

MEGATRENDS

RESHAPING SERVICES

The investment implications of technological disruption



WINTER 2021

For professional investors only.
All investments involve risk,
including possible loss of capital.



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FOREWORD

Over the past century, the global economy has transitioned from being dominated by agriculture and manufacturing to being powered primarily by services. Services now represent three-quarters of the workforce in developed markets and two-thirds of global GDP.¹

Since World War II, services have been transformed by shifting consumer and corporate preferences, technological change, and globalization. But after a 20-year period of relative stability, services are now once again at the cusp of a major disruption.

Advances in technologies such as cloud computing, artificial intelligence and machine learning are radically reshaping winners and losers across the service sector in both developed and emerging markets – and at an even faster pace after the COVID-19 pandemic.

This technology transformation will allow new entrants to disrupt key components of the services value chain. At the same time – and to a greater extent than in manufacturing and retail – a select group of technology-forward incumbents will benefit from some unique features of the services sector (such as client acquisition costs and regulatory complexity) to survive, and even thrive, during the process of creative destruction ahead of us.

To understand the investment implications of this next revolution in services, we have drawn on the insights of more than 70 investment professionals across PGIM's fixed income, equity, real estate, private credit, and alternatives managers – as well as leading academics, technologists, industry analysts and venture investors. We focus our investment lens on the three sectors that represent the vast majority of the services sector and 35% of the MSCI ACWI: financial services, healthcare, and transportation and logistics.² Our analysis reveals the hidden risks and emerging investment opportunities in services across public and private asset classes in both developed and emerging markets.

At PGIM, we believe investors who fully recognize the multiple pathways through which technology is transforming the global services sector will be best positioned to navigate the rapidly shifting investment landscape.



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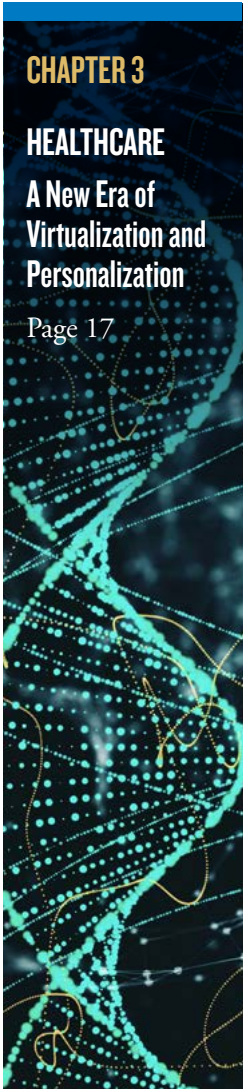
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CHAPTER I

A CENTURY OF SERVICES

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While in many ways the service sector is simply catching up to the manufacturing sector, this next wave of innovation will be disruptive in different ways.”

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CHAPTER I

A CENTURY OF SERVICES

One hundred and fifty years ago, more than two-thirds of the American and British workforce was employed in agriculture, mining, and manufacturing; that share has now fallen to approximately 20% in each country (Exhibit 1).³ A similar transition has been happening over the last 50 years in middle-income emerging markets.⁴ For example, agriculture and manufacturing represented 88% of the Chinese workforce in 1978; by 2020 that share had fallen to 52%.⁵

Where have all these agricultural and industrial jobs transitioned? The short answer is to services. The service sector now represents 75% of the workforce in developed markets, almost 50% of the workforce in advanced emerging markets, and 30% of the workforce in less developed emerging markets.⁶

Key Drivers of the Global Shift to Services

The transition to a services-driven global economy has been powered by a complex web of factors, but five are particularly worth highlighting:

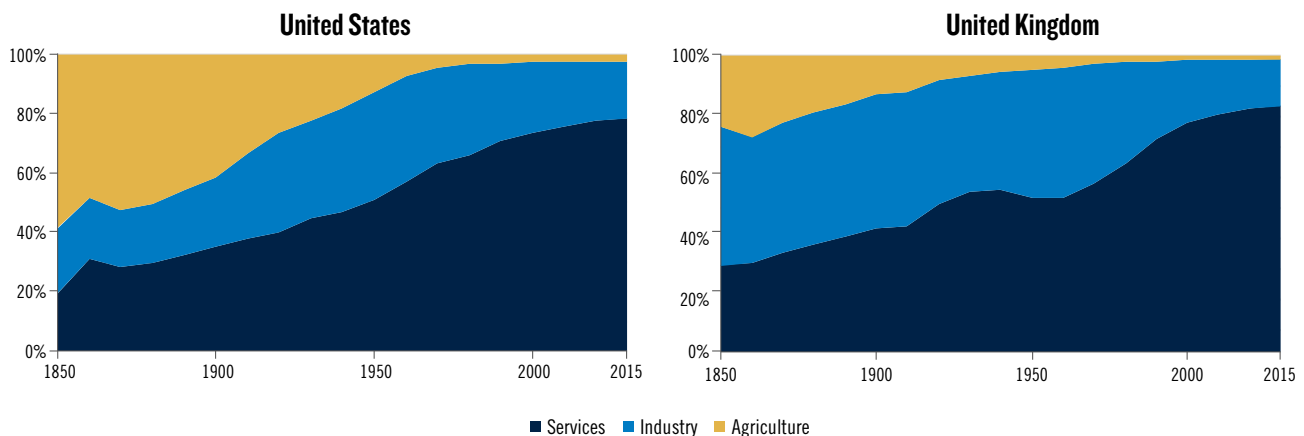
1. Successive waves of technologies – tractors, mass-produced automobiles, earth-moving equipment, power tools, assembly lines, computer processing

power – have taken over tasks in agriculture, manufacturing and mining that humans would have previously done.⁷

2. Rising consumer affluence following WWII led to increased demand for healthcare, financial services, leisure, travel, and other entertainment services (Exhibit 2). This shift in consumption towards services is also evident in emerging markets – the share of household expenditure dedicated to services has doubled in South Africa and increased fivefold in India since 1950.⁸

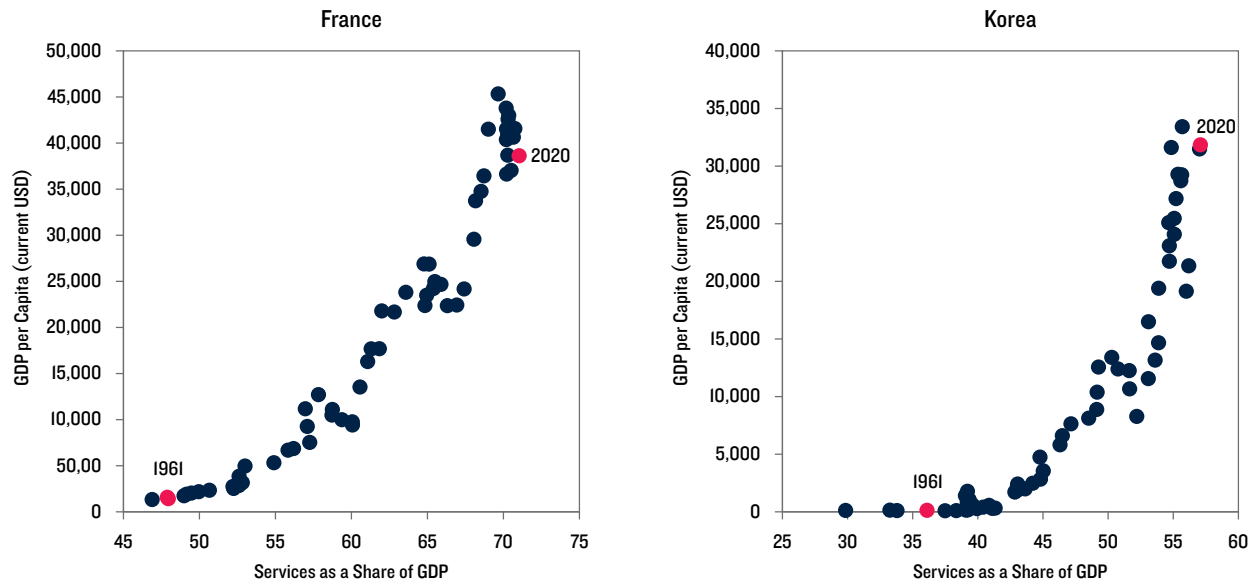
3. The innovations in technology and rising affluence noted above spurred rising demand for high-school and college education. This, in turn, created a literate and numerate services-oriented workforce that could manage complex organizations, trade

Exhibit 1: Service jobs are growing as a share of total employment



Source: McKinsey Global Institute analysis; IPUMS USA 2017; US Bureau of Labor Statistics; Groningen Growth and Development Centre IO-Sector Database; Moody's; IMPLAN; US Bureau of Labor Statistics; FRED; Bank of England.

Exhibit 2: The Service Economy Grows as Countries Become Wealthier (1965-2020)



Source: PGIM analysis, World Bank.

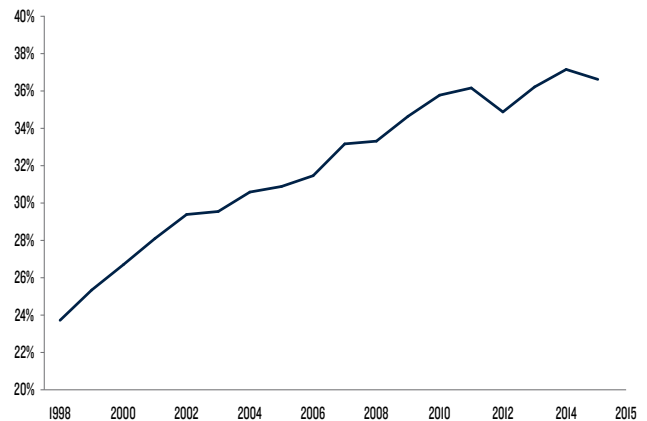
an increasing array of products and services, offer financing and insurance, provide healthcare and administer government services.⁹

4. Advancements in global supply chains, booming trade, and the rise of multinational corporations led to a surge in globalization with agricultural and manufacturing jobs increasingly moving to emerging markets with comparative advantages in labor cost or agricultural productivity. This further spurred the transition to the service sector in developed markets.
5. More recently, there has been a growing “servicification” of the manufacturing sector, with many traditional manufacturing firms housing a growing number of service-related jobs. This is due in part to the growth of in-house management of logistics, supply chains and marketing.¹⁰ The share of employees working in service-related jobs within traditional manufacturing firms has grown from about 25% in 1998 to over 35% today in the US (Exhibit 3).¹¹ IBM is a prominent example of this trend: Originally a leading manufacturer of mainframe and other computer hardware, IBM now offers custom technology solutions for businesses and governments that integrate services and hardware.¹²

The rising share of the global workforce in services has, in turn, made it the dominant component of global

GDP and a critical driver of global growth. The service sector now represents more than 70% of the GDP of high-income countries and 55% of low- and middle-income countries. For example, the share of services in the UK’s GDP has risen from 48% to 80% over the last 100 years.¹³ Similarly, services account for nearly half of India’s GDP today, compared to 37% in 1990.¹⁴

Exhibit 3: Embedded service jobs within manufacturing firms are growing (% of service jobs within manufacturing firms)



Source: Mercedes Delgado, Daniel Kim, and Karen Mills, 2021. “The Servicification of the US Economy: The Role of Startups versus Incumbent Firms,” in Aaron Chatterji, Josh Lerner, Scott Stern, and Michael J. Andrews (eds.), *The Role of Innovation and Entrepreneurship in Economic Growth*. University Chicago Press, forthcoming (available as NBER Working Paper).

The Next Revolution in Services

Technological change has always played a key role in shaping the service sector (Table 1). The first major wave of change – the mechanization of agriculture and industry – didn’t directly impact service-sector productivity but did lead to an influx of labor to services from other sectors of the economy. In contrast, the second major technological shift – the computerization and digitization of the global economy – had major implications for services. From the 1980s onwards, automation and growing computing power meant that routine, codifiable tasks in the service sector – such as bookkeeping, retail transactions, clerical work, and administrative jobs – were displaced by simple computer software and performed by desktop personal computers.

A third phase of technological change is now coming to services – and its impact will be profound. As advances in cloud computing, artificial intelligence (AI), machine learning (ML) and big data analytics enter the mainstream, an array of companies in the service sector are deploying these new technologies and transforming (Table 2). Collectively, these disruptive technologies are radically reshaping the way many service sector companies operate.

While in many ways the service sector is simply catching up to the manufacturing sector, we believe this next wave of innovation in services will have a quite different trajectory and outcome than in the manufacturing and retail sectors, creating new challenges and opportunities for institutional investors, who typically invest more than one-third of their public and private portfolio in services.¹⁵

Table 1: Three phases of technology evolution

	Phase 1 Machine	Phase 2 Computer	Phase 3 Cloud+	
Examples of key enabling technologies	<ul style="list-style-type: none"> Gasoline- and electric-powered motors 	<ul style="list-style-type: none"> Personal computers and mainframes Physical network of computers Limited high-speed internet (mostly commercial) 	<ul style="list-style-type: none"> Cloud-based computing and networks Artificial intelligence and machine learning Distributed ledgers and blockchain Widely available broadband and 5G networks 	
Examples of key innovations	<ul style="list-style-type: none"> Automation of agriculture, construction and industry (e.g., tractors, cranes and bulldozers) 	<ul style="list-style-type: none"> Automation of administrative and business support services (e.g., Excel spreadsheets, shared drives for digital files) 	<ul style="list-style-type: none"> Analysis of big data (e.g., algorithms to optimize global supply chains) Edge computing done on mobile devices Automation of complex tasks that requires human judgment (e.g., autonomous driving and visual recognition software) 	
Impact				
	Agriculture	High	Low	Medium
	Industry	High	High	Medium
	Services	Low	Medium	High

Source: PGM analysis, Erik Brynjolfsson and Andrew McAfee, “The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies,” 2016.

Table 2: Select Technologies Driving Disruption in Services

	What Is It?	Potential Use Cases	Challenges and Hurdles
Big Data / Prop Data	<ul style="list-style-type: none"> Big data contains greater variety (e.g., structured and unstructured) and comes in greater volume and frequency than more traditional data Proprietary data is data that is created and owned by an individual entity Analysis of big data and proprietary data is enabled by advanced data processing capabilities 	<ul style="list-style-type: none"> Underwriting insurance risk with minimal human involvement Price optimization via comparisons Operational efficiency of internal processes (e.g., loan processing by lenders) 	<ul style="list-style-type: none"> Data security concerns Data privacy regulations Data silos that limit usefulness across systems Correlations without a theory of underlying causal relationships
Artificial Intelligence/ Machine Learning	<ul style="list-style-type: none"> Artificial intelligence is the process by which computers simulate human processes and tasks using algorithms Machine learning is a form of artificial intelligence where algorithms are built to process new data and “learn” new tasks without additional human intervention 	<ul style="list-style-type: none"> Prioritization of large volumes of data or images (e.g., MRIs, job applications) Detection of fraud or unusual activities in financial accounts Optimization of network routes for logistics planning 	<ul style="list-style-type: none"> Data security concerns Data privacy regulations Spurious correlations or overfitting of data Bias in AI (e.g., race or gender)
Cloud Computing	<ul style="list-style-type: none"> Cloud computing is the delivery of computing services – including servers, storage, software, analytics and intelligence – over the internet Offers greater computer processing capacity, economies of scale and flexible resources 	<ul style="list-style-type: none"> Enabling millions to access online video content stored online via platforms Storing and analyzing customer data in a structured and unstructured format Efficient rollout of new platforms and data-centered services can be done very quickly and at low cost 	<ul style="list-style-type: none"> Compliance issues around storing sensitive personal data Integrating cloud-based systems with legacy and proprietary Operational risks around relying on third-party vendors for essential services Security on the cloud, especially for enterprise use cases

Disruptive technologies are radically reshaping the way many service sector companies operate.

We'll Get There When We Get There: Tech Inertia in Services

While it is always difficult to predict the timing and pace of technological change, our base case is that disruption in the service sector will be an evolution rather than a revolution. The breathless media accounts around today’s cutting-edge

technologies like blockchain, AI, autonomous vehicles and drones typically exceed the near-term opportunity set in services. Entrenched interests, sticky client bases, slow adoption and legacy processes can often delay the pace of real-world change and the return potential for investors.

In the 1990s, for example, the internet consisted primarily of email accounts and search engines. It took a decade or more of developing infrastructure (e.g., faster and wireless internet, standard protocols such as HTTPS, internet access in emerging markets) to unleash its full potential across the global economy. In many ways, today’s innovative technologies are in a similar place, driven by four key factors.

First, the technologies themselves are still evolving. The infrastructure around distributed ledgers, for example, is in its infancy; standardized protocols are in flux and the mining ecosystem is still being configured. Considerable advances in basic operational metrics (i.e., transaction speeds and energy usage) will need to occur before blockchain can be a serious threat to existing financial powerhouses.

These new technologies present immense legal and regulatory challenges that need to be resolved.

Second, these new technologies present immense legal and regulatory challenges that need to be resolved. For example, accessing big data can be thorny due to personal data privacy and security. Machine learning and AI algorithms raise serious concerns around bias and causal explanatory power. The regulatory environment around public blockchains is also quite murky.

Third, many services continue to suffer from “tech inertia,” particularly those with strong regulatory oversight such as financial services and healthcare. Regulators are cautious about the risks of new technologies and often require time to develop the in-house expertise to evaluate and approve new technologies.

Fourth, historical path dependency slows down the pace of disruption in services, especially in sectors with a vast existing infrastructure already in place such as transportation and logistics. For example, there is enough global infrastructure in place today to provide gasoline to every corner of the world to fuel internal combustion engines. The global network of oil wells, pipelines, refineries, oil tankers and other delivery vehicles will not be replaced easily, meaning electric vehicles will have an uphill climb.

In summary, the next wave of technological change has arrived at the shores of the service sector and will likely revolutionize many services.

But investors will need to be vigilant in separating hype from reality, with many of the most attractive near-term opportunities focused on the application of new technologies to solve specific, tangible problems today.

Scope and Structure of This Report

To understand how the next wave of technology will transform the service sector, this report focuses on tech-driven disruption in three of the largest components of the service sector: financial services, healthcare, and transportation and logistics. Together, these three industries account for a quarter or more of most countries’ GDP and 35% of global equity market cap.¹⁶

Importantly, the story of tech adoption in each of these industries is often complex and defies simple characterization. Some areas of financial services like mobile payment platforms have forged ahead with digitization, while others remain bogged down by cumbersome mainframes and legacy systems. Likewise, innovation in medical therapeutics (gene editing) and pharmaceuticals (mRNA vaccines) is apparent, but the delivery and administration of healthcare services in many countries often feels archaic. Lastly, while logistics firms like DHL, Amazon and UPS are leaders in robotics and automation, freight hauling has largely lagged.¹⁷ Indeed, the specific dynamics of disruption are unique to each sector as well.

Across the next four chapters, this report guides investors through this shifting investment landscape in services. Using the framework above to understand the key innovations driving disruption in services, Chapters 2 through 4 outline the resulting investment themes in the financial services, healthcare, and transportation and logistics sectors, respectively. Chapter 5 concludes by discussing the portfolio-wide implications of the reshaping of the service sector, with an agenda of potential actions for CIOs to consider.

CHAPTER 2

FINANCIAL SERVICES

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In many ways, traditional financial services firms in developed markets are ripe for disruption.”

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CHAPTER 2

FINANCIAL SERVICES: THE FUTURE IS WEIGHTLESS

In many ways, traditional financial services firms in developed markets – including banking, payments, insurance, and wealth and asset management – are ripe for disruption. Many are buried under cumbersome legacy technology platforms and often reliant on high-fee transactions conducted exclusively in brick-and-mortar branches.

But will digital companies like Venmo, Alipay and Paytm be able to build brand recognition and tap into a global affluent clientele? Or will incumbents acquire existing fintech firms and their technology to modernize their businesses, or at least build giant moats around them? Or instead, will disruptors in financial services expand the accessible market for financial offerings, reaching customer segments that were previously underserved by banks and insurance companies?

We believe five technology trends across the key business lines in financial services will be particularly relevant:

- The rise of neobanks and fintech platforms
- AI and big data drive smart underwriting
- Unexpected winners of robo-advising
- The power of the private blockchain
- The transformative power of tokenization

The Future State of Financial Services

The rise of neobanks and fintech platforms

There are two interrelated trends that are reshaping banking and payments: the rise of neobanks and fintech payment platforms. The last few years have seen a global boom in neobanks – banks with no branches that only exist in the cloud and online. Neobanks like Nubank in Brazil, N26 in Europe, and Chime in the US have several distinct advantages over traditional banks.

First, they are held to a different set of regulatory standards. Traditional banks are subject to more

stringent capital and liquidity requirements and face tighter limits on interchange fees – the transaction fees they can charge merchants.¹⁸ Neobanks have been able to take advantage of this regulatory asymmetry. Second, neobanks are almost completely “weightless” and don’t have the physical overhead – namely, legacy mainframe systems and brick-and-mortar branches – of traditional banks.¹⁹ With no mainframes, branches or paper statements, their cost of customer acquisition and distribution is considerably lower. With much lower overhead and regulation, neobanks are expanding the consumer banking market and reaching previously disengaged and underbanked populations in ways not economically feasible for traditional banks. Third, neobanks are digitally savvy and often partner with other online platforms to embed their products right where the need for that financial solution arises – such as offering a credit card when customers make an online reservation at a hotel or overdraft protection when their balance drops precariously low. This kind of embedded finance is a key aspect of the fintech business model.

Point of sale (POS) payment platforms like Lightspeed and Square are essential for small businesses. These payment platforms may not have the same volume of transactions as traditional players, but they are highly disruptive. Digital payment platforms like Adyen process, validate and make payments for large enterprises like Nike and Netflix and are displacing commercial banks. By diverting a range of retail transactions away from banks and payment systems like Mastercard and Visa, these fintech platforms have clearly disrupted payments. With a growing number

of businesses making payments to their suppliers through these platforms, they have essentially created an expanding payment ecosystem that is independent of traditional incumbents.

These payment platforms are also increasingly embedding credit to service small businesses more effectively. They are leveraging their unique visibility into daily cash flow and inventory churn and are beginning to extend financing to small businesses for inventory and supply chain management either on their own or through their partners. In doing so, they can generate additional revenue streams from their current commercial clients.

This kind of small-scale credit has not been attractive to traditional banks, creating a significant financing gap for small businesses in the US (Exhibit 4). Through their use of embedded credit, fintechs have the potential to partially fill this financing gap.

But what about incumbent banks? Some are rapidly falling behind, while others are adapting to new technology and enhancing their efficiency and customer acquisition. Zelle is a digital payment app owned by a group of US banks that allows free payments between their accounts. Also, HSBC has leveraged cloud-native AI with Temenos and boosted its credit card customer acquisition rate.

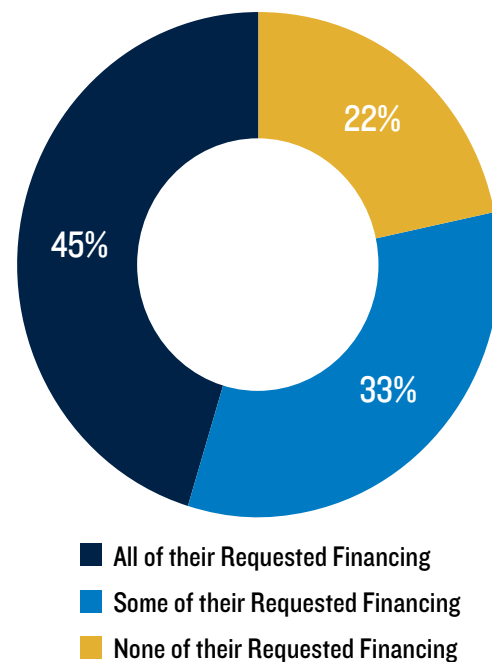
Insurance: AI and big data drive smart underwriting

Technology has powered a range of innovations in insurance as well. Perhaps the most striking is the ability of tech-forward insurers to harness the combined power of big (and often proprietary) data and AI to reinvent underwriting and claims management for the cloud era. This kind of data-centered service reduces the cost of underwriting new customers and managing claims and is a key element to achieving scale and profitability in an increasingly commoditized business.

Auto insurers like Root, for instance, are using telematics apps on drivers' mobile phones to record driving habits, offer discounts and adjudicate claims. Similarly, leading life insurers are now leveraging AI to underwrite policies, helping them achieve better operational efficiency. The results of a questionnaire – as well as widely available information (such as

Exhibit 4: Most small businesses in the US face a shortfall in financing

(% of small firms requesting financing, 2016-2020 average)



Source: Small Business Credit Survey: 2021 Report on Employer Firms, US Federal Reserve Banks, 2021.

driving records) – are used as an input into an AI-powered algorithm that determines underwriting and pricing. The algorithm leverages big data – namely, the proprietary database of millions of prior applicants – to come up with timely evaluations for underwriting and pricing that are supported by actual data. This eliminates the need for costly and cumbersome blood tests or medical exams in some cases and drives the cost of underwriting simple, small-scale policies lower.

The next evolution in life insurance is likely the increased use of data from wearables (e.g., Apple Watch, Fitbit, Garmin, Oura). By incorporating the steady stream of data from these devices, life insurers can move from static underwriting to a more iterative process where risk is constantly being re-evaluated. For example, customers with demonstrated and consistent healthy behaviors can be offered a rebate on their premiums.

Leading property and casualty (P&C) insurers are also employing cloud-enabled AI and big data to enhance their climate modeling and risk evaluation. With the likelihood of tipping points around climate

change, models need to be more predictive, rather than historically probabilistic – and these new technologies have allowed insurers to better predict the frequency of extreme weather events.

In addition to transforming underwriting and risk management, these technologies are reshaping claims management, both lowering the cost of claims and increasing the ease of use for customers. For example, Lemonade can settle an auto claim in seconds based on photographs from a cell phone rather than the costly, time-consuming process of sending insurance adjustors into the field. Going forward, the combination of “high tech and high touch” is likely to be a winning formula in life insurance. An omnichannel approach allows customers seeking claims to speak to a human while simplifying many of the documentation and validation steps along the way through automation.

P&C insurers are also applying cloud-based technology to their proprietary big data. Large firms like Chubb are using AI to glean relevant insight from their vast set of historical underwriting and claims data. They then use this insight to become smarter in setting terms and conditions of coverage and in managing claims when they do occur.

Wealth management: Unexpected winners from robo-advising

Conventional wisdom continues to hail robo-advisors as a revolution transforming wealth management the way ETFs transformed traditional asset management. In reality, robo-advisors don't incorporate true AI, machine learning or sophisticated asset allocation, instead relying on fairly standard asset allocation, streamlined rebalancing and excellent front-end digital interfaces. But without a solid source of customer acquisition, they have failed to threaten traditional wealth managers, let alone drive them into extinction.

Potential disruptors in the space – like Betterment, Personal Capital, FutureAdvisor and Wealthfront – could not effectively leverage their early advantage. While they offered customers attractive digital interfaces, they lacked access to distribution networks and found it hard to scale up to a profitable business.

Instead, incumbent wealth management firms either acquired (e.g., BlackRock acquired FutureAdvisor, Empower acquired Personal Capital and JPMorgan

acquired Nutmeg) or built (e.g., Vanguard, Schwab) their own robo-advisors, targeting mass affluent customers, who couldn't be profitably served by their traditional wealth management arms, and younger customers, who are more accustomed to digital-first interactions. As a result, instead of being disrupted by robo-advising, wealth managers have successfully integrated the technological enhancements offered by challenger robo-advisor startups into their own businesses. Successful incumbents have used technology to streamline operations like portfolio construction and rebalancing, and create better digital interfaces for customers. Indeed, what began with the potential of a tumultuous revolution in wealth management fizzled out as tech-savvy incumbents captured all the innovative elements of the robo-advisor offering.

Embedded credit in the fintech ecosystem offers another compelling investment opportunity

The power of the private blockchain

At its very core, blockchain is a system for recording transactions in a database that collects information in groups, also known as “blocks.” Once a block is filled according to a predefined storage capacity, it is added onto the previous block, creating a chain of data known as a “blockchain.” Importantly, a blockchain can be categorized by whether it is open to the public or if it is only open to permissioned users (Table 3).

The best-known blockchain versions – those used for crypto-assets like Bitcoin and Ethereum – tend to be public. This type of blockchain was originally envisioned to eliminate intermediaries and remove the need for trust within transactions. While this architecture has created a range of investable assets, it has also led to concerns around anti-money laundering (AML) and environmental, social and governance (ESG) issues. These concerns, along with the uncertain regulatory environment around public blockchains, and the difficulty in scaling some of them, limit their attractiveness for institutional users.

Table 3: Public vs. private blockchain

	Public Blockchain	Private Blockchain
Features	<ul style="list-style-type: none"> Open access to join, read and write Participants remain anonymous 	<ul style="list-style-type: none"> Only permissioned participants can join, read and write Participants are easily identifiable
Scalability	<ul style="list-style-type: none"> Low 	<ul style="list-style-type: none"> High
Use Case	<ul style="list-style-type: none"> Public cryptocurrencies like Bitcoin and Ethereum Decentralized Finance (DeFi) and Non-Fungible Tokens (NFTs) 	<ul style="list-style-type: none"> Financial transactions between permissioned corporations and banks

Most applications of blockchain by financial institutions, however, are in the form of private (or permissioned) blockchains. While these still require central authorities or intermediaries to authenticate users, they can reduce transaction complexity, increase ease of authentication (e.g., property titles), enhance transparency and improve fraud controls for participating institutions. Private blockchains can also reduce transaction costs, as they eliminate many of the administrative expenses of record keeping and transaction reconciliation. Private blockchains tend to be more easily scalable and will likely have the largest impact on firms and investors in the near term.²⁰ For example, JPMorgan is using private, permissioned distributed ledger technology to facilitate near real-time money movement across the globe.*

The transformative power of tokenization

While it still faces significant hurdles today, the tokenization of financial assets has the potential to transform financial services, and is an area investors in the financial services space will want to monitor closely. In some ways analogous to securitization, tokenization essentially creates an immutable digital representation of a real-world asset which can then be settled and cleared on a distributed ledger and traded in whole or fractional parts. Tokenized financial and real assets recorded on a blockchain would disrupt virtually all aspects of investing – from back-office functions like clearing and settlement, to how assets are custodied, accounted for and serviced, to even how they are bought and sold. However, this use of blockchain

remains at a nascent stage and some significant challenges still need to be resolved.

First, the lack of clear regulatory, legal and tax guidelines around tokenized assets leads to compliance uncertainties. Second, while distributed ledger technology is already being employed by banks on a limited basis in their operations and in repo transactions, it needs to be further refined to work across other asset classes and at efficient scale under real-world conditions. Lastly, market participants, investors and regulators need to build trust in these new systems and adapt their internal processes to them.

If all (or most) financial assets were digitized and accounted for on distributed ledgers, it would drastically reduce frictional costs from transacting and servicing them. Tokenization could also significantly alter the landscape for private assets like infrastructure, real estate, and private equity. By digitizing the privately held shares of their portfolio companies, PE firms, for instance, could see a tremendous drop in transaction costs alongside a boost to liquidity and price discovery. Tokenizing could open more possibilities for fractional ownership of private and real assets. This would have front-office implications for portfolio construction and would widen the pool of potential investors by making these assets more accessible to smaller institutional investors.

Tokenization offers substantial benefits on the operational side as well. A fully digitized financial asset landscape would significantly reduce clearing and settlement costs. It could also eliminate title searches

* Distributed ledgers are digital systems for recording data and transactions across several locations or multiple parties to generate a single source of truth, eliminating the need for reconciliation and validation. The terms blockchain and distributed ledger are often used interchangeably by investors, but it's best to think of blockchain as one type of distributed ledger.

and valuation checks for real estate or mortgage transactions. While fully tokenized financial markets are a long way off, tokenization might even be able to automate dividend payments to shareholders and interest payments to bondholders and significantly reduce the cost of custody and servicing of assets.

Investment Implications

Global equity opportunities in the expanding fintech ecosystem

Neobanks present attractive opportunities for both public and private equity investors around the world. Their business model entails offering basic banking services to underbanked populations or those disengaged from traditional banks (for example, Millennial or Gen Z workers) and then upselling them other services like debit cards, credit cards and overdraft protection. By linking fees with services customers have explicitly opted in to, neobanks are able to overcome consumers' strong resistance to fees. This model has gained traction in most parts of the world: for example, Monzo and Starling in Europe, WeBank in Asia and Dave in the US. As a young customer base matures, it will have greater need for higher margin services. Emerging markets like India, Brazil and China tend to have larger unbanked populations and growth potential for this kind of business model.²¹

Looking forward, neobanks are beginning to evolve in one of two ways. Many are starting to take a highly segmented approach for broadly underbanked or disengaged communities. A neobank with a focus on a niche community or affinity group with common needs can customize marketing and services and deliver more efficient client acquisition – albeit in a narrow segment of the market. VC-funded neobanks in the US provide some good examples: Daylight and Superbia focus on the LGBTQ community, while NewBank in New York and Fair in Texas aim for local immigrant populations.

Alternatively, major retailers are beginning to explore their own neobanking services, leveraging their large customer base and distribution network to rapidly scale. Walmart soon plans to launch Hazel by Walmart, a fintech platform that offers customers

everything from credit cards to portfolio analysis to virtual currency transaction processing services.²²

Of course, neobanks present some significant risks for investors as well. Some of the regulatory advantages neobanks benefit from are due to their small size and are unlikely to be a permanent feature. Additionally, regulators in some countries are treating neobanks with a light touch because they serve underbanked populations and expand the market for financial services. However, this gentler treatment is by no means assured going forward. Finally, given their highly targeted and segmented customer base, their ability to continue acquiring new customers and scale up is limited.

Furthermore, with less regulatory oversight, it is possible neobanks are prone to greater operational and control risks. For example, UK authorities recently initiated investigations into anti-money laundering controls at Monzo, a prominent neobank.²³ Furthermore, many neobanks are so new they have not experienced a cyclical downturn and have, therefore, not proven their staying power through a full economic cycle.

The proliferation of cloud technology has also opened other channels for financing that were previously considered too small-scale to warrant interest from incumbent commercial banks. These new pathways create opportunities for venture capital investors. For example, online platforms like Pipe.com, Capchase and Clearco provide marketplaces for small businesses to monetize recurring revenue streams or account payables. Once again, these cloud-based fintech platforms target underbanked segments of the economy and expand the market for financial services.

Embedded credit in the fintech ecosystem offers another compelling investment opportunity in VC and PE. An example of this is the constellation of global companies that offer online consumers interest-free financing as they are completing their purchase, known as “pay-later” services. Firms like Afterpay in Australia, Affirm in the US and Klarna in Sweden pre-arrange a discount or fee with online sellers and get paid back for the full price by buyers in installments. In many cases, they are even partnering with major retailers to offer customers fully integrated pay-later plans – including Affirm's recent partnership with

Amazon. Installment payment schemes are quite common in many parts of the world and appeal to younger generations who may be wary of traditional credit cards. For example, pay-later already accounts for 23% of online transactions in Sweden and almost 20% in Germany.²⁴ Essentially, the “fee” for this POS financing is paid for by the seller. In this way, online retailers can provide customer financing through an intermediary embedded in the online purchase process.

Insurance firms that integrate advanced data analytics will succeed

With AI, big data and cloud computing enabling life insurers to automate large segments of the underwriting process, early movers will be able to capture market share, build scale and have more resilient businesses. Those property and casualty insurers who embrace cloud technology in their risk management and underwriting will be winners as well.

While sizable tech budgets are a common feature across the insurance industry, debt and equity investors should focus on a few key characteristics to determine how effectively insurers deploy cloud technology. First, access to a sizable pool of relevant data is a necessary element for leveraging the cloud. The proprietary databases of the largest life insurers, for instance, give them a head start in this respect. Second, having the right talent. A data science team that is experienced and has a record of accomplishment in their area is vital. Third, investors should assess the extent of AI-enabled underwriting within the organization and how well they do it. Examining the range of insurance underwriting that is linked to cloud-enabled algorithms as well as the throughput rate – that is, what percentage of their total new business is handled this way – can be useful indicators for how well an insurance firm leverages new technology.

Focus on targeted blockchain applications that solve specific problems today

Blockchain and distributed ledgers provide a range of early-stage opportunities for PE and VC investors. While there is considerable hype around blockchain as a broad-ranging transformative force across financial services, the ventures most likely to perform well

are those that apply this technology to solve specific problems. A good example of this is Figure, which is streamlining mortgage origination and securitization. With more than \$5 billion in mortgages underwritten, securitized, and serviced on its distributed ledger platform, there are efficiency and transparency gains for all players in the mortgage origination and securitization process. Figure recently merged with mortgage originator Homebridge to scale its platform.²⁵

For the most part, large commercial banks are not competing with neobanks for the same customer segments.

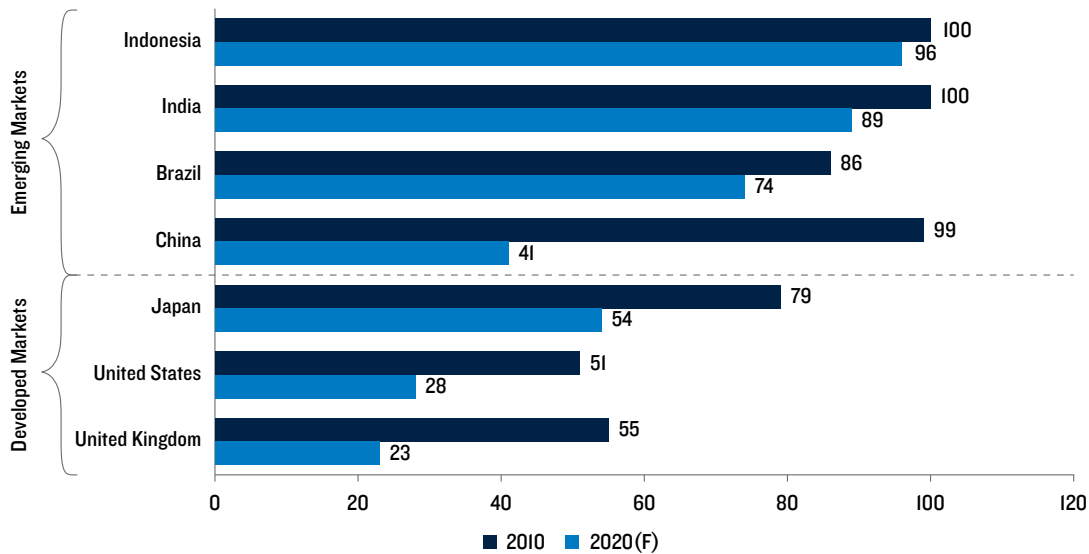
Incumbent banks leveraging new technology will thrive and widen their moats

Despite the growth of neobanks and payment platforms across the fintech ecosystem, “old-school” incumbent banks will not be easily displaced. Indeed, incumbent banks that leverage cutting-edge technology to streamline their operations or build new digital business lines may be especially attractive for debt investors.

For the most part, large commercial banks are not competing with neobanks for the same customer segments. Neobanks are making gains mostly among underbanked and disengaged customers that large incumbent banks are unable to profitably serve. Furthermore, lending to less-than-prime consumers and businesses comes with heavy capital charges for highly regulated incumbent banks and scrutiny from fair lending advocates. Consequently, in the US and Europe, large banks have mostly ceded this segment of the market. In the US, for example, large consumer banks like Citi, Bank of America and JPMorgan dominate the steadier prime consumer and business lending segments and are less likely to be directly impacted by neobanks.

Within the traditional banking sector, debt investors should focus on banks that invest most effectively in technology to reduce costs and increase efficiency.

Exhibit 5: Cash continues to dominate in most EMs, but this is evolving
(Cash as a share of total payments volume)



Source: McKinsey & Company, "The 2020 McKinsey Global Payments Report," October 2020.

Key metrics like software depreciation rates and the frequency of tech write-downs are good ways to identify those banks that leverage technology to modernize operations effectively. In Europe, for example, BBVA and Banco Santander integrate technology into their operations very effectively. Additionally, debt investors should look for incumbent banks that are able to source technology-driven distribution opportunities to access new customer bases. ING Bank's partnership with small business lender Kabbage is one example.

The proliferation of cloud technology has also opened other channels for financing that were previously considered too small-scale to warrant interest from incumbent commercial banks.

Next generation payment systems allow tech-forward incumbents and select new entrants to thrive

Though digital payments are growing in both number and volume, incumbent payment systems still have room to grow. Visa and Mastercard are examples of incumbents that are embracing technology and shifting their services to meet a more digital world. Emerging markets are at a stage of their development where they are evolving away from cash payments – which still account for roughly 90% of payments in countries such as India and Mexico – and adopting other forms of payment (Exhibit 5). Mobile payment platforms enable EM consumers to leapfrog the plastic card phase of payment evolution and go from paper payments directly to digital. The recent proliferation

of mobile payment platforms like AliPay, WePay and MercadoPago has dampened growth opportunities for Mastercard and Visa in emerging markets, but there is still room for them to grow.

In developed markets, Mastercard and Visa are evolving right along with consumers who are ditching plastic cards in favor of contactless payments from mobile devices. They are also leveraging blockchain and tokenization themselves in business-to-business payments. For example, when a consumer books a hotel room through a travel website like Hotels.com, Mastercard will issue a one-time token to the hotel, which has all the instructions for digital payment from the website to the hotel when the consumer checks in. This eliminates the need to share personal data across platforms, significantly increasing customer data privacy.

CHAPTER 3

HEALTHCARE

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Advances are being made to cater to a new generation of tech-savvy consumers who no longer accept the archaic medical systems of the past.”

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HEALTHCARE: A NEW ERA OF VIRTUALIZATION AND PERSONALIZATION

While cutting-edge innovations in therapeutics such as gene editing and mRNA vaccines are revolutionizing medical treatments and pharmaceuticals, healthcare services – namely, the delivery and administration of care – remains one of the sectors with the lowest degree of technology utilization.²⁶ Yet, advances are being made to cater to a new generation of tech-savvy consumers who no longer accept the archaic medical systems of the past. This is leading to a major shift in how healthcare is delivered and administered globally. Three key themes are emerging for the healthcare system of the future.

Future State of Healthcare

Virtualization

Increasingly, healthcare is being pushed out of hospitals and into clinics and homes. While this trend was certainly advanced by the lockdowns and overloaded hospital systems during COVID-19, underlying digital technologies have enabled it for years before. The plethora of new telehealth platforms, for instance, now give patients access to urgent care or mental health advice services from the comfort of their homes. At its peak in April 2020, telemedicine was responsible for roughly 40% of all ambulatory visits in Australia and the US – and 77% in Canada.²⁷ While this usage has come down off its peak, it is likely to permanently remain far above pre-pandemic levels. These platforms are also being deployed to monitor chronic conditions as well as provide physical therapy.

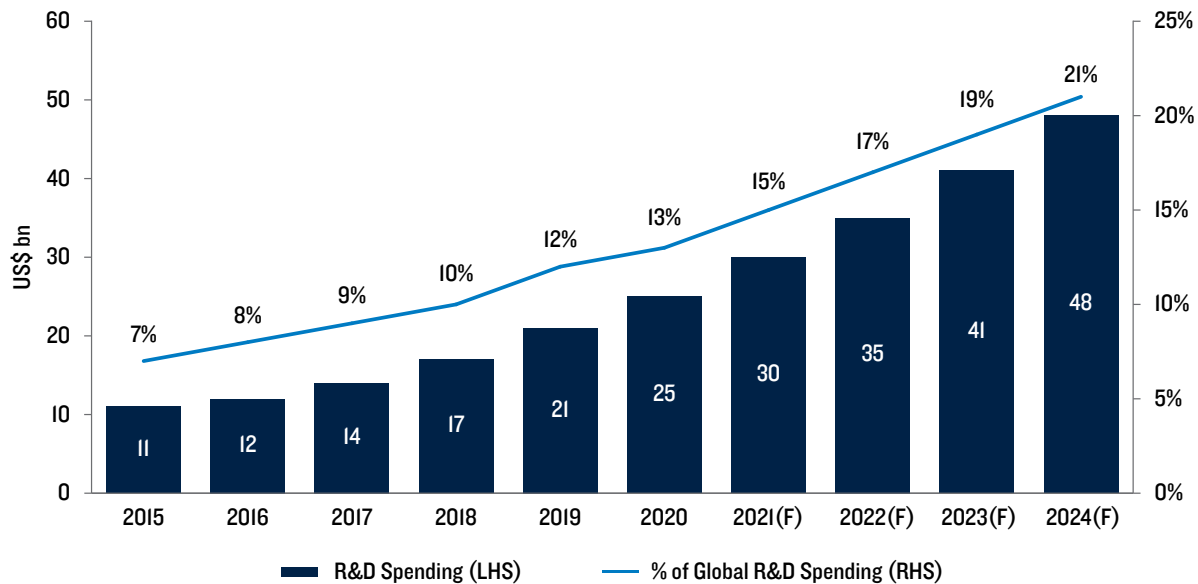
This trend towards lower-care settings has also been enabled by remote, internet-enabled monitoring devices, which give patients and their doctors continuous access to health metrics and data. These devices are now being used by more than 20 million patients in the US alone and have proven to significantly reduce hospital re-admission rates and increase patient satisfaction.²⁸

Personalization

Simple blood tests at an annual physical have been the basis of healthcare for decades. Today, new wearables and advances in genetic sequencing have led to the creation of a much more personalized kind of medical care. New smartwatches, bracelets and rings track heart rate, exercise levels and sleep patterns, providing patients and doctors with a broader perspective on well-being. Furthermore, the advances in low-cost genetic sequencing are empowering patients and doctors to make more personalized decisions about their healthcare. Direct-to-consumer (DTC) genetic testing kits from companies such as 23andMe, for example, started as a way for people to track their ancestral roots. Today they are becoming key inputs into healthcare decisions. US authorities allow 23andMe to test for genetic illnesses like Parkinson's, Alzheimer's, and celiac disease.²⁹ Armed with this type of genetic data, nearly 30% of consumers who undergo DTC genetic testing share their reports with healthcare providers.³⁰

Similarly, companies such as US-based Veritas Genetics give consumers the ability to map their entire genome on a smartphone app. The app then provides care recommendations for people predisposed to certain diseases.³¹ And with new gene therapies being used to address chronic health risks such as cardiovascular

Exhibit 6: China's pharmaceutical R&D spending is growing



Source: Jefferies, Frost & Sullivan.

disease, this form of personalized medicine is set to revolutionize healthcare. Additionally, personalized wellness programs like Vitality combine technology, data and incentives to inspire healthy habits and other positive changes in individuals.

Segmentation

There is no real possibility of a winner-take-all, global market for healthcare. Given the fragmented and inherently localized nature of the industry, it is simply not feasible. This is driven in large part by the vast differences in how healthcare is regulated, delivered and paid for from country to country.

Successful healthcare innovators are instead finding relevant niches to disrupt. Increasingly, firms are focusing on transforming a narrow segment of the healthcare market, often with great success. They are adept at creating individualized journeys for people. For example, apps such as Selfapy or Bluecall are being used to expand mental health services in Europe. Meanwhile, specialized apps that target patients with chronic illnesses such as diabetes (e.g., Omada Health in the US) and pulmonary diseases (e.g., COPD

Co-Pilot in Europe) have been clinically proven to improve patient outcomes.³² Given the unique challenges patients face based on their geographic location, individual lifestyle and health risks, the trend towards increased segmentation and specialization within healthcare is very likely to grow.

Increasingly, healthcare firms are focusing on transforming a narrow segment of the market.

Investment Implications

Emerging markets offer new opportunities and risks for biotech and pharmaceuticals

While the US is often considered the key market for healthcare innovation, burgeoning markets such as China and India offer excellent opportunities as

well.³³ China is a particularly intriguing market that presents growth opportunities for equity investors. It is the world's second-largest healthcare market and remains one of the fastest-growing ones globally, with growth rates three times that of the US (Exhibit 6).³⁴ With China's aging population and accelerating rate of diagnosis, the government has instituted various reforms to encourage innovation in the healthcare sector. Notably, the Chinese government has recently instituted a more formal reimbursement process and started paying for more novel drug treatments, creating commercial opportunities for both Chinese and foreign healthcare firms. In 2019, Chinese pharmaceutical companies filed over 200 requests for clinical trials, more than double the filings in 2014.³⁵ One result of the surge in drug research is Chinese authorities approving 12 novel drugs in 2019 – up from just two in 2015.³⁶ With the Chinese government still spending less than half of what the US government does as a share of GDP on healthcare, there is still significant growth potential in the sector.

One growing area for Chinese healthcare is oncology. With over 4.3 million new diagnoses annually, cancer is a rising challenge in China.³⁷ In response, China's market around oncology biotech and treatments has been growing at double-digit rates. Some of the

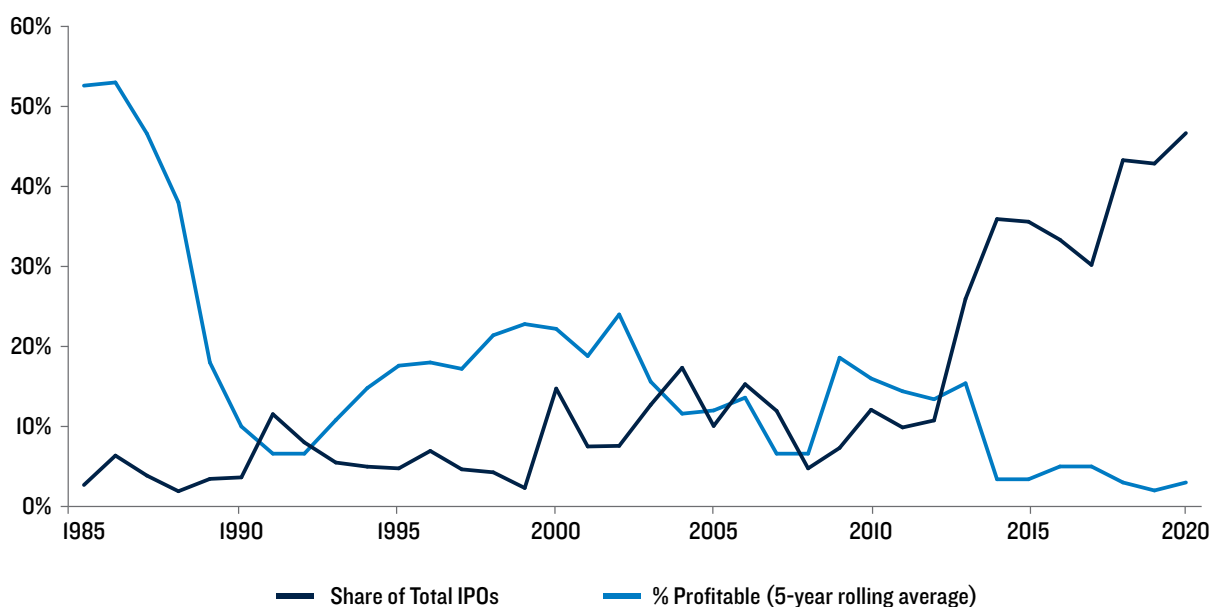
most promising treatments in the world come from Chinese firms like Innovent, I-Mab, BeiGene and Zai Lab, while companies such as Hygeia are providing innovative and targeted radiation therapy treatments to Chinese cancer patients.

Though the underlying fundamentals are strong in the Chinese healthcare sector, investors must remain aware of the unique risks as well. Specifically, issues around intellectual property and government policy remain prominent and can create headwinds for even established companies. For example, China's volume-based procurement program has led to an average 60% reduction in pricing for some generic pharmaceuticals and medical devices.³⁸ These risks are especially elevated for private equity and private debt investors, who are not afforded the same type of investor protections as those operating in public markets. It is crucial for investors to have extensive in-country knowledge and experience before entering the Chinese healthcare market.

Investing in small-cap US biotech firms requires active management

Biotech companies have been leading the charge towards more personalized medicine. Yet, with over

Exhibit 7: The share of biotech IPOs is increasing, but profitability is decreasing



Source: Jay Ritter, data as of June 21, 2021.

700 publicly listed biotech firms in the US alone and a rapidly evolving scientific landscape, investing in biotech stocks requires a thoughtful targeted investment approach (Exhibit 7). With such a large investment universe, it might seem that a passive index approach would be the best investment strategy. However, maintaining a nimble, dynamic approach to US biotech stocks is key. Given the inherent turbulence around early-stage biotech firms due to regulatory approvals, clinical trials and constantly changing scientific data, an index approach is likely to leave investors holding the bag when most of these firms inevitably fail. Instead, a thoughtfully curated, active investment approach that constantly monitors new developments and adjusts the portfolio accordingly is much more beneficial.

One notable development around biotech investing has been the changing landscape for clinical trials. Investors used to need solid phase II clinical trial results from hundreds of patients to even consider investing in a biotech firm. Yet, advances in our understanding of diseases and human genetics are allowing investors to make decisions based on the biomarkers of just one or two patients. Once again, the constantly evolving methodology around clinical trials demands an active investment approach in this area.

A thoughtfully curated, active investment approach that constantly monitors new developments in biotech firms and adjusts the portfolio accordingly is much more beneficial.

Care from an app, outside of the doctor's office

Health outcomes are often considered to be tied to the quality of care a patient receives from their doctors. Up until recently, the healthcare industry has ignored the significantly greater portion of time people spend *outside* of the clinic. There is now a

growing recognition that health outcomes are driven in large part by the countless number of small, everyday choices made outside of a doctor's office or hospital. Driven by this idea, many healthcare startups have begun offering platforms that help people make better behavioral choices for their health through personalized approaches. These platforms offer attractive investment opportunities for public and private equity investors.

This model is particularly promising for people managing chronic conditions such as diabetes, heart disease, rheumatoid arthritis or fibromyalgia. Livongo, for example, offers an app-based platform for diabetes management. Through a combination of connected glucose meters, real-time feedback, personalized health coaching and custom alerts, the app is helping patients effectively manage their diabetes.³⁹ Given the ability of these personalized out-of-clinic care providers to reduce healthcare costs, this trend will likely continue to thrive. Investors should consider venture capital funds that invest in these types of applications.

Specialized healthcare platforms provide VC and PE opportunities

The segmentation of the healthcare market has created new space for platforms that address specific needs such as women's healthcare or mental health. These platforms help patients navigate the complex healthcare system and offer holistic approaches for narrow healthcare segments. Increasingly, as healthcare systems transition from a fee-for-service model to an outcome-oriented, value-based care model, these platforms are especially attractive to employer-sponsored benefits programs in the US. A growing number of companies recognize these specialized health platforms can improve employee health outcomes and reduce insurance expenses, while leading to enhanced employee retention as well.

The women's health sector is one that has tremendous potential to grow. Shifts in cultural and societal norms as well as demographics are resulting in women having children later in life and being more open to discussing fertility, maternity and menopause. Cleo is a platform that offers personalized support for families

through individual coaching, programs for pregnancy risk screening and a benefits marketplace for services such as childcare, fertility, education and nutrition services. Maven, meanwhile, offers employees end-to-end family planning services ranging from fertility programs to adoption support to surrogacy programs. Both companies have proven to reduce overall family medical expenses and improve parents' return to work ratios following the birth of a child.⁴⁰ Investors with VC and PE allocations might want to look for funds that have exposure to these specialized employer-sponsored health platforms.

Medical devices as a service offer stable cash flows for debt investors

Medical devices are an important catalyst for change across the healthcare industry, especially as healthcare becomes more digitized. Increasingly they are serving as platforms for health monitoring services as well. Companies that are integrating software-driven services into their devices are particularly attractive to debt investors given the subscription-based cash flows stemming from these devices. BioTelemetry, a subsidiary of European device maker Philips, offers patients annual subscriptions for its cardiac home monitoring services, for example. While still a relatively small portion of total revenue, this service provides Philips with a substantially more stable source of revenue than pure equipment sales.

Furthermore, large US equipment makers such as Stryker, Zimmer and Medtronic have been able to

secure their market positions via acquisitions and regulatory barriers. In most countries, it is a long and expensive process to get medical devices approved by regulators. Even after approval, the fragmented nature of the healthcare system means it is very difficult to find distribution channels outside of the pre-established, relationship-based ones. As a result, incumbent medical device makers are fairly insulated from external disruption and can easily acquire new devices or software, given their scale and distribution network. These dynamics protecting their cash flows make the incumbent medical device makers attractive debt investments.

Companies that are integrating software-driven services into their devices are particularly attractive to debt investors.

Lab testing and diagnostics offer steady cash flows for debt investors

As personalized medicine continues to grow, the testing and diagnostic equipment necessary for this transformation will also thrive. The proliferation of

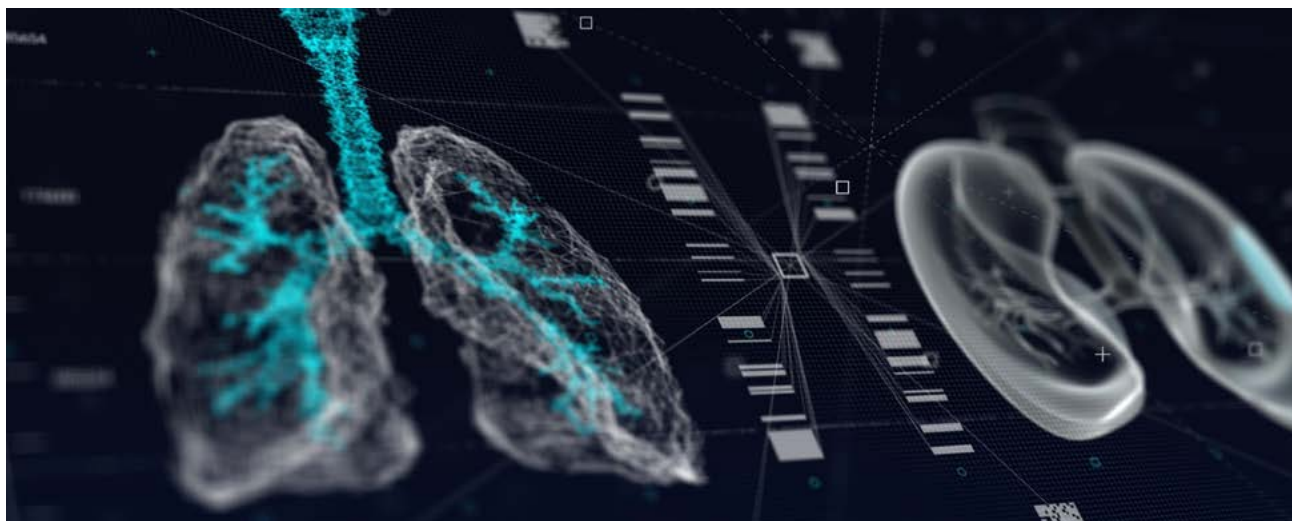
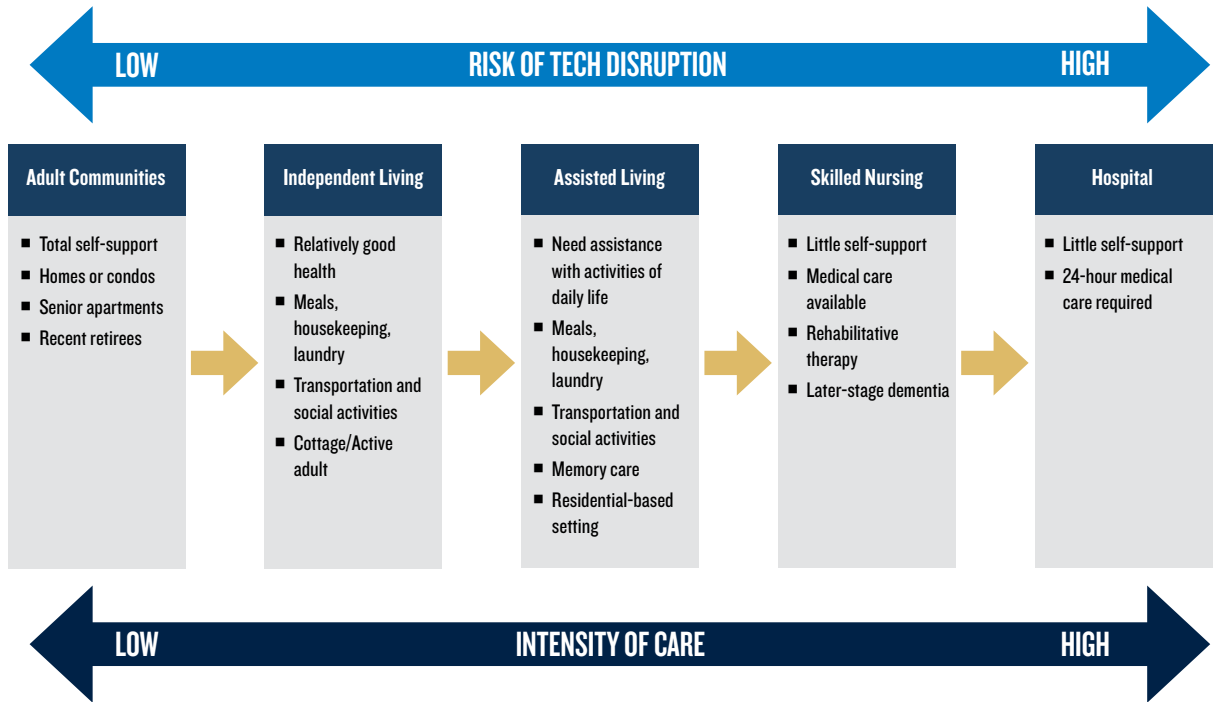


Exhibit 8: Senior housing continuing care retirement communities



Source: PGIM Real Estate.

precision medicine and other biotech advances such as liquid biopsy, spatial genomics and proteomics provides enduring demand growth for equipment and materials like testing consumables, laboratory machines, assays and reagents. This market offers attractive investment opportunities for debt investors. In the US, firms like Thermo Fisher, Agilent, Illumina and Danaher are leaders. In Europe, Hoffmann-La Roche, bioMerieux and Qiagen are the large players in this space. Given their scale, distribution relationships and the regulatory barriers around their products, these large incumbents should be able to maintain their market position and acquire new, potentially disruptive, products. Debt issued by these firms can be attractive to fixed income investors.

Senior housing remains attractive for real estate investors

Aging developed market populations create a compelling source of demand for senior housing today and in the future. This is especially the case in the US where the senior population is poised to increase 45%

by 2030 – from 23 million in 2020 to 34 million – as the post-war baby-boomer generation reach their 80s.⁴¹ This category of real estate is also less correlated with the business cycle than other segments. While virtualized and personalized healthcare technologies such as remote monitoring and telehealth are allowing people to receive care at home, they do not herald the end of the investment opportunity in senior housing. In fact, professionally run senior housing facilities will likely be early adopters and have better access to health tech than most seniors would in their own home. These innovative technologies can offer better levels of care and also help streamline operations and improve profitability in a very operationally intensive business.

Senior housing facilities can be categorized along a spectrum of care. Low-care settings include adult communities and independent living. Options for high-care settings include assisted living and skilled nursing facilities and hospitals (Exhibit 8).

Technologies such as remote monitoring devices, telehealth solutions and smart-home appliances are making it easier for people to not only age outside

These innovative technologies can offer better levels of care and also help streamline operations and improve profitability in a very operationally intensive business.

of intensive care facilities, but also recover at home after acute injuries or medical procedures.⁴² Higher care settings like skilled nursing facilities will likely be exposed to tech disruption as fewer people require intensive care for long periods of time.

However, lower care settings that provide attractive lifestyle options are unlikely to see demand decline any time soon. This is driven by a few key factors. First, technology is allowing residents who might have

needed highly skilled nursing care in the past to be well cared for in less intensive care settings like assisted and independent living facilities. Second, assisted and independent living arrangements offer residents more than just medical care. There is a strong social element to these communities, which cannot be replicated by technology. Lastly, there is a strong human element to patient care, which is nearly impossible to replace with automation and robots.

Though the pandemic has given pause to recent growth in the industry, the long-term demographics driving demand for senior housing persist. While strong opportunities exist in the US, other markets with similar aging demographics like the UK, Japan and Australia should see more attractive opportunities as the sector matures there. Going forward, emerging markets may also present opportunities for investors as the retirement populations increase in Latin America and China with fewer familial caregivers.

CHAPTER 4

TRANSPORTATION & LOGISTICS

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While logistics firms like DHL and Amazon employ cutting-edge technology and automation in their operations, overall, the sector is at an early stage of disruption.”

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CHAPTER 4

TRANSPORTATION & LOGISTICS: THE FUTURE WILL BE GREENER AND MORE AUTONOMOUS

Transportation and logistics broadly refers to the movement of people and goods and includes passenger transport, trucking, freight, supply chains, distribution and warehousing. While logistics firms like DHL and Amazon employ cutting-edge technology and automation in their operations, overall, the sector is at an early stage of disruption. While highly transformative innovations like autonomous vehicles (AV) are on the horizon for transportation and promise to be a major part of the future, they are having little impact today as AV technology is in a trial phase.

In logistics, optimization and efficiency are the current focus and those firms that are quick to digitize their processes, leverage telematics devices and embrace renewable energy sources and cloud-enabled data analysis will gain an advantage and position themselves for enduring success.

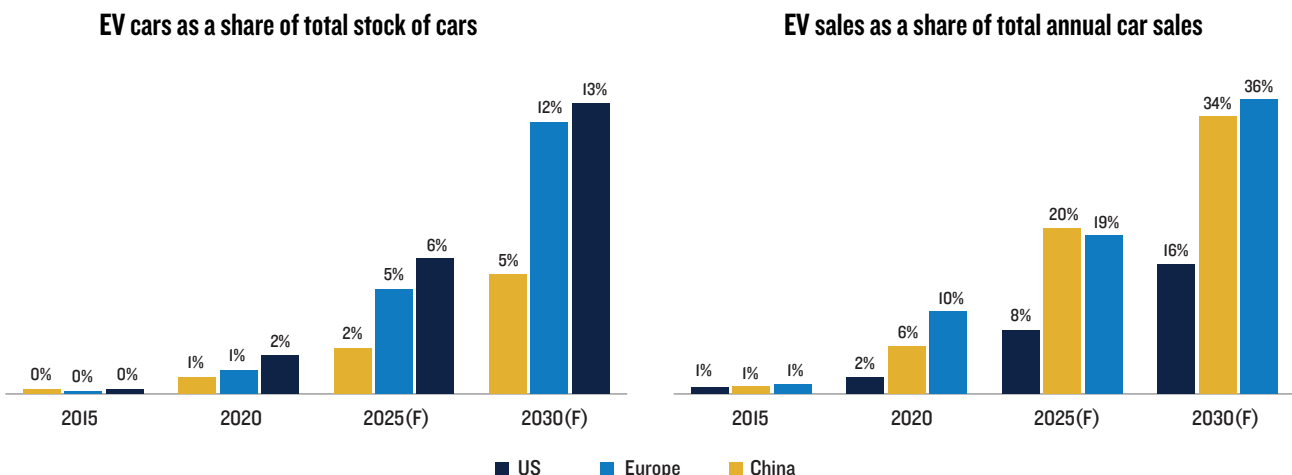
Adoption of EV and AV will not evolve in the same way or at the same pace in all parts of the world.

The Future State of Transportation and Logistics

Automobiles will be greener – and ultimately autonomous

The technology for electric vehicles (EV) exists today and will certainly be a growing part of the automotive landscape going forward. Indeed, EV sales in many parts of the world are growing rapidly. For example, nearly a million EVs were sold in China in the first half of 2021 – more than doubling in size from a

Exhibit 9: Despite growth in annual sales, EVs will likely represent a small share of total cars in 2030



Source: Global EV Data Explorer, International Energy Agency, 2021.

similar period in 2019.⁴³ In Europe the total market share of EV is increasing sharply – albeit from a modest base. EV market share in Germany has grown from under 4% in June 2020 to nearly 11% in September 2021. The UK has also shown a significant rise in the share of EV over the same period, up from 4.7% to over 8%.⁴⁴

However, growth of EV will be uneven across different countries. Because of this, EV will not be displacing the global stock of internal combustion engines (ICE) for several decades. The global aggregate data make this point clear: In 2020, more than 95% of total new cars sold globally were powered by ICE (Exhibit 9). Even across the EU where carbon emission goals and other policies have boosted demand, only 1 in 10 new cars sold in 2020 were powered by electricity.

Despite the sharp growth of EV in some countries, the tremendous stock of ICE vehicles already in place will have a long sunset. Even under the International Energy Agency’s (IEA) optimistic scenario, two out of three new cars sold in 2030 will still be ICE vehicles. In 2050, when EVs are projected to make up 60% of annual new car sales, the majority of vehicles on the road will still be fueled by gasoline.⁴⁵

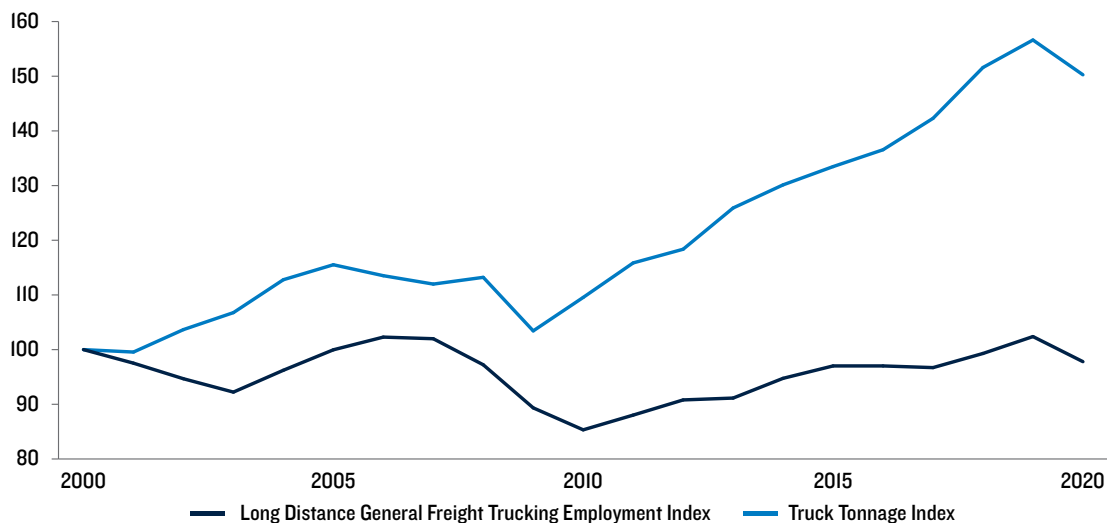
With the proliferation of AV, individuals will find it less cost-effective to own their own car and the ride-sharing model currently disrupting taxis will be

ubiquitous. Corporate business models focused solely on manufacturing autos or ride-sharing platforms will be challenged in an AV-dominant world. The future business model for automotive transport will likely revolve around providing fleets of autonomous ride-sharing vehicles. Auto manufacturers and ride-sharing platforms will need to team up to achieve this – and promising partnerships are already forming.

Of course, the utility and cost-efficiency of AV or EV will not replace personal ownership of an ICE vehicle for all people in all places for several reasons. First, outside of major population centers ride-sharing is often not in great supply and may require a lengthy wait. Consumers in rural areas may opt for the convenience of owning their own car. Second, it will be hard to replace the primal appeal of owning and driving your own car. Automobiles have a prominent place in US culture, for example. Owning and driving the newest, fastest model of sports car or truck and feeling the rumbling of an ICE engine brings an irreplaceable joy to many Americans.

Importantly, adoption of EV and AV will not evolve in the same way or at the same pace in all parts of the world. Autonomous trucking is likely to emerge first in the US, which depends on long-haul trucking for distribution and transport of goods and where drivers make up roughly 40% of trucking costs.⁴⁶

Exhibit 10: Freight tonnage has increased faster than employment in the US



Source: FRED, data accessed July 2021.

Labor shortages also loom large for the industry and autonomous trucking could help freight trucking keep pace with the tremendous demand (Exhibit 10).⁴⁷

But other parts of the world are much more likely to lead the way when it comes to both electric and autonomous cars. European governments are increasingly taking measures to push EV adoption and their environmental commitments are reducing reliance on gasoline-powered cars and vans.⁴⁸

Meanwhile, in China, there are a growing number of urban roads designated for AV testing and fleets of autonomous robo-taxis are already roaming the streets of Beijing. These are poised to disrupt local taxi and minivan transport.⁴⁹

The new and ongoing demand for online deliveries has spawned interest in logistics and warehouses in places where online penetration had been exceptionally low.

Global shift to online shopping yields greener logistics

The pandemic has driven a surge in online shopping that is not likely to fully recede. Importantly, it surged in regions that had been previously resistant. Central and Eastern Europe, for example, saw retail e-commerce grow by almost 30% in 2020, China by 28% and Western Europe by 26%.⁵⁰ Even as the limitations of the pandemic ease, this tech adoption by consumers will remain. The new and ongoing demand for online deliveries has spawned interest in logistics and warehouses in places where online penetration had been exceptionally low – like Spain and Greece.

The logistics industry will continue to leverage AI, ML and other technologies to be even more efficient – and also more green. Technology to move goods along from sprawling distribution centers located far from

city centers to smaller last-mile warehouses near cities is rapidly evolving and altering location dynamics of warehouses. Additionally, operations of these warehouses are increasingly integrating solar, hydrogen and other green energy sources.⁵¹ Solar panels on roofs provide power for the highly automated distribution centers where hydrogen fuel-cell powered forklifts and electric trucks operate through the night to replenish stock in last-mile warehouses for tomorrow's same-day delivery.

Investment Implications

Fragmented landscape for autonomous vehicles provides equity opportunities

The autonomous vehicle space provides a wealth of opportunities for global equity investors. The industry is in the very early stages of developing and testing the technology. Consequently, many partnerships between auto manufacturers and tech firms have been formed and there are likely to be some first-mover advantages. The landscape is evolving quickly, and it remains unclear which partnerships may produce a mass marketable autonomous platform first.

Despite the uncertainty, there are some characteristics of autonomous platforms and partnerships that equity investors should look out for. First, on the auto manufacturer side, there needs to be sufficient capital and commitment to support the lengthy processes of testing, regulatory approvals and production capability to mass produce successful models. On this front, the larger automakers can leverage their size and regulatory experience.

Second, rigorous and thorough testing under all kinds of circumstances is required. Countries like China that are supportive of AV testing on their roads and smart infrastructure will have an advantage.⁵² In fact, testing of robo-taxis and other vehicles is already underway in multiple densely trafficked cities like Beijing, Guangzhou and Wuhan.⁵³

Third, when it comes to the hardware associated with AV – all the cameras as well as the myriad of sensors – reducing size and weight is critical. Furthermore, integrating these inputs seamlessly with the operations

of the car are vital to make the best real-time decisions and ensure the safest rides.

Fourth, the algorithm that interprets all the input from cameras and sensors needs to be able to process all this data quickly and efficiently. For example, the first-generation AV algorithm used between 500 and 800 watts of power and required considerable ventilation and cooling. The most advanced AV algorithms today run much more efficiently, using less than 50 watts of power, and requiring far less cooling.⁵⁴

Based on these criteria, in the autonomous car and robo-taxi space, Chinese AV firms DeepRoute (partnered with Dong Feng), Pony (partnered with Toyota) and WeRide (partnered with Nissan) are examples of potential front-runners and are in the midst of testing autonomous platforms.

In the autonomous trucking space, Aurora's partnership with Volvo is currently testing in North America. Meanwhile, Daimler's partnership with Waymo and Navistar's partnership with TuSimple appear to be promising as well. Investors should also be aware that developments in autonomous trucking will have implications for logistics and warehouses.

Digital platforms to optimize supply chains, logistics and transport

While some parts of the logistics and delivery ecosystem like UPS, DHL and FedEx are very tech-savvy, adoption of technology has been inconsistent. The less tech-forward portions of the logistics and supply chain sector provide a growth opportunity for software firms and investors alike. Cloud-based platforms to digitize supply chains provide many possibilities for freight forwarders, customs brokers, and other logistics players to increase efficiency. For public equity investors, leading players like Canada's Descartes Systems Group can be attractive growth opportunities. Descartes offers a supply chain management platform that optimizes logistics, operations and shipping routes as well as connects the different parts of the chain using real-time messaging and data.

In private equity, British tech firm Connexin specializes in the Internet-of-Things and offers an integrated transport and logistics platform for trucking and warehouses. They provide both the hardware –

telematics devices and sensors – used to generate data as well as the software to integrate and analyze it for optimization of fleets, routes and warehouses.

Software platforms can offer attractive opportunities for debt investors as well. Their subscription models and essential function in businesses make for steady and reliable cash flows during all phases of the economic cycle. Software platforms for transportation and logistics offer some of the best examples. Spanish software maker Amadeus provides an operational platform for managing both airports and airlines. It can optimize runway and gate usage for airport operations as well as flight schedules, re-bookings and upgrades for airlines. The Convoy shipper platform is another example in logistics. It offers a digital freight network where tens of thousands of independent freight haulers in the US can find partial or full loads for their trucks.

Europe offers new opportunities and challenges in logistics real estate

With relatively low e-commerce penetration compared to other regions, Europe has lagged in online shopping. However, the pandemic has allowed it to catch up quickly. The surge in online shopping due to COVID-19 restrictions created tremendous growth in demand for distribution and logistics facilities. This has directly led to an increase in demand for remote distribution centers outside major cities like Berlin, Madrid, Paris, and Brussels, as well as smaller last-mile warehouses closer to population centers.⁵⁵

Aside from rising rental prices on existing facilities, there is considerable room for new development as well. In the UK, land outside big cities like London and Manchester that is close to major motorway junctions has become especially coveted as demand for same-day delivery soars.

However, European regulation and infrastructure also present some unique challenges for investors. European motorways and urban streets are generally narrower than other parts of the world and may not be able to easily support the volume of electric scooters, vans and trucks needed to sustain more e-commerce deliveries.

Also, policy initiatives that are designed to make societies greener and more socially responsible may have some unintended consequences for e-commerce

and the logistics space broadly. For example, local efforts across the EU to reduce city traffic – like congestion pricing and low emission zones – are growing.⁵⁶ This poses a risk to delivery vehicles. Additionally, efforts in Germany to support sustainable supply chains will take effect in 2023 and its rippling impact up and down value chains remains very unclear.⁵⁷ With more scrutiny of global sourcing, closer-to-home sourcing of goods and materials will gain prominence and may shift demand for logistics and warehouses from import facilities to local manufacturing hubs.

Policy initiatives that are designed to make societies greener and more socially responsible may have unintended consequences for e-commerce and the logistics space broadly.

Green technology alters the locational analysis for warehouses in the US

In mature markets like the US, technology is altering the locational analysis for distribution centers. These are the sprawling, more remotely located facilities that replenish the stock of smaller last-mile warehouses closer to major cities. For example, autonomous trucking with an efficient transfer hub model or multiple trucks linked together to reduce drag may make it economically and logistically feasible to locate distribution centers further from last-mile facilities.⁵⁸

Other dynamics are also nudging distribution centers further away from urban centers. In the past, distribution centers needed access to major metropolitan areas and large electricity grids to meet their demand for ample labor and power. The proliferation of automation within the facilities augments labor and may diminish the need for access to large labor pools. Furthermore, renewable energy from solar panels on their expansive roofs and hydrogen fuel cells in major machinery play a growing role in powering distribution centers today. As a result

of distribution centers becoming greener, proximity to a major power grid is less critical, though many choose to remain close to sell excess power to the grid and repurchase power as needs change.

Opportunities in the transition to greener and smarter infrastructure

Given new government-funded infrastructure plans in the US and Europe, it is important to recognize the investment opportunities around the transition to smart, green infrastructure. Rest stops and gas stations along major roadways have long been attractive infrastructure investments, for example. Going forward, investors will need to be mindful of the transition to EV. There will be a lengthy transition period where motorists will have a need for both EV charging as well as gasoline at highway rest stops. Investors can look at debt of highway service providers, like Autobahn Tank & Rast in Germany, who are tuned into the needs of local motorists and can switch the balance between refueling and recharging as local demand warrants.

Other examples lie in municipal infrastructure. As technology is increasingly being employed to make cities smarter, investors can find attractive opportunities in both the manufacturers of these systems as well as the public-private partnerships that enable smart cities. Chicago Parking Meters, for example, is a public-private partnership that operates street parking in parts of the city. Their user app has a predictive parking feature that leverages proprietary data and AI to help users find empty parking spaces today or in the future. They also use camera-enabled AI to determine whether cars are in compliance with local parking regulations and can issue tickets based on that information.⁵⁹

A very long road for EV presents ICE opportunities for debt investors

Electric vehicles are clearly part of the future, but it is also clear internal combustion engines will have a very long sunset. While auto manufacturers are being pushed by government emissions regulations to develop EV, not all consumers will opt for them given they are often more expensive than comparable

ICE vehicles. The unpleasant reality is global auto manufacturers will be selling at least as many ICE as EV vehicles for the next 10 years – or more. It is clear gasoline-fueled autos will play a prominent role in the global landscape for decades to come – and perhaps even longer in places like the US. It is also clear the businesses and infrastructure that support it (e.g., parts makers, gas stations, etc.) will still be relevant and sources of reliable cash flows, even if their revenue growth slows. For debt investors, there is a compelling investment case to be made for auto parts distributors and retailers like NAPA in the US, which may be priced for more imminent obsolescence.

Logistics incumbents embracing cloud technology will thrive

While US trucking is likely to be disrupted by autonomous trucks and consolidate significantly, trucking companies that embrace new technologies and leverage the efficiency gains from it will most likely be part of the future. This type of tech-forward firm can offer resilient cash flows to debt investors.

US trucking company Old Dominion provides a good example. It is investing heavily in technology to modernize its operations and reduce risk. The company utilizes telematics devices on its entire fleet to track and record basic data about each and every truck in the field, including speed, acceleration, and braking. The firm leverages this proprietary data using cloud-based analytic tools to optimize operations of vehicles, drivers, and routes.

Chapters 2-4 examined the significant investment opportunities and risks for specific asset classes (Table 4). CIOs also need to consider some of the hidden risks and implications of disruption across asset classes. The next chapter provides actionable recommendations to help CIOs navigate the tumultuous aspects of technology disruption in services across their entire portfolio.

Table 4: Investment Implications Summary

	Public Equity	Public and Private Debt	Real Estate and Infrastructure	Venture Capital	Private Equity
Financial Services					
Global opportunities in the expanding fintech ecosystem (e.g., neobanks, payment and other platforms)	●			●	●
Insurance firms that integrate advanced data analytics will succeed	●	●			
Focus on targeted blockchain applications that solve specific problems today				●	●
Incumbent banks leveraging new technology will thrive and widen their moats		●			
Next generation payment systems allow tech-forward incumbents and select new entrants to thrive	●	●		●	●

	Public Equity	Public and Private Debt	Real Estate and Infrastructure	Venture Capital	Private Equity
Healthcare					
Emerging markets offer new opportunities and risks for biotech and pharmaceuticals	●			●	●
Investing in small-cap US biotech firms requires an active approach	●				
Care outside of the doctor's office, from an app				●	
Specialized healthcare platforms				●	●
Medical devices as a service offer stable cash flows for debt investors		●			
Lab testing and diagnostics offer steady cash flows for debt investors		●	●		
Senior housing remains attractive for real estate investors			●		
Transportation and Logistics					
Participating in fragmented AV landscape	●			●	●
Digital platforms to optimize supply chains and logistics	●	●			●
Europe offers new opportunities and challenges in logistics real estate			●		
Green technology alters the locational analysis for warehouses in the US			●		●
Opportunities in the transition to greener and smarter infrastructure		●	●		
A very long road for EV presents ICE opportunities for debt investors		●			
Logistics incumbents embracing cloud technology will thrive		●			

CHAPTER 5

PORTFOLIO IMPLICATIONS

“

While there will be new winners, disruption in services will actually increase the dominance of a small group of technology-forward incumbents.”

CHAPTERS

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CHAPTER 5

PORTFOLIO IMPLICATIONS

The current wave of technological change in the service sector raises critical issues for CIOs thinking of long-term implications *across* their entire portfolio, beyond the specific asset class and regional investment opportunities and risks discussed so far. We believe CIOs should evaluate four actions to capture the upside and mitigate the risks of disruptive technologies in the service sector.

I. Position the portfolio for service sector disruption – which will have a radically different trajectory than manufacturing and retail disruption

Disruption in manufacturing (Tesla, 3-D printing, iPhones) and retail (Amazon) became a significant headwind for – and at times made obsolete – a long tail of incumbents that were caught flat-footed as new entrants took market share and as intermediaries (e.g., shopping malls, wholesalers) became increasingly redundant.⁶⁰

While there will be new winners, disruption in services will actually *increase* the dominance of a small group of technology-forward incumbents rather than leave the trail of destruction seen in retail and manufacturing, for several reasons:

- Technological change in services has lagged manufacturing and retail, so service sector incumbents have seen the writing on the wall. They are acutely aware of the “adapt or die” imperative that tech innovation presents. Winning incumbents will not be complacent.
- Two of the largest service sectors – financial services and healthcare – are heavily regulated in most countries. This slows the pace of change given the power of industry lobbyists as well as the tendency for regulators to be gradualists, aiming to avoid binary disruptions. This has, for example, dampened the enthusiasm of North American tech giants from aggressively entering these

sectors compared to pursuing opportunities in less regulated parts of the economy (e.g., car-sharing).

- When it comes to services, distribution networks and access to customers are critical for successful firms. Disruptive tech firms have discovered gaining access to customers and counterparties has been much harder than anticipated. For example, early robo-advisors found it extremely difficult to access wealth management clients and distribution platforms. In healthcare, innovative biotech firms are unable to access the networks of doctors and hospitals they need. As a result, many cutting-edge tech firms opt to be acquired by incumbents rather than going it alone and challenging their dominance.

Consequently, the technology imperative will “barbell” the services sector. Those incumbents who embrace new technology and the new business models they present will successfully make the leap into the digital and cloud era – even as other legacy service companies are left behind. And the number of disruptive new entrants will be higher in those sectors where the regulatory and customer acquisition barriers to entry are less daunting, such as consumer and small business digital payments.

For CIOs assessing “obsolescence risk” in their services portfolio (i.e., identifying winners and losers among existing, established services companies) there are three characteristics to potentially consider. This is especially relevant for long duration investments such as private assets and long-maturity debt that are most vulnerable to obsolescence risk:

- **Incumbents with sufficient scale to fully leverage the current wave of new technologies.** The Goliaths will overpower the Davids. Service sector companies with the operating scale and revenue base to buy or build expensive next-generation technologies will triumph over smaller services companies that won't be able to make the critical minimum technology investments to succeed. Robo-advisors like Betterment are an example of potential disruptors in wealth management that lacked the distribution platform to build a sustainable business model themselves. Instead, large incumbent firms like Schwab in the US and Aion Bank in Belgium replicated or acquired digitally savvy customer platforms and leveraged them successfully.⁶¹ US freight trucking firm Old Dominion provides another example. It's not waiting to be disrupted by tech platforms tomorrow. Instead, it is utilizing telematics devices and AI to streamline freight operations and reduce risk today.
- **Incumbents willing to forego legacy systems to embrace disruptive technology early.** Forward-thinking incumbents are willing to move on from their legacy systems and embrace new technology before it disrupts their industry. Leaping to new technologies and writing off legacy systems can be a costly proposition, but it also may mean the difference between survival and extinction.

Netflix provides a useful illustration of a company cannibalizing its own legacy business – unlike Blockbuster. Netflix quickly adapted from shipping physical DVDs to streaming video online and has been able to leverage that first mover advantage. JPMorgan's experimenting with blockchain for clearing and settlement systems is another example of an incumbent aggressively embracing new tech paradigms despite its heavy investments in legacy systems.
- **Incumbents supplementing in-house development with strategic tech acquisitions.** Investing programmatically in technology startups (and sometimes more mature technology firms) allows firms to access the cutting-edge technology and human capital needed to transform their businesses. By participating at an early stage, incumbents can help shape the technology to best meet their needs and expand their offerings. Examples of this include ING Bank's partnership with small business lender Kabbage and medical device maker Philips' acquisition of BioTelemetry.⁶²

2. Make complementary investments in the technology infrastructure underpinning the next wave of service sector disruption

In addition to actively evaluating leaders, laggards and new entrants in individual service sectors, CIOs will also want their in-house investment teams and asset managers to identify the companies providing the backbone to the coming wave of disruption in services. This includes the companies that provide cloud computing, fiber optic networks, data centers, AI- and ML-powered toolkits, underlying technology

Table 5: Complementary Opportunities in Global Tech Infrastructure

Cloud computing	Public Equities examples: Alibaba, Microsoft, NTT, Amazon, Google
Data centers, especially hyperscale data centers (Exhibit I)	PE and Real Estate examples: Equinix and Digital Realty
Cybersecurity, including edge and cloud security	Public Debt and Leveraged Loans examples: Ping ID, Sentinel One, FireEye
Fiber optic network and telecom infrastructure for a cloud-enabled world	Private Equity examples: Firstlight Fiber, China Telecom, CityFibre Public Equities examples: American Tower, Cellnex, SBA Communications
Fiber optic component makers	Public Equities examples: Furukawa Electric, Huber+Suhner AG, Prysmian Group

platforms, and the related “pipes and plumbing” to integrate these technologies into the service sector ecosystem. We believe long-term active investors can find many attractive investment opportunities across multiple asset classes (Table 5).

3. Brace for regulatory backlash as it spills over into services

Regulatory uncertainty is common across many of the new technologies discussed earlier – though specific focus areas vary significantly by region and sector. Investors often overlook the unsettled regulatory environment in which today’s emerging tech firms operate. Recent examples of “techlash” in China, for example, caught many investors by surprise and knocked tens of billions of dollars from market valuations.⁶³

In financial services, neobanks and fintech payment platforms find loopholes to extend credit to consumers and small businesses without being subject to the same stringent capital and liquidity standards as mainstream banks. This regulatory asymmetry is a key element of their business strategy, but as the neobanks grow, some of their regulatory burden will become more like large commercial banks. It may no longer be economically viable for neobanks to target their main customer

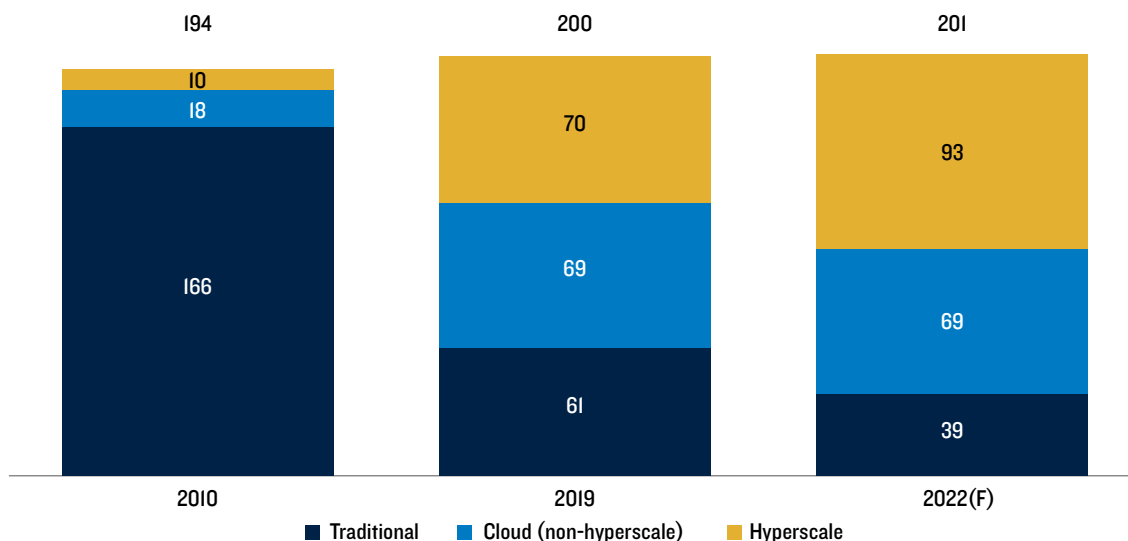
base – underbanked and disengaged consumers. Furthermore, regulators may justify a light touch on these players so long as they broaden access to financial services. But that tolerance is not assured going forward and can easily shift.

Even technologies explicitly designed to operate outside the reach of monetary authorities – most notably bitcoin and the associated decentralized infrastructure and exchanges – raise numerous legal, ESG, and regulatory challenges that are increasingly being surfaced.

In China, it is unclear whether the regulatory pushback on payments platforms and ridesharing apps may fundamentally alter the way technology companies evolve and are financed. Additionally, the recent regulatory turbulence may impact how rapidly new technology is adopted by consumers and firms going forward.

With transportation, development of autonomous driving systems is dependent on ample testing in real-world conditions. Government rules and regulations around such testing can affect the timing around developing robust systems. Chinese authorities, for example, have been supportive of AV testing as they view it as a key technology for their economy. An accident during AV testing in Arizona, where an autonomous car struck and killed a pedestrian, led to

Exhibit II: Hyperscale Global Data Center Energy Demand (TWh)



Source: International Energy Agency, data accessed June 2021.

a suspension of testing even though an investigation showed the human passenger responsible for monitoring the car was at fault.⁶⁴

Investors will want to ensure technology-driven regulatory risks are explicitly captured in their investment framework when looking at services opportunities powered by new technologies. CIOs should have explicit discussions with their asset managers around investments in next-generation disruptive service providers to ensure the investment thesis isn't undermined by antitrust legislation, the extension of data privacy laws into current "grey" areas, or the updating of light or outdated regulations. And institutional investors making investments in-house will want to directly monitor both policymakers and the lobbying organizations representing various service sectors to understand how their investment will perform given the different regulatory scenarios.

Many cutting-edge tech firms opt to be acquired by incumbents rather than going it alone and challenging their dominance.

4. Proactively engage your board and senior leadership on next generation technologies

The implications of the current wave of new technologies in services are too far-reaching to leave technology just to the tech sector analysts or the back-office IT team. Technological change is no longer confined to the formal "IT" sector – it is disrupting key components of the services value chain. CIOs can enhance their team's understanding around technological disruption through a range of actions including:

- Engaging external asset managers in targeted sessions to learn how they monitor technology risks and opportunities across their security and asset selection process.
- Identify the metrics and key performance indicators that may be relevant for each asset

class in identifying winning incumbents that are successfully making the technology transition (e.g., seniority of chief data officer, number of data scientists, investment spend on new technologies, technology M&A activity levels).

- Convene in-house sector specialists across fixed income and equities – both public and private – to debate the impact of the current wave of new technologies (e.g., cloud, AI/ML, big data, distributed ledgers) on each of their current service sector holdings.
- Leverage their technology and middle/back-office vendor relationships to engage with the technology thought leaders at these firms (e.g., technology experts at their current key accounting, custody, administration, enterprise software, cloud, and other vendors).
- Arrange a virtual or physical off-site for board and senior investment leaders – for example, in Silicon Valley, Shanghai, Tel Aviv, Berlin or Bangalore. In this way, institutional investors can "mark to market" the current technology advances and their investment implications in a series of conversations with startups, venture capitalists and even the CTOs of forward-thinking incumbents.

The current wave of technological change has jumped from manufacturing and retail into the heart of the service sector. Big data and its analysis, machine learning and artificial intelligence, cloud computing and the immense processing power that comes with it will reshape global services. A few new firms will no doubt revolutionize some tired corners of the service sector. Meanwhile, some scaled tech-forward incumbents will increase their dominance and render the remaining legacy services players increasingly irrelevant. At PGIM, we believe long-term investors will want to be ahead of this transformational phase in the services industry by actively positioning their portfolios to capture the investment opportunities, and mitigate the risks, from this impending wave of technology-driven disruption in services.

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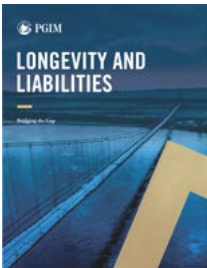
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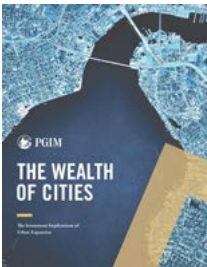
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