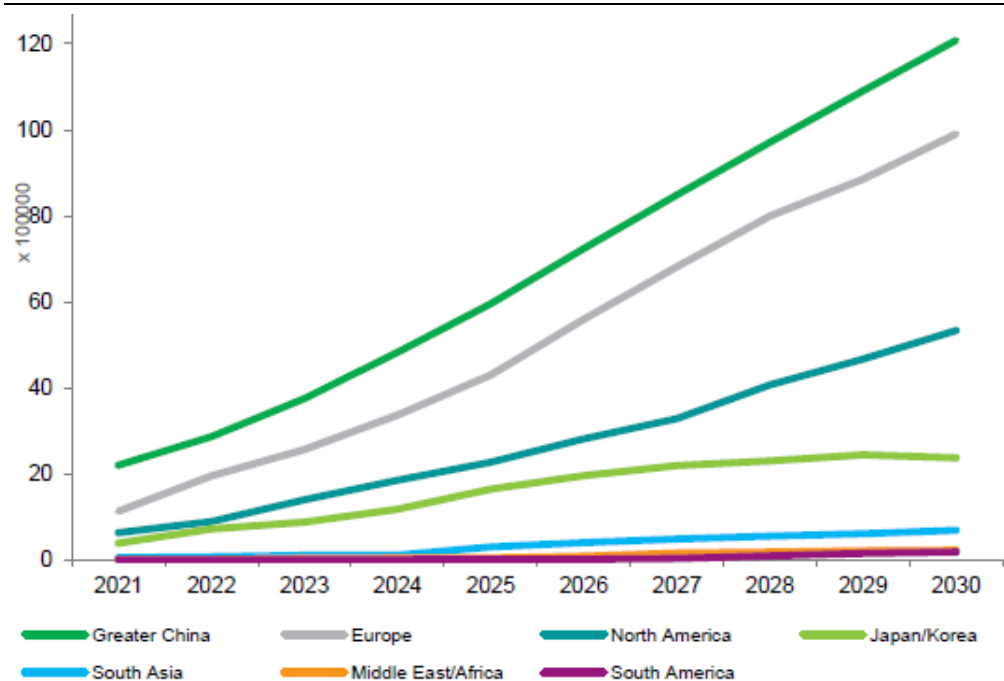
Exhibit 80 - Regional powertrain technology outlook



Source: IHS

Electrification can have many geopolitical implications. For instance, China looks to be using electrification as the medium to exert its power on the automotive (and other, think resources) industries. As shown below, China is expected to increase its volume and scale advantage on EVs relative to North America.

Exhibit 81 - Global EV production by region



Source: IHS

The scale of investment required to meet battery supply is enormous and will have large geopolitical ramifications.

Perhaps one of the biggest risks to BEV adoption is battery supply. We estimate that there was a little over 400GWh of lithium ion battery cell capacity in 2020. If we were to assume 95 million global light vehicles, 100% BEV penetration and a 70kWh/vehicle average suggests 6.7TWh of capacity eventually needed for light vehicles alone. Note that many coming vehicles have battery pack sizes closer to 100kWh, though we expect the average to come down as vehicles from a wide range of price points and segments come to market. Even a 60kWh/vehicle average would be 5.7TWh needed. Tracking capacity announcements is difficult, but we believe there could be close to 4TWh of planned capacity by 2030.

However, this means that significant investment is needed to achieve the 2030 capacity and beyond. We believe the average capex/GWh could be \$75M. That would mean a nearly \$475B investment (assuming no efficiencies are made) just to satisfy light vehicle demand. Tesla has suggested that 10TWh of capacity is necessary for 100% renewable energy across other industries (commercial vehicle, other transport, stationary storage) which by our calculation would require a nearly \$750B capex investment; Tesla indicated 10TWh would require a total \$2T investment in materials, cell and battery manufacturing. This type of investment and the resources required could have large geopolitical ramifications. For instance, President Biden has made it a priority to 1) address vulnerabilities and opportunities for advanced batteries and 2) secure the domestic production of batteries to shore up U.S. competitiveness.

U.S. companies are taking note. Ford is spending \$7B (as part of an overall \$11.4B spend with partner SK Innovation) for U.S. cell capacity. This includes an all-new \$5.6B campus in



Tennessee called Blue Oval City, a vertically integrated ecosystem for Ford to assemble an expanded lineup of electric F-Series vehicles and will include a BlueOvalSK battery plant, key suppliers and recycling. Then, in central Kentucky, Ford plans to build a dedicated battery manufacturing complex (two battery plants) with SK Innovation for \$5.8B called BlueOvalSK Battery Park. The battery plant in Tennessee and two battery plants in Kentucky will produce a total of 129GWh, which Ford says is enough for >1M battery packs including long-range packs for SUVs and trucks. Overall, Ford plans to spend >\$30B on BEV investments through 2025. Meanwhile, GM plans to build four battery cell-manufacturing plants in the U.S. by mid-decade, one each in Lordstown, OH and Spring Hill, TN with partner LG Energy Solutions and two more whose locations have not yet been disclosed. GM plans to spend >\$35B on electric and autonomous investments through 2025. The company has also announced plans to be carbon neutral by 2040, an aspiration to have all light-duty vehicles be EV by 2035, and a commitment to source 100% renewable energy to power U.S. facilities by 2025.

Commodity Strategy: Critical minerals in critical places

This excerpt was written by Head of Global Commodity Strategy and MENA Research Helima Croft and Commodity Strategist Christopher Louney, with the assistance of Megan Schippmann (Senior Associate) and Brian Leisen (Associate) from RBC Capital Markets, LLC's Global Commodity Strategy team.

As Energy was to the fossil fuel age, Minerals will be required to transition to a cleaner future.

While sun and wind is more evenly distributed across the globe than oil or natural gas, the critical mineral building blocks that will be needed to scale up cleaner and greener technology and infrastructure are still concentrated in a small number of nations.

As a result, we expect that the geopolitics of tomorrow's commodity markets may lie in critical minerals in critical places.

For Required Commodity Strategy and MENA Research Conflicts Disclosures, please see page 261.

At COP26 leaders sought to reconcile differing priorities and policy approaches to reach all-important net zero climate goals – this work towards reconciling occurred against a challenging social and economic backdrop with Europe and Asia facing a potentially escalating energy crisis that could negatively impact GDP growth in the event of a cold winter.

Some have suggested that the energy transition will radically restructure the resource dependency relationships between producers and consumers that has been a hallmark of the fossil fuel age. Sun and wind are more evenly distributed across the globe than oil or natural gas, yet the critical mineral building blocks that will be needed to scale up cleaner and greener technology and infrastructure are still concentrated in a small number of nations, more than a few of which have profound governance and security problems.

This poses a serious question: could the energy transition eliminate concentration risk or just swap out reliance on one set of commodities and commodity producers for another? International organizations such as the IEA and World Bank have already begun to stress the need to focus on such minerals through their scenario analysis and we have already seen members of the Biden Administration highlight this as an issue.

Given the scenarios laid out by these organizations to achieve a 1.5-2°C scenario, on its own the green industrial revolution poses a quandary of how to source the amount of raw minerals needed to deliver the rapid growth in electric transportation, wind turbines and solar panels to reach net zero, and the necessary grid buildout to electrify new industries – never mind the potential scarcity, geographical concentration, and other issues if known reserves could end up being restricted by hosting nations for the purpose of national interest.

The production of critical minerals such as lithium, graphite and cobalt could need to grow by multiples, and even metals that we more traditionally think of in the commodity landscape, which have their own supply and demand challenges, are also an important part of the picture and should not be disregarded in a conversation around critical minerals. **Some metals are more concerning than others – both due to their potential importance throughout the green industrial revolution and because of geographical supply concentration – but this theme generally underscores the types of tension that could typify the next decades as we “Imagine” them out.**

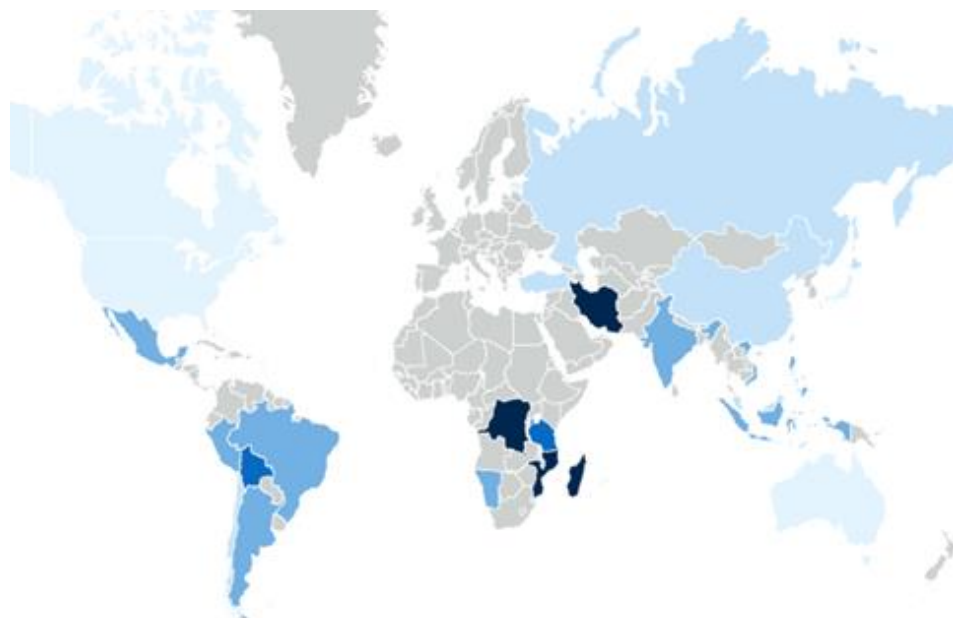
Political risks aside, reasons for supply chain disruptions could span from countries trying to move up the supply chain, resource nationalism, geopolitical/trade conflict and more. While there is an opportunity for resource rich countries here, there are also challenges in increasing production in a responsible manner, equitably distributing the gains and benefits, avoiding the resource trap driven mistakes of the past.

We believe the market should keep a particular eye on lithium, cobalt, graphite, and nickel given the likely need for new production (versus current levels), importance to green technologies as well as the geographical supply concentration. Manganese and rare earths also should bear watching as should those already thought of as financial commodities (copper, aluminum, zinc, etc.). Cost swings could hit policy priorities of a number of countries and thus complicate already tenuous geopolitical relationships further as well as imperil climate goals.

Such trends may drive a new round of investable commodities on futures exchanges and in index investment alike, but suffice to say, the geopolitics of tomorrow's commodity markets may lie in critical minerals in critical places as we "Imagine" it.

Exhibit 82 - Risk and Development Index – Countries analyzed in this report

	Ease of Doing Business	World Bank (2019) Corruption Perceptions Index	Transparency International (2020) Human Development Index	United Nations (2020) Risk and Development Equal Weighted %
Afghanistan	173	19	0.511	13%
Argentina	126	42	0.845	51%
Australia	14	77	0.944	92%
Bolivia	150	31	0.718	35%
Brazil	124	38	0.765	45%
Canada	23	77	0.929	89%
Chile	59	67	0.851	74%
China	31	42	0.761	63%
DRC	183	18	0.480	9%
Estonia	18	75	0.892	87%
India	63	40	0.645	49%
Indonesia	73	37	0.718	51%
Japan	29	74	0.919	87%
Madagascar	161	25	0.528	19%
Malaysia	12	51	0.810	73%
Mexico	60	31	0.779	54%
Mozambique	138	25	0.456	18%
Namibia	104	51	0.646	47%
Peru	76	38	0.777	54%
Philippines	95	34	0.718	45%
Russia	28	30	0.824	62%
Tanzania	141	38	0.529	28%
Turkey	33	40	0.820	65%
United States	6	67	0.926	88%
Vietnam	70	36	0.704	50%
Average	79.6	44.12	0.740	



Note: End scale – higher is better, color scale lighter color corresponds to high end of scale. Selected countries determined by being listed in this piece and data being available. Raw scores – WB: lower is better, TI: higher is better, UN: higher is better. Risk and Development % scores – equal weighted after adjusting to % scale. Source: World Bank, UN, Transparency International, RBC Capital Markets

Critical minerals, such as graphite, lithium, and cobalt would require production to grow by over 500% by 2050 to meet demand for clean energy technologies.

And yet, much of the current critical mineral production that will be needed to scale up electric vehicle use globally is concentrated in a small number of nations, more than a few of which have profound governance and security problems.

Energy Transition Snapshot: Critical Minerals in Critical Places

At COP26, global leaders sought to reconcile differing national priorities and policy approaches to reaching the all-important net zero climate goals against a challenging social and economic backdrop. Europe and Asia are currently in the throes of an escalating energy crisis that could negatively impact GDP growth in those regions if it is an especially cold winter and there is growing concern that there could be a populist backlash against renewables along the lines of what was witnessed in France in 2018 with the yellow vests protests as consumers struggle to afford rising utility bills. One issue that we believe will take on ever increasing importance in the coming years is access to the critical minerals that will be required to build out the clean electricity infrastructure. According to the World Bank, critical minerals, such as graphite, lithium, and cobalt would require production to grow by over 500% by 2050 to meet demand for clean energy technologies. Some have suggested that the energy transition will radically restructure the resource dependency relationships between producers and consumers that has been a hallmark of the fossil fuel age. With sun and wind more evenly distributed across the globe than oil and natural gas, no one region or set of suppliers should be able to garner an outsized share in the market according to such a line of argument. And yet, much of the current critical mineral production that will be needed to scale up electric vehicle use globally is concentrated in a small number of nations, more than a few of which have profound governance and security problems. In our view, this poses serious questions about whether

the energy transition will really eliminate concentration risk or just swap out reliance on one set of commodities and commodity producers for another.

For example, will the Democratic Republic of Congo (DRC), the world's largest cobalt producer, gain outsized influence in the Net Zero narrative?

The Central African nation, which accounts for 70% of current cobalt production and is home to 50% of cobalt reserves, could serve as the case study for the “resource curse.” The country experienced such a brutal form of colonial rule based on natural resource exploitation that it purportedly served as the inspiration for Joseph Conrad’s “Heart of Darkness.” The demise of Belgian colonial rule sadly did not result in a reversal of the DRC’s fortunes. Mobutu Sese Seko absconded with much of the country’s mineral wealth, leaving its citizens facing abject poverty amid some of the world’s worst human development indicators. Mobutu’s demise also brought little respite, as the country would become the scene of one of the world’s worst wars at the dawn of the new millennium as the lethal dynamics unleashed by the Rwandan conflict spread across the border to eastern Congo. Eight African nations dispatched troops to DRC in a conflict that was funded by largely illicit mineral extraction. Over five million people would die between 1998 and 2007 from the fighting as well as the hunger and disease that was a direct by product of the ruinous war. DRC’s current leader, Felix Tshisekedi, came to power following a controversial backroom election deal in 2018 worked out with then head of state Joseph Kabila in order to prevent Martin Fayulu from taking power. Despite the rather inauspicious start, Tshisekedi is vowing to make a sharp break with the country’s troubled past and has pledged to improve governance and accountability. After sidelining the Kabila holdovers and consolidating power in April, Tshisekedi has moved to review some of the most important mining contracts, including the \$6bn deal signed with China in 2008.

China has provided substantial infrastructure funds and loans to many African nations in return for access to their natural resource endowments, without the conditionality attached to budgetary support from multilateral financial institutions. Such relationships with key critical mineral producers have helped China consolidate its control over the supply chain for EVs, much to the concern of Washington and elsewhere. Some experts have suggested that the Biden Administration actively encouraged Tshisekedi to review the Chinese deal, which covers both copper and cobalt. The IMF, for its part, pressed the Congolese government to reduce the size of the deal from \$9bn to \$6bn, making such a reduction a condition for a \$1.5bn credit facility. China’s decision to swiftly recognize the Taliban government in Afghanistan may also in part be linked to a desire to access the country’s critical mineral endowment. A 2010 Department of Defense Memo called Afghanistan the “Saudi Arabia of lithium.” Global demand for lithium and other critical minerals is set to increase dramatically as countries seek to meet climate goals. Afghanistan has been unable to develop its critical mineral endowment because investors and operators have avoided the country given the serious security and infrastructure challenges. On the other hand, the Chinese may be less skittish than Western investors and Beijing’s decision to recognize the Taliban may involve some calculation about being able to tap this resource to further solidify its control over the entire renewables value chain.

The green industrial revolution may merely present a shift of geopolitics away from “energy commodities” more squarely towards “minerals” throughout an energy transition and green industrial revolution.

Which Minerals and Where?

While the transition to more renewable sources of power and transportation technologies may seem to potentially present a more benign geopolitical dynamic versus the sometimes fractious nature of geopolitics in fossil fuel markets, the green industrial revolution may merely present a shift of geopolitics away from “energy commodities” more squarely towards “minerals” throughout an energy transition and green industrial revolution. The minerals critical to build and propel the transition forward are indeed natural resources, and in some cases, may face concerns and risks not dissimilar to that seen in the energy space today. The

challenge is to avoid at least some aspects of the resource trap that has ensnared aspects of fossil fuel production when it comes to the minerals of the energy transition if the world is to make considerable progress in the face of climate change.

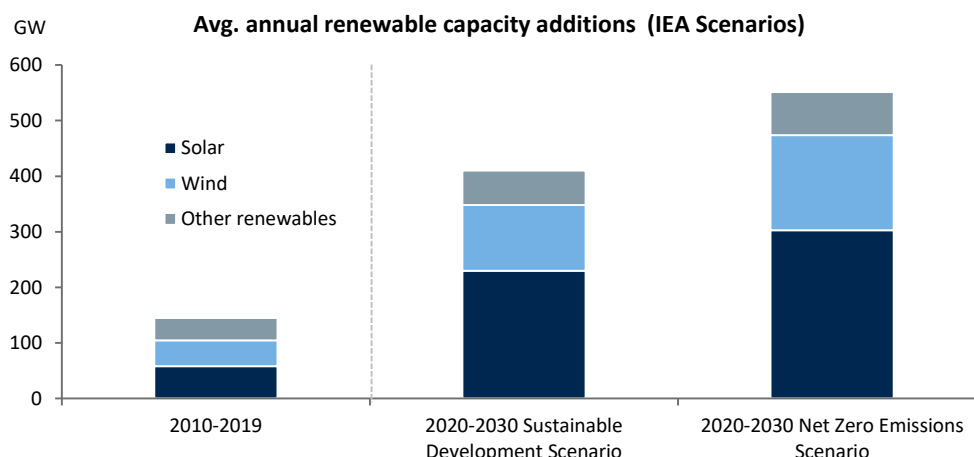
Now which technologies are set to drive this growth in demand for critical minerals? International organizations such as the IEA and World Bank have already begun to stress the need to focus on such minerals through their scenario analysis and we have already seen members of the Biden Administration highlight this as an issue. On its own, the green industrial revolution poses a quandary of how to source the amount of raw minerals needed to deliver the rapid growth in electric transportation, wind turbines and solar panels to reach net zero, and the necessary grid buildout to electrify new industries – among many other (and very important) things. The following information is derived from the International Energy Agency (IEA) in their scenario analysis for the *World Energy Model*.

- Stated Policies Scenario (STEPS): In the IEA projections, the STEPS scenario offer a “more conservative benchmark” that takes into account existing policies and those that are in process of actual implementation. The modeling for these scenarios starts at ground level and goes on a sector by sector basis for countries.
- Sustainable Development Scenario (SDS): The SDS is formulated on the basis of an increase in clean energy policies being enacted in countries globally to reach Paris Agreement goals. This scenario seeks data modelled consistent with a 1.65°C rise in temperature (to remain below a 2°C rise for many global warming mitigation goals). For 2021, SDS also includes the sustainable development packages announced by countries in the wake of COVID-19.
- Net Zero Emissions Scenario (NZES): This is the ambitious, narrow pathway laid out by the IEA for the global energy sector to hit net zero target by 2050. Further, it would also meet UN Sustainable Development Goals and is modelled to limit global temperature rise to 1.5°C. This scenario depends on strong cooperation between countries on net zero goals.

The growth of operating renewable power required to meet net zero, or even sustainable goals is substantial.

The growth of operating renewable power required to meet net zero, or even sustainable goals is substantial to say the least. In the IEA’s analysis, the average annual capacity additions for the sustainable development scenario would be 230 GW photovoltaic solar, 118 GW wind, and 62 GW of other renewables this decade. For the steeper net zero emissions scenario it would be 303 GW, 171 GW, and 77 GW respectively. For comparison, the global annual average capacity additions for all three of these categories between 2010 and 2019 was 145 GW. In the more near term forecasts, IEA projects solar deployment to further surpass records and reach 162 GW by 2022 – which would be about 50% more than the pre-COVID-19 levels in 2019. We note this because it is clear that solar PV deployment is fast-tracked in the near term as well and will likely provide a continuous, immediate pull on critical minerals resources.

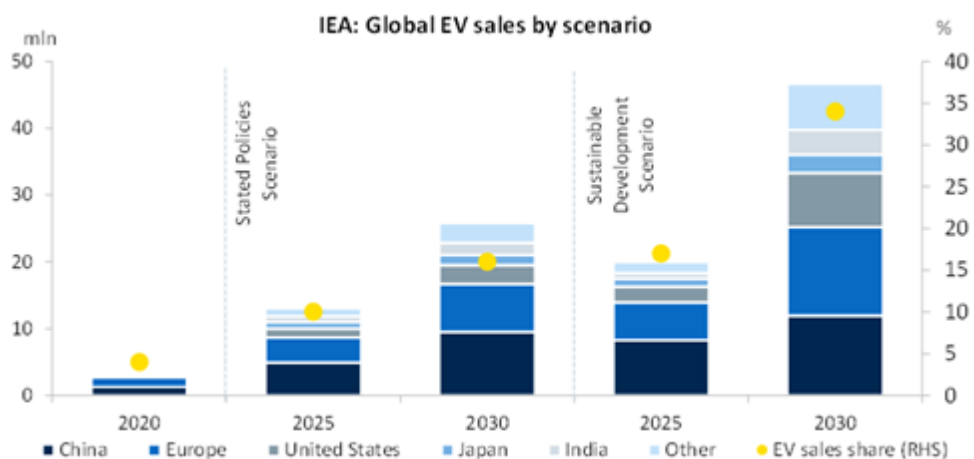
Exhibit 83 - Average annual renewable capacity additions by IEA scenario



Source: IEA, RBC Capital Markets

Global wind, too, saw astronomical growth recently with a +90% growth rate in 2020 to reach 114 GW in IEA data. While the next few years of wind capacity growth is not expected to match the rate of solar, it is still set to be more than 50% higher in 2021/2022 vs the 2017-2019 average seen globally. For electric vehicles in the Stated Policies Scenario, the global fleet grows from 11 million in 2020 to nearly 145 million by 2030 (and are projected to then make up 7% of global fleet). In the SDS, the global EV fleet would reach 230 million vehicles by 2030 (12% of projected global fleet). For background, the IEA incorporates population and energy demand assumptions by region and integrates an assumed economic growth of 3% on average annually through 2050 as a constant across the scenarios.

Exhibit 84 - Global EV sales by IEA scenario (2025 and 2030 focus)



Source: IEA, RBC Capital Markets

Moreover, beyond the minerals used in production of the renewable energy technologies themselves, a large demand driver will be the battery storage required to integrate the clean energy growth if not simply for the purposes of reliability. The growth of the energy storage market will be a major linchpin to critical mineral demand. In RBC's [Energy Storage Primer](#), it is highlighted that the energy storage market could grow to 220 GW over the next decade, and by

Beyond the minerals used in production of the renewable energy technologies themselves, a large demand driver will be the battery storage required to integrate the clean energy growth.

Mineral cost pressures, and even inputs beyond just critical minerals, have the potential to impact buildout and drive tensions. The minerals going into solar panels, wind turbines, lithium-ion batteries, and EV charging units all bear watching.

1,676 GW through 2050. This would be relative to the 2021 11 GW market. In CAGR terms, this is 30.2% growth through 2030 and 16.9% growth through 2050. The US market alone could attract upwards of \$120bln in investment to achieve growth rates. Moreover, Lithium-ion (Li+) configurations of electrochemical battery technology are likely to remain dominant for energy storage systems due to their unparalleled battery densities and relative cost profiles (RBC primer). Of the Lithium-ion configurations available currently for large scale grid operations, Lithium Nickel Manganese Cobalt Oxide (NMC) and Lithium Iron Phosphate (LFP) tend to be the largest competitors due to balanced profile and relatively reasonable cost structure.

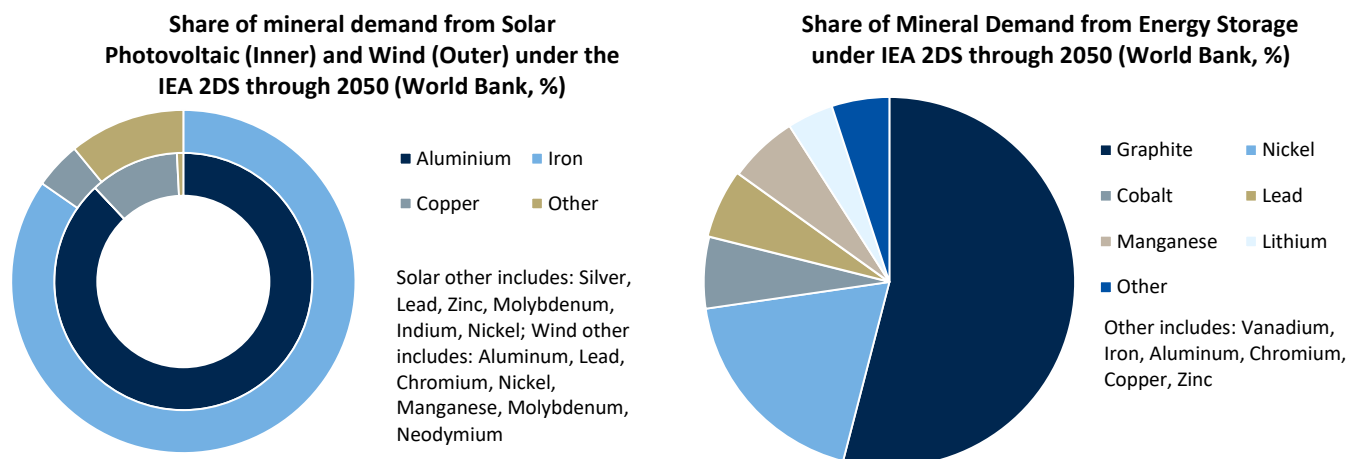
Clearly these scenarios depend on the balancing of cooperation and competition between all countries globally in battling climate change and reducing emissions, inclusive of the Great Power Competition between the U.S. and China. In many regards this relationship between the world's two largest economies may typify much of the concerns we are talking about in this piece with China having been cited as one of the foremost challenges for U.S. policy. Likewise, China is currently the world's largest CO₂ emitter (the U.S. is second in that regard) and features prominently in foreign policy discussions, whether concerning the green industrial revolution, climate change, commodities, trade and more, and of course, critical minerals. It is a relationship not without its challenges, particularly with the climate challenge at hand, as the country features prominently in many other aspects of Washington policy, geopolitics broadly, and mineral commodity markets. As such, the energy transition and green industrial revolution may be more similar to energy commodity markets in that regard that some are willing to admit.

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As we mentioned at the outset, according to a World Bank report, “the production of minerals such as graphite, lithium and cobalt could increase by nearly 500% by 2050 to meet the growing demand for clean energy technologies” as minerals and metals are needed to achieve a below two degree Celsius future laid out in the scenarios of leading international organizations (World Bank, IEA, etc.). Likewise, metals that we more traditionally think of in the commodity landscape, which have their own supply and demand challenges, are also an important part of the picture and should not be disregarded in a conversation around critical minerals. According to BHP, up to four times as much copper is used in electric vehicles compared to petrol-based cars, and while it can be and is one of the most recycled metals in the world, that and the implication of an expanding electric grid (distribution lines, generators, transformers) and the electrification of everything (residential, commercial, consumer products, vehicles, etc.) point to heightened copper demand in the future. Steel will also be needed to build new green infrastructure such as wind turbines and there are a number of metals that come to mind when it comes to increasing electrification and growing clean energy infrastructure generally. Nickel is vital in the making of lithium-ion batteries used in EVs, which remains the favored battery chemistry broadly. As it stands, there are a host of minerals that

will face growing demand in the green industrial revolution with EVs, batteries and zero or low emissions power generation as examples.

Exhibit 85 - Share of mineral demand in IEA scenarios



Source: World Bank, IEA, RBC Capital Markets

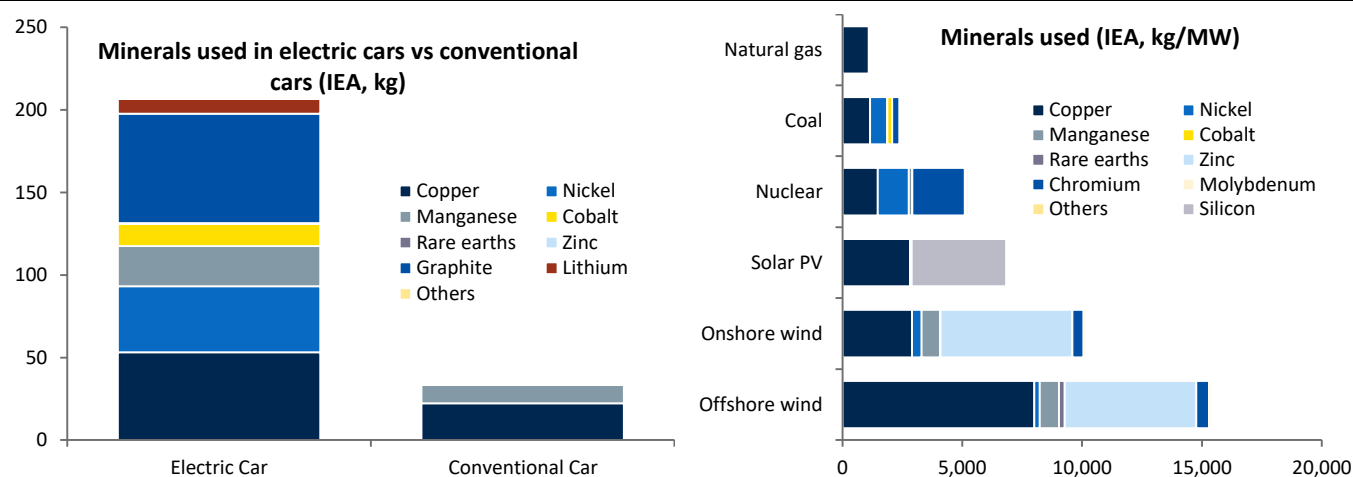
Some metals are more concerning than others – both due to their potential importance throughout the green industrial revolution and because of geographical supply concentration, particularly from the perspective of Western Democracies, and the United States specifically. This theme underscores the types of tension that could typify the next decades as we “Imagine” them out. From a US perspective, lithium for example has very limited supply chain activity domestically (to the point where the USGS even withheld domestic production data in its January 2021 Mineral Commodity Summary so as to not disclose company proprietary data). Lithium is key because 71% of end-use lithium goes to batteries which has grown in recent years due to use of lithium in electronics, tools, vehicles and grid storage. According to USGS, there are five mineral operations in Australia, Argentina and Chile have two brine operations each, and just two brine and one mineral operation in China accounted for the majority of world lithium production. Given the aforementioned importance of the batteries that could power much of the energy transition, lithium supply security has become a top strategic priority for technology companies (and others), which has further put it on the radars of governments. While there are notable reserves in both the United States and Canada, combined it is still less than that in China, Argentina, and of course Australia. In terms of resources, lithium resources exist in the US and are high in Bolivia, Argentina, Chile, United States, Australia, China, Congo, and Canada and elsewhere. Of course, there are substantial risks and other chemistries are possible, lithium-ion batteries are the favored chemistry as we have highlighted above in key applications.

Staying on the topic of batteries, cobalt is yet another metal of concern. Mined production of cobalt is highlighted as concentrated in DRC – as a reminder, about 70% of global production and in terms of refining/processing -- and China is nearly as dominant with about 65% of processing capacity. China’s consumption is high as well, with more than 80% of its consumption going to rechargeable batteries. While resources exist in a number of countries (including in the United States both byproduct and otherwise) reserves are currently concentrated in the DRC, with Australia a distant second. Cobalt content in batteries is being reduced -- in some cases, even cobalt-free substitutes that use iron and phosphorus (USGS), but we cannot write off the criticality of cobalt.

Some metals are more concerning than others – Lithium (71% of end-use lithium goes to batteries), Cobalt (70% of global production in DRC), Graphite (60% of total world output in China), Nickel, and rare earths (highly concentrated in China).

Graphite is yet another mineral with highly concentrated supply and immense importance to cleaning up emissions in the transportation sector through electric vehicles. While not produced in the United States in 2020 (natural graphite), applications for graphite are heavy in the EV sector where it is used for batteries, brake linings. It is also used in lubricants, powdered metals, refractor applications and steel making. It is recyclable, but the principal import sources of natural graphite into the United States were China, Mexico and Canada, the foremost of which, China, is the world's leading graphite producer, at over 60% of total world output, while North America (i.e. Canada and Mexico) only produced about 2% (USGS) - note that two companies are potentially developing graphic projects in Alabama and Alaska. A number of countries stand out globally in terms of both reserves and resources (Madagascar, Mozambique, Namibia, and Tanzania deposits were being developed). To underscore the importance, while currently, chip shortages have shown some of the supply chain vulnerabilities in the auto sector, graphite supply concentration is key given its importance to EV production. In the US, automaker lithium-ion electric vehicle battery producers are key use cases to watch going forward with one US plant expected to require 35,200 tons per year of spherical graphite to use in anodes for lithium-ion batteries.

Exhibit 86 - Minerals Used



Source: World Bank, IEA, RBC Capital Markets

Exhibit 87 - USGS Mineral Commodity Summary Data on 2020 production versus reserves

USGS Mineral Commodity Summary Data (top five reserve countries, mln metric tons)																					
Countries		Argentina	Australia	Brazil	Chile	China	Cuba	DRC	Indonesia	Madagascar	Mexico	Mozambique	Peru	Philippines	Russia	Turkey	United States	Vietnam	Total	% of total	
Reserves																					
	Cobalt	1.40					0.50	3.60						0.26	0.25				7.1	85%	
	Copper	88.00		200.0							53.00		92.00		61.00				870.0	57%	
	Graphite (nat)		70.00			73.00				26.00		25.00				90.00			320.0	89%	
	Lithium	1.90	4.70		9.20	1.50											0.75		21.0	86%	
	Nickel	20.00	16.00				5.50		21.00						6.90				94.0	74%	
	Rare Earths (REO equivalent)		21.00			44.00				6.90					12.00			22.00	120.0	88%	
	Zinc	68.00				44.00					22.00		20.00		22.00				250.0	70%	
2020 mine production																					
	Cobalt	0.01					0.00	0.10						0.00	0.01				0.1	82%	
	Copper	0.87		5.70							0.69		2.20		0.85				20.0	52%	
	Graphite		0.10			0.65				0.05		0.12				0.00			1.1	83%	
	Lithium	0.01	0.04		0.02	0.01											W		0.1	95%	
	Nickel	0.17	0.07				0.05		0.76						0.28				2.5	53%	
	Rare Earths (REO equivalent)		0.00			0.14				0.00					0.00			0.00	0.2	62%	
	Zinc	1.40				4.20					0.60		1.20		0.26				12.0	64%	

Note: W – withheld by USGS. Source: USGS, RBC Capital Markets

Nickel is another metal, albeit one far more familiar to commodity market participants, as it is indeed a traded commodity like copper, aluminum, zinc, and silver, which will also play a role in the green industrial revolution. Nickel is used in wind generation technologies and in minimal amounts in solar, but nuclear applications, if such are built out, do use nickel in a higher quantity per megawatt than coal or natural gas generation. Like a number of minerals, the US does have domestic production and reserves, but those are dwarfed by that in places like Indonesia, Australia, Brazil, Canada and China. Importantly, nickel is no stranger to geographical concentration risk which we will touch on in a moment.

Rare earths, which oft get the critical mineral limelight, fit this mold of risks in the energy transition. According to the USGS, there was some production of rare earths in the United States (38kmt of rare-earth-oxide equivalent). Limited quantities of rare earths are recovered from recycling batteries, permanent magnets and fluorescent lamps, leaving imports to plug the gap globally. In the US, 80% of rare-earth compounds and metal imports were from China, with 5% from Estonia and some from Japan and Malaysia. The US government does maintain a stockpile. According to the USGS, reserves are most plentiful in China, far ahead of Vietnam and Brazil, as well as Russia, India and the United States. In terms of resources, while rare earths are relatively abundant in the earth's crust, minable concentrations are less common, making them "rare" earths indeed.

One refrain that should be clear is that China has a clear dominance in a number of critical mineral supply chains (in some cases worryingly so amid growing demand for green energy infrastructure, semiconductors, technological solutions to the world's biggest challenges, and the types of geopolitical conflict that have typified other commodity markets). China's international relationships with the rest of the world are not without their tripwires. It is true that China has become more involved internationally as it stepped into some of the vacuums of interest that emerged and/or grew during the Trump administration, and it has long had a lead in development relationships with key mineral producers around the world.

The trajectory of demand, ESG-friendly sourcing, supply chain concentration and U.S.–China relations all point to increasing friction points that would result in a larger geopolitical factor for critical minerals and potential disruption.

The geopolitical risks for critical minerals play a greater importance as more of the supply chain is concentrated in a smaller number of countries. Global cobalt supply serves as a particularly good example as there are various political challenges and potential fail points that could arise and significantly disrupt supply chains key to global energy transition targets. DRC's President Felix Tshisekedi declared a month of martial law in two eastern provinces recently as a surge of violence left hundreds of people dead. Additionally, over 40% of DRC mining capacity is controlled by Chinese mining companies. Moreover, when looking at refining in terms of battery application China makes up ~80% of total global output of cobalt sulphate and oxides. The trajectory of demand, ESG-friendly sourcing, supply chain concentration and US-China relations all point to increasing friction points that would result in a larger geopolitical factor for critical minerals and potential disruption. We've already seen examples of where supply chain dominance by a single country has been used as leverage during rounds of political brinkmanship. In 2011 China halted rare earth metal exports to Japan (roughly 50% of the country's imports) for 2 months following a territorial dispute over the Senkaku Islands. More recently, trade conflicts like the ongoing trade war between the US and China since 2018 or the US Trump-era steel tariffs all have more severe effects when the majority of global supply is sourced from a single nation. Given the expected scarcity, even known reserves could end up being restricted by host nations for the purpose of national interest. Mexico has already worked on passing legislation that would restrict future mining operations for select government-designated critical minerals, reserving them exclusively for government development. Political bouts aside, reasons for supply chain disruptions could simply be countries trying to move up the supply chain, capturing a larger part of the value add in country. Indonesia has banned the export of unrefined copper and nickel to ensure refining remains in country. Regardless of the underlying cause, the finite sourcing, inherent scarcity, and rapidly rising demand will require a more vigilant political lens as we move further into the transition in the coming years.

Exhibit 88 - Critical mineral needs

IEA - critical mineral needs for clean energy technologies									
Clean energy technology	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminum
Solar PV									
Wind									
Hydro									
CSP									
Bioenergy									
Geothermal									
Nuclear									
Electricity networks									
Evs and battery storage									
Hydrogen									

High = dark blue, moderate = light blue, low = gray

Source: IEA, RBC Capital Markets

Challenges, Opportunities, and Duties as we Imagine the Future

While there is an opportunity for resource rich countries here, there are also challenges in increasing production in a responsible manner, equitably distributing the gains and benefits, avoiding the resource trap driven mistakes of the past, and supporting the energy transition with stable and responsibly sourced supplies.

Given the technological and industrial buildout necessary, we would keep a particular eye on lithium, cobalt, graphite, and nickel given the likely need for new production (versus current levels) as well as the geographical supply concentration.

Manganese and rare earths also should bear watching, as should those already thought of as financial commodities (copper, aluminum, zinc, etc.).

To that end, The Climate-Smart Mining Initiative is important, and necessitates international cooperation. This in itself implies that geopolitics and US-China relations are important as it is hard to ignore the idea that at least some key parts of the road to the green industrial revolution run through China. Historically, the conversation about natural resource security has largely focused on energy in the Middle East, but we think minerals will be the next important chapter, particularly for those critical to the green industrial revolution. China's large market share in various parts of the supply chain reinforce the idea that Washington policy on China is key, as are global geopolitics given the increasingly universal policy priority of meeting the climate challenge. Likewise, there will be as many price implications as there are geopolitical implications from the growth in demand and the need to source more minerals in more places – especially since it needs to be done in a socially and environmentally conscious way if the world is not to repeat past mistakes or compound existing problems in some current producing regions.

Through the industrial revolution, given the technological and industrial buildout necessary, we would keep a particular eye on lithium, cobalt, graphite, and nickel given the likely need for new production (versus current levels) as well as the geographical supply concentration. Manganese and rare earths also should bear watching as should those already thought of as financial commodities (copper, aluminum, zinc, etc.). In some cases, where there may even be enough mined material, a potential lack of diverse capacity to process those metals into specialist chemicals could pose problems. In either case, swings to costs could hit policy priorities of a number of countries and thus complicate already tenuous geopolitical relationships further as well as imperil goals in certain places (such as the phasing out of internal combustion engine vehicles) simply due to supply and cost of key minerals. Whether the future is distributed globally, or concentrated in the supply and processing capacity in a handful of places, the path to a green future lies in new and existing minerals. This may potentially drive a new round of investable commodities on futures exchanges and in index investment alike, but suffice to say, the geopolitics of tomorrow's commodity markets may lie in critical minerals in critical places as we "Imagine" it today.

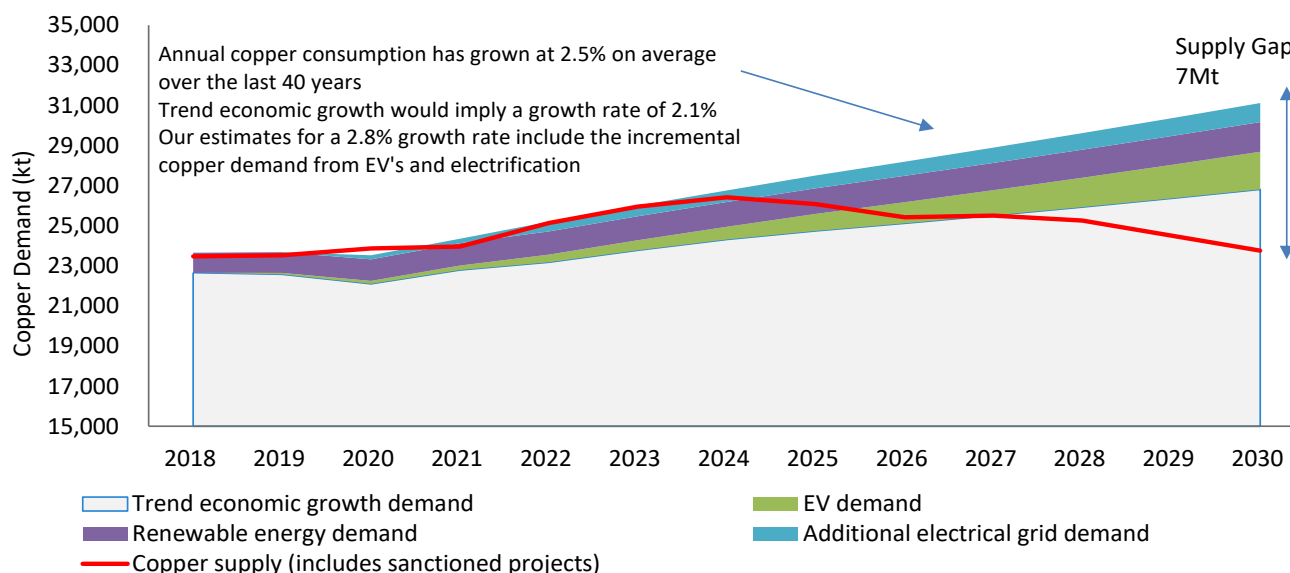
Mining: Got copper? The world needs more, but it's getting harder to mine

**For Required Equity
Research Non-U.S. Analyst
and Conflicts Disclosures,
please see page 259.**

Copper supply growth for the energy transition

Renewable energy, EVs and grid spending add a new source of copper demand growth, and we estimate copper supply needs to grow 30% by 2030 to support the energy transition. This is set against an aging supply base and a secular trend of declining ore grades while increased ESG focus make permitting and social license more challenging and adds costs to mitigate environmental impacts.

Exhibit 89 - Copper has a key role in energy transition which will require significant supply growth

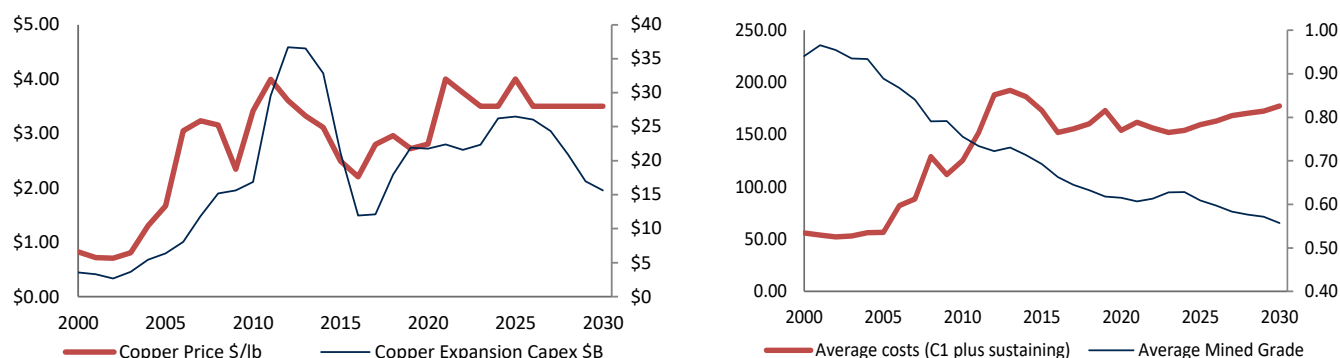


Source: Wood Mackenzie, RBC Capital Markets estimates

The growth paradox

Miners remember all too well that the 'production growth at all costs' mindset in the commodities super cycle from 2000–2012 ended with a 5-year supply glut, cost overruns, strained balance sheets, and management turnover. The current mantra is to balance shareholder returns with measured growth, but a pivot towards more growth is likely required to fill the supply gap noted above. Current high metal prices are likely to spur further investments but a key question is whether this will be enough to avoid demand destruction.

Exhibit 90 - Industry still recovering from prior capex boom and weary to repeat fallout, while secular grade decline continues

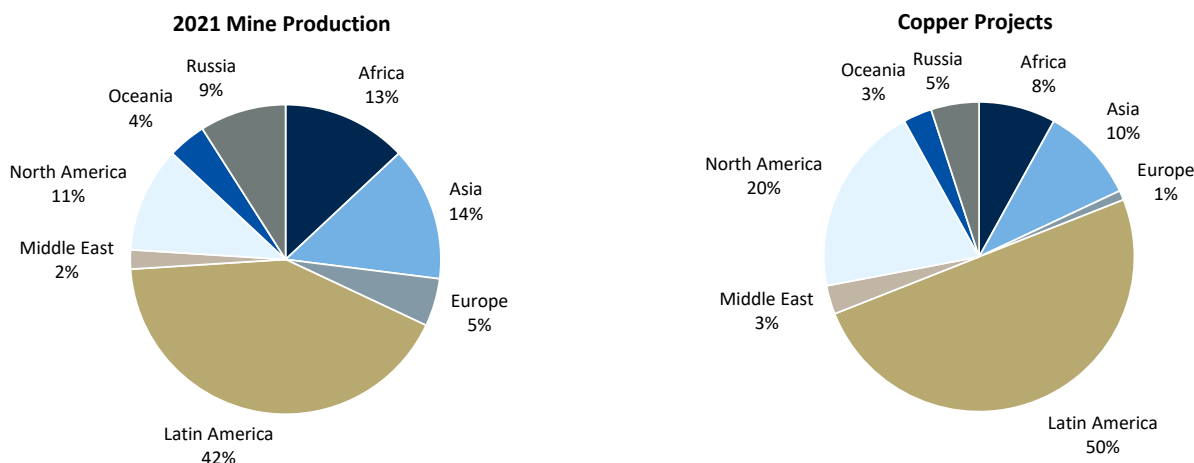


Source: Wood Mackenzie, RBC Capital Markets estimates for future years

Let's get political

China has an outsized influence on the copper market representing 50% of demand and 46% of refined production and despite only 8% of mine supply, they have made several investments in foreign mining operations. Governments in key producing countries, namely Chile and Peru, have proposed higher taxes on the mining industry, and this raises interesting questions around the relative competitiveness of certain regions with potentially growing political risks.

Exhibit 91 - Proposed tax changes in key producing areas such as Chile and Peru raise questions about investment risk premia



Source: Wood Mackenzie, RBC Capital Markets estimates

Technology friend or foe?

The effort to use technologies to lower costs, increase productivity and improve safety at mine sites has accelerated in recent years. Autonomous trucks, AI to analyze data, ore sorting, new metallurgical recovery processes are just a few examples that are driving measurable change; however, this has largely just offset rising costs elsewhere. On the demand side, if the mining industry cannot supply enough copper, there is potential for substitution and thrifting of copper with technological innovation. Japanese HVAC manufacturer Daikin's recent announcement to substitute aluminum for copper in air conditioners, and car part's maker Aptiv's concepts to lower copper contained in an EV to be more in line with an ICE, are two recent examples that underscore this potential risk.

Industrials: Water scarcity

The Earth has essentially the same amount of water today that it had two billion years ago. Fresh water, essential to life, represents just 3% of the water on Earth, with much of it inaccessible in the polar icecaps and permafrost. The troubling collective impact of population growth, industrialization, pollution, climate change, and an overall lack of water stewardship poses a palpable threat to the planet's relatively fixed supply of fresh water. Projecting out these mounting threats, the unthinkable Malthusian question needs to be asked: could we eventually run out of water? The short answer is unlikely, at least not in the foreseeable future assuming advances in smart/digital water systems, water reuse, and conservation. However, over the next 5–10 years we expect to see water scarcity issues in national headlines with alarming frequency. In our view, the implications of water scarcity are far-reaching, and can be grouped into (1) economic, (2) geopolitical, and (3) health/humanitarian categories.

Water supply & demand imbalances

Water supply and demand is ultimately a local issue. The adage is that water is in short supply where it is needed/demanded the most, and in overabundance (think flooding) where it is not wanted or needed. North America has an enviable position of having access to 15% of the world's renewable fresh water supply to support just 8% of the world's population. In contrast, China has 21% of the world population, but only 7% of the water supply, according to the UN. Roughly 70% of the global demand for fresh water is for agriculture, but more than half of it is wasted from evaporation and leaks. Industrial use of water accounts for 20% of water demand, with residential at 10%. Globally, water consumption is doubling every 20 years, more than two times population growth. Water demand in the U.S. has tripled in the past 30 years, while population growth has been just 50%.

Economic implications of water scarcity

Expanding industrialization, especially in emerging markets, is stressing already-limited water resources. In many cases, reliable access to water supplies will be a limiting factor to where many water-intensive businesses will be able to operate. Businesses that need access to water include food & beverage, semiconductor, pharma, mining, chemical and petrochemical, among others. Water scarcity can limit the industrialization of emerging markets. Developing markets today only use 11% of water for industrial use versus 42% for developed countries.

Water–energy nexus

Energy production is the second largest demand for water resources globally, after agriculture, although most of the water used is returned to its source. The International Energy Agency estimates that at current demand levels, water for energy production will increase by +60% over the next 25 years. At this pace, there will not be enough freshwater available to meet global energy needs by 2040.

Geopolitical implications of water scarcity

Water insecurity multiplies the risk of geopolitical conflict. Since freshwater is a non-renewable and scarce resource, it should come as no surprise that water is the center of many geopolitical disputes today. The flash points are likely to be where countries share a river or aquifer. According to the UN, there are 276 transboundary river basins and 200 transboundary aquifers. Notable water disputes include the Middle East, where disputes stemming from the Euphrates and Tigris Rivers involve Turkey, Syria, and Iraq. The Jordan River conflict pits Israel, Lebanon, Jordan and the State of Palestine. Water-related disputes over shared water sources include ownership, fishing rights, and pollution.

Over the next 5–10 years, we expect to see water scarcity issues in national headlines with alarming frequency.

At the current pace of demand, there will not be enough freshwater available to meet global energy needs by 2040.

Humanitarian/health implications

Food price spikes caused by droughts can inflame conflicts. Where economic growth is impacted by rainfall, episodes of droughts and floods have generated waves of migration and spikes in violence within countries. The lack of clean water has a domino effect on communities. Local commerce declines, incomes go down, tax revenues decrease, population declines due to lack of employment opportunities, and cities and the surrounding communities shrink.

Solution set to water scarcity

There is no silver bullet solution, but part of the answer to water scarcity starts with increased investment in smart/digital systems along with artificial intelligence to improve the efficiency of water treatment, detect leaks, and perform remote monitoring and testing. We expect to see greater investment in developing/deploying large-scale desalination systems. There needs to be greater acceptance of water reuse, along with the advanced filtration systems needed to insure water quality and safety. Look for efforts on improving farming practices and upgrading aging water infrastructure. There also needs to be renewed efforts at conservation and demand-based pricing of water. We expect to see more investment in water-friendly products and services emerge, addressing their conservation advantages. There will likely be more emphasis on decentralized solutions like point-of-use filtration rather than relying on large-scale, aging municipal systems. We also expect to see more focus in the U.S. at raising water tariffs to more closely approximate the true cost of water treatment. Notably, the U.S. still pays on average nearly four times less for municipal water than some European countries such as Denmark, Switzerland, and Germany. The reality is that water remains chronically underpriced.

There is no silver bullet solution. We expect to see increased investment in smart/digital systems and in developing/deploying large-scale desalination systems.

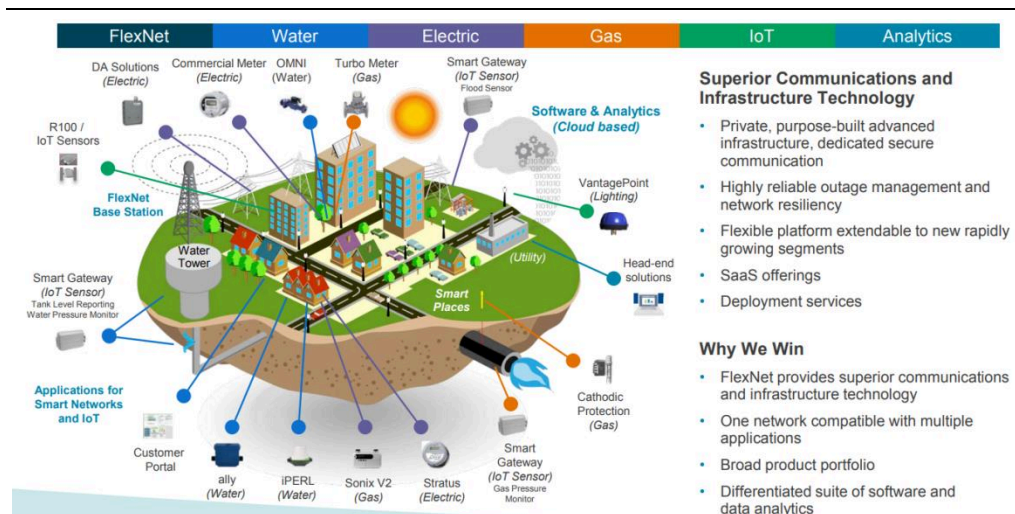
We expect more investment in water-friendly products and services and more focus in the U.S. at raising water tariffs to more closely approximate the true cost of water treatment.

Finally, we think AI will be used to improve the efficiency of water treating, leak detection, and remote monitoring and testing.

Development of smart water systems could stem the tide

Smart water networks use connected devices/sensors, the Internet of Things, and information technology to help municipalities improve their monitoring and diagnostics capacities, optimize investment dollars, ensure proper stewardship of watersheds and infrastructure, and serve their communities more effectively. Smart water networks represent one of the biggest growth opportunity within the global water sector to help address water scarcity.

Exhibit 92 - Xylem's smart water solutions for smart cities



Source: Xylem Company reports

Energy & Utilities: Renewable natural gas

In the Great Balancing act, innovative energy solutions will be required and one that holds major promise is Renewable natural gas (or “RNG”). RNG production remains a small part (<1%) of the current U.S. natural gas supply mix, but we expect it to become more meaningful over time. The biggest hurdle is cost, with economics on RNG right now primarily supported by government incentives that place most RNG into the transport fuel market (natural gas vehicles). However, as broader ESG motivations and GHG emission-reduction goals expand, we have seen increasing willingness from gas infrastructure companies, oil majors, gas utilities and socially-conscious end-use companies to support RNG production amid the higher costs (through voluntary programs at a higher fee).

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RNG production remains a small part (<1%) of the current U.S. natural gas supply mix, but we expect it to become more meaningful over time.

RNG growth potential

We view RNG’s potential growth story as a “demand pull” development. Consumer demand and political will appear essential to grow the necessary credit and incentive structure that would make RNG more competitive with conventional natural gas. RNG’s plug and play nature make it an ideal, and we believe RNG could grow to account for ~7–11% of natural gas supply by 2040, consistent with most industry analyses. The addressable market is technically whatever total natural gas demand is; the market for RNG should be driven more by consumer tastes for cleaner fuels. Supply of natural gas for transport could easily be met by growing RNG supply, whereas RNG into the pipeline grid would help reduce emissions where “electrify everything” is not well-suited 100% of the time.

RNG project economics

We previously provided a broad overview on RNG in a note titled [Renewable Natural Gas – Where the Gas is Green and Grids are Pretty](#). In that note, we provide basics on the RNG production process and project economics. To briefly summarize, RNG (also known as “biomethane”) is pipeline-quality gas produced from natural waste. Current production is primarily via anaerobic digestion from landfills, dairy farms (manure), and wastewater treatment facilities. When used as a transport fuel, RNG qualifies for incentives under the federal Renewable Fuel Standard (RFS) and state-level Low Carbon Fuel Standard (LCFS) programs (California’s LCFS program is most relevant, but other states have followed, or might soon). We estimate project-level IRRs of ~20–40% depending on process and incentives.

Government incentive structures support RNG growth

We highlight the LCFS program specifically, because we view this dynamic as emblematic of one state’s goal to reduce emission profiles. We think the LCFS program is highly supportive for RNG growth over the next decade. The LCFS works by assigning carbon intensity (“CI”) scores to various fuels, which are then compared against a declining CI target for the entire fuel pool each year. The sale of fuels below the benchmark (like RNG) generates credits, while the sale of fuels above (like petroleum gasoline and diesel) generate deficits. More carbon-efficient fuels generate more credits. Sellers and producers of petroleum products ultimately need to purchase LCFS credits from producers of renewable fuels in order to satisfy their regulatory obligations, which creates a market-based pricing system for carbon.

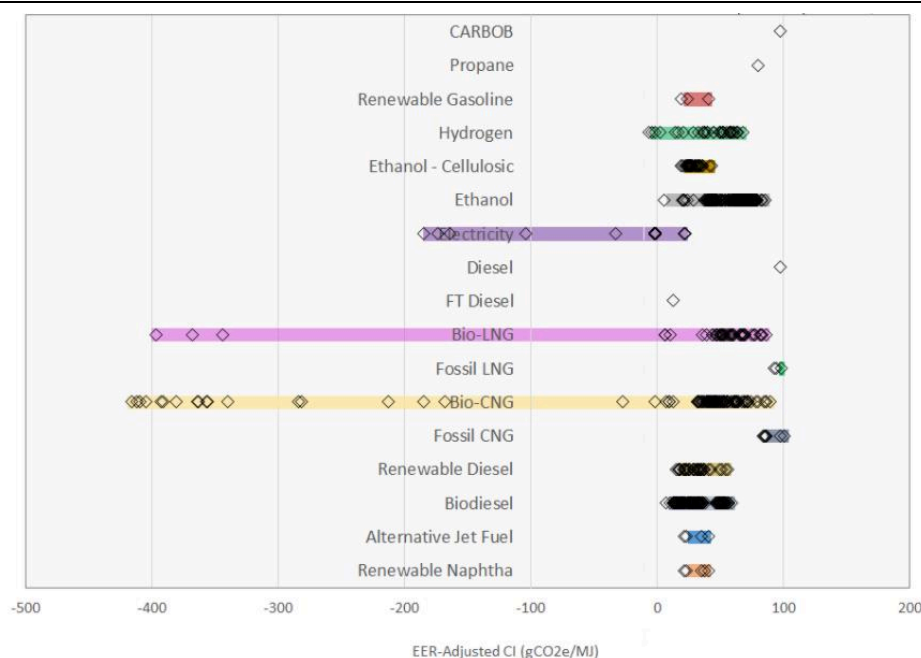
Fuel attractiveness boils down to production cost, supply and demand, and the credits generated for type of fuel. With credit generation determined by the carbon intensity score, lower CI fuels are more attractive.

Exhibit 93 - Carbon intensity by fuel type – 2020

In this chart, each line represents a particular fuel type and each “marker” represents a specific project that is developing that fuel.

“Bio-CNG” line in yellow equates to RNG, with the markers equating to various landfill, dairy, wastewater, etc. projects.

Landfill gas typically has a CI score sub 50, which means its carbon intensity is >50% lower than diesel.



Source: CARB

Voluntary programs

Growing RNG demand outside the incentives is a focus. RNG sold to gas utilities for things such as building heating or residential use does not receive the same government incentives; therefore, the gas utility company would need to pay up for the RNG and then pass on the extra costs to its customers to earn a profit. This is already happening, and early indications are encouraging that the support from gas utilities can continue. Further, several larger public companies have announced intentions to pay this “green tariff.”

Renewable natural gas should lead to improvement in key ESG metrics for sectors such as Midstream Energy

The Sustainability Accounting Standards Board (SASB) has identified three key environmental issues that midstream should focus on. These are greenhouse gas emissions, air quality, and ecological impacts. We think the incorporation of renewable natural gas projects to a midstream company’s portfolio should improve the standing of midstream in each SASB environmental category. We see potential runway for renewable natural gas, which should benefit midstream businesses with more natural gas exposure. With more RNG projects taking place, there will be a need for infrastructure to transport natural gas from farms and landfills to end users. Investments into these projects should help generate business longer term and make midstream businesses more resistant to the many risks of oil and gas.

RNG is one of several key sources of renewable energy that will help minimize the harmful effects on the environment.

According to the California Air Resources Board (CARB), RNG sourced from landfills can provide a 125% reduction in greenhouse gas emissions, and RNG sourced from dairy manure can result in a 400% reduction in greenhouse gas. Methane is also a problem for the environment as methane is 25–85x more potent in the atmosphere than carbon dioxide. By investing in RNG initiatives, digesters are able to capture methane that would otherwise be emitted into the

We think the incorporation of renewable natural gas projects to a midstream company’s portfolio should improve the standing of midstream in each SASB environmental category.



atmosphere. RNG initiatives are key to helping the environment, which is why companies and organizations focused on ESG are making investments into these kinds of initiatives.

Waste: There's a new fuel in town

We believe the multitude of known and emerging beneficial use cases of waste fuel will serve to increase the prevalence and investment into technologies and infrastructure that aid in the conversion of waste to fuel.

In our view, capturing landfill gas and converting it into RNG creates a more sustainable, circular economy while also helping to further accelerate the shift away from fossil fuels.

Building upon our earlier Renewable Natural gas discussion, waste fuel also holds future promise in the global sustainability effort of The Great Balancing Act. “Waste fuel” is commonly described as the second-derivative fuel byproducts created by the treatment of waste (and the gas generated by that waste) that is disposed of at landfills. Right now, the primary source of fuel from generated waste comes from landfill gas, which is most commonly converted into renewable natural gas (RNG) – as discussed in the preceding section, a fuel source that can be used for a variety of applications including consumer use, Compressed Natural Gas (CNG) for transportation, electricity, or combined with other proven technology to produce green hydrogen. The landfill gas is extracted through an elaborate series of wells and pipes and then routed to the RNG facility where CO₂, nitrogen and other impurities/contaminants are removed. In addition to RNG, other fuels that can be derived from the treatment of waste (both organic and inorganic) include biodiesel and hydrogen-based fuels. Looking ahead, we envision a world where landfills become increasingly important sources for alternative energy as companies invest further into waste/feedstock conversion.

Multiple beneficial use cases for waste fuel

For the waste majors, perhaps the most obvious near-term use case is to have the landfill gas converted to RNG to fuel waste collection vehicles, creating a closed-loop feedback system. Right now the percentage of landfill gas projects/facilities that are currently able to do this is relatively low, however we envision a future where an increasing portion of the waste fleet is fueled via RNG captured at their existing facilities – thereby creating both meaningful environmental and financial (fuel cost savings) benefits. Further, we believe the use of RNG also incentivizes improved management of existing waste streams, which we see leading to potential long-term water and air quality benefits beyond the production of RNG. Overall, we believe the multitude of known and emerging beneficial use cases will serve to increase the prevalence and investment into technologies and infrastructure that aid in the conversion of waste to fuel.

What role can waste majors play in the energy transition?

In our view, the waste majors are at the center of the evolving energy transition and have a crucial role to play going forward. Given that the U.S. EPA recognizes RNG as a renewable energy resource and one that is used beneficially as a fossil fuel alternative, we believe there is a significant opportunity for the majors to capitalize on robust demand from utility companies, governments, and other renewable energy providers and increase the rate at which they convert waste and landfill gas into RNG and other renewable energy sources. In our view, capturing landfill gas and converting it into RNG creates a more sustainable, circular economy while also helping to further accelerate the shift away from fossil fuels.

Future evolution of waste-to-fuel conversion within the waste industry

Landfills provide some of the lowest cost, most predictable and longest-term feedstock of any renewable fuel. Additionally, we would highlight that landfills, wastewater treatment plants, and dairy & food digesters represent critical infrastructure and are often viewed as perpetual feedstock sources of RNG given the long lifespan of these assets. Thus, there is plenty of runway for landfill gas-conversion technologies and processes to continue to evolve. For example, landfill gas can be used to create green hydrogen through steam methane reform (SMR), a process where the technology has already been proven via real-world application, and costs are expected to be below the targets of other zero-carbon hydrogen producers. We note that the waste sector has already begun to explore green hydrogen initiatives, with one of the majors recently entering into a partnership with a small renewable energy company to convert organic waste to produce green hydrogen at one of their landfills, and we would



expect the other majors to eventually follow suit as green hydrogen grows in prominence as a credible resource.

Materials: Substrate wars

Perception

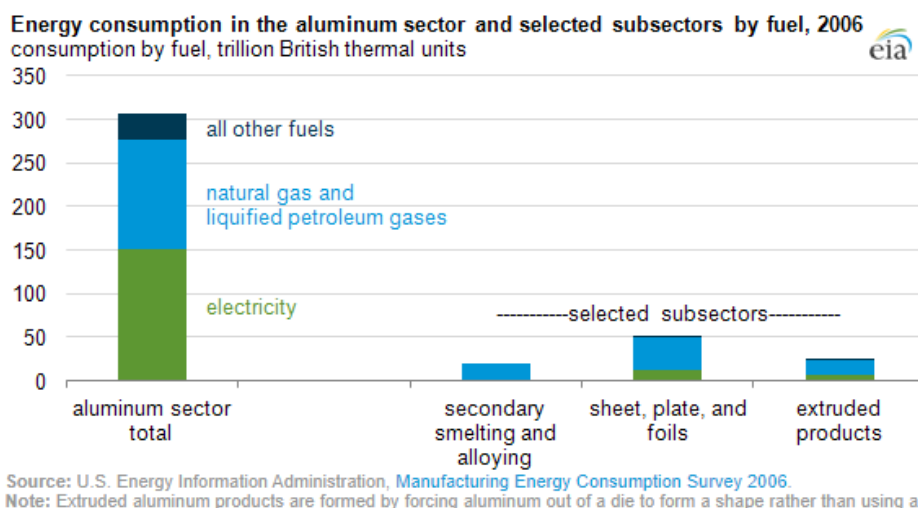
It is our belief that the aluminum can and glass packaging have the highest perceived sustainability perception by the general public, while Styrofoam and PET (plastic) have the lowest. However, it is worth taking a deeper look at the total energy consumption for each packaging substrate (including production, freight, reusability recycling energy consumption etc.) to determine which packaging substrate truly has the lowest carbon footprint and is in fact the most sustainable packaging solution. Plastics is typically perceived as having the most negative environmental impact, although it costs less energy to make plastics vs metals and plastic does offer hygiene and infection protection benefits. On the other hand, glass packaging has a high sustainable perception, which it deserves as glass is made from natural earth raw materials and is infinitely recyclable. That said, glass is heavy and therefore has high freight and energy cost associated with transportation. Finally, while paper is perceived as a tree chopping substrate, most paper packaging comes from recycled paper and/or tree farms that are designed to be net neutral to total trees in the ground.

It is not clear which packaging substrate has the lowest carbon footprint due to factors such as reusability, recycling rates (which varies geographically) and freight/logistics cost.

Carbon footprint

We examine the total carbon footprint of packaging substrates, which not only include the circularity of the specific substrates themselves but the energy and freight cost associated with creating the substrate. For example, aluminum cans are “infinitely” recyclable and thus over time the aluminum can has a relatively low carbon footprint, assuming the aluminum is recycled and reused (~75% of all aluminum ever created is still in use today). Secondary aluminum production, which involves recycling aluminum scrap for new products such as food/beverage cans and automotive casting is significantly less energy intensive. Therefore, we would see recycled aluminum and aluminum as a packaging substrate as a low-carbon footprint packaging material that is highly dependent on recycling rates.

Exhibit 94 - Aluminum energy consumption rates

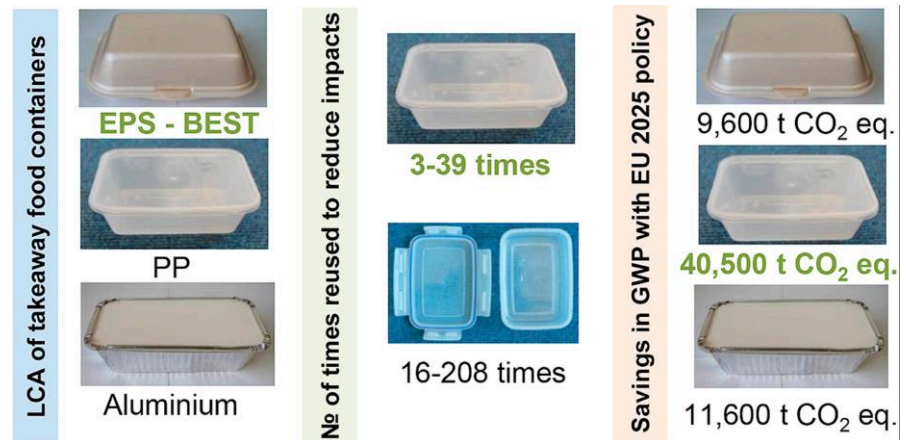


Source: U.S. Energy Information Administration

The total energy required to produce 33 billion liters of bottled water is equivalent to 32–54 million barrels of oil (although not all the energy used comes from oil). Energy to produce bottled water accounts for about one-third of one percent of total U.S. energy consumption.

Styrofoam containers have the lowest production carbon footprint when looking at the environmental impacts of disposable takeaway food containers (~50% lower than aluminum cans and ~3x lower than plastic bottles), according to the University of Manchester. However, Styrofoam cannot be considered sustainable since it is not reusable and most of the Styrofoam containers end up in landfills.

Exhibit 95 - Takeaway food containers carbon footprint



Source: Journal of Cleaner Production, LCA – Life Cycle Assessment

In total, it is not clear which packaging substrate has the lowest carbon footprint due to factors such as reusability, recycling rates (which varies geographically) and freight/logistics cost. It is our opinion that the aluminum can, which admittedly has a high production carbon footprint, is the most sustainable packaging substrate if, and only if, the aluminum is recycled and reused.

Pollution and circularity

Containers and packaging make up the majority of municipal solid waste (MSW) amounting to ~82 million tons of generation or ~28% of total generation, according to the EPA.

Cost

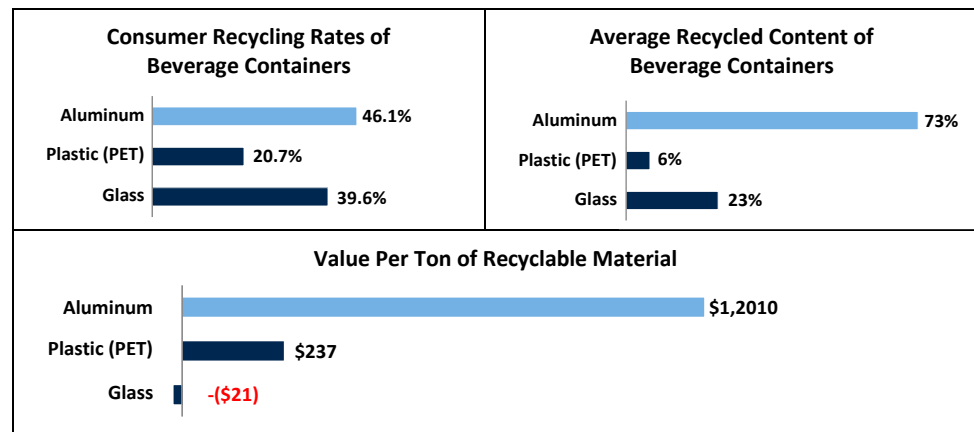
We believe the cost associated with creating and using virgin plastic is so far below the cost of using recycled plastic (due to lack of PET recycling technology and locally PET recycling plants) is one of the main drivers that forces products (such as bottled water) to opt for virgin plastic as opposed to recycled plastic. With that said, there is an industry wide R&D push to come up with sustainable and cheap recyclable plastic that can be used for products prefer plastic packaging due to their seal-ability and infection prevention characteristics, which we believe are superior to other substrates.

Recycling rates

Aluminum has the highest recycling rates (compared to PET and glass) and the highest recycled content per unit (recycled content per substrate for aluminum cans is 73%, glass 23% and PET 5.6%). In addition, aluminum's lower weight and stackable characteristics allows for easy transportation. Finally, aluminum cans are recycled over and over again creating a true "closed loop" recycling process. Unlike glass and PET which are typically "down-cycled" into other products such as carpet fibers or landfill liner.

It is our opinion that the aluminum can, which admittedly has a high production carbon footprint, is the most sustainable packaging substrate if, and only if, the aluminum is recycled and reused.

Exhibit 96 - Recycling rates by substrate



Source: The Aluminum Association

Finally, aluminum cans help make municipal recycling programs possible. Many of these programs rely on re-selling recycled material and the high value of aluminum in the recycling stream effectively subsidizes the recycling of less valuable materials in the bin. The Aluminum Association report finds that aluminum can scrap is worth \$1,210 per ton on average versus \$237 per ton for plastic (PET) and -\$21 per ton for glass. The data reflects an average price for recyclable materials from February 2018 – February 2020. The implications are clear – **without aluminum, very few curbside pickup programs would be financially viable.**

Marine sector: Shipping sector dominated by one topic – the path to net zero

While supply chain restraints get all the headlines of late, what has been less-well covered is the great challenge that the global merchant shipping sector faces in the coming 30 years: Managing the ambitious decarbonization targets set and enforced by the IMO regulator.

Tight environmental rules for new ships

Shipping accounts for c.3% of global CO₂ emissions. That may not sound like much, but merchant ships run on heavy-fuel-oils, which have a very high pollutant content (SO_x, NO_x, etc.) and regulation on emission-reduction had been lax compared to other industries. For example, until 2020, merchant ships were not required to use SO_x filters (scrubbers) to clean their exhaust gases. Times are changing as the regulator, the International Maritime Organization (IMO), set out ambitious emission targets for the global merchant fleet, including a 50% GHG reduction by 2050. It is also increasingly clamping down on environmental compliance of the c. 100,000 merchant vessels globally. Already by 2025, new ships must have a 20% improved efficiency (vs. 2013 levels and measured as CO₂ per ton-mile). With a broad regulatory framework (EEXI, CII and CEMP) the IMO is no longer nudging, but forcing the global merchant shipping sector towards cleaner technologies.

A 50% GHG reduction by 2050 for an entire fleet is an ambitious target; to achieve these targets, shipyards will need to churn out highly efficient vessels already in the coming five years and replace some 4% of the global fleet per year going forward. We expect the pace of fleet replacement to accelerate.

Technologies needed to comply with a 50% GHG reduction target

A 50% GHG reduction by 2050 for an entire fleet is an ambitious target, to say the least, especially if one considers that the useful lifetime of a merchant ship is around 30 years. To achieve a 50% GHG reduction by 2050, shipyards will need to churn out highly efficient vessels already in the coming five years and replace some 4% of the global fleet per year going forward. We expect the pace of fleet replacement to accelerate. For system suppliers this creates a very attractive market environment as each stage of new legislation creates a need for more tech content on new vessels, but also a need for retrofits on for the existing fleet (as seen with bilge water regulation in 2013, NO_x emission regulation in 2016, and sulfur emission regulation in 2020).

Slow-steaming: the most promising technologies to reduce GHG in shipping

There is no one path of achieving an energy-efficient vessel. Instead, the shift requires a whole basket of green technologies. The market currently places the biggest R&D on vessel propulsion (fuel-electric hybrid propulsion, wind propulsion) and fuel mix (from heavy fuel oil to LNG, ammonia, H₂, battery). But there are other engineering areas that can contribute to reduced emission, such as on-board cleaning systems, carbon capture systems and navigation (just-in-time arrival, wave-adjusted routing, autonomous).

Exhibit 97 - Technologies pursued to reduce CO₂ and other emissions by vessels

Technology	Routing, Logistics	Vessel design	Propulsion	Fuel	After treatment
	<ul style="list-style-type: none"> • Speed reduction • Optimized vessel utilization • Larger vessels • Navigation (wave, current and wind adjusted) 	<ul style="list-style-type: none"> • Hull coating • Hull shape optimization • Air lubrication 	<ul style="list-style-type: none"> • Engine optimization • Engine de-rating • Hybridization (battery, multi-fuel) 	<ul style="list-style-type: none"> • LNG/LPG • Biofuel • H₂ • H₂-based fuels (ammonia, methanol, eDiesel) • Wind 	<ul style="list-style-type: none"> • Waste water recovery • Exhaust gas treatment and capture • Carbon capture and storage
CO ₂ /toxic emission reduction potential	>20%	5-15%	5-20%	20-80%	>30%

Source: RBC Capital Markets, Det Norske Veritas

There is no one path of achieving an energy-efficient vessel. Instead, the shift requires a whole basket of green technologies.

Below we give brief overview of promising emission-reduction technologies:

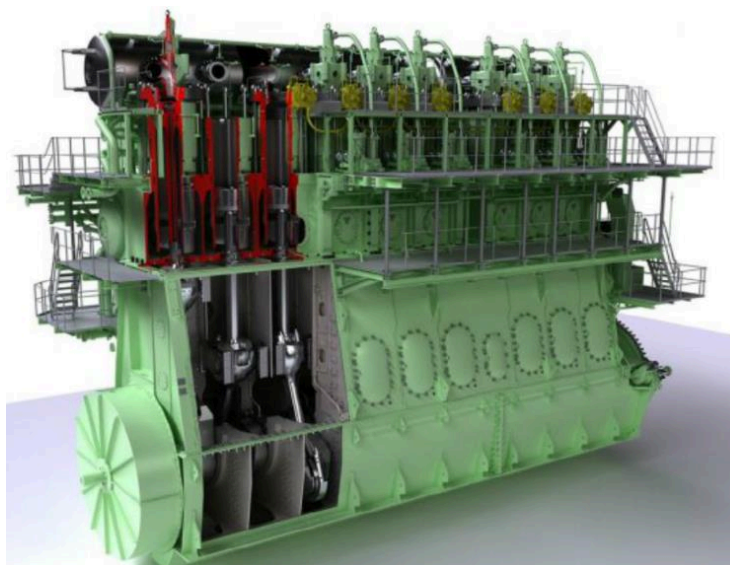
- 1) **Slow-Steam**: Perhaps the easiest way to reduce fuel consumption in shipping – and the one with a biggest impact – is the adoption of slow-steaming, whereby a vessel reduces its travel speed by up to 50%, saving up to 30% on fuel for the same route. The biggest benefit is achieved for the “first 3 knots,” (i.e., reduction from – say -24kt to 21kt, which saves c.25% of fuel per mile). Extreme slow-steaming has technology challenges (clogging up of turbochargers, poor combustion efficiency) but engine makers are working on solutions.

Main obstacles: Slow-steaming is an easy win for the International Maritime Organization’s GHG reduction targets, but it creates a need for a far larger global shipping fleet. Slowing all ships by 30% requires a 42% larger shipping fleet.

- 2) **New combustion engine technology:** The conventional 2-stroke engines run on highly polluting HFO fuel and the trend is going towards cleaner MGO/LNG powered ships. In the transition period (20–30 years) 2-stroke engines can be designed to seamlessly switch between HFO, MGO and LNG (so-called dual-fuel engines). Dual-Fuel is already standard in the industry today. In the meantime, leading engine makers (**VW’s** MAN ES, WinGD, **Wartsila**) also develop combustion engines that can run on ammonia (free of CO₂ emissions), methanol (CO₂-neutral if derived from renewables, such as C-captured H₂) and hydrogen.

Main obstacles: Test runs for ammonia and H₂ engines look promising. The main challenge is the fueling infrastructure at ports, the storage of the fuel on ships (H₂ has a very low energy density per volume) and safety concerns (ammonia is explosive and corrosive, but ignites poorly).

Exhibit 98 - Dual-Fuel engines enable vessels to switch from HFO to LNG and future eFuels



Source: MAN ES 2-stroke engine

- 3) **New propulsions:** Wind-assisted propulsion has the potential of saving 5–10% of fuel for merchant vessels and we observe a renewed interest in the technology (Alfa Laval/ Wallenius JV). Technologies include rotor sails (a technology developed in the 1920s), retractable stiff sails (Alfa Laval/ Wallenius) and flexible kite sails (SkySail).

Main obstacles: Cheap fuel prices in the past and the owner/charter structure in the shipping market have so far prevented any meaningful commercial use.

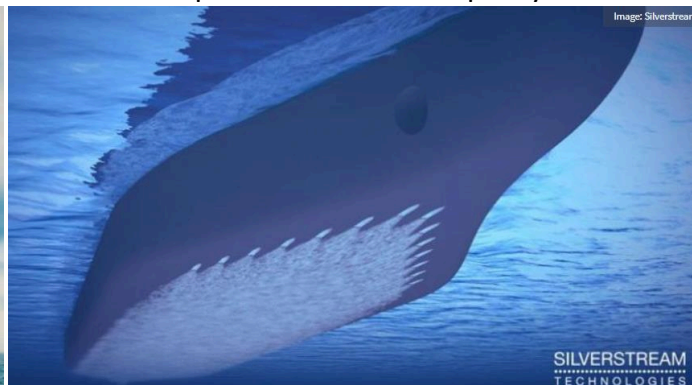
Exhibit 99 - Every little bit helps: wind propulsion and air lubrication are amongst the technologies pursued to reduce GHG emission of the shipping sector

Retractable sails tested for car carriers



Source: Wallenius, Wartsila/ Silverstream, RBC Capital Markets

Air lubrication for ship hulls can reduce fuel consumption by 4%



- 4) **Routing software:** Ships increasingly use navigation software that calculates the safest and most efficient route, utilizing the latest navigational charts (weather, current, wind). The route is continuously re-calibrated and the vessels direction and engine speed automatically adjusted to minimize fuel consumption, while allowing the ship to arrive just-in-time for its port slot.

Main obstacles: Digitalization of vessel fleets.

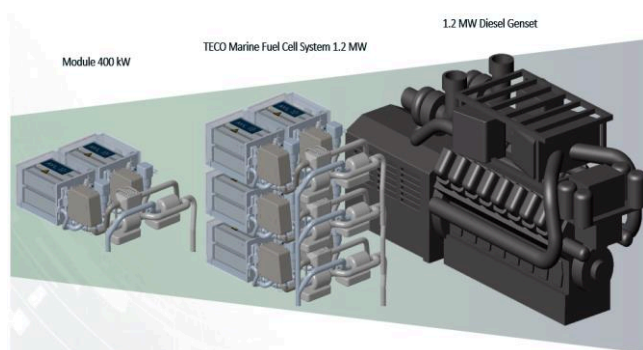
- 5) **Electric propulsion (fuel cell, battery):** Batteries and fuel cells do have a market in shipping, but will likely remain a solution for near-shore vessels (tugboats, port service vessels, small ferries) that can frequently refuel and don't run 24/7. Both MAN Energy Solutions and Wartsila offer hybrid ship propulsion (e.g., LNG engine + 2MWh battery pack), while TECO 2030 recently announced a fuel-cell deal for over 120 small cargo vessels (c. 1.2MW power output each).

Main obstacles: The use of battery power as main propulsion for merchant ships will likely not become a commercially attractive solution before 2050, at least not for ocean-going vessels above 10,000t. Beside the issues of battery weight and cost/MWh, large merchant vessels also require a constant mechanical engine output of 20–30MW over a period of 3–four weeks. To put this in context: A large ship would consume the electricity stored in the world's largest on-land battery storage system (the 1,200 MWh BESS Project, Moss Landing, California) within two days.

Exhibit 100 - Alternative fuels: Shipping put great hopes in H2-based fuels, including fuel cell and ammonia (via carbon capture)

TECO 2030 fuel cell for river barges

TECO Marine Fuel Cell compared to diesel engine Genset



Source: TECO 2030, Wartsila

Wartsila engine test with ammonia fuel



- 6) **Ship hull lubrication:** Air lubrication of ship hulls reduces the drag of the vessel in the water. Around 4–5% fuel saving can be achieved (source: Silverstream) and eight such systems have just been ordered for newly built LNG carriers in South Korea.

Main obstacles: Need for new hull designs.

- 7) **Carbon-capture:** On-board carbon capture is still in an early phase of development. We know that Mitsubishi Shipbuilding is currently testing a system on board a coal carrier. The project's aim is to "verify the efficacy of capturing and storing CO₂ from a vessel's gas emissions" and to test the operability and safety of CO₂ capture facilities at sea. TECO 2030 and Chart Industries also jointly developing a CO₂ capture system.

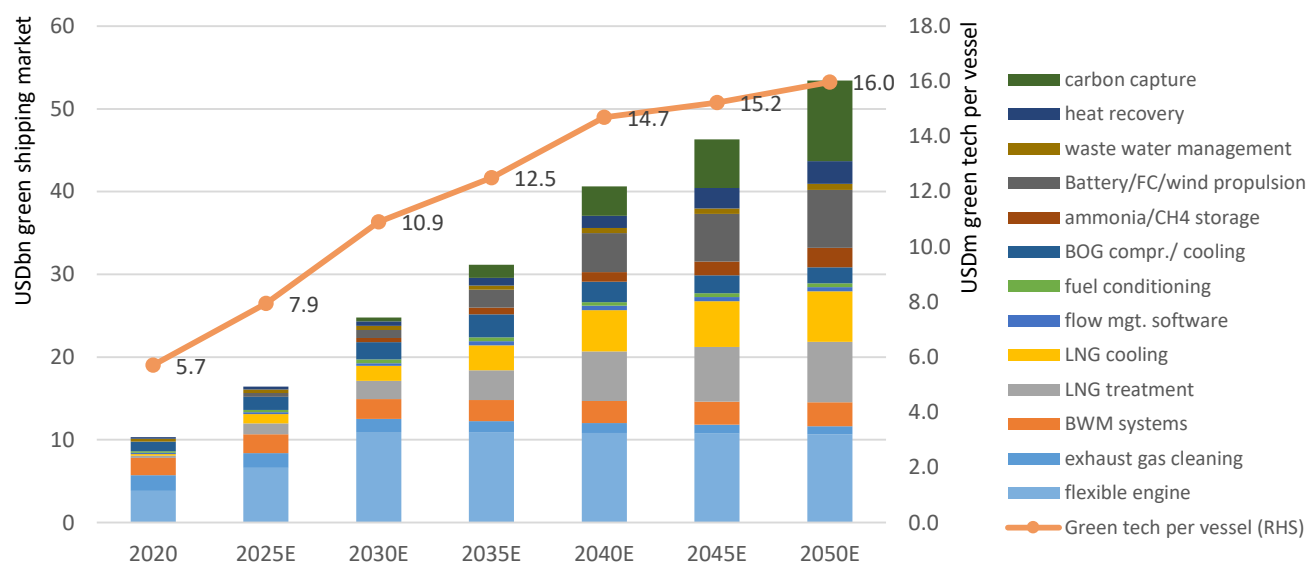
Main obstacles: High technological challenges, including high energy need to capture CO₂, high weight and volume of captured carbon, high installation costs.

Onboard capex needs to triple by 2030

Putting a number on the onboard capex needs by 2050 is not easy. We have a good idea on the direction of regulation and pace of vessel replacement. We also know which technologies are currently being developed. We estimate that a modern commercial vessel has a green

technology content of around \$5–6M. This is an average over all vessel classes above 40,000t weight. We find the highest content in cruise ships (\$30M) and the lowest in small bulk carriers at (<\$2M). We expect the content to grow to an average \$16M per vessel by 2050 (c.3.5% CAGR) with the main drivers being engine technology, LNG treatment and carbon capture (from 2040).

Exhibit 101 - Market for green-tech for the commercial shipping market to grow by +6% CAGR 2020–2050



Source: RBC Capital Markets, Det Norske Veritas, Clarkson, Wartsila

The replacement of vessels currently stands at around 1,900 ships per year. Assuming a 5–6% pa increase in global trade and 3% pa efficiency gain (trend towards larger vessels) and a new-built/scrap ratio of 1.5 per year, the global fleet will need c.3,600 new vessels annually by 2050 (c.2% output growth pa). This puts the overall “green tech” market for merchant ships at around \$58B by 2050 from \$11B today (+6% CAGR). The number does not include the effect from slow-steaming. If included, the required fleet size would need to be drastically larger: We calculate that each 5% fleet increase would require 13,000 additional vessels to be built by 2050 (incl. some scrapping), adding c.50bps to the 2020–2050 CAGR of the green tech market.

Capital Markets: The green financing solution

Large investments will be needed to finance the energy transition and drive forward The Great Balancing Act innovations we have discussed. Various sources put the requirement at different levels. The EU commission (July 2021) estimates that Europe alone will need to invest EUR350B in additional investments per year to meet its 2030 emission reduction target in energy systems alongside EUR130B needed for other environmental goals.

Governments and public sector entities have played a large role in the financing of investments towards a more sustainable economy but the contribution of banks and other financial institutions has been increasing. As part of its EUR800B recovery fund, the EU plans to issue EUR250B of green bonds making it the largest issuer of green debt. The proceeds will be passed on to member states to spend on energy efficiency, transport and nature protection.

Europe has been faster in addressing climate concerns. For example, green bond issuance (based on Dealogic) in Europe was \$212B in the first 9 months of 2021 (9% of total DCM) compared to \$64B in North America (2% of total).

Regulators and financial market supervisors have been working on standards that assure funds are used for the targeted purpose but there is still an area of uncertainty leading to general concerns of “greenwashing.”

It is not possible to generalize that green bond issuance comes at lower spreads than other comparable bonds given the many factors contributing to the pricing (e.g. size). However, supply and demand dynamics have in most cases led to tighter spreads on green bonds than ‘brown’ bonds. While the pricing differential on the debut green bond recently issued by the EU was only 2bp, the difference could be higher for other issuers and debt instruments compared to other instruments issued by the same entity.

On the bank lending side, the fact that banks have large liquidity buffers in combination with upcoming regulatory changes (e.g., Green asset ratio in Europe from 2022) has increased the supply of green loans. A study by the Sustainable Finance Program of the Smith’s School of Enterprise and the Environment, University of Oxford (April 2021), for example put the pricing differential between fossil fuel financing via syndicated loans and loans related to renewables at 40bp. Banks have argued that on a net basis margins on green and brown financing are similar.

As supply of green financing is likely to increase, the scarcity discount might erode. However, there are a number of reasons why financing of green assets might continue to come at lower spreads than brown financing. Bank regulation has become fiercer with tight timelines especially in Europe (e.g. stress tests in 2021/2022) which could have profitability implications for the banks that require an offset with an adjustment in their funding costs. The ECB announced in July 2021 that it will adjust its corporate bond-buying program to incorporate climate change risk, which is likely to reduce the cost of issuing green bonds compared to other bonds.

The transition to sustainability will impact the profitability of banks and other financial institutions. Stranded assets, higher capital requirements and higher loan losses are potential risks to bank profitability longer term. On the other hand, those banks that have positioned themselves well to support this transition, should gain market share (e.g. in green bond issuance, financing of renewables, sustainable investments) and attract a premium in share prices for their reputation.

The challenge is to balance long-term climate goals with short-term pressures arising from factors that touch on other sustainability objectives. For example, during 2020 a number of banks expanded their fossil fuel financing to assure job security in affected sectors.

The transition to sustainability will impact the profitability of banks and other financial institutions. Stranded assets, higher capital requirements and higher loan losses are potential risks to bank profitability longer term.

On the other hand, those banks that have positioned themselves well to support this transition, should gain market share and attract a premium in share prices for their reputation.

Insurance: The first line of defense in climate change

Insurance companies will likely be at the vanguard of both trying to identify and quantify the risks as well as seeking solutions to lessen the impact.

Despite our global sustainability effort in The Great Balancing Act, there's no doubt the adverse impacts of climate change will continue to occur, and insurance is evolving to help accordingly. P&C insurance companies have been at the point of the spear of climate change for several decades bearing direct financial responsibility for the impact of severe weather events, an increase in natural disasters and related human made catastrophes. If you construct a list of the greatest environmental challenges over the next 10 years and beyond, insurance companies will likely be at the vanguard of both trying to identify and quantify the risks as well as seeking solutions to lessen the impact.

- Property and Casualty Insurers face rising catastrophe frequency and severity as climate and weather patterns change over time.
- Life mortality and morbidity could be impacted by increasingly contagious and deadly diseases, as well as potential increases in exposure-related casualties.
- The timeline for change extends beyond 2025, but expectations will narrow and defense strategies will be more clear in five years. Technology plays a key role in loss mitigation as society adapts.

Exhibit 102 - Environmental challenges over the next 10 years

Environmental	Extreme weather events (e.g. floods, storms)	Major property, infrastructure, and/or environmental damage as well as loss of human life caused by extreme weather events
	Failure of climate-change mitigation and adaptation	The failure of governments and businesses to enforce or enact effective measures to mitigate climate change, protect populations and help businesses impacted by climate change to adapt
	Major biodiversity loss and ecosystem collapse (terrestrial or marine)	Irreversible consequences for the environment, resulting in severely depleted resources for humankind as well as industries
	Major natural disasters (e.g. earthquakes, tsunamis, volcanic eruptions, geomagnetic storms)	Major property, infrastructure, and/or environmental damage as well as loss of human life caused by geophysical disasters such as earthquakes, volcanic activity, landslides, tsunamis or geomagnetic storms
	Human-made environmental damage and disasters (e.g. oil spills, radioactive contamination)	Failure to prevent major human-made damage and disasters, including environmental crime, causing harm to human lives and health, infrastructure, property, economic activity or the environment

Source: World Economic Forum

While scientists and politicians seek long-term solutions – insurers will use advanced analytics, risk management and capital market tools, evolving building codes and insurance terms and conditions as their shield against climate and the impacts it can and will have on property.

For life insurance the impact of climate is less direct but potentially no less severe. Climate challenges allow for new variations of bacteria and diseases to propagate, and climate volatility can increase the frequency of high mortality events. Life expectancies will change as the cities that house us become less suitable for the elderly and young, which also impacts mortality and bottom-line results at life insurers.

If insurance is the financial tool that allows people and companies to manage uncertainty, there are few uncertainties greater than those posed by climate change. At its heart climate change is a long-term issue, and while scientific consensus on particular topics continues to

evolve the likelihood that insurance companies will be asked to bear the uncertainties that underlie climate topics isn't likely to diminish anytime soon.

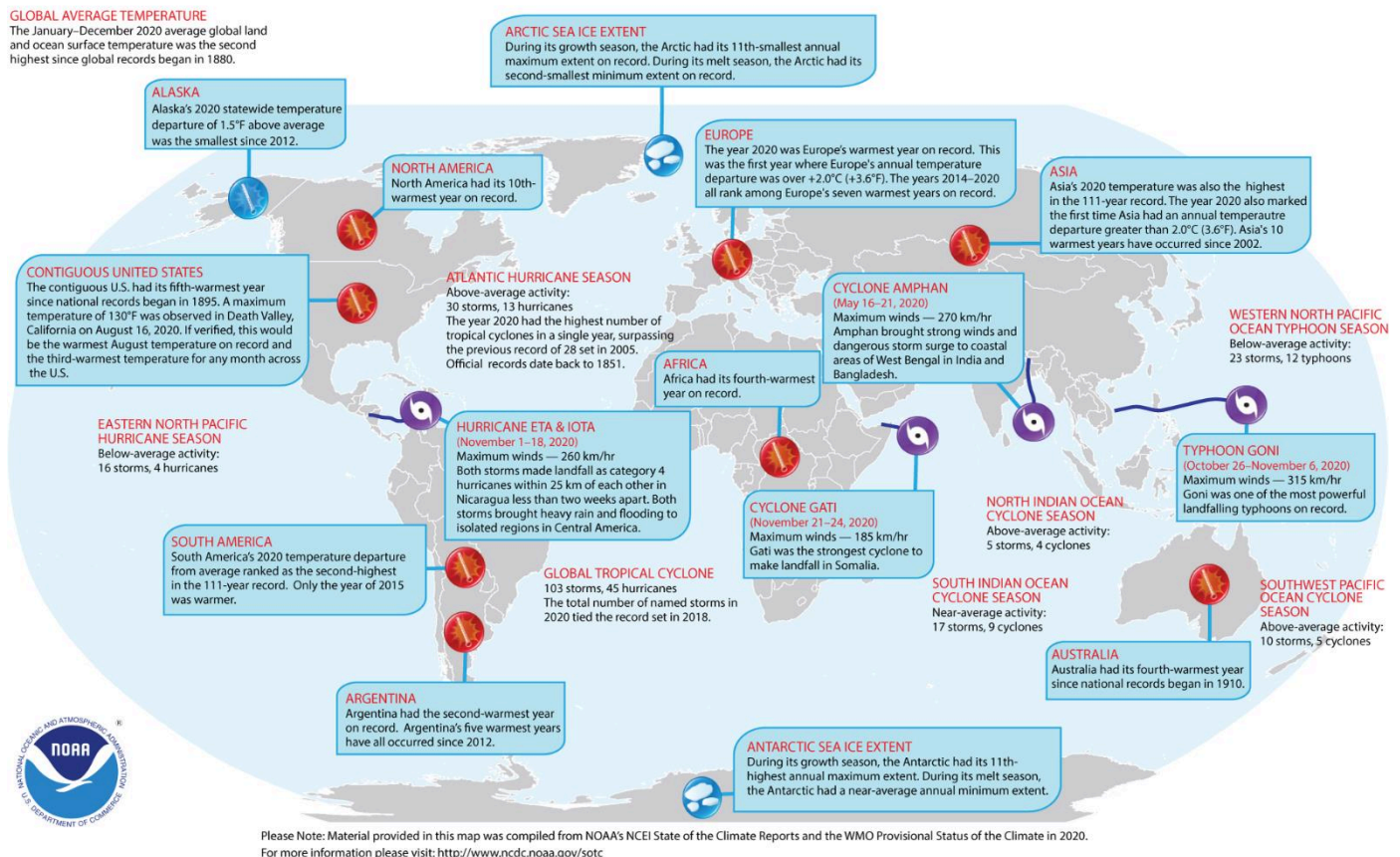
Climate change and P&C insurance

Our property and casualty insurance coverage faces the most clear impacts from climate change with the most glaring impact being the changing nature, frequency and strength of both normal and catastrophic weather events. In simplest terms, climate change makes weather and catastrophic events more frequent, more severe and more unpredictable, which proves a distinct challenge in risk management and modelling.

After record 2017 and 2018 catastrophe loss years, 2019 was more mild before a resurgent 2020. In the last five years, we have seen several of the largest wildfire burn years in the U.S. (2017 and then again in 2018), substantial flooding of the agricultural regions of the U.S. in 2019, the record-breaking 2020 hurricane season (by count, not losses) and extreme winter storms in Texas in 2021. All have been linked to climate change. While the problem of changing climate is long term in nature, some of the effects are being felt today and by 2025, it is likely that impacts will remain severe despite ever-greater mitigation efforts. Said differently, whatever the impact is right now, it probably gets worse before it gets better.

Exhibit 103 - 2020 Global weather events

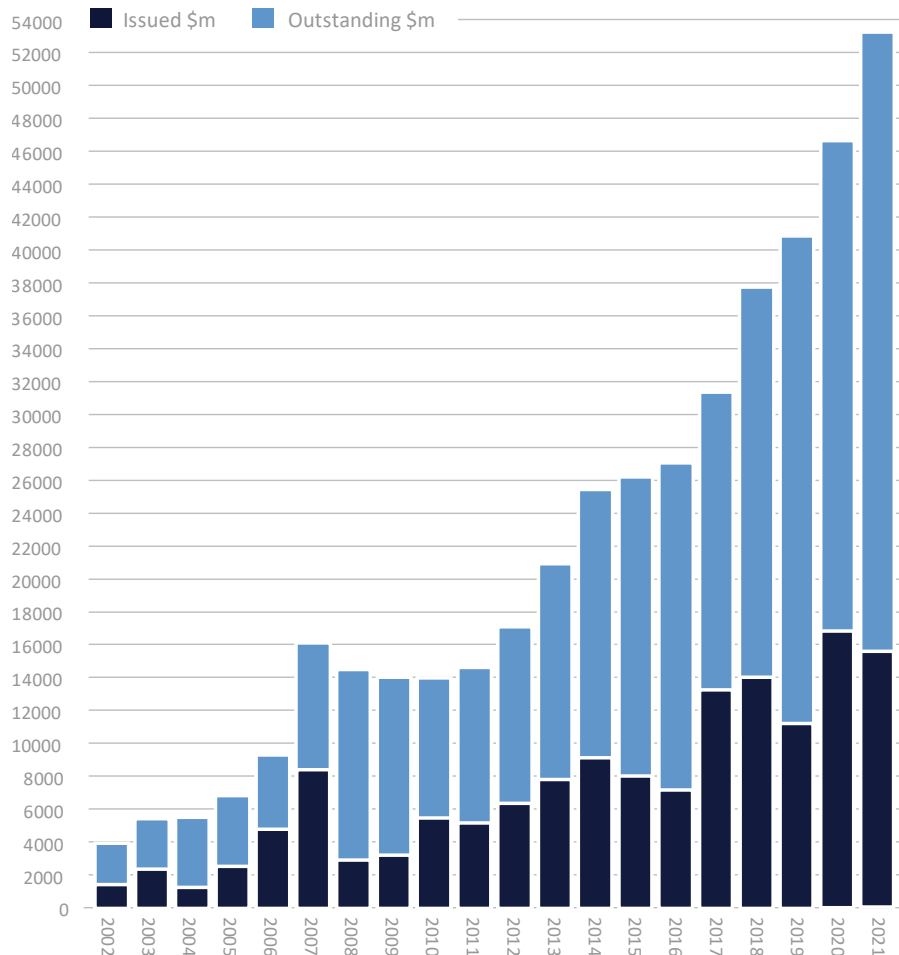
Selected Significant Climate Anomalies and Events in 2020



Source: National Oceanic and Atmospheric Administration

P&C insurers, specifically property insurers have always faced the challenge of pricing and managing risks of large loss events. Reinsurance has played a part in disseminating risk of 1 in 100 or 1 in 500 type events across the industry, preventing catastrophic weather events from becoming devastating financial events for the sector. As time progresses and risks become increasingly uncertain and costly, the role of reinsurance, Lloyd's and newer risk-sharing products like catastrophe bonds will expand and become increasingly important as insurers with exposures in geographies more acutely impacted will attempt to shed risk.

Exhibit 104 - Cat Bond issuance and capacity through 3Q21 (\$M)



Source: Willis Re Securities, Artemis

More than two-thirds of economic losses, particularly in developing countries, are already uninsured. This percentage only rises if losses become more severe.

The major takeaway for climate change's impact on P&C insurers is that increasingly frequent and severe catastrophic storms, flooding, fires and climate-driven events will increase the risk of underwriting in many geographies. It is already the case that more than two-thirds of economic losses, particularly in developing countries are uninsured. This percentage only rises if losses become more severe.

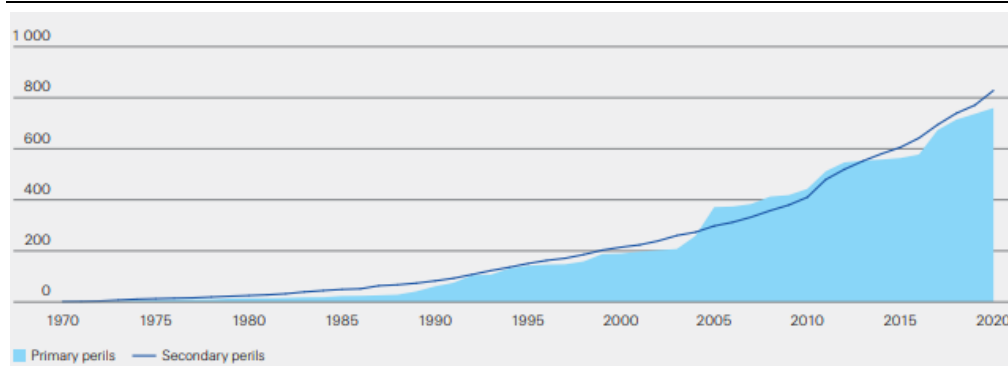
The simple solution is risk sharing and pricing increases. But rate increases are inherently unpopular and regulators and politicians will push back against them, which counters the price-signal that insurance provides in risk management.

For example, in 2017 U.S. legislators passed a bill to reform the National Flood Insurance Program (NFIP) and raise rates to “actuarially sound levels” over 10 years. The rate increases were ultimately cancelled as they were perceived as too costly to homeowners (i.e., voters). The upshot being that the NFIP continues to lose money and new construction continues to take place in climate vulnerable areas because that construction is effectively subsidized by insurance premiums not adequately priced for present risk, let alone future risk.

Similarly, state regulators can act to limit pricing increases, and even attempt to force underwriting in some situations. California has done the latter in recent months, outright barring the cancellation or non-renewal of residential property insurance (homeowners’ policies) for 22 counties that are in high-risk wildfire areas. The order covers 325,000 policyholders and lasts one year. While California, or other states, cannot compel insurers to cover someone forever, the attempts to limit exiting of high-risk areas is certainly an interesting approach.

We think it is clear that in the next 5, 10, 20 and 100 years individuals and governments will have to become more conscious of the environmental risks in areas for new development, as insurers are clearly turning their attention to the increasing risks of many regions.

Exhibit 105 - Cumulative insured catastrophe losses since 1970 (\$B, 2020)



Source: SwissRe Institute

Beyond property risk, climate risks for insurers could feasibly extend to liability losses as well. Just as cigarette manufacturers were sued for covering up the danger of their products, activists have filed suits against oil companies and power generators in recent years. Should the suits prove successful, D&O and general liability underwriters would ultimately be on the hook. We think assessing damages would be difficult and take years to litigate, but the risk is out there.

Climate change and life insurance

While P&C insurance faces the most glaring impacts from climate change, the risk to life insurance is not zero. Climate change could have drastic impacts on life expectancy through the further proliferation of infectious disease, which could impact morbidity and mortality assumptions for insurers. Changes to society from relocation of individuals into cities could also impact life expectancy. Finally, climate itself will also take a toll as death from heat exposure and cold exposures become more frequent as weather becomes increasingly irregular and life-threatening events become more frequent.

On the final point, a study published in the journal Lancet Planetary Health looked at 20 years of global deaths attributable to heat- and cold-related deaths. The study concluded that heat-

The risk to life insurance is not zero. Climate change could have drastic impacts on life expectancy through the further proliferation of infectious disease, increased frequency of exposure to extreme weather events, and lifestyle changes from relocating into cities.

and cold-related deaths accounted for 9.4% of deaths annually in the last 20 years, and produced excess (above normal) mortality of 74 deaths per 100,000 people per year. Heat-related deaths are on the rise, but cold related deaths make up 94% of exposure-related mortality, according to a separate study.

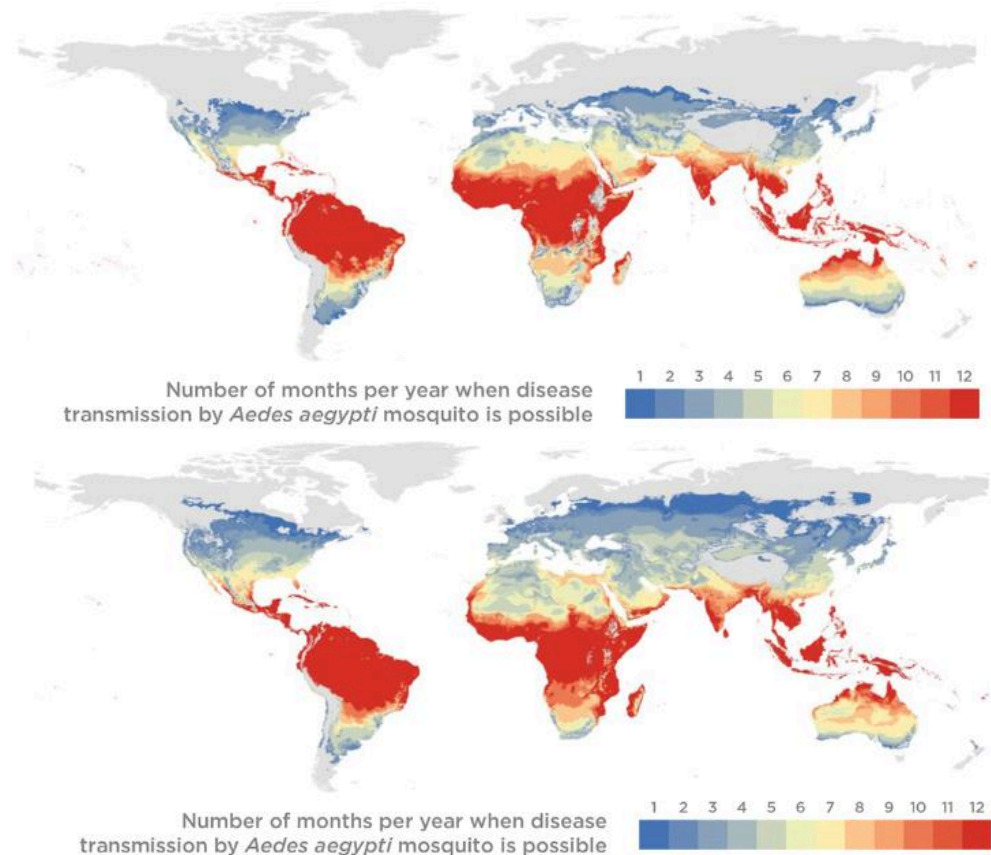
Each year, nearly 100,000 people die from cold in the U.S., compared to about 2,500 from heat exposure. The phrase “global warming” might lead some to believe that warmer temperatures could increase life expectancy by reducing cold exposure. We note that most of these deaths occur during extreme weather events, such as the early 2021 Texas winter storms. Climate change is expected to result in warmer average temperatures, but is also expected to increase the frequency of tail events (both hot and cold), and could result in more exposure-related deaths, which in turn could result in claims to life insurers.

Beyond exposure to the elements, the clearest example of how climate change can impact life insurers has played out in the last year. While COVID-19 did not arise from a climate anomaly, it shows the dangers poised by infectious diseases. One of the concerns about climate change is the way it can increase transmission of mosquito-borne disease, amongst others.

The projected range of *Aedes Aegypti*, the yellow fever mosquito, is broken out below. The yellow fever mosquito spreads deadly diseases such as Zika, dengue fever, yellow fever and others. It has not been as lethal as its cousin, the *Anopheles* genus mosquitos that spread malaria (and kill about 400,000 per year in Africa), though all mosquitos could see their ranges extended in similar manners due to climate change.

Climate change has the potential to increase the transmission of mosquito-borne disease (among others).

Exhibit 106 - Estimated 2019 range (top) vs projected 2050 range (bottom)



Source: Sadie J. Ryan, Colin J. Carlson, Erin A. Mordecai, and Leah R. Johnson via NPR

As the above projection demonstrates, increased temperatures globally increase the viable lives of mosquitoes and their geographic footprint. Outside of mosquitoes, other disease carriers are seeing their range increased. A recent study by New Scientist determined that Lyme disease infections in the U.S. could rise by 92% as a result of increased tick viability due to higher average temperatures.

The recent COVID-19 outbreak also exposed the fragility of the global economy and how unprepared nations around the world were for the disease. With extensive credit-exposed investment portfolios, the response to the pandemic, including economic shutdowns, is as important if not more important to life insurers as any mortality impact that may arise.

While society has inevitably learned some lessons from COVID-19 there could well be more lessons to learn to the extent extreme climate conditions create new challenges.

Technology and climate change

Climate change is an inherently slow-moving macro condition. It will not occur overnight and our understanding of the impending issues will improve over time. This should allow scientists and engineers to find solutions to mitigate issues as nature takes its course. It will be important for insurers to remain up to date on the latest scientific consensus, and advocate for the use of improved modeling, building materials, and risk scenarios in their analysis of underwriting risks moving forward.

It will be important for insurers to remain up to date on the latest scientific consensus, and advocate for the use of improved modeling, building materials, and risk scenarios in their analysis of underwriting risks moving forward.

One of the major factors that can decrease potential future losses from hurricanes is building standards and conscious development. A number of Gulf Coast states have drastically increased their building standards for new homes in recent years. Florida has been a leader in improving building code and therefore durability to increasingly common, strong hurricanes.

Over a decade ago, the Insurance Institute for Business and Home Safety created a standard for disaster-proof structures called “Fortified Homes.” The homes are built to rigorous standards, and one of the few homes built to the standard was at Mexico Beach in Florida when Hurricane Michael made landfall as a Category 5 nearby, see below:

[Exhibit 107 - A fortified home survived Hurricane Michael \(Cat 5\) at Mexico Beach](#)



Source: Johnny Milano, NY Times

The home was one of the only structures in the entire town to survive the storm broadly unscathed. The fortified home was specifically designed to survive all manner of catastrophes, whether it be wind, flood or other potential threats. It sits 12 feet above the ground and is anchored 28 feet below the surface. The home was built in 2016 to the highest level of Florida standards. It is not cheap to build these homes, but we think it will become increasingly necessary to fortify structures as climates shift.

There have been great strides in recent years in terms of weather forecasting and hurricane modeling specifically, which can help save lives and property as storms approach.

Land use is also a tool communities can use to mitigate losses. When one looks at the above picture one question is why did this house stand? Another question might be why were there any houses there in the first place that weren't built to the highest possible standard? Every community loves tax revenues and oceanfront property provides that, but the trillions of dollars of insured property that is within 25 miles of a coastline is both the most valuable and the most vulnerable and only building codes can balance that risk.

Other technology is useful to help save lives and property as storms approach. There have been great strides in recent years in terms of weather forecasting and hurricane modeling specifically. Together, these can lead to earlier evacuations and more time to batten down the hatches and limit the damage presented by hurricanes.

The National Hurricane Center found that models have essentially improved accuracy by a day every ten years, meaning that a 5-day forecast today is as accurate as a 4-day forecast in 2010 and a three-day forecast in 2000. This improves our ability to evacuate, prepare and respond to the increased severity and frequency of storms, which should help mitigate dollar losses.

Exhibit 108 - Hurricane modeling improvements (1990–2017)



Source: National Hurricane Center- Eric Blake

Climate shifts will pose massive problems for infrastructure and property, but technology (supported by investment from Insurers) is a positive tool that can help limit downside as society adapts.

Death counts from hurricanes have fallen precipitously over the last 100+ years. In 1900, a Category 4 storm wiped Galveston off the map and killed 20% of the population. In 2017, Puerto Rico declared a state of emergency days before Irma reached the island. The 2010 Russian heat wave, Hurricane Sandy in 2012, and 2013 U.S. cold spell were accurately modeled up to eight days before occurrence. El Niño can now be predicted 3–4 months ahead of its cycle.

Climate shifts will pose massive problems for infrastructure and property, but technology is a positive tool that can help limit downside as society adapts. Look for insurers to continue to invest in cutting-edge modeling capabilities and loss mitigation efforts as they look to maintain or improve existing underwriting in catastrophe-prone areas.

Consumer: Luxury and retail resale

Personal luxury goods has been a laggard in terms of resale market development, even though its attributes are quite supportive including high price points, high quality and value retention.

If value realisation and recycling of previous spending are material drivers of future spend, we envisage the luxury sector (particularly soft luxury) may need to adjust to a lower volume growth outlook.

The next frontier for luxury brands relates to the resale market in our view, with supportive demand and supply side-enabling factors nurturing market development as part of the Great Balancing Act. Individual empowerment, better understanding of circularity concepts and Internet-enabled connectivity supports the development of secondary markets across personal product categories. Personal luxury goods has been a laggard in terms of resale market development, even though its attributes are quite supportive including high price points, high quality and value retention. The jury is still out whether resale is a net positive or negative for brand owners, even if it has improved product availability, price transparency and customer choice.

Within 10 years, resale could constitute 20%+ of luxury demand, which has knock-on implications for future revenue growth, new customer recruitment and product control. Effectively, the market is being disrupted by secondary marketplaces that trade products outside of the control of brand owners.

Demand side drivers supporting growth include consumer's changing perception of luxury goods as an investment as much as a consumable (and price discovery), weight of aspirational consumers who wish to participate in luxury brands who however are value constrained (price savings), demand for difficult to obtain products in the primary market (product scarcity), the growing desire of consumers to recycle and reduce waste, and the catch up of China's resale market (which is behind the curve relative to other major luxury markets – 6% resale incidence vs 30% for U.S., according to China Luxury Research Centre – but catching up fast given changing perception of second-hand goods).

On the supply side, strong primary market growth in recent years (increasing volume of product in people's wardrobes), increasing number of platforms with greater reassurances on authentication guarantees, high profile M&A/IPO transactions and social shopping and online communities have contributed to a more dynamic resale marketplace in recent years.

Brand bifurcation is one of the consequences of an expanding resale market with higher levels of price transparency, as we have seen in the luxury watch industry (which is ahead of the curve in terms of resale market development). There is a positive feedback loop between the highest-profile brands which have strongest value retention/price appreciation at the expense of the rest of the industry which has more normal value retention characteristics.

A well-functioning secondary market is largely complementary to the primary market, as it enables aspirational and price conscience consumers the opportunity to participate in luxury consumption, who often progress to purchasing in the primary market further down the line. It also offers brand owners the opportunity to further embed the relevance of sustainability as an end goal and product circularity into their business models, given the nature of the products they are producing (long life, high quality), even if taking an indirect view on resale.

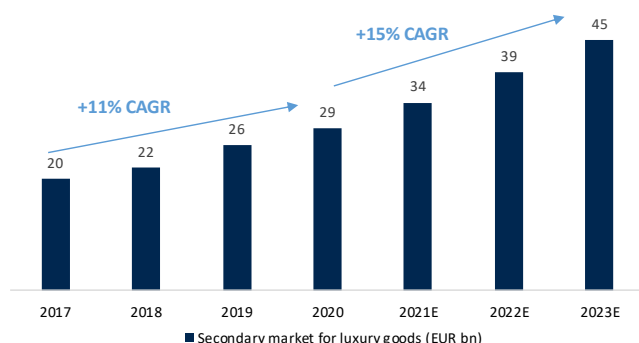
What is less clear at this stage is the extent to which resale market share growth will impact primary market growth, particularly in less developed markets such as China. If value realisation and recycling of previous spending are material drivers of future spend, we envisage the luxury sector (particularly soft luxury) may need to adjust to a lower volume growth outlook.

Luxury brands' approach to resale so far has been relatively nascent with a clear preference for brand equity over economic interest. We agree with this approach for now, given the relatively early stage of resale market development. However, if we fast forward 20 years, it is likely luxury resale will be an established and prominent feature that sits alongside the primary

luxury market. Tension points are presenting, particularly around brand representation, authentication and counterfeits.

Exhibit 109 - Resale market growth should accelerate to +15% CAGR (from +11%) and reach €45bn by 2023E

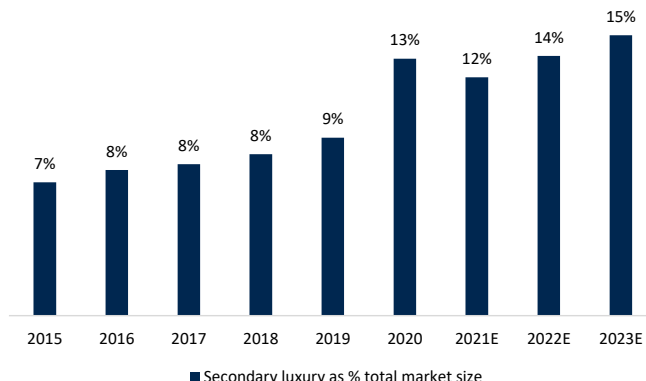
Secondary Personal Luxury Goods Market size (EURbn, %chg yoy)



Source: Statista, RBC Capital Markets

Exhibit 110 - Resale market share is 13% and forecast to reach 15% by FY23E and likely 20%+ post FY30E

Secondary market as a % of total Personal Luxury Goods market (% total)



Source: Bain Altgamma, Statista, RBC Capital Markets estimates

We believe that resale and rental offers a new path for retailers to connect with customers and appeal to more ESG-focused consumers, but that the growth of second-hand and peer-to-peer selling may serve to cannibalize traditional retail sales over time and could be a threat to retail margins.

In Retail, apparel rental and resale is gaining in importance, as consumers look for greater circularity in fashion. We expect the majority of growth in second-hand clothing to come from resale, with popular online platforms helping to drive peer-to-peer selling. According to data from resale platform ThredUP, the second-hand clothing market is expected to double in size over the next five years, growing to ~\$77B. The majority of this growth is expected to come from resale, which is projected to more than triple in size over the next five years, to ~\$47B.

We anticipate similarly strong levels of growth from the clothing rental market, which is projected to grow to ~\$7B by 2025, according to Statista, up from ~\$3.5B in 2020. We have also been seeing growth from traditional retailers and department stores moving to introduce subscription rental schemes into their stores.

An opportunity and a threat. We believe that resale and rental offers a new path for retailers to connect with customers and appeal to more ESG-focused consumers. However, we note that the growth of second-hand and peer-to-peer selling may serve to cannibalize traditional retail sales over time. Additionally, we note that expansion into these areas may also be a threat to retail margins. We believe that the consumer mindset has shifted, with second-hand clothing now more acceptable or, in the case of vintage collections, even preferred. The convenience offered by peer-to-peer platforms provides a trendy alternative to traditional retail. We think the global apparel names and the online retailers are leading the way in this area.

Technology and Industrials: A renaissance in supply chain management

The disruptions in 2020 and 2021 have exposed the risks of just-in-time inventory and long global supply chains and have led to a renaissance in supply chain management.

Supply chains have faced unprecedented stresses in 2020 and 2021. The impact started from the early days of COVID-19 when consumer hoarding and demand spikes lead to localized stockouts of specific goods like hand sanitizer and toilet paper. Next, freak events like the Ever Given container ship becoming disabled in the Suez canal applied pressure across multiple supply chains. More recently broad shortages of semiconductors, backlogs at global ports, and general overall supply tightness is impacting the supply chains for almost all manufactured goods.

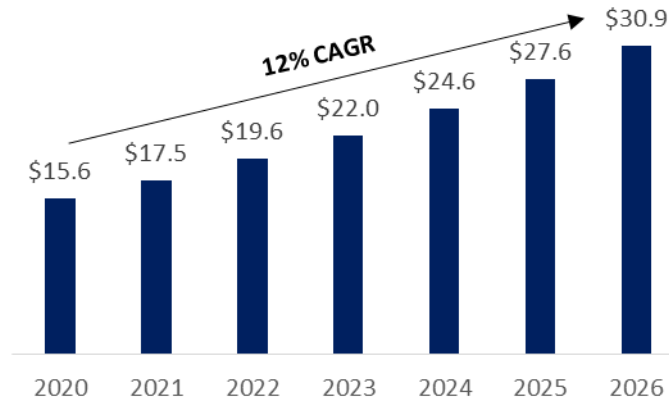
The “bull whip” effect amplifies the disruptions in 2020/2021. In supply chains, the “bull whip” effect refers to the cascading and increasing fluctuations in inventory as one moves further up the supply chain. The result is that even small changes in demand on the retail level can have significant impact on upstream suppliers. Global supply chains operate typically on a just-in-time basis, where on-hand inventory is kept to a minimum in order to maximize inventory turnover and return on assets and invested capital. In order for just-in-time supply chains to operate without stockouts and disruptions to production, they require uninterrupted and predictable supply. Prior to 2020 and 2021, the supply environment for the vast majority of industries was quite stable. However, in 2020 and 2021, the “bull whip” from changes in demand or shortages of specific components is creating havoc on supply chains.

The move to more resilient supply chains. The disruptions in 2020 and 2021 have exposed the risks of just-in-time inventory and long global supply chains. New technologies help improve the resiliency of supply chains, where improved visibility to potential disruptions allows companies to make adjustments before experiencing shortages and help mitigate the “bull whip” effect. Additionally, companies are able to make better-informed decisions when making changes to their supply chain, such as knowing the full cost or risks associated with potential changes. Large global organizations are re-considering their supply chain strategies and starting to prioritize investments in technologies to provide better insight and the ability to react to changes in upstream supply and downstream demand. Examples of new technologies include:

- **IoT (Internet of Things)** sensors to help provide visibility to the movement of goods and supplies;
- **Artificial intelligence/machine learning (AI/ML) software** to help better analyze and predict changes in supply and demand;
- **Next-generation telematics** to help optimize the routing of delivery vehicles;
- **Messaging and automation software** to accelerate the pace of notifications and status updates
- **Cloud-based solutions** to provide access to supply chain information anywhere and anytime; and
- **Digitization of new supply chain information** the addition of new metrics such as sustainability (i.e., carbon intensity) and reliability to help organizations optimize supply chain strategies beyond just lowest cost.

Global supply chain management software is growing 12% CAGR to \$31B in 2026. According to Statista, global supply chain management software spending is forecast to increase at a 12% CAGR from \$15.6B in 2020 to \$31B in 2026. Sub-categories in supply chain management include: supply chain planning, transportation management systems, warehouse management systems, and manufacturing execution systems. While on-premise deployments represent the majority of supply chain management spending, the cloud is growing rapidly, particularly given advantages like higher uptime, scalability, resiliency, and pre-integration into third-party software.

Exhibit 111 - Statista forecasts global supply chain management software spending to increase 12% CAGR between 2020 and 2026E



Source: RBC Capital Markets estimates, Statista

Blockchain to help improve supply chain transparency. Global organizations are under tremendous pressure from governments, consumers, shareholders and other stakeholders to provide more transparency and information on their supply chains. This includes disclosures regarding carbon emissions, the source of ingredients and raw materials, welfare conditions of animals, ages of employees, and usage of conflict minerals. The ability for organizations to accurately track this information through their entire supply chains is difficult at best with existing technologies. Most large organizations utilize hundreds or thousands of suppliers, which use multiple suppliers themselves, making it difficult to track raw materials back to their origin. Blockchain is emerging as a key technology to help global organizations trace the source of the materials in their supply chains. Blockchain is a distributed ledger, which allows the chronological, trusted and auditable documentation of the trail through which a good or material has progressed through the supply chain. A distributed ledger used globally helps improve traceability and improve coordination between the various intermediaries in supply chains (see below for an illustration):

Exhibit 112 - Blockchain helps improve traceability and transparency in global supply chains

Capturing the Details of a Simple Transaction: Conventional vs. Blockchain Systems

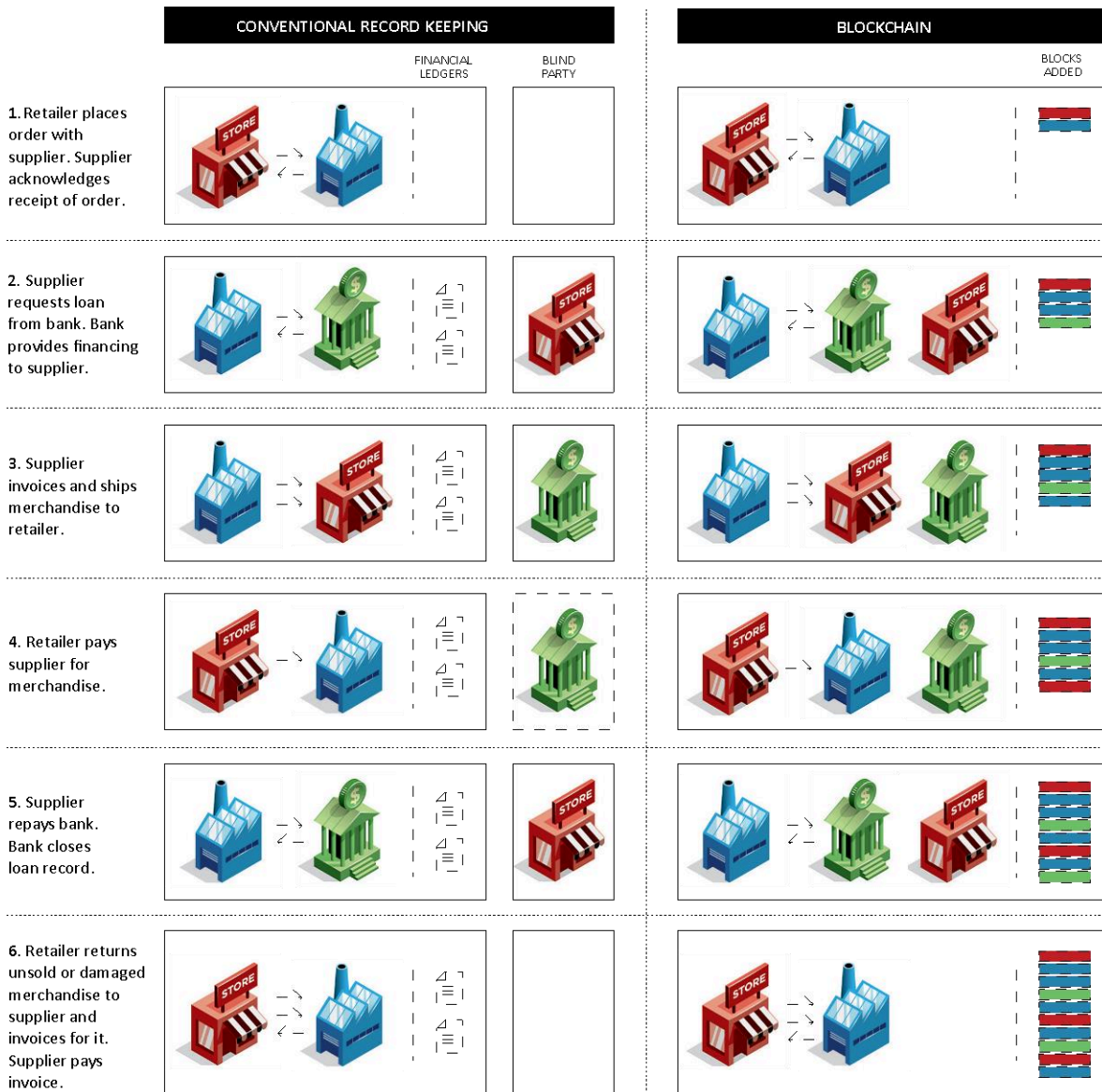
The financial ledgers and enterprise resource planning systems now used don't reliably allow the three parties involved in a simple supply-chain transaction to see all the relevant flows of information, inventory, and money. A blockchain system eliminates the blind spots.

KEY



Retailer
Supplier
Bank

Information flow
Inventory flow
Financial flow



Source: Harvard Business Review, V. Gaur. and A. Gaiha, Building a Transparent Supply Chain," May-June 2020.

See additional details on blockchain in [The Individual Revolution](#)

Manufacturing: Gone local – could growth rates double for capital goods companies?

We see a strong growth outlook for near shoring in labor-intensive manufacturing that should benefit investment in areas such as Eastern Europe, Turkey, North Africa and Mexico.

Initial noises around onshoring post the outbreak of COVID-19 started to quickly fade away as Asia reopened faster than the West and economic and profitability considerations took priority. However, the >6x jump in global shipping rates is another reminder that is reigniting this issue. We see a strong growth outlook for near shoring in labor-intensive manufacturing that should benefit investment in areas such as Eastern Europe, Turkey, North Africa and Mexico. We also expect continued growth in automation (an ongoing trend which has already seen global industrial new robot installations increase at a 13% CAGR from 2010–19), but with a shift towards incrementally higher growth in Europe and the U.S. relative to Asia. Global capital goods companies will be key beneficiaries from this structural tailwind as they act as the enablers of a realigned global manufacturing footprint. The build-out of the Chinese manufacturing footprint was a key factor in European capital goods companies achieving growth rates at more than double the rate they have seen in recent years. A shift to localization could have a similar impact on growth rates over the next decade.

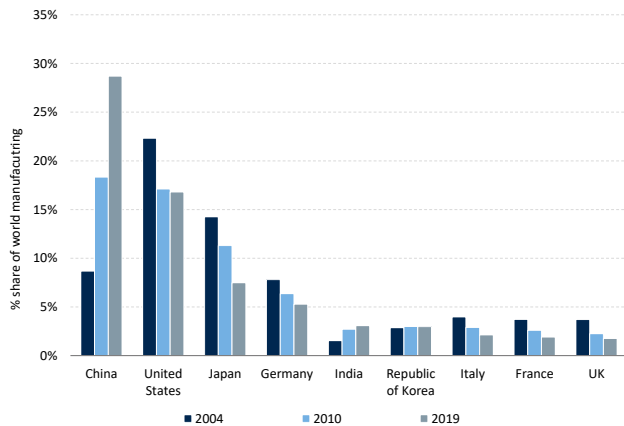
The growth of Chinese manufacturing

Global manufacturing has shifted fundamentally over the last few decades as China and other emerging markets saw significant growth in their manufacturing sectors and Western companies focused their growth in these regions while at times downsizing their domestic footprints. This was driven by a combination of:

- 1) **Lower costs** – China and other markets have offered the opportunity for lower cost manufacturing. In 2000 the average annual wage in China was \$818 versus the average wage in the USA of \$31,195 and the average wage in Germany of \$19,501. It was not just a labor cost saving, with the capital cost of establishing a plant in China in the early 2000s about one-third of the cost of building a similar plant in Europe.
- 2) **Following growth** – While lower costs was a benefit for many industries the investment in China and Emerging markets was also about following the growth as Chinese sales in the Industrial sector grew at 10+% CAGR over the early 2000s.

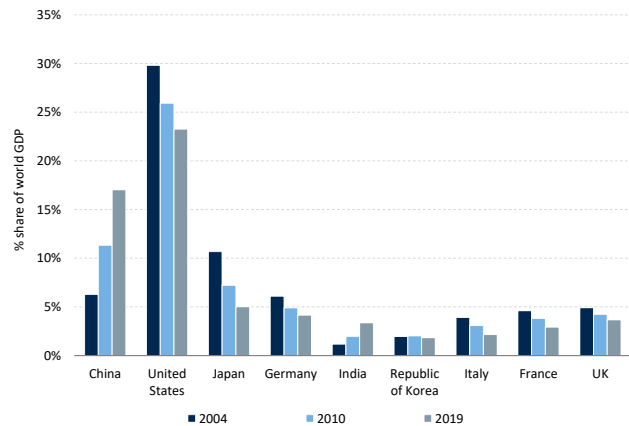
China represented 9% of global manufacturing in 2004, but by 2019, this had risen to 29%. In contrast the 5 largest western nations as of 2004 represented 52% of global manufacturing and this had shrunk to 34% by 2019.

Exhibit 113 - World manufacturing by country (as % of total)



Source: United Nations Statistics - Value added at current prices in USD

Exhibit 114 - GDP by regions (as a % of total)



Source: OECD

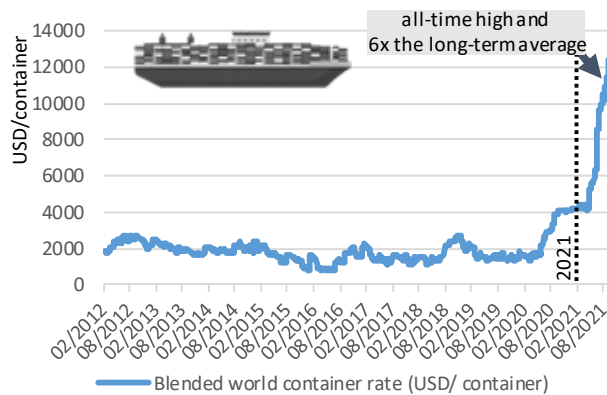
Could this now reverse?

Emerging markets still offer cheaper manufacturing options, but the gap has closed. Average wages in China have increased ~10x since 2000, versus growing 2x in Germany and ~1.8x in the U.S.

COVID-19 has brought the risks around global planning of supply chains more into focus as companies have considered the reliability of supply if they are over dependent on one country or region, and also now transport costs.

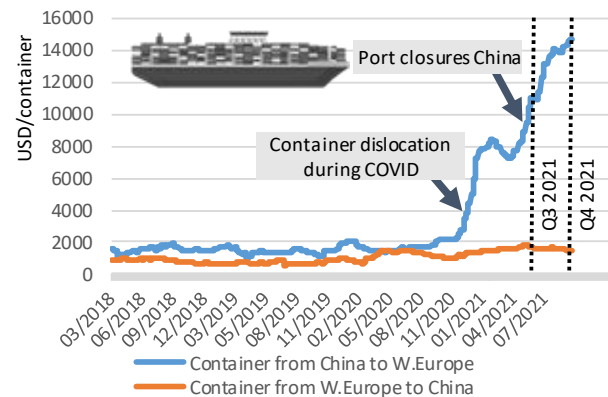
Early in the COVID-19 pandemic there was a lot of discussion around onshoring / near shoring driven by the concerns around reliability of supply. However, to some degree these faded as China reopened quicker than most Western countries and manufacturing supply chains returned nearer to normal quite quickly (versus many other facets of life that were more severely impacted by COVID-19). We believe that in reality as the manufacturing sector reopened, the economics of shifting the global manufacturing base as well as factors such as availability of affordable labor began to limit enthusiasm for onshoring. However, with stretched global supply chains and the >6x rise in average global container transport costs (with shipping rates from China up nearly 10x on where they were in 2019), it is now coming back into focus as a profitability consideration.

Exhibit 115 - Blended global container shipping rates



Source: Bloomberg

Exhibit 116 - Shipping rates by direction



Source: Bloomberg

Given the barriers of higher labor costs and lower labour availability, we think companies will focus on near shoring (and not onshoring) and improved automation.

Near shoring or onshoring, capital equipment companies will be the enablers of this trend.

Near shoring and automation offer solutions

The shift is not an easy one though, and the barrier in terms of labor costs and labor availability remain real. Many companies in the U.S. in particular are being impacted by labor shortages in 2021. We see two main solutions:

- 1) **Near shoring not onshoring:** Manufacturing in Germany or the U.S. can be expensive, especially in more labor-intensive businesses. However, while China and Asia may offer low wages, there is also the potential to grow near shore. Whether this is North Africa and Eastern Europe to supply into Europe (wages in Bulgaria today are around one-sixth of what they are in Germany, Poland is around one-third), or if it is Mexico or the Caribbean for the U.S.
- 2) **Increased automation:** The other option is to increase manufacturing in higher cost markets, but replace people with machines. Automation already has a growing presence in the manufacturing sector on an ongoing basis, already reducing costs and increasing consistency in many situations. This should just accelerate it further.

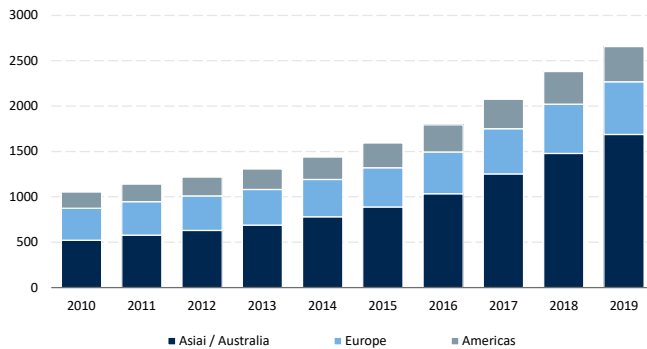
Capital equipment companies should benefit

For most sectors this will be about cost mitigation – the shifts will only be practical if companies can sustain profit margins. Wages in the likes of Bulgaria, Turkey and Mexico have moved below China in recent years proving that from that perspective near shoring is viable.

The beneficiaries will be capital equipment companies. U.S. and European capital goods companies will have to invest themselves to align with this trend as they look to continue to align their footprint with their customers. However, in the main they will be the enablers of this trend and will be beneficiaries in terms of increased demand for capital equipment and automation products.

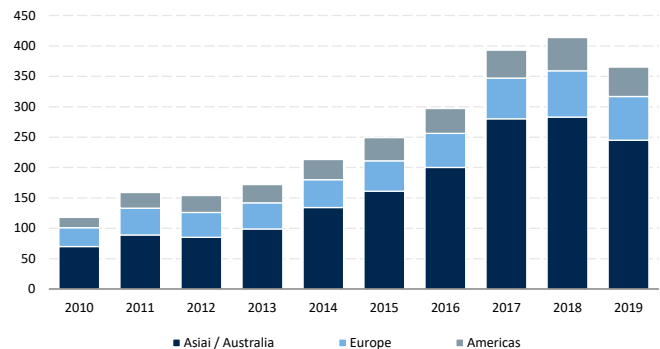
According to the International Federation of Robotics, the CAGR for the global robot stock since 2019 has been +13%, and while a nascent industrial recession in 2019 and COVID-19 in 2020 have been a short-term setback, this automation trend looks set to reaccelerate in 2020.

Exhibit 117 - Operational stock of industrial robots ('000s)



Source: International Federation of Robotics

Exhibit 118 - Annual new installations of industrial robots ('000s)



Source: International Federation of Robotics

We do not see this supply chain shift as about new or radical technology, but rather continued investment in tried and trusted automation solutions with a growing level of digitization and AI.

We do not see this shift as about new or radical technology – the industrial sector moves slowly and “new” technologies that have the potential to be the next big thing take a long time to evolve (see 3D printing which has been a market focus for ~15 years but still makes up less than 1% of global manufacturing). Rather, it will be continued investment in tried and trusted automation solutions with a growing level of digitization and AI (which in turn will allow for increased automation of roles that potentially previously were not seen as automatable).

As an example of the potential around automation, U.S. manufacturing accounts for ~11% of U.S. GDP (\$2.7T) and ~9% of the U.S. workforce. The U.S. manufacturing sector employs about 13 million people. If half of these jobs were automated over a 20-year period then based on an average wage that is currently ~\$85k (according to the U.S. National Association of Manufacturers) the cost reduction in wages would be ~\$550B for the economy. Assuming a two-year payback on investment, this would suggest that \$1,100B could be spent over the theoretical 20-year period in the U.S. alone on automation – equating to \$55B per year. And this is before you allow for the fact that this is looking at the existing footprint, not incremental growth in local manufacturing.

The European capital goods sector was one of the major beneficiaries of the growth in Chinese manufacturing since the turn of the century as its more global nature saw it win ahead of its U.S. competitors. The sector grew at a 7% organic sales CAGR over 2003–2011 as it benefited from the “super-cycle.” However, as China became more mature, this growth rate fell to only a 3% CAGR over 2012–2019 (i.e. more than halved). Therefore, the idea of a growth in the Western manufacturing footprint doubling sector growth rates over a prolonged period would not be unrealistic if we were to see an aggressive shift to localization of manufacturing.

Industrial Real Estate: Just In Case inventory

Supply chains today are more interconnected across the globe and more exposed to disruptions; stakeholders are increasingly forced to diversify production locations where possible and increase overall inventory levels to attempt to better navigate the inevitable production/transportation issues.

Retailers likely need to invest heavily in their logistic networks to meet current demand and service level expectations.

Supply chains evolving to meet demand and service level expectations

Consumers expect greater product selection and faster delivery times, both of which increase the importance of logistic networks. Successful retailers are placing more value on their logistic networks and see it as a tool to improve the overall customer experience. Customers today are demanding more product offering selections and expect improved service levels. However, most logistic networks are not positioned to meet these expectations, and this issue has only been amplified by the pandemic-driven supply chain disruptions. Retailers are losing sales by not having enough inventory on hand to execute orders. As a result, more companies plan on transitioning to a just in case inventory model from a just in time model. Stakeholders are rethinking how goods are moved from manufacturers to end consumers, and the new model will require more adaptable, well-stocked logistic networks that could also allow for the more efficient transportation of goods.

Global supply chains are more exposed to macroeconomic shocks. Supply chains today are more interconnected across the globe and more exposed to disruptions. These issues not only stem from natural disasters, congestion, and labor disputes, but also include larger scale issues such as BREXIT, trade wars, and pandemics. Stakeholders are forced to diversify production locations where possible and increase overall inventory levels to attempt to better navigate the inevitable production/transportation issues. **Prologis, Inc. (PLD)** estimates retailers and logistic companies will need to increase inventory levels by more than 5–10%, which would translate into 57–114 million SF, or 0.63% of additional real estate demand a year over the next five years. The inventory to sales ratio dropped considerably to 1.46x in 2019 from 1.72x in the mid-1990s (reached as low as 1.35x in 2011) as just in time inventory models were implemented. By our estimate, this ratio would only increase to 1.54–1.61x if stakeholders increased inventory levels by only 5–10%.

Real estate design and locations matter. Retailers likely need to invest heavily in their logistic networks to meet current demand and service level expectations. When Amazon announced it was reducing the standard prime delivery time down to one day from two in 2019, the e-commerce giant also made several announcements highlighting the expansion of its logistic network and large inventory investments focused around major population centers. It is vital for retailers and logistic companies to operate warehouses close to population centers to decrease delivery times. It is also increasingly more difficult to find these locations as there is generally a higher and better use other than industrial. This could result in real estate companies being more creative, developing multi-story industrial product in order to justify paying up for the underlying land. These infill, last touch distribution centers are meant to facilitate high throughput and are not feasible to hold large amounts of inventory. Inventory will need to be held in facilities just outside the city, and given labor cost pressures, we could see larger buildings with higher clear heights equipped with more automated technology to better utilize the vertical space and reduce labor needs.

Just in Case inventory expected to be key driver of rail volume

Just in Time inventory systems benefitted trucking firms (at the expense of the rails) when introduced during the 1970s. Just in Time (JIT) inventory systems were a key driver of trucking volumes in the 1970s and 1980s as these systems required goods to be delivered as close as possible to when the goods were actually needed. This benefitted trucking firms as their on-time delivery performance during this time period was meaningfully better than the railroads. We note that rail networks were plagued by service issues and that businesses implementing JIT inventory systems could not rely on rail due to inconsistent delivery schedules. Rail therefore lost significant market share to truck during JIT implementation on the back of significant service disparity.

We expect the shift to Just in Case inventory systems to reduce the importance of on-time delivery and therefore drive further over-the-road conversions to rail reflecting lower costs and ESG benefits of rail compared to truck.

Rail service has improved markedly over the last decade and rail is expected to be a key beneficiary of a transition from Just in Time to Just in Case (JIC) inventory systems. The pandemic has created a new focus for inventory management, emphasizing the need to hold inventory for longer periods of time in the event of significant supply chain disruption. As a result, we see a shift developing away from JIT and into JIC. Since JIC involves holding larger inventory, there is less of a need for extremely high on-time service – which advantages rail. Further, rail service has improved meaningfully due to the adoption and implementation of Precision Scheduled Railroading (PSR). PSR has led to improved on-time delivery and helped rail drive over-the-road conversion from truck. While rail service still lags, we nevertheless expect the shift to Just in Case (JIC) inventory systems to reduce the importance of on-time delivery and therefore drive further over-the-road conversions to rail reflecting lower costs and ESG benefits of rail compared to truck.

The opportunity is significant. Truck accounts for a significant portion of freight moved in the U.S. with approximately two-thirds of total freight moving on truck, according to the U.S. Bureau of Transportation Statistics. By contrast, rail transported approximately 15% of total freight in the U.S. in 2019. We therefore see a significant opportunity for the rails even through small share gain. For example, if rail were to gain a 1% share of total freight volume this would represent a 7% growth in freight at the rails. Our view is that the rails with access to the biggest ports and largest population centers in North America stand to benefit the most from a transition to JIC inventory systems.

Biopharma: The global innovation bifurcation

We see more complex policy dynamics fueled by an increasingly more assertive China setting the stage for higher likelihood of conflicts and disruption.

The pandemic highlights global political, economic, and social divides likely to fuel future conflicts. Though the global recovery is continuing, prospects for a rapid rebound to near-normal conditions have weakened as outbreaks continue to disrupt global supply chains and optimistic growth numbers mask deteriorating prospects in low-income developing economies. The IMF predicts that by 2024 aggregate output for the advanced economies will exceed levels predicted by pre-pandemic trends by 0.9%. By contrast, estimates predict emerging and developing economies (excluding China) will lag pre-pandemic forecasts by 5.5%. The difference is driven, in part, by widely different access to vaccines and uneven policy and fiscal support capabilities. Though some countries, particularly commodity exporters, may benefit from near-term conditions, we expect as a group emerging economies will be forced to continue to limit fiscal support amid labor disruptions, inflation expectations, and compounding supply chain issues, ultimately limiting at least medium-term performance. With continued economic and supply chain uncertainty on the horizon, coupled with dimmer prospects for some emerging economies, we see more complex policy dynamics fueled by an increasingly more assertive China setting the stage for higher likelihood of conflicts and disruption.

Balancing innovation and access / affordability issues will be key in the coming years. We think a middle-of-the-road approach will prevail, with moderate concepts like greater price transparency, value based pricing, and potentially inflation caps on price increases balanced by greater funding for innovation.

U.S. near-term domestic policy must navigate the challenge of striking a balance between innovation and access/affordability issues. Public debate around costs of medicines has been spotlighted by the recent approval of BII's high-priced Alzheimer's treatment Aduhelm, and is unlikely to fade with continued concern around general social, economic, and racial inequality as a backdrop to healthcare costs. That the U.S. pays the highest healthcare costs is an undeniable fact, but this effective subsidization of global R&D is also balanced by the U.S. having significantly greater access to medicines vs other areas like the EU (~90% vs 70–50%). How to address this delicate balance is even less clear, with a range of proposals including international reference pricing, direct government negotiation, favored nation pricing, more targeted proposals aimed at the highest priced drugs, capping price increases, or a continuation of the current policies. The impacts of any policy are also difficult to gauge – we estimate that biopharma profits could be impacted in the 5–10% range, while trade organizations like PhRMA suggest the impact could be as much as 40% to revenue. Additionally, we note the impact on innovation varies as well, with some estimates by the CBO suggesting a 10% decrease in the number of new drugs brought to market over the next 10 years (~30 drugs), with a top range as high as 100 fewer drugs over the decade. Ultimately, we think a middle-of-the-road approach will prevail, with moderate concepts like greater price transparency, value based pricing, an accelerated path for generics and biosimilars, potentially inflation caps on price increases, as well as the potential for out-of-pocket caps in certain segments of the population (e.g., those on Medicare), balanced by greater funding for innovation. We expect these could help control costs and improve efficiency and equality of care but still maintain innovation. However, striking this balance is likely to remain a challenge over the next decade.

Globally, we expect greater focus on intellectual property protection and potentially more narrow academic exchange. Debate around intellectual property rights, with the U.S. backing strong IP protection vs. a more lax approach in China, is likely to complicate policies and regulations around cross-border agreements and joint venture formation within healthcare. Likewise, academic free-exchange and cross-border investment might come under greater control if the U.S. government continues to prosecute violations of funding agreements that limit interactions with foreign governments. Though the Committee on Foreign Investment in the U.S. (CFIUS) has traditionally been more associated with high-tech and military hardware, we see possibility for increased scrutiny around biotechnology potentially limiting foreign funding of sensitive U.S. biopharma. We see limited direct near-term impact to innovative

biopharma, which tends to operate on a more limited geographic scale in pre-revenue phases, but potential talent shortages could emerge if visa regulations are tightened. We do, however, see potential for addressing healthcare need in the developing world, though note potential for complex requirements and pricing particularly for highly innovative products such as gene therapies and complex biologics. Notably, **PTC Therapeutics** markets Waylivra, Tegsedi, and Translarna in developing markets including Brazil and Russia where political risk may be higher than in developed markets. In rare diseases, including DMD (**Sarepta Therapeutics**, **PTC Therapeutics**), AADC (**PTC**), HAE (**BioCryst Pharmaceuticals**), Huntington's (**PTC**, **Neubase Therapeutic**), diagnosis and patient identification lacks in developing markets where advanced diagnostics and genetic screening are significantly less common. Manufacturing and supply chains, particularly for generics, could be disrupted by conflict as occurred during the pandemic, and the U.S. has indicated a desire to be less reliant on foreign manufacturing operations for pharmaceutical products.

Outside traditional biopharmaceuticals, there exists opportunity for biotechnology particularly in food security and environmental protection. Though mostly early stages, companies are developing plant non-animal based 'meats' and sources of protein, in part, to address environmental strains associated with farming. With global concerns associated with deforestation and land mismanagement increasing, we see a need for more sustainable and productive agriculture particularly in the developing world and note the potential for agricultural biotechnology to improve farming practices. Though the industry has not seen the same level of innovation and product development as biomedicine, the technology for genetically modified crops stems from the same building blocks used for advanced therapeutics and we expect eventually a surge in interest and development likely led by a combination of large agricultural companies and innovative start-ups.

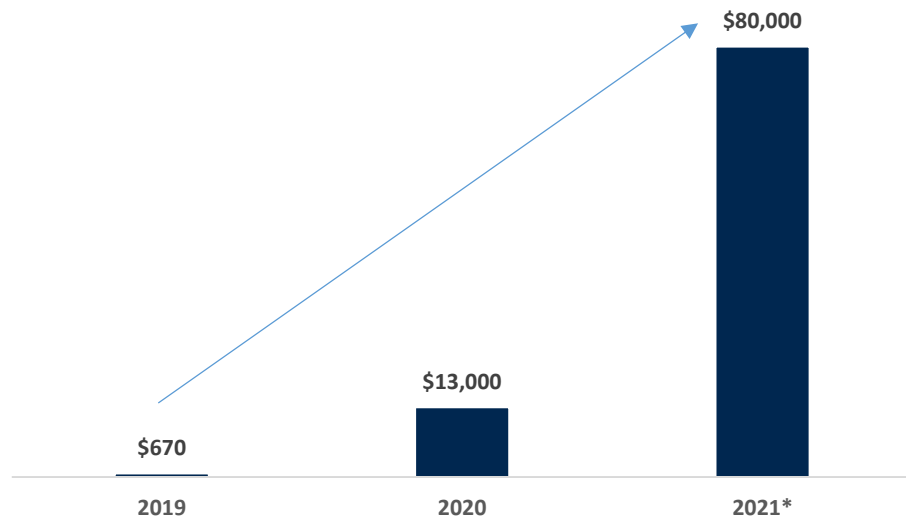
We see a need for more sustainable and productive agriculture particularly in the developing world and note the potential for agricultural biotechnology to improve farming practices.

Decentralized Finance: The “Conflict Economy” will need a currency

We foresee the rise of conflicts as potentially propelling the use of cryptocurrencies as a means to transfer value, while maintaining equality and operating outside the traditional regulatory & centralized framework.

We foresee the rise of conflicts as potentially propelling the use of cryptocurrencies (no opinion on which one) as a means to transfer value, while maintaining equality and operating outside the traditional regulatory & centralized framework. A point in fact is that a totally new token could be created for this vary purpose or be created by various factions in order to fund/support a specific cause. As conflicts escalate, a parallel world of trade will emerge, which will increasingly expose consumers to the benefits of anonymity vs. the need to “trust” in a centralized authority. As a result, we expect Decentralized Finance (DeFi) to rapidly emerge. Although still in its infancy, there are already ~ \$80B (as of May 2021) of digital assets in DeFi services, up from ~\$1B in 2019 (and we believe that, in concert with greater conflict, that this number could massively increase). In addition, the number of DeFi related apps grew from 8 to more than 200 from 2019 to 2020, while users increased from ~100K to ~1.2M over that same time period. As with Crypto in its early beginnings, as consumer onramps become more easily acceptable through the various Decentralized Apps (Dapps), we believe more financial services will reside on a blockchain settlement layer, including payments, lending, trading, and investments.

Exhibit 119 - Digital assets locked in DeFi smart contracts (\$M), FY21E is through May 2021



Source: World Economic Forum, RBC Capital Markets

Software: Cybersecurity

We believe digital transformations will continue to increase, which expands the attack-surface making cybersecurity the precursor to digital transformations. As an enabler of secure change, we feel cybersecurity will increasingly be a source of competitive differentiation for worker enablement, expanding security budgets, and helping to realize the perimeter-less network.

Creating solutions; looking to the future

Over the next 10 years, we believe the core value proposition of security will expand. Creating a secure network environment has become more challenging as environments widen in a post-pandemic world becoming increasingly hybrid and complex to accommodate the “new normal” of work. At the same time, we’ve seen an increase in bad actors, particularly in the form of nation-states targeting enterprises. In the end, we believe security transformations will need to become a precursor to digital transformations.

In a period of digital transformation, enterprises are looking to accelerate their transition to the cloud and hybrid work environments, which is creating new stresses for security to avoid being a limiting factor in this advancement. As such, we view security as the key to worker enablement, moving beyond a cost to unlock productivity by safely enabling employees to work from anywhere on whatever device and with whatever applications they are most efficient. This is a major revolution in what the security industry can be, which is increasingly reflected in security valuations as investors realize the magnitude of TAM expansion these trends are driving.

Security is no longer a siloed or isolated part of the technology stack, but the center for integration. This enables digital transformation to be done safely while allowing for the speed and agility of these new environments to be secured intrinsically. Looking forward, we feel that from SMBs to federal governments, organizations are going to be looking for security transformation as a precursor to digital transformation, with a regulatory and threat environment that should only accelerate the transition. The keys to these new environments in our opinion will be context-based identity, enabling secure access from anywhere, and protecting cloud workloads.

Starting at the top

While viruses and malware have been around for many decades, in recent years attacks have increased in both their breadth as well as their sophistication. As advancements continue in areas like DevOps and cloud computing, similar techniques are being utilized by bad actors to lower the bar for becoming an adversary to a simple download from the dark net. There is an additional set of bad actors that have become more sophisticated in attacking a broader set of targets and taking advantage of increased attack surfaces from cloud environments. We believe security tools need to evolve even faster to keep pace with these evolving threats. Overall, we believe the use of cloud-based security solutions will increase dramatically over the next 10 years.

One particular challenge over the past year has been an increase in attacks from nation-states during the pandemic. According to Nation States, Cyber-conflict, and the Web of Profit by HP Wolf Security, there has been a 100% increase in ‘significant’ nation state incidents between 2017 and 2020. 75% of the experts surveyed for the report agreed that COVID-19 represented a significant new opportunity for Nation States to exploit seeing a 40% rise in Nation State incidents between July to September 2020, compared to January to June 2020. While this feels like a matter of government policy, and it is, in an analysis of over 200 nation state incidents

We believe security transformations will need to become a precursor to digital transformations and view security as the key to worker enablement.

since 2009, the report shows that enterprises made up 35% of the targets compared to government bodies and regulators at 12%, a ~3x difference.

With nation-states both providing funds as well as safe havens for bad actors, the question will continue to rise around what is a proportionate response to a non-kinetic cyberattack? To date, the damage has been largely financial, leading to financial responses in the form of increased sanctions. Looking at the future of these trends, the largest change would be if we start to see increased attacks against critical infrastructure such as power grids or cyber-kinetic attacks, designed to cause physical damage through the use of cyber-warfare.

This remains a situation where the best offense is likely a good defense; we feel the recent Executive Order on Improving the Nation's Cybersecurity is a good place to start. The U.S. government is following the enterprises' lead to create a more robust network environment including adopting a Zero Trust Architecture and accelerating its movement to secure cloud services. This remains a major tailwind to the cybersecurity industry, and dealing with the growing risk of attacks as well as the financial and reputational ramifications is the greatest pure security tailwind to the industry, one that we feel will support security budgets for years to come.

New problems need new solutions

Traditional networks were built around on-premise data centers, which made sense in a pre-cloud world. When desktops, data, software, applications, and users all resided within the traditional network perimeter, this strategy was effective, but as endpoints and workers became distributed and the rise of the cloud sent software and applications off-premise, enterprises needed to increasingly modify the network perimeter to accommodate the "new normal" of work.

As enterprises found out with COVID-19, traditional infrastructure was never designed to scale out when companies tried to adapt continuity plans (which were typically suited for 15–20% remote workers, and then quickly went to 100%). While workers and devices being remote may be new, the software, applications, services, and data have become increasingly remote over the past several years.

We view the future as enterprises moving from surviving to thriving in a distributed work environment. The Secure Access Service Edge or "SASE" is a security strategy to support the digitization of the enterprise and the dissolution of the traditional network perimeter, allowing for security at the point of access. SASE converges network (SD-WAN) and network security services (such as SWG, CASB, FWaaS, and ZTNA) and is primarily delivered as a cloud-based service.

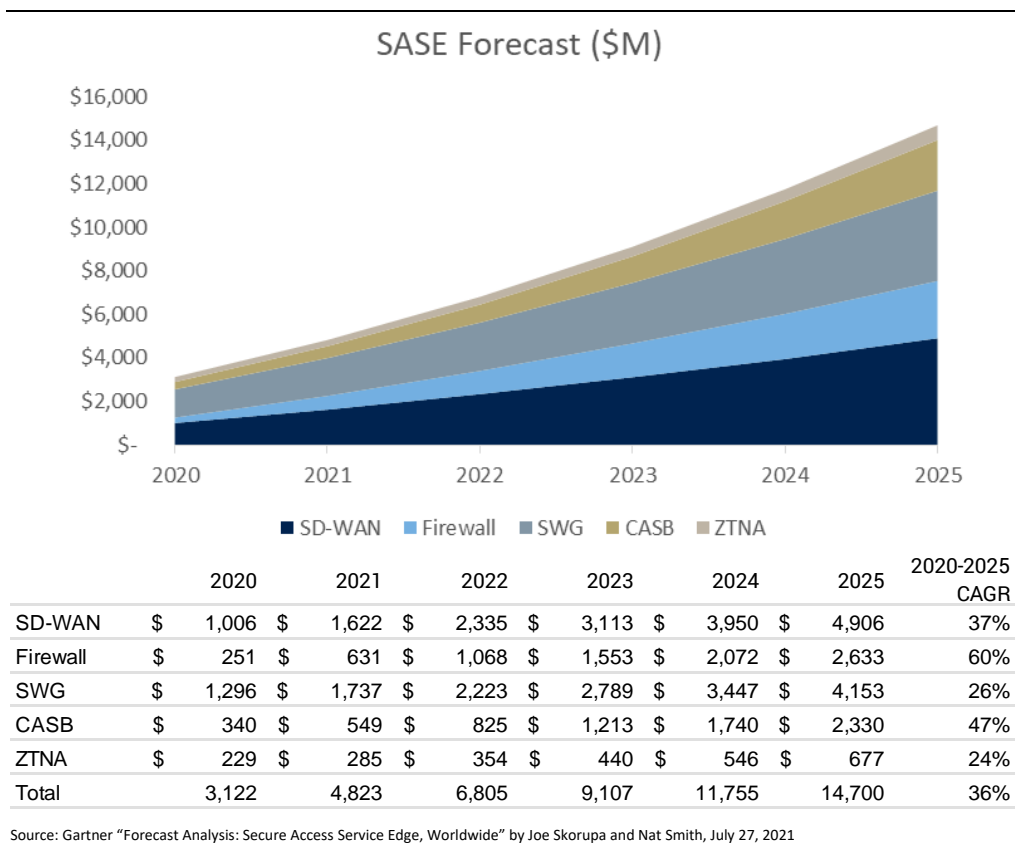
SASE is enabled by policy-based security that can be applied at the point of access revolving around the ability to properly identify endpoints and users and understand access requirements. This type of dynamic policy-based security requires a next-gen solution that can combine the speed and scale of the cloud-based environments they are securing.

As seen below, based on our interpretation of Gartner ("Forecast Analysis: Secure Access Service Edge, Worldwide" by Joe Skorupa and Nat Smith, July 27, 2021), the industry is taking notice of the needs for these technologies, with SASE technologies expected to grow at a CAGR of 36% through 2025 reaching \$15B. This compares to the overall information security and risk management CAGR of 10% over the same time period. We feel that this framework is going to be increasingly important post-pandemic as enterprises are now protecting a perimeter-less environment, which requires security to be much more flexible and dynamic to adapt to these

We view the future as enterprises moving from surviving to thriving in a distributed work environment.

ever-changing requirements. Importantly, this highlights that while the pandemic has sped up these trends, we are still in the early innings of security transformation.

Exhibit 120 - Forecast SASE



User-centric security

As mentioned previously, we believe the largest security-centric tailwind to spend is the rising threat environment and the expanding attack surface. In our opinion, the largest overall driver for security comes from a perception shift through the pandemic. Security has evolved from a cost into a source of competitive differentiation for user-enablement that ultimately results in both costs savings and revenue generation. In short, security has gone from a more reactive department focused on prevention to a more proactive department focused on securely enabling employees to work from the location, with the device and applications that make them most productive.

One of the most important aspects of the SASE framework, and an area that we think could have faster growth than reflected above, is in Zero-Trust Network Access. A cornerstone of the government's new cybersecurity initiative, ZTNA provides identity-aware access. Removing network location as a position of advantage eliminates excessive implicit trust, replacing it with explicit identity-based trust. We feel ZTNA will continue to see tailwinds from the move towards user-centric security and a focus on secure enablement.

ZTNA improves the flexibility, agility, and scalability of application access, enabling digitally transformed businesses to function without exposing internal applications directly to the Internet (they become invisible), reducing the risk of attack. Companies can have much more control over east-west traffic with fine-grain application access without opening up the entire

We believe security has evolved from a cost into a source of competitive differentiation for user-enablement that ultimately results in both costs savings and revenue generation.

network. This idea of creating the least amount of privilege possible is consistent with the defensive approach of zero-trust. Secondly, organizations rely on ZTNA to allow unmanaged devices and external partners to securely access applications without the need to trust the device connection.

While this definition sounds restrictive, the outcome is the opposite, allowing users to utilize applications from any device and any location by making security identity aware. This allows the system to grant access based on the individual users and not make blanket policies that restrict access towards least privileged users.

We continue to view security and workforce enablement as a balancing act. What we have come to realize from conversations with vendors, customers, and users is that the companies themselves do not always get to control that balance. Not only does it benefit employee satisfaction and retention to let employees work from wherever and with whatever device and application they feel are most efficient, it also benefits security because employees are likely to do these things anyway. The first step to securing a perimeter-less network is visibility. By embracing distributed workforces, unmanaged devices, and business applications, enterprises can gain a fuller network visibility and mitigate risk while driving efficiency. The key to this balance is context, identifying high-risk assets and access while enabling general work on a broader scale. This will accelerate the need for AI/ML as well as security at the new perimeter, which are the users themselves.

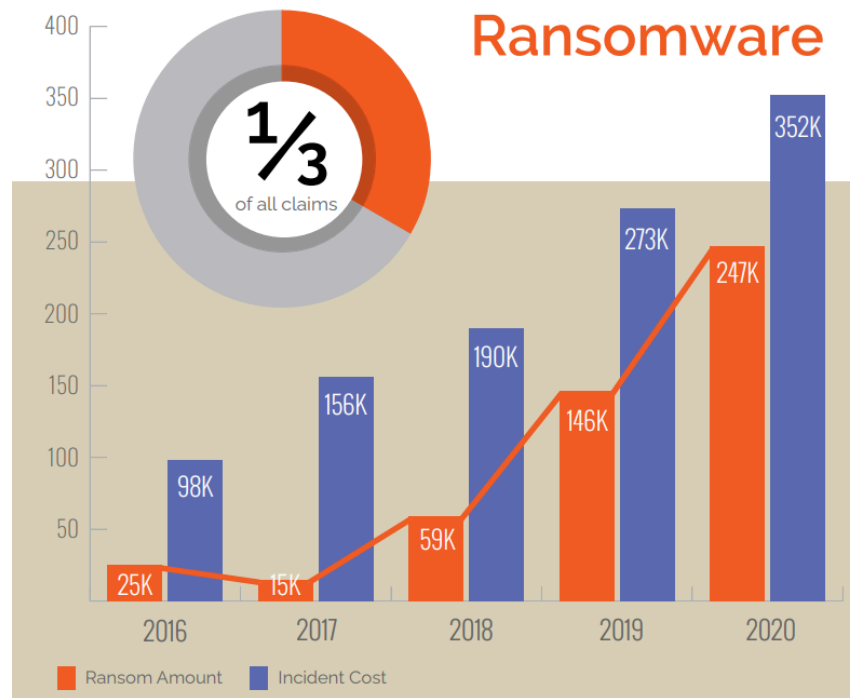
When we think about user-centric security, it encompasses both giving the user freedom through identity and access management solutions, but also recognizing the user as statistically the weakest point in the enterprise environment. As network cybersecurity posture continues to improve, users evolve much less quickly and there is no patch to stop users from clicking on phishing e-mails. We feel the user will continue to grow as a threat vector, which will result in even more focus on minimizing the attack surface of the individual by bringing security to the edge and focusing on each individual based on the context of who they are to the environment.

Insurance: Cybersecurity and physical risk

Cyber risks are growing and evolving quickly. Three years ago, data breaches were the main concern and attacks were focused on stealing sensitive customer information. More recently, ransomware attacks have come to the fore that seek to collect quick payment in exchange for the release of company systems.

These two types of attacks have different real-world implications for insurers and policyholders and increasingly transcend the lines between the virtual and 'real' economy.

Exhibit 121 - Cost and frequency of ransomware attacks are rising



Source: Net Diligence Cyber Claims Study, 2021

The May 6th ransomware hacking of the Colonial Pipeline was a well-publicized example. In practical terms the cost was quite low – 75 bitcoins (about \$5M at the time, 63.7 of which were later recovered) but the economic impact was far greater with widespread fuel shortages throughout the Southeast, airline disruptions and untold number of plans that had to be delayed, altered or cancelled.

Another, more tragic example occurred in recent weeks. During July & August 2019, the Springhill Medical Center (a hospital in Alabama) was under siege from a ransomware attack. The hospital was without computer systems for 8 days. During that time, a baby was delivered with the umbilical cord wrapped around its neck. The child died nine months later and there has been a lawsuit ongoing ever since over who bears responsibility for the death. Depending on what judges ultimately decide – it could be the first ransomware death in history.

Ryuk, the hacker group responsible for the attack, has attacked 235 hospitals and healthcare facilities as of June 2021, according to a Wall Street Journal report. The software has collected more than \$100M in payments during this time, an average of nearly \$700,000 per attack.

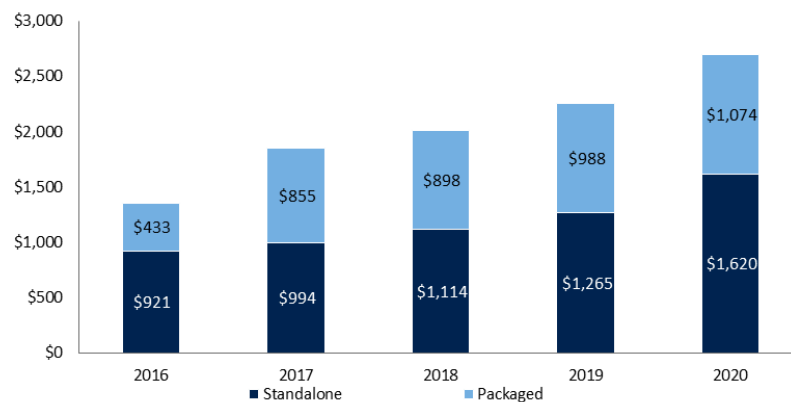
Numerous studies and surveys point to cyberattacks and ransom attacks as top concerns of both companies and managements as well as individuals.

Who pays for cyberattacks? How they should be insured? Where does shared liability begin and end? These are just a few of the questions that companies, insurers and governments will increasingly need to address.

Sizing the cyber-risk market & a potential cyber-catastrophe

The cyber-insurance market has been growing rapidly in recent years and projections are for further growth. A.M. Best data suggests that U.S. cyber premiums have doubled in the last 5 years to nearly \$2.7B. Both packaged and standalone policies have seen substantial growth during the period as awareness of the risk has grown.

Exhibit 122 - Premium growth has been substantial in recent years (\$M)



Source: A.M. Best data & research

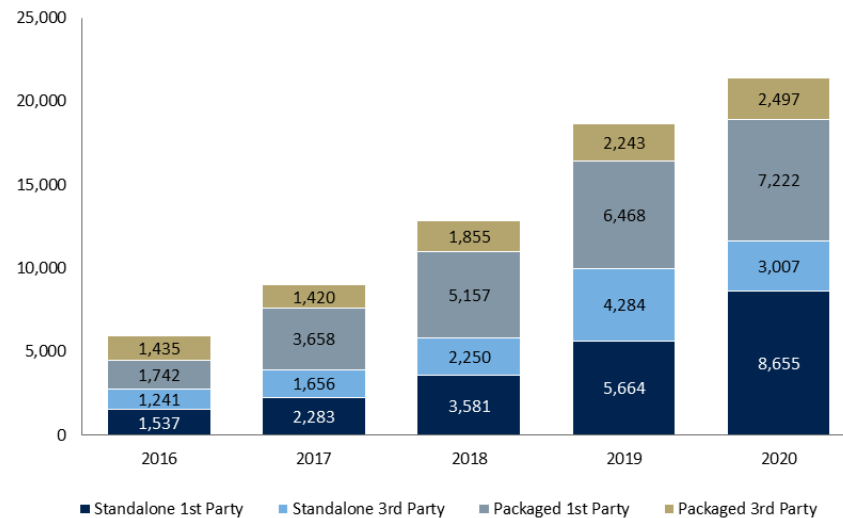
Industry projections are for further growth through 2025. Forecasting company MarketsandMarkets™ indicated that they saw total global cyber premiums rise to \$7.8B in 2020, and they think it could grow 21.2% annually to over \$20.4B by 2025.

Ultimately, the size of the cyber-insurance market will be dictated by the size of the overall risk to be insured, and this is where questions begin to arise. As a nascent and growing risk, it is difficult to ascertain what the potential size of the cyber-insurance market could be in the next five or ten years, but all signs are pointing to bigger than today.

Unfortunately, for insurers, as fast as cyber insurance premiums are rising and policies are being written, claims counts and costs are rising faster. In the five years following 2016, U.S. insurance premiums doubled whereas total claims increased by 259%.

Aon reported that cyber rates for most clients would rise by 20% to 50% in 2021, mostly in response to the proliferation of ransomware events since 2018. Total ransomware events rose 486% between 2018 and the end of 2020, while data breach and privacy events were down slightly in 2020.

Exhibit 123 - U.S. cyber claims have nearly quadrupled in the last 5 years



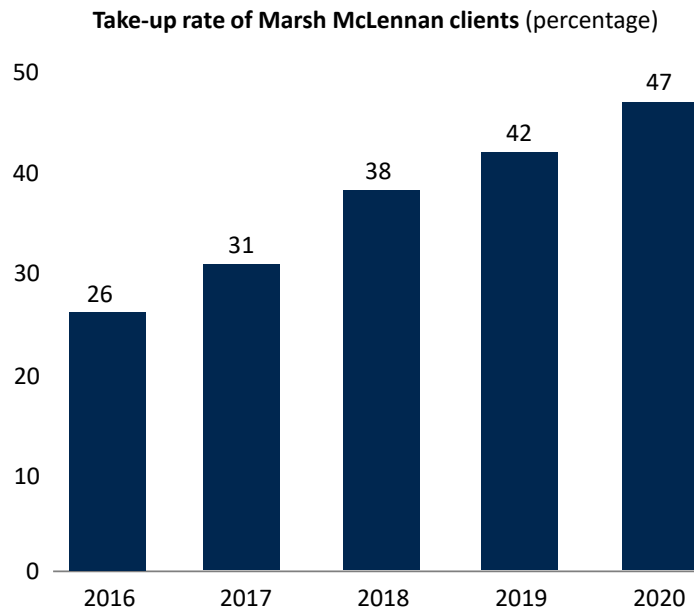
Source: A.M. Best data & research

We think that a bigger question for the burgeoning line of business is who will underwrite all this risk? With claims rising, several insurers have acted to tamp down tail risk by lowering limits and raising prices. New entrants have begun writing cyber insurance but the market remains fairly concentrated.

Ultimately, we would expect pricing & fears of undefinable large losses to force some self-insuring, but we think the cyber-insurance market is likely to be a growing mainstay longer term. As insurers get a better grasp of the risk they are writing, we would expect appetite for premium growth to match the growing level of overall market exposure and the business line to grow substantially.

How is market penetration changing? While the market has grown substantially in the past five years, cyber coverage gaps continue to exist across broad areas of the economy. By 2020, global insurance broker Marsh & McLennan reported that just 47% of its clients purchased cyber insurance, compared to 26% in 2016. That still leaves over half of customers largely uninsured.

Exhibit 124 - Cost and frequency of ransomware attacks are rising



Source: GAO presentation of data from Marsh & McLennan (GAO-21-477)

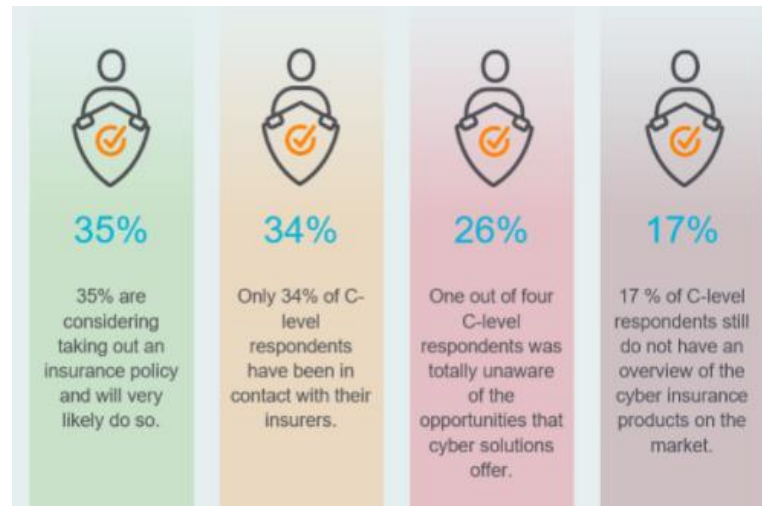
Marsh noted that cyber coverage is still primarily bought by large companies, not small and mid-market businesses, meaning the less well-defended mid and small cap companies are more vulnerable to attack and uncovered in the event of the attack.

Data remains central to most businesses. We think over time cyber insurance will be as common as property and general liability coverage and maybe even more important.

High-profile data breaches are likely to continue to be a sales driver: The best advertising for cyber coverage is large cyber losses. A number of reports from brokers and industry groups have suggested that one of the top reasons for new clients inquiring about cyber insurance is large public events (Capital One, Equifax, Target, Colonial Pipeline).

Cybercrime is not an intuitive risk: Cyber exposure is not something that one thinks of naturally when thinking of business risk. Most companies do not appreciate their vulnerability nor anticipate why hackers would find them an attractive target.

Exhibit 125 - MunichRe cyber-insurance survey results: 2021



Source: Munich Re

What are the emerging risks? We think the primary vectors for cyber exposure are pretty well known. The recipe of hacking + ransomware is pretty well explored and while the software may change, these sorts of attacks from individuals remain the thing that should keep investors and management teams up at night.

Cyber threats are a constant arms race. No sooner do companies and managements identify one threat and figure out how to defend it then a new threat emerges.

What's next? There's no way to know but imagine the following:

- What if there are court decisions ruling that certain losses caused by cyberattacks extend out to other areas like property, business interruption that carriers did not think were covered?
- What if it becomes more common for consumers to have cyber insurance that could go alongside their auto and home insurance policies? Will customers need separate cyber liability coverage for their autonomous vehicle?
- What if the U.S. was hit was a massive cyberattack that caused outages at several major institutions or parts of the country? What are the implications and what would the insured loss total look like?
- Imagine an update to a widely popular app that renders phones inoperable. Where does liability begin and end for cyber events that are not intentionally disruptive, but turn out to be so?
- What if there was a major cyberattack on the U.S. government by another country and what would be the economic fallout?

The emerging risk we see as the most likely concern is the proliferation and increasing interconnectivity of the world. A recent forecast from IDC predicts that there will be 75.4 billion devices connected to the Internet of Things by 2025, up from around 27 billion at the end of 2019. That is a lot more areas for hackers to find weakness, and these access points connect into a system that is increasingly interdependent.

The connectivity increases the number of weak links in the system, opening new areas for hackers to attack. As technology proliferates, the possibility of hacks rises and the severity of attacks could rise as a result of increasing potential for cyber contagion.

What would a cyber “catastrophe” look like? We have seen a number of cyber attacks that impact individual companies or sectors. The question remains what a widespread contagion attack would do, and what it could mean for economic and insured losses. Several years ago, Guy Carpenter partnered with CyberCube to take a stab at this topic and identify what a cyber catastrophe could be. This could really happen at almost any time and realistically it is a matter of when, not if such an attack will occur.

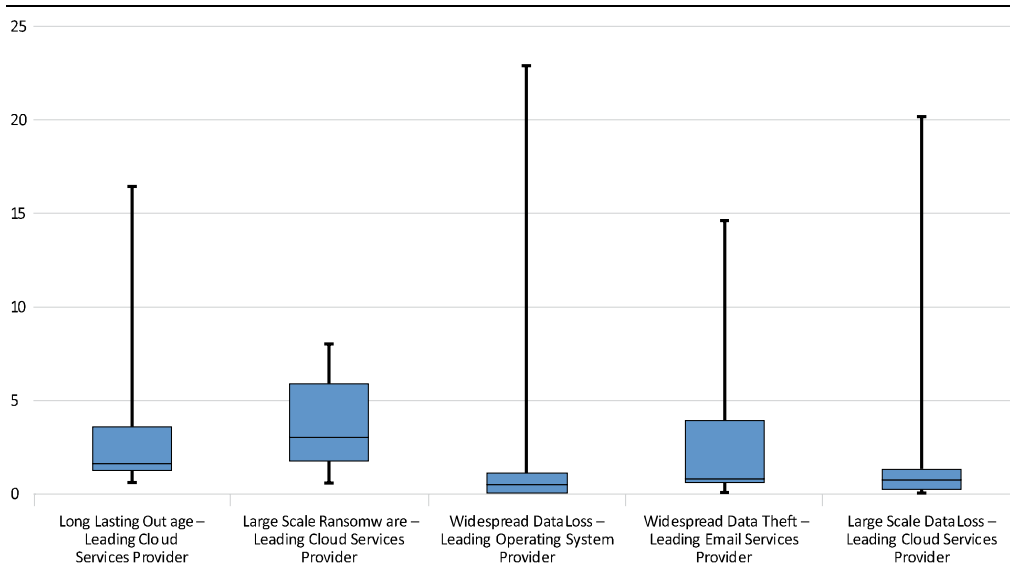
Exhibit 126 - Largest source of risks (by average annual loss and max loss)

Rank	By AAL	By Maximum Insured Loss
1	Widespread Data Theft – Leading Email Services Provider	Widespread Data Loss – Leading Operating System Provider
2	Large Scale Ransomware – Leading Cloud Services Provider	Large Scale Data Loss – Leading Cloud Services Provider
3	Large Scale PoS Theft – Leading Retailer	Widespread Data Theft – Leading Email Services Provider
4	Widespread Data Loss – Leading Operating System Provider	Long Lasting Outage – Leading Cloud Services Provider

Source: Guy Carpenter, CyberCube Analytics

Guy Carpenter and CyberCube identified data theft from an email provider and a ransomware attack on a cloud service provider as being potentially the two most catastrophic insured loss events. The group identified that losses from the two most likely, in their view, events, would be roughly \$22B to \$24B. These sizes are rather large and essentially are equivalent to a good-sized hurricane.

Exhibit 127 - U.S. insured loss distribution by scenarios (\$B)



Source: Guy Carpenter, CyberCube Analytics

We do not know which scenario will arise and prove to be a devastating cyber event, or when it will occur. In insurance, managements often use a form of analysis called probable maximum loss (PML) to assess the risk and size of loss in extreme situations. We do not think this is a one

in two event (one sort of loss every two years), but it is not unreasonable that large cyber losses could begin to occur every 5, 10 or 20 years as we become increasingly tied to technology.

Cyber-insurance as a solution

Alongside cybersecurity spending, cyber-insurance has been a fast-growing sector of the market in the last decade. The growth has been aided by an increase in client interest and an increase in price per unit of risk, as the pace and scale of cyberattacks has accelerated.

The U.S. government as a backstop: Although there have been no claims to test these backstops, while private insurers can price individual risks and losses, some have speculated that existing government insurance provisions could cover cyber-terror losses. There has also been commentary that existing programs, such as the Terrorism Risk Insurance Plan, could be extended to also cover cyberattacks.

In 2021, the General Accountability Office (GAO) undertook a study of the cyber-insurance market and the government's role in helping proliferate the coverage. One of the items in the report focused on the definition of cyberterrorism and its applicability to TRIP (Terrorism Risk Insurance Plan), which was established in response to the September 11th attacks.

The TRIP backstop is triggered when the U.S. Treasury Department certifies an act of terrorism. The definition in the act reads, "must be violent or dangerous to human life, property, or infrastructure, generally result in losses in the United States, and be part of an effort to coerce the civilian population of the United States or affect the conduct of the U.S. government by coercion." To date, no attack has resulted in TRIP being activated.

The question then is could a cyberattack trigger this provision? This is a question the GAO will be exploring in future reports but our read is that it could, and we would expect future development on the cyber front as the government seeks to respond to attacks.

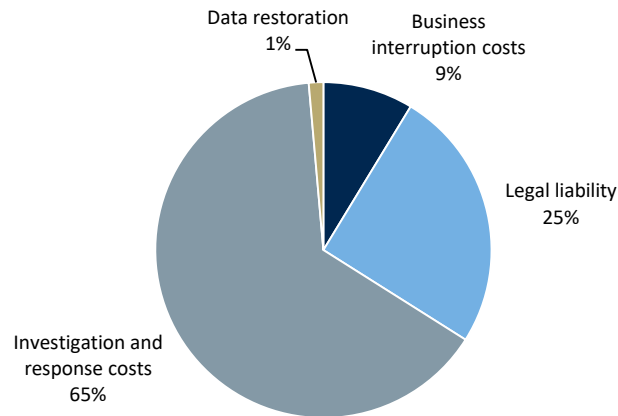
The attacks on hospitals and the Colonial Pipeline show that critical infrastructure can be damaged, altered, or destroyed by cyberattacks. Loss of life is also possible. With increased automation in rail systems, airlines, and public transit, one can envision a cyberattack creating a mass casualty event, or significant property loss.

The question of a government backstop remains a longer-term prospect with the way things work in Washington D.C., but we would think that more clear guidelines and regulation are coming to the sector. One would hope the changes are anticipatory as opposed to reactive, but we will have to wait and see.

Current private offerings: Private cyber insurance is an evolving product and can mean a lot of things. The product sold today has changed meaningfully in the last five years and by 2025 we would expect further evolution to occur in response to changed attack tactics and evolving buyer need.

Today's policies are sold as either standalone, or alongside existing liability products. Cyber policies typically cover incidence response, loss of information and regulatory and compliance costs. This will include things such as credit monitoring, notification, cost to fix the breach and/or restore data and any information tech costs. What is typically not covered is consequential damage resulting from fraud associated with the lost information – that is normally self-insured.

Exhibit 128 - Theoretical losses from data theft at leading email service provider



Source: Marsh & McLennan

Based on our experience, normal limits for large financial institutions are around \$250M. Other coverages could potentially take this higher but it is unlikely, at the maximum, to be any more than \$500M. Limits have been tightening over the years and pricing has risen dramatically as areas of loss are more clearly understood.

For a claim, there will be some initial funds advanced fairly quickly under the policies, but it tends to take at least two years for full claims resolution based on experiences at Target and Experian.

One of the bigger changes in recent years has been the attempt to remove “silent” cyber coverage from broader policies. Silent coverage means that the policy could in theory cover cyber based on its wording, but cyber is not the intended purpose of the policy. AIG announced in September of 2019 that as of 2020, all policies they issue would explicitly cover or exclude physical or non-physical cyber exposures (meaning you will be specifically charged for cyber on all your policies).

We expect to see similar moves at companies that are not already explicitly including/excluding cyber coverage and expect to see product terms and conditions tighten substantially as insurers batten down the hatches as cyber becomes a larger risk.

Biopharma: Amid global conflicts, IP matters, biotech an example

We expect continued U.S. leadership in biomedical innovation, though China's ambitions may further politicize global healthcare efforts. The U.S. retains the largest share of global biotechnology venture capital investment, with Asia-Pacific second and Europe third. Investment in basic and translational research has paid dividends and we continue to believe U.S.-led biotechnology is in an innovation boom and expect advances in biomedicine, agricultural biotechnology, and potentially new fields including industrial and marine biotechnology. Reputational advantages persist at U.S. biomedical institutions, particularly the FDA - where decisions and debate over drug approvals have considerable influence globally. Nonetheless, China has ambitions of global leadership in innovation, and aims to increase R&D spending 7% per year from 2021–2025, with a particular focus on cutting-edge industries including biomedical research, neuroscience, genetics, and healthcare generally. Indeed, debate surrounding “vaccine diplomacy” and China’s preference for tying commercial incentives or loans to vaccine “donations” highlights the potential for healthcare allocation to be used to influence strategically important emerging nations. China’s domestic biotechnology industry is also growing and increasing in sophistication, with support from the central government, and investment by domestic VCs, coupled with an increasing entrepreneurial business culture driving mid-to long-term potential. We believe current and likely future U.S. administrations will continue to recognize the value of continued U.S. biotechnology leadership, recognizing the intangible investments required to maintain our position and that defending U.S. healthcare/biotech interests could both fuel conflict and generate opportunities for investment.

Imagine Industry Implications

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Consumer

Consumer – The Quest for Immortality

The movement towards a healthier lifestyle has been one of the most important consumer trends over the past few years, it has accelerated during the pandemic, and we believe will become even more important over the next five years. We believe consumer health will improve both as a result of breakthroughs in medicines and therapeutics, as well as consumers' individual choices towards healthier life options, such as a focus on healthier food/beverage options, a more active lifestyle, and improving mental health. These factors will drive fundamental changes in the way consumer staples companies operate and interact with their consumer base.

- **Longer retirements.** Thanks to breakthroughs in medicine and therapeutics, increased healthcare access, and healthier lifestyles, we believe average life expectancy will increase across the world, and particularly in developed countries. For example, based on OECD data, the average life expectancy for women and men in the U.S. at 65 has risen to 21 and 18 years respectively, from 16 and 13 years in the 1960. In Japan, average life expectancy at 65 is 25 years for women and 20 years for men, up from 14 and 11 years in 1960, respectively. Most of the developed world is going to converge to Japan over the next five to ten years. With longer life expectancy, the number of years each consumer spends in retirement will increase, even net of an expected increase in retirement ages. As a result, companies need to prepare for a higher percentage of their consumer base being represented by retirees and start to think about adjusting their product offerings and marketing messages.
- **Expansion of consumer spending curve and further trade up.** Longer life expectancy and longer retirements will also result in an expansion of consumer spending curves. Companies could benefit from this by increasing their consumers' lifetime value by focusing on loyalty rates and retention rates. In other words, each consumer acquired is much more valuable given a longer spending curve. Importantly, as consumers age, they tend to spend more on higher-end items (again, Japan is a great case study here).
- **Importance of self-care.** When combining rising healthcare costs with an aging population, we believe consumers will increasingly focus on self-care in order to sustain healthier lifestyles. We see this trend emerging in consumer healthcare products (e.g. OTC, vitamins, supplements, etc.), food & beverages (e.g., healthier/better-for-you options, plant-based proteins, etc.), and home-fitness devices (wearables, Peloton, the Mirror, etc.). Ultimately, consumer companies will need to offer products that enable people to manage their own health and wellbeing. Several innovative products and services have been developed and are being tested.
- **Further income divide.** We'd expect the "quest for immortality" will materialize unevenly across different consumers based on income, demographics, and infrastructures. This should further increase the health and wealth gap between consumers at the two ends of the income spectrum. As a result consumer products companies need to be ready to market and offer products to an even more polarized world, offering products at different price-points.
- **Rising importance of mental health.** One of the many effect of the COVID-19 pandemic was a significant increase in mental health disorders across a significant part of the population, including emotional distress and anxiety. Companies offering therapy-on-demand, such as Talkspace, saw large increases in their user base during the pandemic, highlighting consumers' need for mental health services. Going forward we'd expect an increase focus on mental health from consumers and governments, with potential for companies to offer new products and services.

- **Progress on brain health.** Our healthcare team sees brain health as the area likely to see the most significant advances over the next decade. With potential treatments for brain diseases, such as Alzheimer's and Huntington's diseases, we'd expect the life quality and brain function of many older consumers will improve significantly. As a result, consumer companies need to be prepared to communicate and target their message towards an older and healthier consumer base.
- **The plant-based win-win:** Healthier diets is a key element in consumers' quest for immortality. Danone found 47% of younger generations are eating healthier and 30% are willing to actually pay a premium for that. The plant-based segment correlates closely with this trend – meat and dairy look-a-like products made from plant-based proteins such as soy, pea, fermented mycoproteins and oat are often lower calorie with more fibre and less fat.

Consumer – The Individual Revolution

As power shifts from the “institution” to the “individual,” we see several implications for the consumer sector. Advances in science, the “shrinking” of technology will enable consumers to receive real time feedback on their lifestyle—heightening the need to develop more custom and personalized products. In addition, the way brands will be built in the future will revolve more around influencers and recommendation than direct messaging from the company.

- **The consumerism of healthcare:** Advancements in science and technology have enabled the movement of devices that were once exclusive to hospitals to retail shelves. Take for example the finger pulse oximeter, which measures blood oxygen saturation. The technology for this was developed in the 1930s, originally measuring via the ear, and the first finger pulse oximeter was not commercialized until the 1970s in Japan, and the 1980s in the U.S. pulse oximeters have been staples in hospitals for decades. Developed for the demand of measuring oxygen during surgery while the use of ventilators during anesthesia became ever more common, they revolutionized the work of anesthesiologists. In certain wearables, features such as pulse ox monitoring are already available, such as in the Apple and Samsung smart watches. While there are notes on caution about the accuracy and reliability of these tracking and data (which we expect to improve over time), we expect similar evolutions to take certain products and categories away from being exclusive to the medical realm and into the area of general consumer health, wellness, and personal care. Continuous glucose monitors are another great case study of the consumerism of healthcare. Today, consumers can get a real time read on their blood glucose levels and manage their diets and lifestyles accordingly (obviously useful for diabetics but also people looking to manage their weight). Other like devices and diagnostics are being developed in labs around the world that we believe will provide even more “data” for consumers to use to manage their buying decisions. Importantly, the consumerism of healthcare could make traditional demographic targeting obsolete as consumers will start to make decisions based on their own bodies versus some stereotypical behavior based on a race/gender/ethnic segmentation.
- **Centers of influence are shifting:** Historically, large consumer companies would leverage massive advertising budgets to influence consumers to buy their products and services. Given the ubiquity of social media, consumers are now taking an increasingly amount of their consumption cues via recommendation from other individuals (social media influencers, friends, family, reviews online). This dynamic will fundamentally disrupt the marketing models for the entire consumer sector. Given the rising importance of recommendation, we believe consumer companies need to focus on product efficacy (does it taste better, clean better, make you feel better) and storytelling.
- **Disruption from gig economy.** From a labor market standpoint one of the key consequences of the “individual revolution” has been the rise of the gig economy, which

was accelerated by the COVID-19 pandemic, as consumers want the ability to work when they want to work. This resulted in a large numbers of employees quitting their jobs: in August 2021, 4.3M Americans quit their jobs, representing 2.9% of the workforce, the highest quit percentage ever reported by the Bureau of Labor Statistics. Consumers have many options when it comes down to the gig economy ranging from ride-sharing jobs (Uber, Lyft, etc.) to delivery services (Instacart, Postmates, etc.), professional services (Freelance, 99design, etc.), household services and handmade goods (Etsy, Care.com, etc.), and asset-sharing services (Airbnb, etc.). These jobs are also becoming increasingly attractive with a ~\$15-30 per hour earnings potential from many ride-sharing jobs vs. a \$7.25 per hour minimum wage. We expect this trend to continue and accelerate going forward: based on a study from Mastercard the number of global gig workers is expected to grow by over 80% by 2023. We'd expect this will result in increasing labor challenges, and labor inflation, for consumer companies in manufacturing, packaging, and transportation jobs.

- **A data focused environment = heightened consumer expectations.** Data and CRM have become a key way for businesses to know their customers. We expect to see even greater levels of personalisation moving forward, with retailers leveraging their data analytics to present a more tailored offering to their consumers, thereby driving increased traffic, both physically and online. For omni-channel businesses, we believe that greater insight will be driven by combining databases for online and in-person customer interactions.
- **Direct-to-consumer growing in prominence.** In retail, we are seeing brands looking to grow their DTC offerings, thereby squeezing out a number of smaller retail partners. The brands are now looking to connect more directly with their consumers. We expect that multi-brand retailers that will maintain their premium positioning with the brands, will be those offering a unique experience or exposure to a customer base or a level of customer loyalty that the brands cannot achieve themselves. Brands want more data about customers to help with better assortment planning and demand forecasting. Retailers can provide this and it should be a win-win relationship.

Consumer – Artificial Intelligence Activated

Over the next decade AI will become a critical component of every part of consumer companies' businesses from R&D to manufacturing and sales & marketing. While the prior decade has been mainly focused on understanding the potential benefits of AI and acquiring capabilities, we believe the next decade will be centered on putting the concepts into actions. We see many applications of AI in the consumer space in terms of internal processes (improving operational efficiencies with greater automation, accelerating R&D) as well as external outputs (AI-enabled products and services, more personalized product offerings leveraging consumer data).

- **Automation across the organization.** From an internal organizational standpoint, we see broader application of AI as significantly improving the efficiencies of consumer staples companies from manufacturing (AI/machine learning, 3D printing, robotics) to packaging (automation of variety packs), marketing (AI-enabled analysis of consumer data), as well as talent acquisition and employee training. We'd expect these improvements will result in increased efficiency for consumer companies, leading to cost savings and potential margin improvements.
- **Accelerated R&D and reduced time to market.** We believe one of the main advantages of broader AI applications in consumer products will be the acceleration of R&D cycles and the reduction of the time it takes companies to bring new products to the market. AI will enable consumer companies to process the increasingly high amount of data collected through social media, e-commerce websites, wearable devices, to develop products

customized to individual consumers in a shorter timeframe. Accelerating the speed to market has been a key area of focus for most consumer companies given consumer preferences are changing faster than in the past and being able to respond to consumer preferences will be a key driver of market share performance. This is particularly true as a number of venture-capital backed start-ups have emerged in the CPG space, providing a more nimble competition to large-scale consumer companies. As a result, companies that will be able to successfully integrate AI and data analytics into their R&D and innovation processes, will be the relative market share beneficiaries in the next decade.

- **AI-enabled product offerings.** AI will also allow companies to offer new products and services that are more customized, which will be key as consumers will demand more and more personalized product offerings (as we discussed in the Individual Revolution section). Examples of AI-enabled products include several beauty products and brands, such as Proven, a skincare company that feeds consumer data into its AI platform (containing more than 100,000 products, 8M+ testimonials, 4,000+ scientific publications) to provide the most effective ingredients for users, or Atolla, a company which uses AI capabilities to customize facial serums for consumers using data collected to test. New AI-enabled devices are also being launch, such as Perso by L’Oreal, the first AI-powdered device able to formulate and dispense personalized skincare and cosmetic products, or Keurig K-Supreme Plus SMART, a coffee pod machine that recognizes the K-cup pod used and customizes the brew settings to that particular coffee pod.

Consumer – Hybrid Living

As consumers adapt to a new hybrid way of living with less focus on physical spaces and an increased importance of virtual and digital spaces, consumer companies need to rethink their internal structures to adapt to a new working environment and also need to increase their marketing and advertising reach into the virtual world. Traditional consumer companies have succeeded for centuries in the physical world and have been able to build very strong brands with their presence at retail and on-premise locations, large advertising campaigns, sponsorships of mass gathering events, and celebrity endorsements. With a change in the ways of living for most consumers globally, consumers companies will face many challenges to keep their brands at the top of mind of consumers.

- **Future of work and rethinking of workspaces.** The COVID-19 pandemic has clearly accelerated a shift in the work environment from the office to the home, or at least a hybrid model. One of the key findings from the pandemic was that a large majority of white-collar jobs could be performed entirely remotely with increased productivity and reduced costs for employers in the form of lower travel and office expenses. While near-term we expect many companies to push to at-least a partial return to the office, we believe the long-term trend towards remote working is clear. A recent Gallup poll showed that 45% of full-time U.S. employees worked from home in September 2021 either entirely (25%) or partially (20%), a still very high number, albeit down from 69% at the beginning of the pandemic. Among white-collar employees, 67% of full-time workers worked at-home in September vs. 83% at the beginning of the pandemic. Importantly, employees working remotely are happy with the new work arrangement, citing avoiding commute time, improved wellbeing, and better work/life flexibility as the main reasons for their happiness. We believe it will be hard for companies to call back white-collar workers with return to the office mandates as ~54% of current remote workers saying they likely or extremely likely to quit their job if employer does not offer remote or hybrid work options. As a result, we’d expect many companies to right-size their office spaces, offer hybrid work solutions to retain talent, and potentially go fully virtual in the not-so-distant future. We also believe new start-ups will likely adopt the virtual model, having a potential competitive advantage vs. larger companies in terms of lower SG&A expenses. As an

example, hair care company Olaplex, which recently went public, operates a completely remote working model.

- **Cocooning and reduction of physical social interactions.** One of the key consequences of increased remote working is a reduction of social interactions, leading to more isolated lives. This trend was already occurring pre-pandemic, particularly among younger consumers. Based on a 2016 YPulse survey 70% of millennials and teens indicated they would rather stay home than go out on the weekends, a trend exacerbated by the rise of social media interactions, digital platforms, videogames, and virtual reality. We'd expect this trend to accelerate with a new generation of consumers growing up in the COVID-19 era and, as a result, more likely to avoid large gatherings, large social interactions, and with less occasions to spend time with friends/coworkers due to changes in the work environment. In this environment, consumer companies will be forced to evolve their marketing and advertising strategies focusing on reaching consumers where they spend their time (social/digital platforms, videogames, virtual reality) and finding ways to recreate some of the experiential aspect of their brand in a home environment.
- **Gamification of everything.** According to the 2021 essential fact report from the Entertainment Software Association, nearly 227 million Americans across all ages play videogames (up from 150 million in 2015), or ~68% of the U.S. population, with about two-thirds of adults and three-quarters of kids under 19 playing video games weekly. Additionally ~51% of gamers spend 7+ hours per week on videogames. The rapid increase in videogame usage over the last decade and further increases in the adoption of virtual and augmented reality will force consumer companies to shift from the physical world towards the virtual world to reach their consumers. As a result, we see an increase in in-game advertising, allowing companies to showcase their brands within videogames, and we'd expect companies to use virtual reality to market brands more broadly.
- **NFTs.** The rise of Non-Fungible Tokens, "NFTs," unique (as in irreplicable), blockchain-derived digital assets, ranging from music to art, fashion, sports, will allow consumer companies to bridge the physical and digital experience and deepen consumer relationships. In our vision of the future, programmable NFT certificates could deepen brand-customer relationships by unlocking certain features to reward consumers based on the depth of interactions with the brand. Some companies are already leveraging NFTs to strengthen consumer relationships in a digital world. For example, cosmetics company e.l.f. Beauty recently launched NFTs for its most popular beauty products, with those purchasing the NFTs also receiving a certificate of authenticity and ownership. High-end fashion brands, such as Dolce & Gabbana and Jimmy Choo, have also recently launched their own NFTs.
- **Bespoke formats are more desirable.** We believe that further localisation is likely to be a particular theme within retail in order to foster a unique buying experience. This is likely to be the case particularly within the travel retail space. We expect that landlords now look for operators that can custom-make a store to suit the key demographic travelling through a specific airport, in order to maximise footfall and thereby revenue. The use of data to analyse customer spend patterns is likely to be key in order to allow operators to adapt to rapidly changing consumer spending patterns.
- **More than just a store.** We think that the most forward looking retailers have transitioned their stores away from just a selling location into event hubs. For example, we note that certain retailers have been hosting regular events and performances in their stores in order to generate footfall and to showcase product. We expect that this will become a wider theme in the sector over the next decade, with stores becoming more of a destination for consumers.
- **Robotics leading to the "mall of the future."** In markets such as South Korea, we have been seeing the growth of shopping malls that seek to provide a more relaxed shopping environment for the consumer, such as the newly opened Hyundai Seoul mall. This

involves the use of robots to greet customers on entry, wider passageways and more natural light. In order to promote the idea of “retail therapy,” the mall has incorporated rest and recreational spaces and indoor gardens. We see these developments as an indicator of what is to come in the global retail space, with physical retailing becoming increasingly experiential.

- **Benefits of the digital channel.** Digital ordering has been a tailwind for restaurants’ average check growth, driven in part by larger order sizes and a higher average number of items per check (also benefitting margins). Restaurants have also used digital-only promotions to increase customer engagement, and as a result, drive higher frequency. Beyond driving sales growth via higher average check, other benefits of digital include operational efficiencies (e.g., improved speed of service), and the development of key marketing tools.
- **Growth of loyalty programs.** Given the recent rapid adoption by customers of restaurants’ digital ordering capabilities, more large, mature, fast-food brands have rolled out their own – in some cases, long-awaited – loyalty programs. Some of the restaurant industry’s most successful loyalty programs – notable examples include those for Domino’s and Starbucks – have not only driven order frequency, but have also provided restaurants with key insight into customer behavior for marketing purposes.
- **Restaurant development & reimaging.** Given the growth in digital ordering and the resultant impact on restaurants’ off-premise sales channels, restaurant prototypes are now evolving towards digitally enabled formats or features, including restaurants with dual drive-thrus, mobile pickup lanes and digital menu boards. Major fast-food brands, including quick service and fast casual concepts, have introduced new prototypes that incorporate more technology throughout, highlight takeout and delivery and improve operational efficiency.
- **The emergence of virtual brands and ghost kitchens.** The rise of these formats (off-premise-focused channels, with food prepared in central kitchens or existing restaurant kitchens that have excess capacity) ramped up during the pandemic, and in some cases, have rapidly driven meaningful levels of sales. For casual dining brands in particular, given how they are used (i.e. a majority dine-in) and frequency of use (i.e. less habitually used than a QSR brand), virtual brands have been a significant driver of off-premise sales.

Consumer – The Great Balancing Act

As the world population continues to rise access to the limited amount of natural resources as well as data and technology access will become increasingly important and will lead to rising in geo-political tensions, increase in cyber terrorism incidents, and trade conflicts among nations. This will create an even more challenging operating environment for consumer companies, particularly multinational companies with operations in several markets around the world. We’d expect multinational companies will have to localize their business, increasing autonomy of local regions, and will have to find new ways to secure raw materials in a challenging global environment.

- **Geopolitical tensions.** The UN World Population Prospects study sees world population reaching 8.5 billion by 2030 (from 7.9 billion in 2021), 9.7 billion in 2050, and 10.9 billion by 2100. Humans are already consuming more natural resources than the planet can continue to sustain, with a 2021 study showing the current world population is using 173% of the world’s total biocapacity (i.e. an ecosystem production capacity of natural resources and its absorption of materials such as carbon dioxide from the atmosphere). As world population continues to rise, we believe access to natural resources will become increasingly challenging and lead to geopolitical tension between nations, particularly between the current developed world (US, Western Europe) and the emerging global powers (China, India). In addition to natural resources, we’d expect significant tensions

will rise among nations for the control of data and technology, which have already become the key drivers of economic development. We'd expect these factors will create a challenging operating environment for many consumer companies, particularly multinational companies with significant operations overseas.

- **Cyberterrorism.** We'd expect the next decade will see more cyberterrorism incidents, both state-sponsored and privately-sponsored, as well as an increase in cyber wars compared to traditional military conflicts. According to statistics reported by Norton, in 2020 the FBI received more than 2,000 Internet crime complaints per day, and the first half of 2021 saw a 102% increase in ransomware attacks compares to the same period in 2020. According to Cybersecurity Ventures, global cybercrime costs are expected to grow by 15% per year through 2025 reaching \$10.5B annually. The May 6th ransomware attack of the Colonial Pipeline was a well-publicized example, leading to significant disruptions in the Southeast. Consumer companies were also targeted, with a ransomware attack on meatpacking company JBS affecting 10,000 employees in June 2021 and causing an increase in meat prices. With the rise in cybercrimes, cybersecurity measures and data protection will become more important for consumer companies because of the potential damage to business operations, as well as reputational risk with data breaches.
- **Localization of multinationals.** Globalization has been the major economic force over the last century and allowed many U.S. consumer companies to expand their presence across the world and establish some of the most well-recognized brands globally (think Coca-Cola). While we don't expect globalization to reverse, we believe large-scale multinational consumer companies will have to increase the localization of their operations to more effectively compete in a challenging geo-political environment. This trend has already started with many consumer products global companies pushing responsibilities to the local markets and changing their organizational structures to be more nimble and make decisions locally in a quicker way. For example, Procter & Gamble and Coca-Cola have both announced global reorganizations removing layers of approvals and pushing decision-making closer to the consumers. More localization should allow multinational consumer companies to respond faster to changes in local consumers, compete more effectively with local competitors, and better navigate geo-political challenges.
- **Raw material sourcing challenges.** With our expectations of increasing geo-political challenges, cyber-attacks, and conflicts globally, we'd expect that raw material sourcing will become incrementally more challenging for consumer staples companies over the next decade. This will be a particular challenge for commodities, where production is concentrated in a few countries. Cocoa is a clear example, with over 60% of the global production concentrated in the Ivory Coast and Ghana. We believe companies relying on such commodities, for example chocolate companies such as Hershey's and Mondelez, will need to find ways to secure raw materials with longer contracts or diversify their sources to ensure availability of raw materials.
- **Peer-to-peer platforms driving resale in retail.** We think that digital developments in the form of peer-to-peer resale platforms have made it quick and easy for consumers to access the second-hand market, with minimal direct involvement. These platforms also allow consumers to access both sides of the market, as both buyers and sellers. Looking forward, we expect greater demand for newness but also sustainability to drive peer-to-peer resale as a way to refresh consumer wardrobes at a low cost, supporting both value-for-money and sustainable purchasing.

Energy and Utilities

Energy and Utilities – The Quest for Immortality

From a sector perspective, we believe the drive to extend individual life spans as well as the quality of life for future generations will continue to have an impact on how we produce energy and how we consume energy. Specifically, we see the key theme impacting the sector as revolving around the shifting nature of energy demand to "green" energy, which includes utility-scale renewables, distributed renewable generation, "greening" conventional energy production, and emerging technologies.

- **Addressing the existential risk related to climate change.** Whether it be a view of a broad existential risk to the human race or just the existential risk to hydrocarbon produced energy, we believe steps being taken to address climate change will be a key driver for investment themes well into the future with many of these infrastructure-based solutions creating numerous large-scale multi-billion dollar investment opportunities.
- **Carbon capture will be an important part of addressing climate change.** As highlighted in a recent RBC ESG Stratify™ report titled *Carbon Capture & Storage – Dare to Dream Big* ([please click here](#)), we believe carbon capture, use and storage (CCUS) has a wide-range of applications within the sector, including providing the potential to use existing hydrocarbon resources on a zero-emission basis. However, economic returns are fragile given the capital intensity and reliance on carbon prices and/or government policies and we look to a combination of incentives, penalties and economics from using carbon production to help underpin returns to accelerate the buildout of CCUS facilities.
- **New energy generation technology as well as increased use of lower carbon fuels will be key to baseload supply.** Many existing renewable energy technologies suffer from being intermittent resources (i.e., their supply is variable and/or at times when the energy is not needed) and currently, those resources are often backed up by carbon emitting generation such as natural gas-fired facilities. As such, we see an opportunity to enhance baseload supply via emerging technologies such as nuclear fusion (especially from small modular reactors) as well as decarbonizing fuels (e.g., hydrogen, renewable natural gas) for combustion turbines will also be key.

Energy and Utilities – The Individual Revolution

Individuals will have increasing options to take greater control of their energy consumption, how energy is produced and where energy is produced. In addition to shifting patterns for energy consumption (e.g., time of day, location), we believe some individuals will take further steps to go "off the grid" or look to supply the grid with electricity via generation and/or connected battery storage (i.e., "Prosumers").

- **Prosumers: a new work-from-home income generating opportunity.** To date, utility-scale renewable facilities have been the major driver behind a significant increase in the mix of electricity coming from "green" sources. However, improving economics behind distributed generation and smaller-scale battery technology could underpin the rise of "Prosumers," who provide excess generation back into the grid with another benefit being reduced transmission "line losses." To date, distributed "net generation" capacity has been relatively immaterial, and in some jurisdictions, regulators have stifled the economics.
- **What's in it for me?** With energy from "traditional" sources being reliable and affordable, we believe policy-makers and regulators will need to use a combination of carrots and sticks to change consumer behavior. On the incentives side, we see the potential for a broader roll-out of subsidies to electrify heating sources (e.g., converting from a furnace to an electric heat pump) or changing utility regulatory frameworks to provide enhanced

economics for customers that produce power into the grid or provide ancillary services such as battery reserves (e.g., from their electric vehicles). For penalties, we note the increased use of carbon taxes or time-of-use pricing can help push consumers to lower carbon energy consumption choices.

Energy and Utilities – Artificial Intelligence Activated

The use of artificial intelligence has a broad range of direct applications, particularly in the utility space, and indirect implications for the oil and gas sector. Generally speaking, we view the role of AI as one of improving efficiency and safety in the Energy and Utilities sector.

- **Coordinating the grid including distributed battery storage.** Artificial intelligence can optimize what will likely become an increasingly complex system of generation supply and customer demand. Specifically, we see applications for AI including the coordination of utility-scale power generation facilities and smaller distributed generation, including the use of electric vehicle batteries for storage and discharge.
- **Predicting demand and providing customers with the ability to shape energy usage.** On top of the role of AI in managing the electric grid, we believe that AI can help consumers optimize their energy usage, particularly in jurisdictions with time-of-use pricing, as well as maximizing the efficiency and net-cost/net-revenue for "prosumers" who can provide electricity back into the grid via distributed generation and/or offering up their electric vehicle batteries as storage (without sacrificing a charged battery when the consumer needs their vehicle). Instead of consumers and businesses being reactive and having to take action to optimize energy consumption, AI-driven solutions can be proactive by incorporating demand patterns and external data (e.g., weather) to provide consumers with greater comfort (e.g., heating or cooling) and savings (e.g., automatically reducing energy usage when it is not needed).
- **Optimizing maintenance schedules including enhanced pipeline integrity.** Companies in the sector are using machine-learning techniques to process vast amounts of data to identify equipment defects and estimate time-to-failure rates that allow operators to optimize the inspection and replacement schedules with the aim of increasing reliability and reducing the total overall cost (including costs related to unplanned outages).

Energy and Utilities – Hybrid Living

We believe a greater focus on the "home as a hub" will result in changing consumption patterns (e.g., location, time of day, nature of the energy consumed) and accelerated adoption of distributed generation.

- **Rising residential consumption could lead to increased overall energy demand (at least temporarily).** With factors such as hybrid work and a shift from multi-dwelling units to larger homes outside of the cities, we see a shift to increasing residential energy consumption. However, we believe this could drive higher overall energy demand given lower efficiency associated with residential energy infrastructure (e.g., air conditioning units) versus those in office buildings as well as it being unlikely that commercial floor plates will shrink in tandem with the rise in hybrid work (i.e., office buildings will have full lighting, heating and cooling in addition to rising residential energy consumption).
- **A concentration of residential energy demand could result in a greater degree of distributed resources.** If households concentrate more of their activities around the home, increased electricity consumption in a residential environment (and away from commercial consumption) could lead more consumers to look at distributed renewable energy resources (e.g., rooftop solar).

Energy and Utilities – The Great Balancing Act

We believe that government policies and regulations that will drive the pace of decarbonization investment may have unintended consequences that could drive greater socio-economic and geopolitical divides. On the flip side, as we have seen in the fight against COVID, the ability to direct resources to address the global pandemic has resulted in numerous breakthroughs in record time.

- **An aggressive energy transition appears set to drive a bigger wedge in the socio-economic divide.** We believe that many policies and programs that could be put in place to support the energy transition may have the unintended consequence of further exacerbating the gap in wealth. For example, we see unintended consequences from carbon taxes being used to drive electrification (e.g., the wealthy can easily absorb the upfront costs of switching to electric vehicles and heating infrastructure), and distributed generation where renters, those living in high density housing or those who cannot afford the upfront costs (e.g., rooftop solar deployment and battery backup) will not have the opportunity to profit from "net generation" (or worse, these consumers may face higher utility costs if wealthier individuals go "off the grid" resulting in the socialization of utility costs among a smaller base of less wealthy individuals).
- **Geopolitics: a new era of cooperation or a new front for division?** While there may be increasing coordination in terms of high level aspirations (e.g., Paris carbon reduction targets), the energy transition has the potential to drive increased global tensions as it relates to: (1) countries that are unable (or unwilling) to take the steps, and bear the cost, of meeting their Paris targets; (2) countries that are currently major hydrocarbon producers that face the existential risk to the economics underlying oil and gas production and at the same time the potential of increased near-term geopolitical power given currently high oil and gas prices with the likelihood of a continued increase in demand for oil and gas in the coming decade; and (3) the race to secure raw materials critical to components of the energy transition (e.g., cobalt for batteries), many of which are located in geopolitically sensitive areas.
- **Technology poised to play a major role in offsetting politically unpalatable rising costs.** While there is a push for electrification, we believe that transitioning residential natural gas-based infrastructure (e.g., furnaces, boilers, hot water heaters, stoves), which is predominant in cold-winter climates will come at a significant cost to the point where we do not believe it will be politically palatable to force that cost onto individual consumers (and by extension, voters). As an alternative, we look to emerging technologies such as small-scale carbon capture, use and storage (CCUS) in residential applications, greater use of automation (both supply and demand response) to reduce the overall cost of energy and the energy delivery system, and the continued reduction in the cost of existing renewable technology (e.g., solar, batteries, renewable fuels) as well as the potential for new clean energy technology (e.g., hydrogen, nuclear fusion).

Financials

Financials – The Quest for Immortality

From a sector perspective, we believe that the quest for immortality will drive consumers to seek out all kinds of new and alternative healthcare measures and services, and therefore solutions will need to be developed to help finance this activity. Specifically, we believe the success of BNPL installment lending within retail goods and services and lead to similar types of financing measures for healthcare. Longer term, we believe that consumer digital health records can even be incorporated into this financing, effectively creating risk grades and/or rewards systems. As life expectancy also continues to expand, consumers will demand sophisticated wealth management products that can provide predictable income sources that can last the rest of their lives.

- **Success of Buy Now Pay Later (BNPL) will translate to installment lending towards all kinds of healthcare treatments.** While the quest for immortality may be therapeutically making progress, consumer's ability to finance this noble quest is far more cryptic and aiding to the ever-widening wealth/health gap. Given the recent success in the Buy Now, Pay Later movement, we believe similarly structured products will spill over into consumer healthcare and more specifically post insurance payments. We foresee a world whereby installment lending, based on a credit profile, capacity to pay, and insurance plan, will be used to offer individuals specific payment plans in advance of procedures. This type of innovation could be coupled with a consumers' digital health records directly into a health tracking App (think Apple Health), as a means to determine the insurance algorithm, which would effectively work as a rewards system.

Financials – The Individual Revolution

Individuals will increasingly become aware that they have value as the ultimate end-product for social media and technology companies. Thus we believe the concept of "self-monetization" will become an increasingly prevalent theme as consumers wrest control of their data for themselves and attempt to monetize it through technology. Additionally, we believe that the increased use of block-chains should help generate change in business models across the banking sector over the next several years, as well as promote the use of digital currencies.

- **Self-Monetization should be an increasingly prevalent theme as consumers start to realize their own value in the context of social media.** As consumers increasingly recognize that they are the product as it pertains to consumption of social media, we believe companies' ability to extract vast amounts of data freely from consumers is coming to an end. As a result, we believe there needs to be a mechanism to exchange the value to consumers from social media companies such that consumers can be rewarded for the use of their personal data, a concept we refer to as self-monetization. Digital tokens are well equipped as a means to monetize personal data, which can easily be transferred to a consumer's digital wallet and/or the social network's platform. We believe that millions of individuals could then be tethered to specific organizations that rely on aggregation of mass data. We believe tech platforms that monetize our data for free will have to create a similar direct monetization channel. If we look to the creator economy as a guidepost for the self-monetization economy, we believe the opportunity could prove very large and disruptive.
- **Blockchains can help drive accelerated model change within the financial sector in time. For consumers, digital currencies and stablecoins can be used to on-ramp financial transactions.** Though it remains to be seen if the overall number of blockchains increases or declines, in highly specialized and regulated markets like banking and finance, we

currently expect to see an increasing number of specialized blockchains. Ultimately, we expect these blockchains to change the business models of some businesses within their respective ecosystems. Some businesses will be more impacted than others, with some thriving from new or enhanced value propositions, while others facing continual structural pressures. With the OCC giving banks approval to issue stablecoins for banking transactions, it could be possible for different banking stablecoins to emerge with the potential for one taking dominance the next two years. The stablecoins would be used to on-ramp financial transactions on a blockchain, but could also potentially be used as a form of real-time gross settlement.

Financials – The Great Balancing Act

We believe that sustained climate change could have profound long-term impacts on P&C insurers as climate and weather patterns become more severe and unpredictable, while the proliferation of infectious disease will impact life insurance. For the banks, green financing solutions are rising, and we believe that increasing government mandates and regulation to support sustainability could have modest negative impacts on the banking sector in general through stranded assets, higher capital needs, and rising loans.

- **Property and Casualty Insurers face rising catastrophe frequency and severity as climate and weather patterns change over time.** P&C insurance companies have been at the point of the spear of climate change for several decades bearing direct financial responsibility for the impact of severe weather events, an increase in natural disasters and related human made catastrophes. Our property and casualty insurance coverage faces the most clear impacts from climate change with the most glaring impact being the changing nature, frequency and strength of both normal and catastrophic weather events. In simplest terms, climate change makes weather and catastrophic events more frequent, more severe and more unpredictable, which proves a distinct challenge in risk management and modelling.
- **Life mortality and morbidity could be impacted by increasingly contagious and deadly diseases, as well as potential increases in exposure related casualties.** Climate change could have drastic impacts on life expectancy through the further proliferation of infectious disease, which could impact morbidity and mortality assumptions for insurers. Changes to society from relocation of individuals into cities could also impact life expectancy. Finally, climate itself will also take a toll as death from heat exposure and cold exposures become more frequent as weather becomes increasingly irregular and life-threatening events become more frequent.
- **Transition to Green Financing will impact long-term bank profitability.** The transition to sustainability will impact the profitability of banks and other financial institutions. Stranded assets, higher capital requirements and higher loan losses are potential risks to bank profitability longer term. On the other hand, those banks that have positioned themselves well to support this transition, should gain market shares (e.g., in green bond issuance, financing of renewables, sustainable investments) and attract a premium in share prices for their reputation.

Financials – Artificial Intelligence Activated

With massive gains in technology and cost savings, bank systems now appear to be designed for more iterative development and extensibility. Banks have been quickly adopting AI over recent years, but we believe that penetration of AI in the banking sector is still limited and that there will be a profusion of trials and errors on where investments are made over the next several years. We think AI investments and development, however, will follow a path similar

to what we have seen in bank M&A – far more likely to realize one’s own cost savings than to generate new revenue synergies.

- **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. We have seen many banks overhauling business processes that are overly complex with lots of paper being pushed. Employees who have been the most impacted are back-office workers who handle data entry and/or data management and anything paperwork related. We expect banks will continue to methodically review their business processes to understand the steps and resources required and to completely overhaul the process with AI bots where prudent.
- **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 improve. Aside from chatbots and virtual assistants replacing call centers and becoming increasingly able to offer customers personalized insights, 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.
- **Risk management/fraud detection to be further augmented and strengthened with human interaction.** 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.** We believe that as this segment, AI-based trading, 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. There will be a continued arms race to develop smarter AI programs with each iteration.

Financials – Hybrid Living

Our belief is that the industry’s shift towards mobile banking and the increased portability of every-day financial transactions into phones has already occurred. In the years ahead, in addition to mobile phones the banking experience will be delivered to consumers across other connected smart devices while offering continuously improving user experience and functionality. The ability to interact with your bank through any channel in any location will be table stakes.

We are seeing this transition being powered today by newer fintechs that are increasingly focused on capturing market and mind-share of younger millennial and Gen-Z demographic cohorts through the proliferation of peer-to-peer services and applications. The banking sector has already and is likely to continue to spend billions over time overhauling digital banking capabilities and streamlining branch networks to accommodate the preferential shift towards mobile banking as the primary form of consumer banking.

Healthcare

Healthcare – The Quest for Immortality

We believe that no sector is better poised to both capitalize on, and drive, the quest for immortality than healthcare. We have seen major breakthroughs in oncology, infectious disease, and brain health, and have seen how rapidly the translation of basic science into paradigm shifting medicine can happen, as evidenced by the rapid development of the COVID-19 vaccines. The sector's promise and focus on innovation can attract new capital, but we expect growing pains too – increasing regulatory scrutiny, as well as budgetary challenges in making life changing medicines available equitably to all.

- **New breakthroughs bring opportunities to patients and investors.** Over the past decade, we have seen many new drugs approved for both rare and common diseases that have both extended lives for patients in highly meaningful ways (hepatitis C cures, CFTR modulators in cystic fibrosis, etc.), demonstrating a clear value proposition while also securing multi-\$B franchises for their developers. We expect this innovative core to remain a driver as we enter the next legs of drug development, focusing more heavily on biologics, cell therapies, gene therapies, and gene editing, and we already see hints of potential paradigm shifts on the horizon, ranging from the targeting of previously undruggable cancer mutations such as KRAS, to the correction of lethal childhood muscular dystrophies. As companies continue to push the limit of innovation, we see bold ideas reaching the capital markets earlier and earlier, and expect biopharma to begin to tackle aging itself.
- **Expect the sector to grapple with cost, access, and the challenges of continuing to innovate.** On the flip side, bold ideas may not always make for successful products (CAR-T uptake challenges in oncology, gene therapy struggles in the EU), and finding the right balance between cutting edge treatments, pricing, and access may prove to be a continuing challenge in healthcare. Truly transformative treatments are hard to come by, and we expect biopharma to continue to struggle with Alzheimer's, Huntington's, and aging over the course of the next decade, despite the possibility that a major breakthrough can come at any time. Further, as the "low hanging fruit" is picked off, we can expect greater spend on R&D, which needs to be recouped, and greater regulatory scrutiny for showing meaningful benefits to patients, all potentially leading to higher drug prices, further straining an already fragile healthcare system.
- **Remote 'Tele'surgery:** Remote surgery capabilities include a range of solutions to make surgery more accessible. This includes digital case support platforms that connect medical device teams to providers and allows them to remotely share best practices and collaborate in real-time during a live procedure. Remote surgery capabilities are being adopted by a wide range of users, but Remote telesurgery is in the future of medical device surgery and Remote stroke intervention is the 'holy grail' for remote surgery as time is of the essence.

Healthcare – The Individual Revolution

Personalized medicine is no longer confined to our dreams – it is here, and present in a wide range of healthcare services, from genomic sequencing of cancer to tailor treatment to an individual's tumor profile, to rare pediatric diseases being treated with gene therapy, to the promise of gene editing correcting a patient's mutation within their own body. We continue to see personalized therapeutics making waves and moving from rare diseases to more common indications, potentially expanding the total addressable market and leaving fewer and fewer patients behind.

- **Expect continued investment in gene therapy, ASOs, cell therapy, and gene editing.** The estimated capital deployment across these four areas has grown from \$27B in 2016 to \$140B in 2021 (see Exhibit 41), and we would expect these trends to continue, with gene editing potentially being the growth leader. However, we acknowledge that in biotech, progress is not often a straight line, and we could see less successful programs fall by the wayside, due to off-target adverse events, low efficacy, or poor commercial execution, and drive greater investor caution and moderate the capital influx into this space.
- **Continued expansion of personalized medicine has the potential to drive long-term biopharma growth.** As technologies improve – most notably more accurate gene editing, better tolerated conditioning regimens, and allogeneic cell therapies, we anticipate that these breakthroughs will gradually make the promise of personalized medicine available to most patients. Those currently excluded because of their immune system, the rarity of their genetic mutations, or because their disease is too advanced, will become eligible as technology improves to treat patients better and faster, which could help grow the market over the long term. Finally, as these better technologies scale, we expect both patients with ultra-rare diseases (which currently may not be economically viable to pursue due to low patient numbers) to benefit, as well as those with more common diseases with cheaper standard of care therapies, as the value proposition of a personalized genetic approach becomes more favorable.
- **‘Smart’ implants and remote patient monitoring:** Smart implants are implantable devices that not only provide therapeutic benefit to treat an underlying disease, but also provide diagnostic capabilities. Smart implants allow for patient monitoring up to two decades post-surgery (e.g., in knees) and may result in improved diagnostic capabilities overtime aided by artificial intelligence. Smart implants could be game-changing for the medical device industry over time as data obtained from the devices could lead to refinements in implant designs, surgical techniques, and strategies for post-operative care as well as rehabilitation.

Healthcare – Artificial Intelligence Activated

R&D costs are one of the top cost drivers in biopharma, and consequently, healthcare as a whole, and more efficient processes can increase the hit rate, develop better drugs, and speed development while reducing costs.

- **Expect greater collaborations between biopharma and tech as well as potential validation of the approach over the next decade.** We are already seeing the seeds of biotech and big tech collaborations being planted, with giants such as MSFT and NVS collaborating, but also among smaller biotechs with AI driven pipeline and discovery platforms. Over the next decade, we expect to see if AI can truly lead to better molecules which navigate the clinical and regulatory hurdles of drug development better, potentially saving billions in costs, or whether human input and rational design is still essential in therapeutics.
- **AI has the potential to bring down healthcare costs by maximizing efficiency and alleviating labor shortages.** With 5–10% of hospital employees employed in the revenue cycle, processes to automate the patient experience and billing cycle could significantly improve the traditionally thin margins of the hospital systems. We expect greater adoption of automation software, and expect it to reduce hiring pressures, alleviate staffing shortages and affect most steps in the billing process from patient scheduling to claims denial management.
- **Autonomous robotics:** One of the most significant innovations in medical devices has been the advent of robotics that has seen strong adoption. Despite that, robotics is still in its infancy with respect to the scale and scope. It appears to be a moonshot opportunity today, but eventually we believe surgeries will be done by autonomous robots controlled

by artificial intelligence (AI) algorithms that receive input from an array of visual and haptic sensors. Robotic surgery has advantages that should minimize surgical variations and make it the standard of care over time. We expect the field of robotics will continue to expand beyond soft-tissue surgery.

Healthcare – Hybrid Living

While the pandemic accelerated the growth of virtual healthcare and telemedicine, we have reason to believe that these trends will outlast the COVID-19 pandemic and become a mainstay of healthcare. By offering more convenient service, faster scheduling, ease of access to specialists, reducing costs, and actually delivering care in the home, we believe virtual healthcare can add value and improve outcomes, and we expect continued growth and investment in the sector.

- **Virtual healthcare can bring high quality, complex patient care to the patient while keeping costs low.** Telemedicine is more than just video conferencing, and can range from mental health visits and tailored prescriptions, to nudges and checkups on behavioral, exercise, and nutritional goals, and even hospital at-home services which can provide care for asthma, COPD, heart failure and pneumonia. Increasing engagement and simplifying logistics can benefit both patients and providers, and we believe the quality of care, bolstered by new technologies and devices, is being underappreciated by the markets and we remain bullish on the sector's growth, even beyond the COVID-19 pandemic.
- **Immense opportunity is being bolstered by strengthening tailwinds.** The U.S. spends over \$3T on healthcare annually, underscoring the potential size of the market that can be addressed – and we see room to grow, as adoption is still in the early stages. We believe empowered consumers, more advanced technology, greater data validating the link between telemedicine and positive outcomes, and the easing of the reimbursement and regulatory landscapes, combined with integration and collaboration with the software industry, will drive accelerating growth in the coming years.

Healthcare – The Great Balancing Act

Healthcare has traditionally been considered a highly inelastic good – and the placing of dollar value on a human life and well-being (either directly or indirectly through drug pricing) has been extremely controversial, underscoring the need to find an appropriate balance of public vs. private interests in this sector. Across the globe, we see that each country finds this balance in a unique place, but also the U.S. dominance is being challenged by innovative companies from China, where R&D spending is rapidly accelerating.

- **Striking the balance between innovation and access will likely be a key theme in the years to come.** The rising cost of healthcare is often cited as a top issue among the U.S. electorate, but on the other hand, high-priced medicines with long patents are important to recoup R&D costs and drive new, high-risk innovation. With continued deadlock in Congress for the foreseeable future, and no clear solutions on the horizon, we expect the debate on how to manage costs to continue over the next decade, the uncertainty of which can pose an overhang for the sector and continue to keep generalists out.
- **Growing international threats to the U.S.'s biotech dominance may continue to keep the sector in focus.** China aims to increase its R&D spend by 7% year over year, and with a focus on cutting edge industries and vaccine diplomacy, the country is positioning itself as a major biotech force. We believe striking the right balance between international collaboration, a major driving force in science, and national interest, particularly when it comes to supply lines and technical skills for essential medicines, will be a focus and could



drive both U.S. government investment (through moonshot initiatives and ARPA-H) and greater regulation of the industry and potential on-shoring requirements.

Industrials

Industrials – The Quest for Immortality

The primal drive to extend individual life springs eternal, as well as the quest to improve the quality of life for future generations. These drivers will continue to have an impact on how industrial companies operate and interact with their customers, suppliers, and employees. Specifically, we see the key theme impacting the sector as revolving around developing new products and services that improve safety and/or produce better health outcomes.

- **Automated smart vehicles can reduce fatalities and increase productivity while also providing potential health monitoring benefits.** Crash injuries are estimated by the WHO to be the eight leading cause of death globally for all age groups, and 94% of serious crashes are due to human error. As a result, autonomous vehicles have the potential to be dramatically better than human drivers. We also highlight how the car is an ideal location to serve as a health sensor such as with biometrics.
- **Indoor Air Quality (IAQ)/Healthy Buildings movement arose due to COVID-19** and should improve the focus on healthy indoor environments for decades to come. The COVID-19 pandemic has been a wakeup call to safeguard our indoor environments against the spread of future contagions. The public awareness on indoor air quality and its associated potential health risks are expected to fundamentally change the way buildings air filtration and disinfection systems operate. Gone are the days of building owners/tenants accepting last-generation stale office building air circulation and the associated “petri dish” of worries.
- **Space infrastructure rapidly on the rise:** Beyond the domain of governments for national security and scientific purposes, a commercial space market is rapidly emerging. The key drivers of this market development include substantial reductions in the costs to access space, on-satellite capacity and capability expansion, and the opportunity space presents for greater human exploration.

Industrials – The Individual Revolution

Within industrials, 3D printing and gene editing equipment drive the Individual Revolution.

- **3D printing offers a new paradigm for engineering design and manufacturing.** 3D printing, also known as additive manufacturing, is a process in which materials are constructed under computer control to create three-dimensional objects. The process features machines laying horizontal cross-sections of versatile metals or other raw materials layer-by-layer by following digital blueprints drawn using computer-aided design (CAD) software. The benefits of 3D printing are myriad; it speeds up the design-build-test cycle by providing product engineers rapid prototyping capabilities so they can quickly gauge the viability of a product and incorporate design changes; it enables the production of customized components at reduced cost and time; it reduces long supply chains, manufacturing footprint, and waste; and it reduces the cost, effort, and skill barriers to produce complex parts.
- **Therapeutic applications using gene editing equipment could offer unique opportunities to prevent and treat human disease.** Gene editing is the ability to edit the molecular code of life (either DNA or RNA). Gene editing tools such as TALENs, and Zinc-Finger Nucleases, have been around for some time, but it was the discovery of the CRISPR/Cas9 system that truly revolutionized the field. CRISPR is exciting due to its high level of on target specificity, high level of editing efficiency, and versatility. As a technology, the ability to alter a gene in a living cell offers many potential benefits, including treating inherited diseases, understanding what specific genes do, generating more resilient crops and even detecting species in the environment. The technology is still young, but as the field understands

more about how best to use these molecular tools, and improves upon their safety and efficacy, we expect the future of these treatments will be for indications that are more common.

Industrials – Artificial Intelligence Activated

The use of artificial intelligence and connected devices has a number of direct applications for the Industrial sector. While in many cases industrial companies will still be producing a good, artificial intelligence and connected devices can bring higher margin services oriented revenue streams to the sector. Furthermore, the use of Big Data and advanced predictive analytics can be used to deliver valuable new insights to management, employees, or suppliers who can then make smarter, faster, and more informed business decisions.

- **While a lot of focus has been on the electrification of vehicles, we see a larger potential change in connected, software enabled vehicles.** In our view, software-enabled vehicles can drive a better, more personalized experience for customers. For example, a vehicle could become an updatable device, much like smartphones today. On the other hand, from an automaker perspective, this enables a shift from selling units to being able to sell more SaaS like, recurring revenue, higher margin services. Additionally, having access to an increasing amount of data can unlock new revenue streams for traditional automakers in other industries, such as the insurance space.
- **The freed up time a passenger gains from autonomous vehicles could lead to new sources of revenues.** Autonomous vehicles will process incredible amounts of data about the environment and the consumer. However, autonomous vehicles can also free up time as there is no longer a driver that needs to pay attention to the road. This could increase work productivity, but in many instances, this could mean an emerging opportunity for media (ads, entertainment, communication, etc.). The onus of course will be on figuring out the right data and thinking of ways to monetize this information.
- **Building the factories of the future.** The scaling potential of changes to manufacturing with the arrival of Industry 4.0 and the industrial Internet of Things is a large opportunity. We believe this can move well beyond “smart” manufacturing to complete end-to-end connectivity across the supply chain allowing for significantly richer information and flexibility. If we think about the number of IoT devices in factories and throughout the supply chain, it is possible that manufacturing can be on the same cusp of scaling that the Internet saw when it scaled as devices moved from mainframes to computers to smartphones.
- **Recent supply bottlenecks, logistical issues, and factory downtime issues have highlighted the need to strengthen supply chains.** Artificial Intelligence, robotics, and predictive analytics can help supply chains run more efficiently. While this will require some investment, it is not hard to imagine that the payback can be quick given productivity, reduced operation costs in logistics, labor, and materials, as well as working capital efficiencies.
- **Unmanned A&D technology wave of the future:** The marriage of artificial intelligence (AI) and unmanned technology is opening up new opportunities while creating new challenges. One example of this is the opportunity to use drones as loyal wingman in support of manned aircraft. There are several programs today looking to incorporate drones into missions in support of manned aircraft, especially fighter aircraft. A second example involves swarming technology.

Industrials – Hybrid Living

As individuals spend more time in their homes, both for work and leisure, the concept of the “home as a hub” will only grow in prominence. With this, we expect material changes in consumption patterns (e.g. how much power is used, when it is used, and how it is used). This will require an accelerated adoption of distribution generation, and Industrial companies will play a critical role in facilitating this transition (think residential and grid infrastructure build out). This does not require new or revolutionary solutions, but rather in general just more of the existing technology. As such the sector is well positioned to deliver on this demand, with many in our coverage already being leaders in grid infrastructure and electrical equipment.

- Hybrid living will require flexible power solutions, metering and control systems. This is incremental to existing drivers such as residential power generation (e.g. solar panels) and electric vehicle infrastructure. Industrial companies operate actively in each of these areas.
- The counter point is that lower commercial infrastructure may be needed meaning fewer office buildings, so fewer lifts, fewer electrical connections, less HVAC etc. However, if the evolution is more hybrid and office and workplace based infrastructure is maintained, the net impact would seem to be more infrastructure than before and we expect this to be the continuing trend.
- As this build out of infrastructure occurs, it will require continued datacenter growth as well (continuing the strong trends seen over the last decade). Supporting this growth will require significant development and innovation from Industrial electrical infrastructure and HVAC solutions companies.
- Regardless of what exact level of hybrid becomes the norm, we see the shift as accelerating the need for a more intelligent grid and as leaders in software automation for industrial and electrical applications our companies will be at the forefront of this implementation.

Industrials – The Great Balancing Act

The growing number of socioeconomic disparities and geopolitical skirmishes pose unique threats across the global manufacturing landscape. But with challenges comes opportunities, and the industrial sector is also acutely positioned to spearhead many of these externalities. For instance, the industrial sector is addressing the energy transition through efficient flow control solutions for hydrogen and carbon capture. A reduction of global CO₂ emissions to combat climate change is being addressed through electric vehicles, more efficient HVAC systems, and even the use of “waste fuel.” Importantly, water scarcity and security has room for improvement through the deployment of smart water systems. That said, the impact that COVID-19 has had on industrial supply chains has also caused a paradigm shift in how these industrial companies operate, from where they operate to how they manage their supply chain. Going forward, we could see a greater shift towards “in-region for-region” manufacturing footprints, with localized supply chains that hold more buffer stock in case of unforeseen disruptions.

- **The global push towards auto electrification is a positive for CO₂ emission, but battery supply remains a potential risk to adoption.** The push for electrification and a key driver of battery electric vehicle (BEV) sales thus far has unsurprisingly been regulatory measures. In the U.S., President Biden has stated a 40–50% BEV goal by 2030. In Europe, under the “Fit for 55” program, they are targeting a 55% reduction in CO₂ from 2021 levels and 100% by 2035. Likewise, China has supported the “new energy vehicle” market with subsidies. Perhaps one of the biggest risks to BEV adoption is battery supply and there is significant investment needed to increase production capacity.

- **Water scarcity and security issues are growing at an alarming rate, but solutions such as smart water and desalination are spearheading the global challenges.** The troubling collective impact of population growth, industrialization, pollution, climate change, and an overall lack of water stewardship poses a palpable threat to the planet's relatively fixed supply of fresh water. Smart water networks use connected devices/sensors, the Internet of Things, and information technology to help municipalities improve their monitoring and diagnostics capacities, optimize investment dollars, ensure proper stewardship of watersheds and infrastructure, and serve their communities more effectively.
- **Advances in "waste fuel" can play an important role in the energy transition.** "Waste fuel" is commonly described as the second-derivative fuel by-products created by the treatment of waste that is disposed of at landfills. Right now, the primary source of fuel from generated waste comes from landfill gas, which is most commonly converted into renewable natural gas (RNG). For the waste majors, perhaps the most obvious near-term use case is to have the landfill gas converted to RNG to fuel waste collection vehicles, creating a closed-loop feedback system. In our view, the waste majors are at the center of the evolving energy transition and have a crucial role to play going forward.
- **The COVID-19 shock to global supply chains are making manufacturers re-evaluate the merits of just-in-time inventory.** The COVID-driven supply chain disruptions in 2020 and 2021 exposed the risks of just-in-time inventory and long global supply chains. New technologies help improve the resiliency of supply chains, where improved visibility to potential disruptions allows companies to make adjustments before experiencing shortages and help mitigate a domino effect of shortages throughout the supply chain.
- **COVID-19 shutdown orders and elevated freight costs could push manufacturers to localize manufacturing.** COVID-19 has brought the risks around global supply chains more into focus as companies have considered the reliability of supply if they are over dependent on one country or region, and also now transport costs. Given the advances in industrial automation, we believe that the affordability equation is more balanced now today vs. historically using low-cost emerging markets to manufacture.

Materials and Mining

Materials and Mining – The Quest for Immortality

The implications for the Materials sector from The Quest for Immortality appear to be tertiary at first. However, there are many positive implications that will come from longer lives, shifting demographics and especially for emerging and frontier economies. Over time, healthier populations, living for longer could help to provide the building blocks for another long-term supercycle for mining, and longer-term demand growth for materials including uranium, fertilizers, forest products, packaging and specialty chemicals, which we discuss further below. Throughout the world, healthier lives should translate into a pickup in productivity and increase life expectancies, particularly in emerging markets.

- **Longer lives will strengthen demand outlook.** The impact on the mining sector from longer lifespans will likely act as another stress on the already strong demand outlook for metals, especially the ones critical for decarbonization. The potential for a population bulge to emerge in the 2030s (as death rates start to slow vs. birth rates) could have important demographic implications for demand. More people, living healthier and longer, will drive a need for more fixed infrastructure (housing, schools, hospitals), increasing demand for building materials like steel, lumber and coatings. Meeting increased energy demand from a growing population while achieving net zero carbon targets will likely require maintaining and growing global nuclear capacity, which should support long-term uranium demand.
- **Demand for more and better quality food will continue to rise, supporting demand for fertilizers.** Fertilizers have contributed to about half of the global improvement in crop production over the past century, and we expect demand to increase as people live longer lives and living standards improve around the globe.
- **With greater focus on health and nutrition, we believe specialty chemicals will become more essential to the development of medicine and vitamins.** One example of this is probiotics demand in Asia, which we believe could continue to grow high single digits through the next five years. Increased demand for medical products would also translate to increased demand for medical plastic packaging materials, and commodity chemicals are used as building blocks for surgical equipment and medical products.
- **I need to see a doctor, quick!** Advancements in mRNA vaccines and the adoption of telemedicine are likely to assist with the health related challenges for miners in remote countries. Mining industry giants BHP and Rio Tinto have both recently acknowledged that future growth will necessarily come from more remote, frontier countries as the industry tries to solve decarbonization's demand challenges. Improved medical access could help to smooth this transition and increase the quality of life for mineworkers.

Materials and Mining – The Individual Revolution

We believe the individual revolution could drive greater impact on ESG related topics for the Materials sector, as increased use of personal data sheds light on individual consumption patterns, and as individuals use social media to voice opinions on ESG issues, ultimately influencing corporate action on these issues.

- **As companies incorporate more data into their supply chains, we think that consumers are likely to become more conscious of their consumption habits.** Similar to how consumers are able to buy carbon offsets to cover carbon emissions during travel, we could see a future where consumers are provided the option to buy carbon offsets to cover the construction of their homes, use of other paper & packaging and chemicals products. We think that consumers are likely to care more about how products are sourced, so tracing products to the root will be key. Premiums are likely to emerge for

metals that are produced with zero carbon footprints. For dissolving pulp producers, we think that ensuring products are sustainably sourced and third-party certified will be necessary to supply major clothing brands.

- **Social media will continue to allow individuals to voice their opinions on ESG issues relevant to the Materials sector.** For example, as social media helped bring greater focus on sustainability and minimizing plastic waste, we have seen chemical companies shift focus towards recycling and setting forth aggressive ESG agendas. Over the last several years, we have seen this most profoundly in the shift away from plastic and glass and into aluminum cans, which are infinitely recyclable, and we expect new product and product conversion will continue to opt for aluminum food and beverage packaging. We think plastic packaging manufacturers will continue to invest in R&D to make their PET based packaging products more sustainable.

Materials and Mining – Artificial Intelligence Activated

Advances in AI, quantum computing, and big data could revolutionize mining, especially considering the low base, and improve efficiency across the Materials sector. Even with all of the technological help we can get, however, there is no silver bullet that will solve humanity's growing supply problems.

- **Big benefits from AI implementation; It's already here but set to have exponential impacts.** Mining is perceived as being old economy, however with the emergence and implementation of artificial intelligence, the industry is on the cusp of rapid change. At its core, mining remains a business of uncertainty and imperfect information; AI and big data could alleviate some of the industry's traditional challenges. AI-enabled understanding of orebodies should drive improved sequencing and planning with far less variance and an ability to see further into the mines' future at less cost and effort. Finding the orebodies will become easier with historical data and machine learning refining targets before they are drilled. Processing plants will have automated control systems that will use terabytes of data to real-time optimize recoveries. The amount of water and power consumption will be reduced. The mines will be safer with data providing more understanding of dangers (and as automation further reduces human interactions in the process). New advanced reactor designs may employ increased automation to improve efficiency and reduce the significant labor requirements of current reactor designs; as a result, nuclear energy costs may decline and become more competitive with other energy alternatives, which in turn could drive uranium demand.
- **Genie in a bottle?** There is a clear challenge that the world is set to face in accumulating enough metal to drive decarbonization. Will the use of technology on the supply side be enough to offset the rapidly growing demand for metal? No, most likely not. With AI proliferation likely a decade out, (into what should generally be mid-term deficits across multiple commodities) we think we are still likely to face tight metals markets, at least for the next 10 years.
- **Artificial intelligence and machine learning may be the key to unlocking precision agriculture's full potential** to sustainably grow increasing amounts of food while also using fertilizers and crop chemicals more efficiently and selectively. Precision agriculture has been increasingly adopted over the past two decades in developed regions, allowing for more efficient use of fertilizers while at the same time increasing crop yields, a trend we expect to continue.
- **We also see artificial intelligence being incorporated throughout the production process for timberlands, wood products, pulp, paper, and packaging products.** Initially, AI can be used to automate more parts of the production process as employers face intermittent labor shortages. AI could also be used to more efficiently manage timberlands and increase productivity.

- **We believe AI along with the general secular growth in digitization will be important growth drivers for specialty chemicals.** We believe AI and digitization will require enhanced networks, next generation chipsets, and more sophisticated technology, requiring greater demand for specialty chemicals that could enable higher per unit chemistry value. AI will allow for targeted advertising when it comes to paint colors based on age, demographic and geographical location, and should improve the way homebuilders purchase and use coatings while on the job site, mostly beneficial to the manufacture and logistics processes, improving efficiency and reducing waste.

Materials and Mining – Hybrid living

A virtual world should start to shift some key paradigms that will liberate the Materials sector, at least to a greater extent, from its historical physical bounds. Changes will take some time but directionally, the implications from augmented and virtual reality have the potential to substantially change the industries and business models from within.

- **Bringing the mine to the comfort of your own home.** We believe the mining sector has generally overcome reduced workforce availability through COVID-19, which bodes well for future trends in remote working, likely to be accelerated by augmented/virtual reality in the future. The most obvious benefit of augmented or virtual reality is that it can remove some (and maybe one day most, or all) humans from potentially dangerous environments. As Rio Tinto has demonstrated in the Pilbara, where it has fully automated mines and rail run via an ops center in Perth, operations can be run effectively remotely. Furthermore, the ability for international consultants and engineers to spend time virtually at a mine site, for example, should enable more rapid problem solving and increase general productivity.
- **Unintended consequences may make communities more hostile.** As these trends continue, fewer people will live in close proximity to mines, which could (over time) be run from thousands of miles away. This would reduce the impact from the “mining economy” that usually bolsters regional economic development. This may leave local communities with less upside, but all of the negative environmental issues that come from mining, which will need to be proactively managed by the industry.
- **Similarly, many roles within the Forest Products industry could one day be performed through augmented reality from the comfort of one’s home.** Manufacturing roles are generally remote, often relatively uncomfortable (loud, hot, etc.), and more dangerous than a standard office job. Augmented reality could help companies address ongoing recruitment challenges while increasing safety.
- **For the packaging industry, as we become more a mobile workforce (i.e. work from anywhere that has an internet connection) we will have a greater need for packaged products that can move with us.** Therefore, we expect sustainable packaging substrates such as aluminum to innovate products such as re-sealable water bottles (similar to easily transportable plastic water bottles).
- **For the chemicals industry, we believe a hybrid environment means new technological advancements that require more enhanced chemical products.** For example, hybrid living will require advanced telecom infrastructure to support this hybrid environment, which could see a revamp of new innovations in the chemicals industry to support electronics end-markets. The coatings industry will be a direct beneficiary of augmented and virtual reality, as consumers will be able to virtually test a color on their walls, and customize their color choices when it comes to automobiles, homes and other electric products.

Materials and Mining – The Great Balancing Act

Bifurcated supply chains, limited critical metals supply capacity and new frontiers for metals production will create substantial complication and risk around our ability to decarbonize. Copper and the ubiquitous nature of its use, about to be supercharged by electrification, is set for deficits and it is not apparent at this time as to whether this can even be avoided. Across the Materials sector, the positives from ESG may need to evolve in order to continue to progress the key challenges facing the sector.

- **There is no easy answer to metals supply challenges.** It is becoming increasingly apparent that the shift towards decarbonization will create disconnects between supply and demand across multiple mined commodities. Spiking demand will pressure underlying capacity for metals like nickel, cobalt, lithium and rare earths, while declining grades and depleting resource bases at mines will affect the supply side for other metals like copper. Increased focus on environmental impact, although a net positive, is hampering the ability for mining companies to gain new permits and/or maintain production rates. Higher prices, and substitution, are the likely eventual outcome but this will come at a cost to society, both economic and potentially by slowing the pace of decarbonization if we indeed reach a point where metals supply capacity is exhausted. Recycling tailings dumps and other less emissions intense metals production is also likely to grow in importance.
- **Looking beyond metals, materials supply chains will need to improve and become more robust.** For example, creating coatings is a raw material intensive process, and given almost everything we interact with has some sort of coatings on it; the global community will need to have these raw materials readily available around the world.
- **ESG's evolution.** While the goals of ESG are clearly positive, the externalities from this mega-trend will need to be managed. The aversion to coal and oil has incentivized companies to slow/stop investment, which in theory speeds up decarbonization. However, this is now creating energy shortfalls, leading to higher inflation and potential for political discord; both of which are forces that could reduce the capacity and propensity for the world to cooperate on climate change. Divestments, at the margin, are increasing the carbon generated by these assets as lives are extended and as new owners look to expand production. The reality that certain metals are critical to decarbonization will likely drive change in the way that ESG is applied to the mining sector over time. Furthermore, while protecting forests does store carbon, reducing the production of wood products could result in the increased use of more carbon intensive and non-renewable materials such as concrete and steel, so attempts to preserve forests for their stored carbon value could backfire.
- **Uranium – balancing benefits and risks of nuclear energy.** Many countries have incorporated nuclear as a critical part of their overall energy mix and consider nuclear as a clean and sustainable energy source that is key to meeting climate goals. However, opponents cite the potential risk from nuclear accidents, challenges with nuclear waste disposal, and proliferation concerns. The nuclear industry will need to carefully balance competing dynamics, especially safe reactor operations.
- **Improved agronomic practices and advanced technologies will be needed to ensure fertilizers are used sustainably.** Fertilizers are required to meet rising food demand, but growers will need to balance the need to increase crop yields with the increasing awareness of farming's impact on our environment.
- **In the packaging industry, The Great Balancing Act will be selecting which products need to be packaged in less sustainable substrates** due to their superior infection prevention capabilities, such as a medical supplies/medicine, which will likely continue to use PET. In addition, consumers still prefer less sustainable packaging for specific goods; therefore it will be up to the consumer to do their part in recycling waste, and companies/governments can invest in recycling facilities to make them more economical. These choices must be balanced

against energy consumption, carbon footprint, pollution and waste, cost, and standard of living.

- **The new strategic front for critical minerals.** Countries like the DRC, with ample and relatively untouched high-grade deposits of copper and cobalt, have already become a hot spot in the growing geopolitical rivalry between China and the United States. The dominance of China in many metals, and a burgeoning requirement for the West to create supply chains of its own, combined with these metals occurring in many non-traditional resource countries, often with security and governance issues, will make the geopolitics of critical minerals rise in importance over the coming decade.
- **As climate change becomes more pronounced, we think forests will increasingly be viewed as a national asset due to their ability to absorb and store carbon.** For wealthy nations, this may result in more forests becoming protected (e.g., the Canadian province of British Columbia is proposing protecting 2.6 million hectares of old-growth forests). For developing nations, protecting forests may come at the cost of slowed development; therefore, we think that wealthy nations are likely to pay developing nations to preserve forested areas.
- **Sourcing commodity chemicals could become an important issue, as a key component for the manufacturing industry.** We saw a glimpse of this when the U.S. and China enacted trade tariffs on various commodities ranging from plastics to Ag products. We believe this event helped China to become more self-sufficient in producing its own chemicals and the U.S. to become more open to manufacturing domestically.

Real Estate

Real Estate – The Quest for Immortality

The life science REITs are key partners to top life science companies, and help create collaborative ecosystems that drive greater innovation. Biotechnology companies are constantly searching for ways to facilitate collaboration among stakeholders to advance research. Therefore, these companies elect to reside in certain markets, and even more specifically, within certain asset clusters.

- **Lab tenants prefer to reside in top clusters:** The life science cluster markets are highly collaborative ecosystems that help drive greater innovation, and in turn, advance life science research at a quicker pace. Big pharma historically owned one-off facilities, but realized the benefits of clustering, and moved research efforts to leased buildings in top markets. Top clusters generally have leading research institutions (create partnerships & talent pools) and high quality healthcare systems with a teaching slant.
- **Biotech boom driving life science real estate boom.** The pace of drug development should accelerate given an uptick in R&D funding along with key technological advancements. The COVID-19 pandemic highlighted meaningful technology advancements (MRNA vaccines) and the importance of medical research. This has also led to increased funding both from a variety of private capital sources (IPOs, follow-ons, VC) to fund advanced research and public sources (NIH) to fund basic research.
- **Manufacturing next real estate demand driver:** New complex drugs such as biologics (large molecule) are much more complex to produce as compared to traditional small molecule drugs. The development of biologic treatment options depends on cultures of living cells and viruses that require particular environments to grow and remain viable. Establishing this manufacturing process, particularly in the beginning phases, needs to be overseen by PHD/MD individuals that were involved in the research and development process. Therefore, the sites need to be located near major cluster markets.

Real Estate – The Individual Revolution

Customized homes for one and all: A manufactured home created today looks very different than a mobile home looked 30 years ago, with modern homes looking increasingly similar to traditional custom built single-family homes. We expect that this trend will continue over time, and that eventually there will be few signs of a difference between the styles. We also think that the application of new technologies, like 3D printing, could keep manufactured home prices affordable despite increasing raw materials costs. In our view, the primary differences between traditional and manufactured homes will eventually be just price and the available level of customization.

Real Estate – Artificial Intelligence Activated

Big data and AI trends will impact the sector in a variety of ways including driving incremental data center demand to store data, helping REITs streamline select investments/operating strategies, and requiring developers to build properties with unique features to facilitate greater automation. The economy's reliance on big data is driving accelerating demand for data centers to store data. Select real estate companies such as PLD and WELL have been more aggressive building out their respective data initiatives to better identify investment opportunities and operating strategies. These companies have heavily invested in their respective data initiatives to track data within their own portfolios and obtain data from other sources to better understand the overall market dynamics. Additionally, developers could be required to build properties with unique features to help tenants utilize automation technology. For example, industrial tenants that are employing more automation would prefer

to have higher clear heights as the automated pickers are able to use the extra vertical space more efficiently.

Real Estate – Hybrid Living

In terms of what it means for real estate, the need for housing is likely to grow at least as fast as populations in our view. We believe the temporary “race for space” during COVID-19 lockdowns is likely to be a slow, but steady long-term trend as people do more at home, only partially offset by less need to store as many physical possessions in a digital world. Similarly, more affordable (and thus often less accessible) locations could well increasingly gain favor (assuming digital connectivity is sufficient), potentially reversing some of the dominant urbanization trends of recent decades. Even concerns about greater difficulties in the delivery of physical goods becomes less relevant if 3D printers become commonplace. Likewise services if augmented and virtual reality improve. Headwinds are likely to vary, but be greater for some of the other subsectors:

- **Retail property:** the impacts of retailers needing less physical retail space are already clearly evident, though how much less and the best format is still unclear. Conversion to residential is an option, but often with relatively unattractive economics.
- **Offices:** we expect employers to find solutions to issues such as less collaboration, training junior staff and culture creation as augmented and virtual reality continue to become more user friendly, greatly reducing their need for office space. The bigger question is the timing and pace of such change.
- **Logistics:** the overall headwinds appear less significant, unless one takes into account 3D printing becoming commonplace. However, owning the right type of warehouses in the right locations on the right economic terms may prove challenging. The exceptionally high prices currently paid in some leading global cities don’t factor in the potential for a reversal in their population trends in our view.
- **Self-storage:** Fewer possessions in a more digital world risks a gradual decline in demand for self-storage space in the long-term. Likewise less need to move houses with jobs in a work-from-home world would reduce another source of demand to use such space. However, most important will be the shift in where their customers live as proximity has typically been a key driver of customers’ decisions.
- **Healthcare:** Demographics in most countries point to a tailwind in tenant demand. Furthermore, while some services will increasingly be provided remotely, most appear likely to continue to require attending in person. We also believe the issues around populations shifting to new locations is less significant given the residential nature of many properties.
- **Student Housing:** Given the typically young age of students, the argument for them adopting on-line learning and avoiding the need to pay for student housing appears strong at first sight. However, we see the appeal of using it as a first step to leaving the family home as enduring.

Real Estate – The Great Balancing Act

Consumers expect greater product selection and faster delivery times both of which increase the importance of logistics networks. Successful retailers are placing more value on their logistics networks, and see it as a tool to improve the overall customer experience. These companies are heavily investing in their real estate footprints by taking down more space to hold more product closer to population centers. This ensures they have products when needed and can deliver them quickly.

- **Global supply chains are more exposed to macroeconomic shocks.** Supply chains today are more interconnected across the globe, and consequently, are more exposed to disruptions. Given several recent macro disruptions (BREXIT, trade wars, pandemic), stakeholders are forced to diversify production locations where possible, and increase overall inventory levels to better navigate the inevitable production/transportation issues.
- **Real estate design and locations matter.** It is vital for retailers and logistics companies to operate warehouses close to population centers to decrease delivery times. It is also increasingly more difficult to find these locations as there is generally a higher and better use other than industrial. This could result in real estate companies being more creative developing multi-story industrial product in order to justify paying up for the underlying land. Given cost constraints, the higher inventory levels will need to be held in facilities just outside the city. We see these buildings being built bigger with higher clear heights and equipped with more automated technology to better utilize the vertical space and reduce labor needs.

Technology, Internet, Media and Telecommunications

TIMT – The Quest for Immortality

Within “The Quest for Immortality,” telemedicine and rural broadband connectivity along with AI-driven real-time monitoring has the potential to transform healthcare – one of the largest and most important verticals across any economy accounting for almost one-fifth of GDP in the U.S. Not only could a more decentralized distribution model have a materially positive impact on both the quality and cost of healthcare, a highly specialized component of the “data industrial complex” allocated to health data (along with other groundbreaking healthcare developments) could truly mobilize significant resources at scale from treatment to prevention ultimately compounding these quality and cost benefits.

- **Telemedicine.** The ability to conduct doctor visits virtually is one of the major irreversible trends from the pandemic. According to a recent McKinsey study, telehealth usage is up 38x from pre-COVID levels. Given the positive outcomes supported by telemedicine (better patient outcomes, greater efficiency for doctors), we expect this tailwind to sustain and expect companies providing technology that enables telemedicine to benefit over the longer-term.
- **Accelerated drug development and more targeted drugs.** With the mRNA vaccines reaching the public in record time, we believe life sciences companies are increasingly looking to expedite the process from ideation of drug development to getting drugs to markets. We believe technology plays a critical role in enabling this, from automating manual processes traditionally done during this life cycle, to better dissemination of information, to changing the way R&D is done, with innovations like digital trials.
- **Democratization of healthcare.** With more digital healthcare devices being sold direct to consumer (following the footsteps of fitness trackers), healthcare is increasingly commoditized and the consumer has greater ability to take control of their overall long-term wellbeing. We see room for more connected devices, including those to track nutrition, physical activity, and sleep, as well as those that can monitor specific conditions better than previous processes.

We would add the ability to embed AI into digital healthcare can potentially change the way healthcare is conducted. Even with advances in telemedicine today, healthcare is still generally 1:1 and time can be a major bottleneck. We would note that 60% of patients wait two weeks or more for a PCP appointment (source: RelyMD) and though that number is likely meaningfully lower with telemedicine, it remains a bottleneck. We see potential to automate routine visits through telemedicine with AI capabilities – for example, healthcare AI that can understand common problems and narrow down next steps, so that patients in need can get immediate treatment, versus having to wait extended periods of time to solve the problem.

TIMT – The Individual Revolution

The “Individual Revolution,” while still early stages, has already had a profound impact on the technology landscape and innovation. Today, we are seeing a rapid shift by organizations to put the customer first and, ultimately adapt to raised customer expectations for personalized, friendly, efficient, and reliable shopping/service experiences through their preferred channels. In turn, we are in the midst of a wave of significant spending by organizations on technologies that can help improve their customer experience, reach to new channels, such as social media, and overall enable experiences that are comparable to that of Amazon, Netflix, etc. In addition, organizations need the data center infrastructure (cloud) to support the exponential growth of customer data and meet the new bar for customer experience. We also point to the ongoing impacts on advertising platforms from increased customer data privacy and protection, including GDPR, CCPA, and the deprecation of IDFA and

third-party cookies. We believe the next iteration of the Internet, now being referred to as the "Metaverse," and a more advanced data-industrial complex will only spur more drastic change, with technology again being what allows all organizations to adapt during the next stages of this revolution.

The emergence of personalized platforms underpinned by a more highly evolved data-industrial complex with sophisticated consumer data ownership, fungible portability and enterprise-grade protections would exponentially expand the pool of anonymously and non-anonymously aggregated consumer information – the impact of which would be nothing short of transformative (akin to what the banking industry by facilitating the flow of capital did for capitalism, market efficiency and the global economy). In fact, we believe that an advanced data-industrial complex represents the single greatest “infrastructure” opportunity over the next half century with wide-ranging economic, social, cultural, political, environmental and national security implications.

TIMT – Artificial Intelligence Activated

AI has meaningful applications directly within technology. Longer-term concerns aside, we expect AI to significantly improve the pace of technological advancement and make existing technology more powerful. We do not expect any technology companies to truly productize general purpose AI in the next five years, but instead expect “smarter” AI systems to become embedded within all areas of technology. Over time, we believe this creates products that, while being the same underneath, are almost custom-tailored to the end user. In software, this creates an interesting dichotomy: with multi-tenant cloud solutions, millions of users are using the same piece of software, but with increased AI capabilities and customization based on user behavior, the experience could end up being so different from user-to-user that there are ultimately millions of different user experiences for the same piece of software. We see the same extending to consumer applications and even hardware devices (especially with the advent of 3D printing).

The massive computing needs of AI will drive solutions for data storage, security and sovereignty, while requiring a significant buildout of compute and storage infrastructure. Companies are also exploring the possibilities of edge compute enabled by 5G, which will require edge data centers and other infrastructure that allows companies, hyper-scalers and perhaps telecom operators to manage large quantities of data.

TIMT – Hybrid Living

COVID-19 has given rise to a massive number of technologies, platforms, and services that serve to enable Hybrid Living. With video conferencing, broader availability of high-speed internet, co-working spaces, and less reliance on pen-and-paper, we believe a significant portion of the population is increasingly shifting to a style of living and working that is tethered less by proximity to the workplace. Similar to how public transportation and internal combustion engines gave rise to the suburb, we believe modern technologies will further shift the future workforce and populations to be even more distributed across regions and even countries. Further, entertainment and living platforms/services such as food/grocery delivery and OTT will, in our view, accelerate the flight from more dense urban populations.

One unifying theme from media history is humanity’s innate quest to transcend time and space (and our interaction therein). While clearly humanity is far from being done transcending “physical time and space,” we do expect a notable acceleration in the human transcendence of “digital time and space,” which today is characterized by a substantially more advanced and extensive technology stack capable of supporting the emergence of personalized platforms within the confines of the Metaverse. With VR/AR/MR and AI, a new era of mediated reality

and mediated intelligence could be ushered in that could begin to rival that of, and in some instances substitute for, the real world. In fact, within a few generations, we believe nobody will be without their own avatar(s) in at least one virtual world.

TIMT – The Great Balancing Act

There is an ongoing "balancing act" across social, political, and environmental topics. Technology, and especially software, are often at the center of socio-political issues, such as is the case with cyber-warfare counter-balanced by investment in cybersecurity software. Software also plays an important role in sustainability efforts — we would highlight two names: 1) Microsoft Cloud for Sustainability, a SaaS platform for helping orgs keep record of, report on, and reduce their carbon footprint; and 2) DocuSign, whose eSignature technology has saved 20B+ pieces of paper and preserved over 2.5 million trees. All in all, some of the largest companies in the world are technology companies and they can play a crucial role in neutralizing some of the tension across these issues given their global footprint and influence.

A tipping point in human mobility? One question that strikes us with all the technology enhancements is the extent to which humanity is becoming “less mobile” as we spend more of our time immersed in a variety of interactive digital environments consuming digital media. If true and human mobility is reaching a tipping point within a few generations and set to decline for the first time in human history, we challenge readers to contemplate this outcome and the vast potential economic, social, cultural, political, environmental and national security implications. Whether it is healthcare, real estate, industrials, IT, communication services, energy and utilities, materials or discretionary, we believe the impact of any meaningful physical-to-digital transition on the re-allocation of global resources and re-ordering of the global economy would be nothing short of profound.

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