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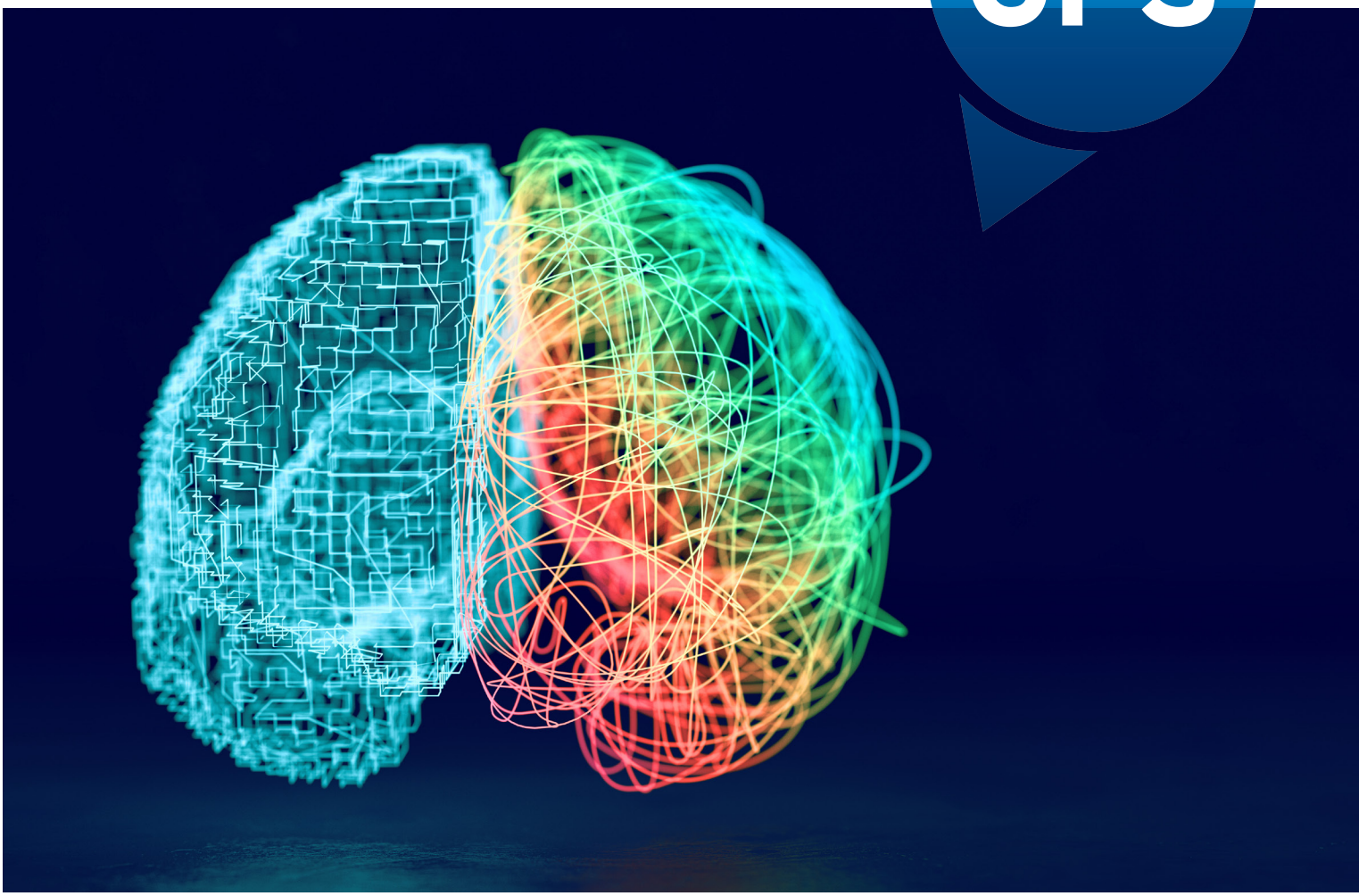

# TECHNOLOGY AT WORK v6.0

## The Coming of the Post-Production Society

**Citi GPS: Global Perspectives & Solutions**

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# TECHNOLOGY AT WORK v6.0

## The Coming of the Post-Production Society

**Kathleen Boyle, CFA**
Managing Editor, Citi GPS

Ever have that déjà vu feeling? Last year about this time, we published our Technology at Work v5.0 report and discussed how COVID-19 restrictions were being lifted and the end of 'work from home' was on the horizon. Apparently, that was just a practice run. This time it's the real deal.

Around the world, businesses are having robust conversations about how employees can safely return to the office. In some regions, restrictions are being lifted at the same speed at which they were implemented back in March 2020. But while we seem to be moving in a direction back to 'normal', and talking about returning to our pre-pandemic ways, in reality, things can't just go back to the way they were.

During the pandemic, working from home became a thing and the stigma around it disappeared. We were okay with losing our commutes and used those hours to work a little more. Our kids didn't stop learning as education shifted from the classroom to the home. And the use of digital everything accelerated — shopping, groceries, doctor visits, payments, and entertainment.

There are definitely things that were part of the 'new normal' during the pandemic that we'll be happy to lose, but some of the changes are going to stick around. Working five days a week in the office seems a lot — surveys indicate three feels like a better number — and a winter snow day from school might become something only you remember. But importantly, working from home came with the realization that if a job isn't place dependent and doesn't need to be done in an office, it can also be done in a cheaper location offshore. Furloughed workers might find their jobs replaced by automation. And as the accelerated shift to digital becomes more permanent, jobs might disappear in brick-and-mortar entities like stores, gyms, and movie theaters.

In the report that follows, we look at how the COVID-19 pandemic may have pushed advanced economies into an era where not only manufacturing jobs get outsourced and automated, but service jobs do as well. This is a world where emerging markets no longer look to manufacturing as a stepping stone to prosperity, and instead use technological advances to attract offshore service jobs such as accounting and banking.

The acceleration of digital during the pandemic may jump-start a new wave of automation, meaning the jobs of the future need to be ones that are sheltered from both automation and offshoring. As governments shift their fiscal spending from providing life preservers to providing fiscal stimulus, the focus is on creating jobs through the green and digital economies. Longer term, policies and stimulus need to focus on creating a competitive advantage in innovation and developing environments that foster interactions, social networks, and knowledge transfers.

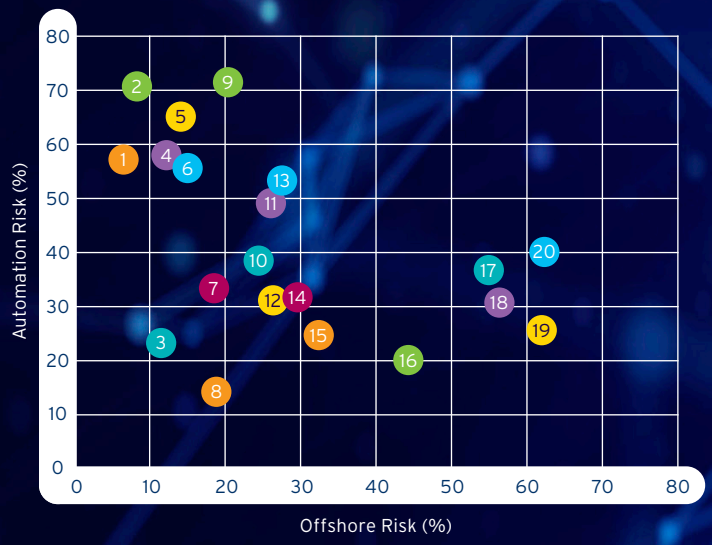
# Towards Innovation and Exploration

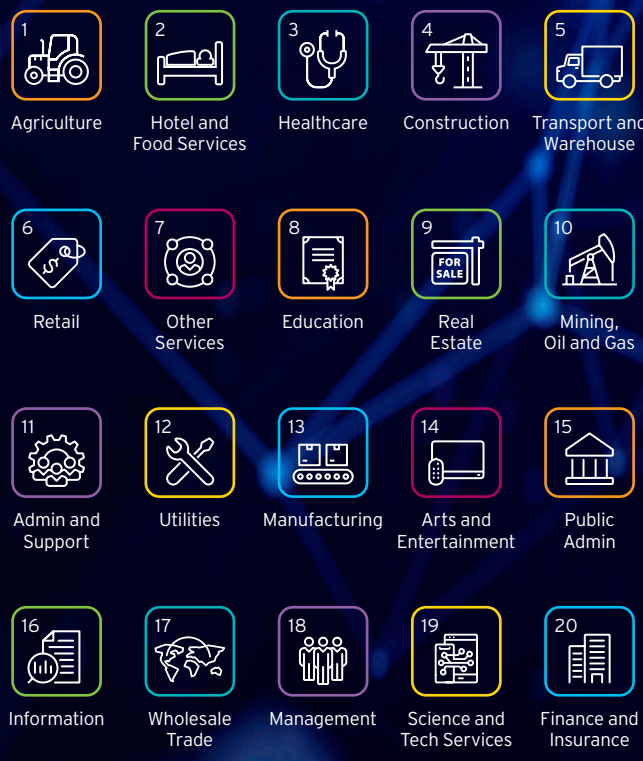
## MOVING TOWARDS A POST-INDUSTRIAL SOCIETY

Advanced economies have already seen a decline in manufacturing jobs due to offshoring and automation. This trend is now gradually moving to many service sectors as the shift towards remote work has made many professional service jobs increasingly automatable and offshorable. Jobs at risk of automation are primarily unskilled, low-income jobs while those at risk of being sent offshore are relatively skilled, high-income jobs.

### U.S. Automation and Offshorability Risk by Industry

Source: Frey & Osborne (2017), Acemoglu & Autor (2010), 2019 ACS 5-year Data, IPUMS USA




## PANDEMIC ACCELERATED DIGITIZATION AND WILL ACCELERATE AUTOMATON

In 2020, our Citi GPS Technology at Work v5.0 report found that advancements in technology meant 52% of U.S. jobs could now be done remotely. In addition to the shift to remote work, the pandemic brought about an acceleration in digitization in many sectors, including retail, healthcare, industrials and finance. Post-pandemic, automation is likely to accelerate due to three shifts:

**Automation vs. Rehiring**
After recessions, routine, low-skill jobs are increasingly eliminated.

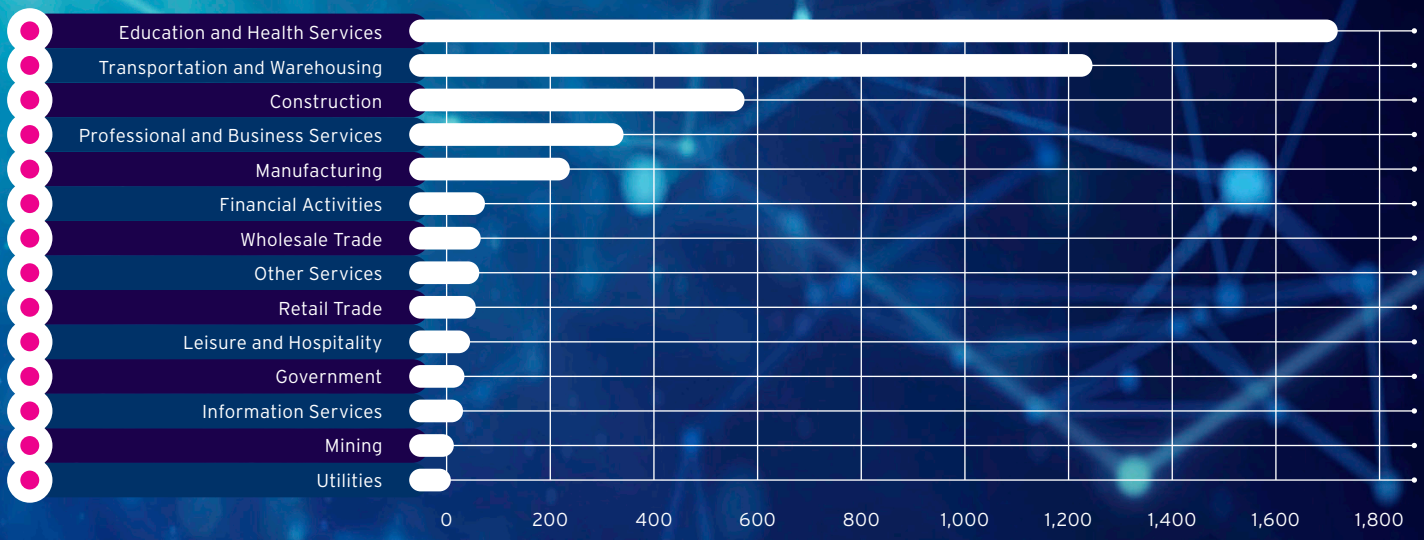
**Resilience to Future Shocks**
Businesses with automation were able to remain open during crisis.

**Consumers Trading Down**
Lower quality goods and services are typically produced with more automation technology.

## FROM FISCAL SUPPORT TO FISCAL STIMULUS

Throughout the pandemic, governments have provided fiscal support to labor markets via job retention schemes and expanded unemployment insurance. While these fiscal 'life preservers' were important, governments must now shift their focus to fiscal stimulus in order to put some 'wind in the sails' of the global economy as it emerges from recession. In the U.S., stimulus should increase employment in key sectors, including education and health services, transportation and warehousing, and construction by 7%, 22%, and 8%, respectively.

**Jobs Created and Sustained by the American Jobs Plan by Sector ('000s)** Source: BLS, Pollin and Garrett-Peltier (2007), Citi Research




## CREATING THE RIGHT ENVIRONMENT FOR INNOVATION

The comparative advantage of rich countries lies firmly in the early stages of the product lifecycle – in the domain of innovation and exploration. While advancements in technology helped to lower the cost or entrepreneurship, policies are needed to foster the creation of new jobs to help shape the future of work over a longer time horizon.

# Contents

# Introduction

**Rob Garlick**
Citi Global Insights

The world changed in 2020 and further changes lie ahead. As former Bank of England Governor Mervyn King recently highlighted, post the support phase during COVID-19, we need to address "the next big challenge — guiding the long-term shift in economic activity that will be needed after the pandemic is controlled." This report explores this needed 'shift' transition, with Carl Frey arguing that we are moving from a post-industrial to a post-production society, in which both goods and services are increasingly produced abroad or by machines.

The first phase of the COVID-19 pandemic included historically large fiscal support. For example, 34% of pre-pandemic employees were furloughed in the U.K., 33% in France, and 25% in Australia. The implementation of job retention schemes for 50 million jobs will make re-openings easier. However other countries, such as the U.S., expanded unemployment insurance and will likely have a more flexible labor supply that can adapt quicker to the changes needed ahead.

The impacts from the pandemic have been historic, but just imagine how much worse things could have been without digital infrastructure that enabled remote work, remote learning, remote healthcare, or the ordering, making and transportation of goods. Thankfully, the Internet did not break. It certainly got tested. Citi analysts note e-commerce trends almost doubled during the pandemic and online grocery penetration did double. The online art market doubled and the digital fitness industry exploded into many people's homes. Telehealth treatments in the U.S. rose 3,000% at the peak, while online drug sales in China almost tripled. The already fast growing contactless economy, is expected to accelerate further. This includes a move away from the use of cash. COVID-19 was the biggest development for the digitization of the financial sector in the last decade, breaking life-long habits. Online education also hit a tipping point and we see edtech spend doubling in the next five years and potentially going up ten-fold from 2019 levels.

Prior to 2020, digital changes for many companies were incremental and piecemeal. Now they have become 'must have' transformation processes, as noted in Chapter 2. However the acceleration of digitization and automation has, and will, impact jobs. Following our previous work that 47% of U.S. jobs are susceptible to automation (link), with higher percentages in many other countries (link), the most often asked question was 'where will the new jobs come from?' The conclusions highlighted in Technology at Work v4.0 (link) on future growth areas such as healthcare, technology and (green) infrastructure, have arguably become even more important.

Another monumental change is the biggest work experiment in history has ushered in a new world of remote work. We went through a one-way door that we have argued will lead to a third phase of globalization, using digital labor (link). In April 2020, almost two-thirds of economic activity was done remotely in the U.S. We estimated in Technology at Work v5.0 that 52% of U.S. jobs could be done remotely going forward. Surveys point to 20% of work being done remotely post the pandemic (or two of five days on average for applicable roles), up from 5% pre-COVID. 'Work from home' can become 'work from anywhere' and in Chapter 1 of this report we estimate 26% of U.S. jobs that could be offshored over time. We calculate that 41% of U.S. jobs are not at risk from automation or offshoring, but this leaves a majority of jobs exposed to change and transition — the 'shift' referred to by Mervyn King. We estimate that 66% of jobs that are not at risk of automation or offshoring are held by men, while 70% of those at risk of both are held by women.

Women have been disproportionately impacted by the pandemic and look to be disproportionately impacted by the transitions needed ahead. Policy and corporations need to address this risk — embracing more flexible and remote work can help.

The next employment phase includes re-openings and fiscal stimulus. Citi economists estimate in Chapter 3 that the proposed U.S. jobs plan can sustain an incremental 6 million jobs for eight years, lifting employment 4% higher each year. They estimate the NextGenEU plan can generate 2.3 million jobs per year for its seven-year duration, lifting employment 1% higher each year in the EU. Both plans highlight the opportunity for job growth from the drive towards net zero climate commitments and we look at the net opportunity from the substitution of brown jobs by green jobs. Similarly the pandemic has shown the importance of both digital infrastructure and digital divides. We look at the opportunity for jobs from a renewed drive towards digital infrastructure.

While infrastructure stimulus medium term is encouraging, a danger is many of the roles needed, say to install solar panels or lay fiber, are one-off in nature. 'Build back better' plans can help people and places that were left behind during pre-pandemic economic growth. As more work moves from temporary to permanently being remote, governments and corporations need to think through the mix between onshore and lower cost offshore. Similarly, post-pandemic concerns over supply chains are raising debates about re-shoring. We argue in Chapter 4 that-long term transition plans for post-production societies need to enhance innovation. The comparative advantage of rich nations will increasingly lie in the early stages of product life cycles — exploration and innovation rather than execution or production — and this will make up a bigger portion of total employment. In turn onshore innovation jobs have a multiplier — previous work has shown that each new technology job creates five new non-tradable jobs.

Without innovation, progress and productivity will stall. We suggest in Chapter 4 a number of ways that policy makers can boost innovation and job creation: (1) restarting startups; (2) lifting business dynamism, which may require a trend change in market concentration and lobbying; (3) jumpstarting R&D; (4) patent reform can help; (5) education hubs are important, and within this a need for more STEM graduates, especially female STEM graduates; (6) attracting global talent, versus increasing barriers being raised; and (7) exposing children to innovation, not just preparing them for the jobs that exist today; and (8) policies that favor employment over automation. We also argue that knowledge industries will remain clustered to help spillovers for the exploration phase, so contrary to a conclusion that place will become less important in the digital revolution, cities will be more important. However the shift to more digitization and remote work can offer opportunities for some lagging cities to catch up and level up. This next 'shift' phase needs to be embraced by policy makers, employers, employees, investors, and educators.

# Chapter 1: The Post-Production Society

# The Post-Production Society

**Carl Benedikt Frey**
Oxford Martin Citi Fellow & Director, Future of Work Programme
Oxford Martin School

In 1974, the Harvard sociologist Daniel Bell predicted the coming of a post-industrial society.[1] According to Bell, the first major change in modern times had been the transition from "an agrarian to an industrial way of life, from a rural to an urban existence."[2] But a second change was now underway as production jobs were being automated away. In Bell's words, "The symbol of the industrial society is the semi-skilled worker, usually the man on the assembly-line who does repetitive tasks and who can learn his job in a few weeks. This symbol was graphically imprinted into our consciousness by Charlie Chaplin in Modern Times. But that reality is vanishing."[3] With mechanical power replacing raw muscle in the art of making more with less in mass production, Bell saw a post-industrial society based on services emerging.

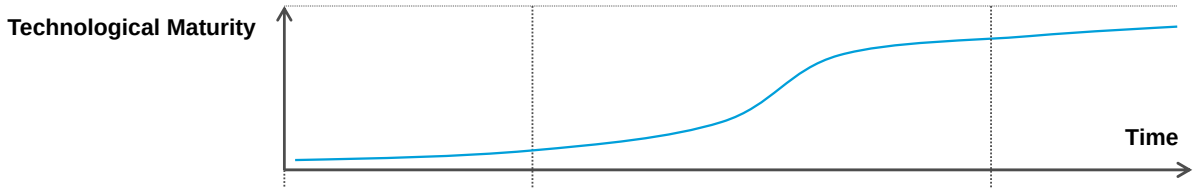
Reading Bell's work, almost half a century after the original publication, it is striking how many things he got right. He accurately predicted that the focal point of opportunity in America was increasingly being defined by education. And he observed that a sizable number of others would be excluded from the world of work because of a lack of education, creating a "permanent underclass, beached by the exigencies of the economic process."[4]

What Bell observed was happening to manufacturing is now gradually happening to many services as well. As we will argue below, the shift towards remote work has accelerated the subdivision of many professional service jobs, making them increasingly automatable and offshorable. Thus, rather than a post-industrial society, rich countries are moving towards post-production society, in which both goods and services are increasingly being produced either abroad or by machines.

What this means is that a growing share of the population will specialize in tasks that relate to the early stages of the technology lifecycle (see Figure 1), which are primarily about generating new prototypes and ideas. They are about exploration and innovation rather than execution and production. A well-known example is the iPhone, which is designed in America, but assembled in China. The same dynamic is now playing out in services. In the future, more people will engage in developing new services like algorithms for automated call centers or robotic receptionists. But fewer people in the rich countries will make a living providing those services.

[1] Bell, D. (1974). *The Coming of Post-Industrial Society*. Harper Colophon Books.
[2] Bell, D. (1976). The Coming of Post-Industrial Society. *The Educational Forum*, 40(4), 574-579.
[3] Ibid.
[4] Ibid.

**Figure 1. The Technology Lifecycle**




| | Formation | Expansion | Stagnation | Decline |
|---|---|---|---|---|
| **Knowledge Spillovers** | Highly Important | Important | Unimportant | Unimportant |
| **Innovation Intensity** | High | Medium | Stagnant | Diminishing |
| **Offshoring/Automation Potential** | Very Low | Low | High | Very High |

Source: Citi GPS

To be clear, the idea of a post-production society should not be taken to imply that all jobs producing goods and services will inevitably vanish in developed economies. What it is intended to highlight is the direction of travel. As Bell aptly put it, "In dealing with social changes, it is important to emphasize that a post-industrial society does not displace an industrial society, as the industrial society did not displace an agrarian society. Clearly, the production of goods will be a feature of our society so long as we seek a rising standard of living. Yet these goods will be produced by fewer and fewer persons".[5] This is also becoming increasingly true of services that center on the later stages of the technology lifecycle (Figure 1).

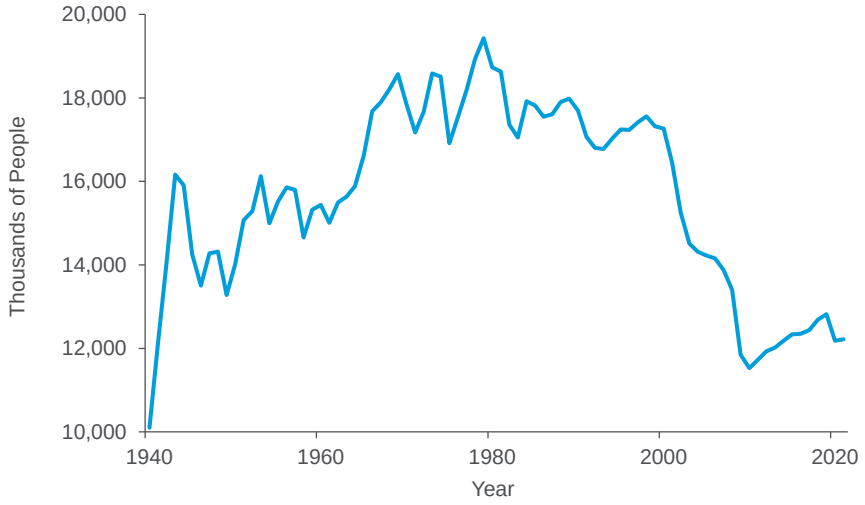
## Manufacturing Decline

Manufacturing decline has had profound consequences for the industrial world in recent decades.[6] While it is often pointed out that the U.S. manufacturing employment share peaked in the 1950s, it did so only because services grew more rapidly. In absolute terms, manufacturing employment in the U.S. peaked in 1979 and has been declining since (Figure 2). Five years after Bell's work was published, the United States had seen its manufacturing heyday.

[5] Ibid.

[6] Berger, T., & Frey, C. B. (2016). Structural Transformation in the OECD: Digitalisation, Deindustrialisation and the Future of Work. OECD Social, Employment and Migration Working Papers, No. 193. OECD Publishing.

**Figure 2. U.S. Manufacturing Employment**



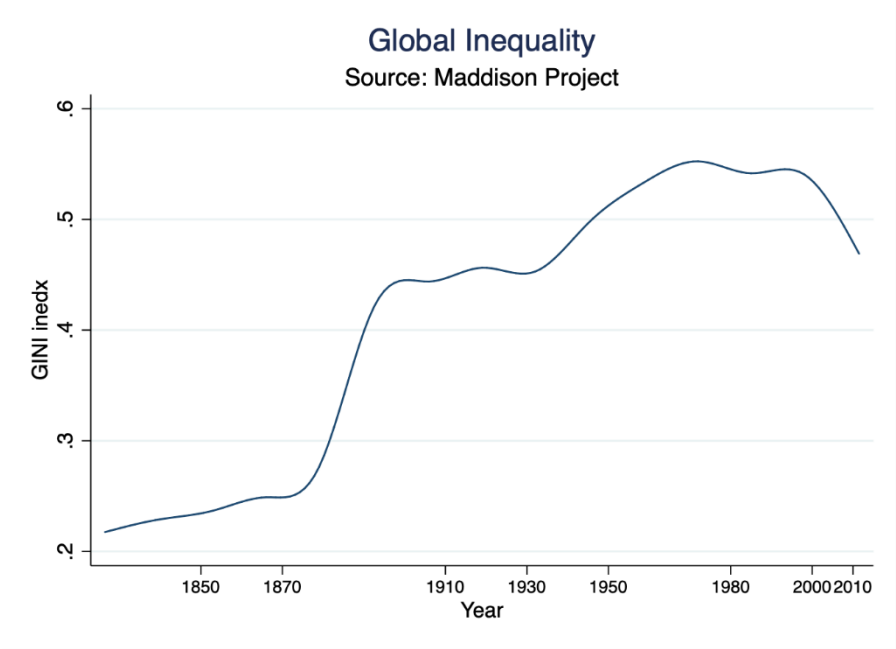

Source: Federal Reserve Economic Data

Part of the reason is that production moved abroad. The rise of offshoring has been pervasive and has even meant a reversal of two centuries of growing global income inequality.[7] The period after the British Industrial Revolution, which took off around 1750, has aptly been called the Great Divergence, as it saw Europe and its offshoots pull ahead of the rest of the world in terms of growth in gross domestic product (GDP) per capita.[8]

Things only began to change in the 1990s, when rapid advances in information and communications technology first made it possible for Western companies to coordinate production at a distance and offshore many manufacturing tasks to low-cost destinations like China. With the rise of Global Value Chains (GVCs), companies like Apple became reliant on components from China and suddenly faced compelling incentives to transfer production technology and know-how to help Chinese companies improve the inputs upon which they came to depend. And as Western companies began to improve foreign technology on a massive scale, global inequality plummeted (Figure 3), prompting what Richard Baldwin has called the 'Great Convergence'.[9]

[7] Milanovic, B. (2016). *Global Inequality: A New Approach for the Age of Globalization*. Harvard University Press.
[8] Pomeranz, K. (2021). *The Great Divergence: China, Europe, and the Making of the Modern World Economy*. Princeton University Press.
[9] Baldwin, R. (2016). *The Great Convergence*. Harvard University Press.

**Figure 3. Global Inequality**




Source: Maddison Project Database 2020. See also Milanovic (2016)

However, while American manufacturing employment has fallen, the manufacturing output share has remained remarkably constant, suggesting that plenty of goods are still being produced within American borders.[10] What's more, the manufacturing decline began long before the so-called 'China shock', following China's accession to the World Trade Organization (WTO) in 2001.[11] The impact of China's integration into the global economy on jobs in the United States has certainly been significant and is well-documented.[12] But since the 1980s, automation has been the bigger factor.[13]

Indeed, even in the 'factory of the world', manufacturing jobs are vanishing. In China, a staggering 12.5 manufacturing jobs have been shredded in only four years.[14] Thus, in many ways, Chinese companies are now facing the same dilemma that American companies have faced for decades. To remain competitive, they can either move production offshore or automate.

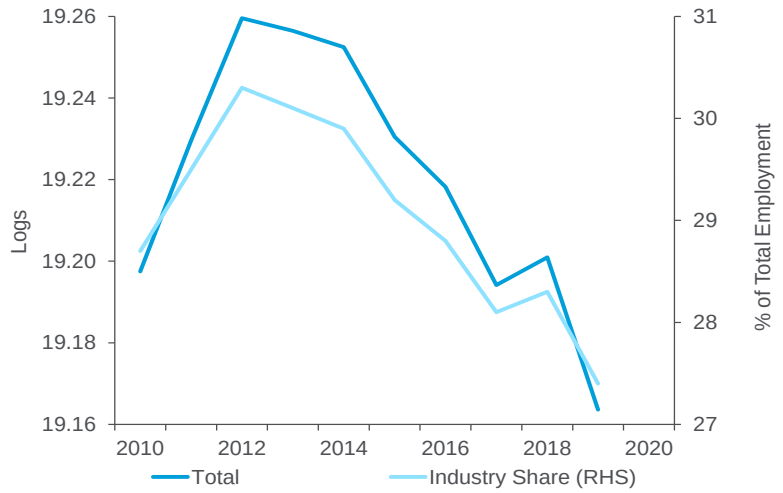
[10] Baily, M. N., & Bosworth, B. P. (2014). US Manufacturing: Understanding Its Past and Its Potential Future. Journal of Economic Perspectives, 28(1), 3-26.
[11] Autor, D. H., Dorn, D., & Hanson, G. H. (2016). The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade. *Annual Review of Economics*, 8, 205-240.
[12] Autor, D. H., Dorn, D., & Hanson, G. H. (2013). The China Syndrome: Local Labor Market Effects of Import Competition in the United States. *American Economic Review*, 103(6), 2121-2168.
[13] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.
[14] Lawrence, R. Z. (2020). China, Like the US, Faces Challenges in Achieving Inclusive Growth through Manufacturing. *China & World Economy*, 28(2), 3-17.

As one union leader at General Electric's Louisville, Kentucky factory put it in 1984, "The automation had to be done, otherwise we would have lost the plant altogether. Some jobs have been lost for the moment, but we had to accept some changes to keep the factory here. We sure as hell didn't want those jobs to go somewhere else."[15]

The logic in China today is the same. To prevent factories from moving to countries like Thailand and Vietnam, where labor costs are lower, the Chinese government has made an explicit effort to accelerate automation. And they have been helped by the rapidly declining cost of industrial robots. In the 2016 Citi GPS report Technology at Work v2.0, we estimated the payback period for a robot in the Chinese auto industry had already fallen below two years. And while industrial robots have been particularly important in the automobile and electronics industries, they will spread much further.

Compared to countries like Germany, Japan, and South Korea, China is lagging behind in what is called 'Industry 3.0'. But they have big plans to join the leaders and leapfrog into 'Industry 4.0', which means "integrating clusters of industrial robots tied together with intelligent networks in order to automate entire manufacturing processes."[16] This plan is at the heart of the country's "Made in China 2025" initiative.

**Figure 4. China Employment**



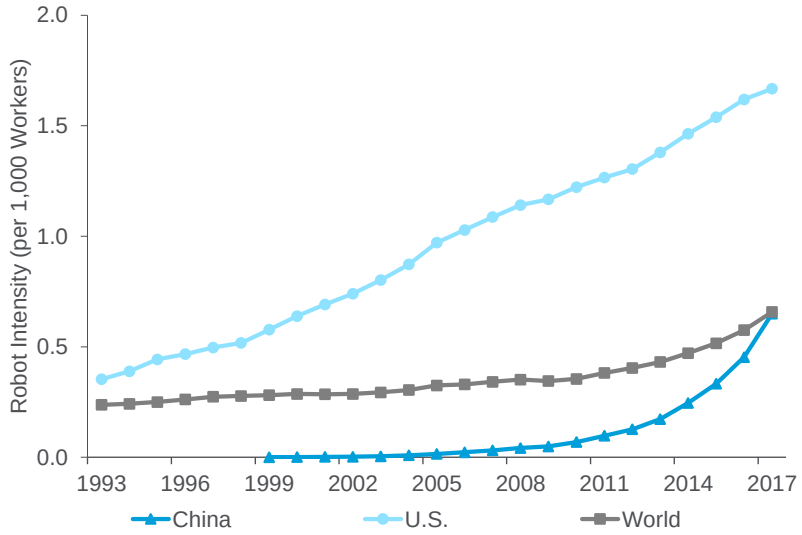

Source: ILOSTAT

The decline of manufacturing employment, in other words, is not just a story of American jobs moving to China. China itself is deindustrializing (Figure 4). Such 'premature deindustrialization' is in large part driven by automation.[17] As shown in Figure 5, the uptake of robots around the world is striking. And the consequences will be significant for developing countries which have traditionally grown rich by shifting labor from agriculture to manufacturing.

[15] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.
[16] Naughton, B. (2021). *The Rise of China's Industrial Policy 1978 to 2020*. Academic Network of Latin America and the Caribbean on China.
[17] Rodrik, D. (2016). Premature Deindustrialization. *Journal of Economic Growth*, 21(1), 1-33; Kunst, D. (2019). Premature Deindustrialization through the Lens of Occupations: Which Jobs, Why, and Where? Tinbergen Institute Discussion Paper 2019-033/V.

For latecomers like Japan, the East Asian Tigers, and China, export-oriented manufacturing served as a powerful escalator to modernity, allowing them to take advantage of their most abundant factor: unskilled labor.[18] But that may not be a feasible development strategy in the future.

**Figure 5. Robot Adoption**




Source: ILOSTAT, International Federation of Robotics

Premature deindustrialization is particularly troubling for African economies which are yet to industrialize. To be sure, before the pandemic, many economies in Sub-Saharan Africa were growing at impressive rates and even faster than at any time since independence. Countries that are highly resource-dependent saw growth rates decline as the commodities boom tapered off, but economies like Ethiopia, Rwanda, and Cote d'Ivoire were still seeing GDP per capita growth rates of over 7%. Much of this growth was due to productivity gains from structural change as workers shifted out of agriculture into cities.[19] But aggregate labor productivity growth in manufacturing was nonetheless disappointing. Strikingly, countries that underwent particularly rapid structural change did not experience any productivity growth at all outside of agriculture. This is not just true of resource-dependent economies. Even in countries like Ethiopia, which has attracted significant foreign investment from China and elsewhere, productivity in manufacturing did not even come close to the productivity gains that late industrializers in East Asia saw when their economies took off. The reason, it seems, is that African urbanization is a demand-side story. The growing demand for urban products could only be met through the expansion of less productive companies at the margin.[20]

In a detailed analysis of the manufacturing sectors in Ethiopia and Tanzania, the economist Dani Rodrik and collaborators show that while larger companies exhibit superior productivity performance, they do not expand employment much. Instead, small firms absorb most workers.

[18] Studwell, J. (2013). *How Asia Works: Success and Failure in the World's Most Dynamic Region*. Open Road+ Grove/Atlantic.
[19] Diao, X., McMillan, M., & Rodrik, D. (2019). The Recent Growth Boom in Developing Economies: A Structural Change Perspective. In *The Palgrave Handbook of Development Economics*, 281- 334. Palgrave Macmillan.
[20] Ibid.

But small companies do not generate much productivity growth. Thus, while economic development has traditionally been a story of dynamic sectors absorbing resources from the rest, "the choice that African manufacturers seem to face is either to increase productivity or to increase employment."[21]

The problem, Rodrik and co-authors argue, might be the nature of technologies available to African firms. Large manufacturing companies in Tanzania and Ethiopia are much more capital-intensive than one would expect based on the income levels or relative factor endowments of the countries in which they operate. Indeed, the largest and most productive companies have a capital intensity similar to the Czech Republic, which is around twenty times richer.

These findings echo the old and largely forgotten debate surrounding appropriate technology for low-income countries. As E.F. Schumacher famously argued in *Small is Beautiful*, first published in 1973, technologies developed in the industrial world may not be suitable to low-income countries. Frontier technologies might be excessively capital-intensive and require economies of scale. The spread of GVCs has made it possible for developing countries to specialize in individual components, but they have also had a homogenizing impact on technology around the world.[22] As developing countries increasingly tap into GVCs to produce for advanced economies, their reliance on advanced robotics seems to cause them to deindustrialize prematurely.[23]

## Services Next?

Since the work of the economist William Arthur Lewis, the manufacturing industry has widely been regarded as the stepping stone to middle-income status. And rightly so: almost every country, from Britain in the eighteenth century, to China today, has taken the manufacturing path to prosperity. The gradual vanishing of manufacturing jobs is therefore of great concern. The good news for the developing world is that services are becoming increasingly tradable. As we discussed in greater detail in the 2020 Citi GPS report Technology at Work v5.0, the Indian model of service-led growth is the exception that confirms the general rule. And it now looks more likely to become the norm. Business process outsourcing (BPO) activities, like accounting, payroll, human resources, and various legal and IT services, have provided middle-income jobs for many Indians as service occupations and industries become increasingly unbundled. The economist Alan Blinder noted this trend already at the dawn of the Great Recession:

[21] Diao, X., Ellis, M., McMillan, M., & Rodrik, D. (2021). Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms. CEPR Discussion Paper No. DP15650.
[22] Rodrik, D. (2013). Unconditional Convergence in Manufacturing. *The Quarterly Journal of Economics*, 128(1), 165-204.
[23] Rodrik, D. (2016). Premature Deindustrialization. *Journal of Economic Growth*, 21(1), 1-33; Kunst, D. (2019). Premature Deindustrialization through the Lens of Occupations: Which Jobs, Why, and Where? Tinbergen Institute Discussion Paper 2019-033/V.

> Contrary to current thinking, Americans, and residents of other English-speaking countries, should be less concerned about the challenge from China, which comes largely in manufacturing, and more concerned about the challenge from India, which comes in services. India is learning to exploit its already strong comparative advantage in English, and that process will continue.
>
> – ALAN BLINDER[24]

At the time, Blinder caused much alarm. He estimated that somewhere between 22% and 29% of American jobs might become offshorable over the next decade or two due to advances in information and communications technology.[25] Blinder, however, was careful to point out that if a job is offshorable, it does not necessarily follow that the job will be offshored. Legislation, relative costs, and many other factors shape companies' decisions to offshore. But as he aptly put it, "It would be nice to know more — or at least to have some reasonable ballpark estimates. For example, the implications for public policy are likely quite different depending on whether offshoring will eventually affect 3 million American jobs or 30 million."[26]

Rather than sending services overseas, companies might prefer to hire remote workers domestically. This is something Blinder didn't consider, and there is some evidence to suggest this has happened in recent years. Subsequent analysis shows that many of the occupations Blinder identified as offshorable did experience employment declines. But many did not, and a shift to remote work seems to be part of the story.

A recent report published by Upwork shows the jobs Blinder predicted to be most at risk of offshoring are strongly correlated with a growing incidence of remote work. From the viewpoint of American workers, this is a more positive story than the offshoring story most commentary has focused on. Rather than reducing the demand for labor, remote work provides greater freedom, flexibility, and fewer commutes. And it offers the potential for lagging cities and regions to catch up by making work less concentrated in a few mega cities.[27]

There are indeed several reasons why companies might prefer to outsource some tasks domestically rather than sending them abroad. One is coordination. One American company, for example, recently hired a team of programmers in India. But even though those workers were highly skilled, the time difference made it hard to collaborate effectively.[28]

And other offshoring hurdles are not hard to come by. Mark Orttung, Nexient's Chief Executive Officer, recently noted that while offshoring works well for certain types of work, like short-term projects, there are projects that change significantly over time and require closer collaboration.

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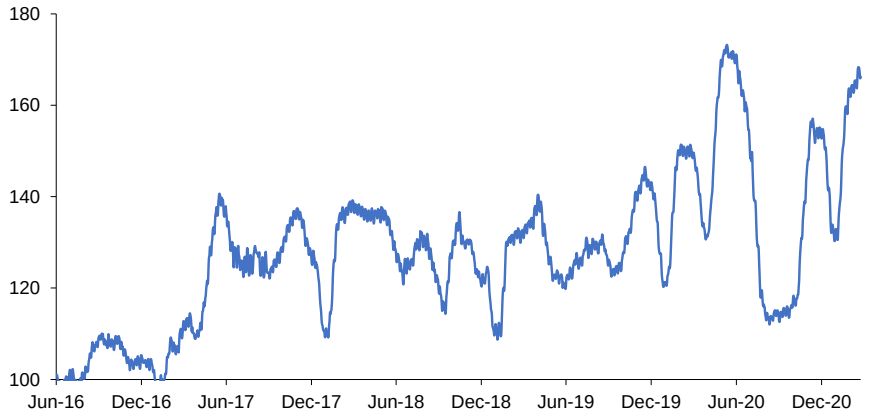
[24] Blinder, A. S. (2006). Offshoring: The Next Industrial Revolution? *Foreign Affairs*, March/April.
[25] Blinder, A. S. (2009). How Many US Jobs Might be Offshorable? *World Economics*, 10(2), 41.
[26] Ibid.
[27] Ozimek, A. (2019). Overboard on Offshore Fears. Upwork.
[28] Casselman, B. (2019). The White-Collar Job Apocalypse That Didn't Happen. *The New York Times.*

In addition, American workers have a comparative advantage in certain projects which require a greater understanding of the business context, like how the American health care system works, or the behavior of American consumers. So while Nexient is based in the San Francisco Bay Area, most of its employees are in Columbus, Ohio or in Ann Arbor, Michigan. These college towns provide new cohorts of young graduates with technical skills every year with living costs much lower relative to Silicon Valley.[29]

**Figure 6. Online Labor Index, 28-day Moving Average**




Source: iLabour Project, Oxford Internet Institute

While there are many such examples, remote work remained relatively rare before the pandemic.[30] Meanwhile, there is compelling evidence that more digital work has shifted towards countries like India in recent years. While demand for work through digital platforms generally comes from the U.S., most of the work is now done in low- and middle-income countries. This trend is likely to continue as services increasingly become subdivided into smaller tasks.

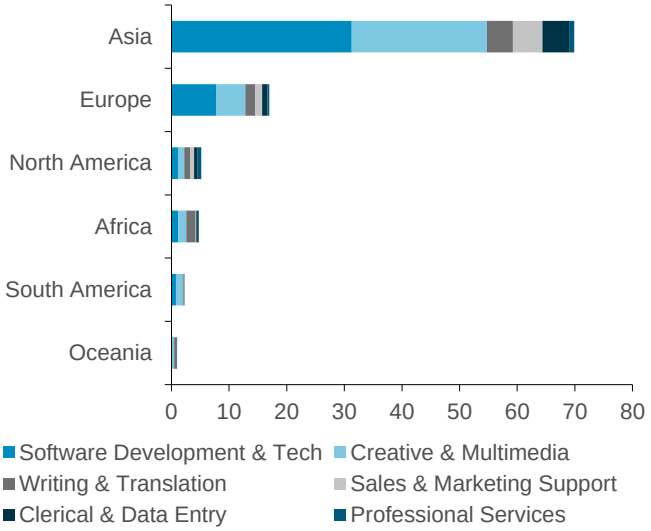
For example, the Online Labour Index (OLI), developed by Oxford's Vili Lehdonvirta and Otto Kässi, tracks how standard employment is increasingly supplemented and substituted by temporary gig work mediated by digital platforms.[31] Figure 6 plots the supply and demand of online freelance labor, tracking the number of projects and tasks executed through digital platforms in real time. It shows that the use of digital labor has grown by a staggering 63% since May 2016, when systematic data collection began. With the exception of clerical and data entry, which is becoming increasingly automated, all occupations examined have seen online freelance labor becoming more common. Over 70% of this work is being done in Asia (Figure 7), where most 'virtual migrants' are engaged in software development, with India, Pakistan, and Bangladesh being the most common destinations for digital work (Figure 8).

[29] Ibid.

[30] Frey, C. B. et al. (2020). Technology at Work 5.0: A New World of Remote Work. Citi GPS: Global Perspectives & Solutions.

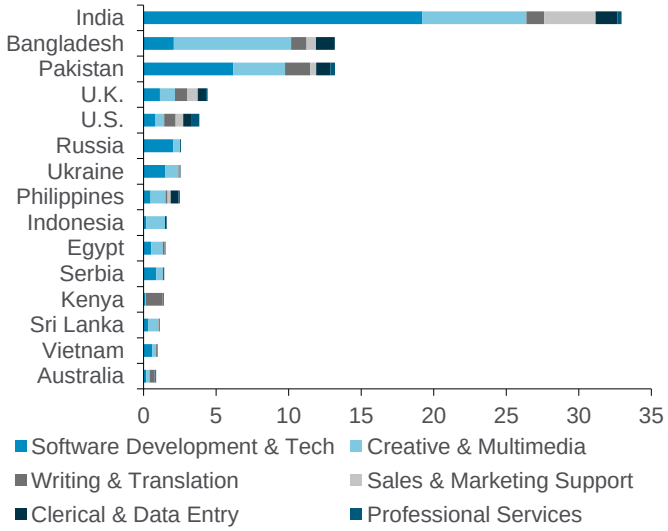
[31] Kässi, O. & Lehdonvirta, V. (2018). Online labour index: Measuring the online gig economy for policy and research, *Technological Forecasting and Social Change*, 137, 241-248.

**Figure 7. Online Workers, April 2021 (%)**




Source: iLabour Project, Oxford Internet Institute

**Figure 8. Online Worker Share, April 2021 (%)**




Source: iLabour Project, Oxford Internet Institute

It is hardly surprising that the top countries for online workers are high-income English-speaking countries (like Australia, Britain, and the United States), while some of the biggest sources of telemigrants are low-income English-speaking countries, like Bangladesh and India.[32] Linguistic and cultural barriers make services harder to trade across countries. But many trade barriers in services are gradually being dismantled, partly because of technology. As we noted in Technology at Work 5.0, improvements in machine translation has made service-led growth feasible for a growing set of countries.[33] The challenge for advanced economies is that the forces Daniel Bell noted were reshaping manufacturing are now also affecting many services.

## COVID-19 and Remote Work

The COVID-19 pandemic has, if anything, exacerbated the trends described above. While platform work plummeted during the first wave of the pandemic, it has rebounded since (Figure 6), and as more businesses shift to remote work, the upsurge seems set to continue.

The growth of remote work in advanced economies is breathtaking. At the peak in April 2020, almost two thirds of economic activity in the United States was done remotely. And while the post-pandemic world will see much lower levels of remote work, the share of work done remotely will be significantly higher than we saw before the pandemic.

[32] Baldwin, R., & Forslid, R. (2020). Globotics and Development: When Manufacturing is Jobless and Services are Tradable. NBER Working Paper No. 26731.
[33] Baldwin, R. (2019). *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*. Oxford University Press.

A recent study that surveyed 30,000 Americans suggests that 20% of all full work days will be done from home after the pandemic, compared with just 5% before COVID-19.[34] This would be good news for productivity, which needs a revival. The study estimates that 'work from home' arrangements could increase productivity in the post-pandemic economy by 5%, largely by saving time by commuting less.[35]

In a recent paper, the authors outline five reasons why remote work will stick.

1. **The stigma surrounding 'work from home' has been reduced.** Before the pandemic, working from home was widely regarded as 'shirking from home'. The normalization of remote work has led to changing perceptions of it, and this shift is likely to be permanent.

2. **Forced experimentation has helped employees and employers to overcome inertia**, both in terms of costs and biased expectations about remote work. This has been a costly experiment which would not have happened on mass scale without the pandemic. But given the investment has already been made, and often with positive results, this new information will lead many companies to stick with the new mode of work, even when the pandemic subsides.[36]

3. **Workers and firms will be able to maintain remote work at lower marginal cost after the pandemic.** The study estimates that the average U.S. worker has invested over 15 hours and about $561 in equipment and infrastructure to support working from home, amounting to 0.7% of GDP. Meanwhile, companies have made sizable investments in equipment and back-end information technologies to facilitate working from home.[37]

4. **There is a widespread reluctance among many to return to some pre-pandemic activities.** For example, a large share of the working population is more likely to avoid crowded places, like elevators, and will prefer working from home.

5. **There has been an explosion in innovation aimed at supporting remote work in the past couple of months.** The share of new patent applications in the field of remote work technologies more than doubled between January and September of 2020, surpassing its previous peak by some margin.[38] As remote work technologies improve, remote work looks more likely to stick.

Clearly, views of remote work remain polarized and not every company will embrace it. At the negative end of the spectrum, Netflix CEO Reed Hastings recently said "I don't see any positives. Not being able to get together in person, particularly internationally, is a pure negative." The median view, however, comes much closer to the assessment of Apple's CEO Tim Cook: "In all candor, it's not like being together physically.…[But] I don't believe that we'll return to the way we were

[34] Barrero, J. M., Bloom, N., & Davis, S. J. (2021). Why Working From Home Will Stick. University of Chicago, Becker Friedman Institute for Economics Working Paper, (2020-174).
[35] Ibid.
[36] Ibid.
[37] Ibid
[38] Bloom, N., Davis, S. J., & Zhestkova, Y. (2020). COVID-19 Shifted Patent Applications toward Technologies that Support Working from Home. University of Chicago, Becker Friedman Institute for Economics Working Paper, (2020-133).

because we've found that there are some things that actually work really well virtually."[39]

In Technology at Work 5.0, we examined which jobs can be done remotely at a time of crisis. We found that 52% of jobs in the United States can be performed remotely in principle. But because a job can be done remotely, does not mean it should be. Studies show that people for the most part are more productive at home than in the office, so there are good reasons to believe that remote work could boost productivity.[40] But while it might be good for productivity, creativity and innovation don't flourish when people work in isolation.[41] And without innovation, progress and productivity will eventually stall.

## How Innovation Works

The location decisions of technology companies, which are at the forefront of innovation, point to the continued value of face-to-face contact. As Harvard's Edward Glaeser puts it, "The fact that Silicon Valley is now the quintessential example of industrial agglomeration suggests that the most cutting-edge technology encourages, rather than eliminates, the need for geographic proximity."[42]

My own research with Thor Berger shows that this view holds more broadly: place has become more important since the digital revolution; not less. Since the personal computer featured on the front cover of Time Magazine in 1982, many new occupations — including computer programmers, software engineers, and database administrators — have appeared. But relative to new jobs of the past, they have been highly concentrated in cities specializing in knowledge work.[43] In a follow-up study we examined the location of new industries, which primarily relate to digital technologies, such as online auctions, web design, and video and audio streaming.[44] Somewhat ironically, we found that "precisely the technologies that futurists once believed would flatten the world have made it more uneven: digital industries have overwhelmingly clustered in cities with skilled populations."[45]

Why are knowledge industries more concentrated than other industries? One reason is that a lot of innovation is driven by sporadic encounters, for which digital technologies still provide poor substitutes. Consider the Volstead Act of 1920, which started national prohibition in America.

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[39] Cutter, C. (2020). What CEOs Really Think About Remote Work. *The Wall Street Journal*,

[40] Bloom, N., Liang, J., Roberts, J., & Ying, Z. J. (2015). Does Working from Home Work? Evidence from a Chinese Experiment. *The Quarterly Journal of Economics*, 130(1), 165-218.

[41] Frey, C.B. (2020). The Great Innovation Deceleration. *MIT Sloan Management Review*. ; Frey, C.B. (2021). We don't need to go back to the office to be creative, we need AI. The WIRED World in 2021 [Special Edition]. *WIRED*.

[42] Glaeser, E. L. (1998). Are cities dying? *Journal of Economic Perspectives*, 12(2), 139-160.

[43] Berger, T., & Frey, C. B. (2016). Did the Computer Revolution shift the fortunes of US cities? Technology shocks and the geography of new jobs. *Regional Science and Urban Economics*, 57, 38-45.

[44] Berger, T., & Frey, C. B. (2017). Industrial renewal in the 21st century: evidence from US cities. *Regional Studies*, 51(3), 404-413.

[45] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.

Because prohibition disrupted people's social networks and thus reduced the likelihood of sporadic encounters, the consequences for innovation were dismal. Not only did collaboration suffer but patenting among solo-inventors also declined as they became less exposed to new ideas. Taking advantage of the fact that states introduced prohibition at different times, the economist Michael Andrews estimates that previously wet places saw patenting decline by 8 to 18% relative to counties that were consistently dry.[46] Innovation only rebounded half a decade later as people gradually rebuilt their informal social networks.

In addition, there is plenty of anecdotal evidence of how informal social networks shape innovation. For some time, the Homebrew Computer Club, where the story of Apple began, met at The Oasis Bar and Grill. Apple's co-founder Steve Wozniak explains the importance of these gatherings:

> Without computer clubs there would probably be no Apple computers. Our club in the Silicon Valley, the Homebrew Computer Club, was among the first of its kind. It was in early 1975, and a lot of tech-type people would gather and trade integrated circuits back and forth. You could have called it Chips and Dips. We had similar interests and we were there to help other people, but we weren't official and we weren't formal. Our leader, Lee Felsenstein, who later designed the Osborne computer, would get up at every meeting and announce the convening of "the Homebrew Computer Club which does not exist" and everyone would applaud happily. The theme of the club was 'Give to help others.' Each session began with a 'mapping period', when people would get up one by one and speak about some item of interest, a rumor, and have a discussion… The Apple I and II were designed strictly on a hobby, for-fun basis, not to be a product for a company. They were meant to bring down to the club and put on the table during the random access period and demonstrate: Look at this, it uses very few chips. It's got a video screen. You can type stuff on it. Personal computer keyboards and video screens were not well established then. There was a lot of showing off to other members of the club. Schematics of the Apple I were passed around freely, and I'd even go over to people's houses and help them build their own.[47]
>
> – STEVE WOZNIAK

Other examples are not hard to come by. The bottom-up process that gave rise to the info & communication technology (ICT) revolution is vividly illustrated in Walter Isaacson's book *The Innovators*, which portrays the numerous people involved in it, and highlights how ideas diffused and developed as inventors and entrepreneurs competed and collaborated.[48] In similar fashion, James Watt's separate condenser, which made steam power efficient and economical, came out of early collaborations with scientists like John Robison and Joseph Black in Glasgow, and a later partnership with Matthew Boulton in Birmingham. As we all know, Watt's invention eventually came to power much of the British Industrial Revolution.[49]

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[46] Andrews, M. (2019). Bar Talk: Informal Social Interactions, Alcohol Prohibition, and Invention. Working Paper.
[47] Wozniak, S. (1984). Homebrew and How the Apple Came to Be. In Ditlea, S. (Ed.), *Digital Deli: The Comprehensive, User-Lovable Menu of Computer Lore, Culture, Lifestyles and Fancy.* Workman Publishing Company.
[48] Isaacson, W. (2014). *The Innovators: How a Group of Inventors, Hackers, Geniuses, and Geeks Created the Digital Revolution*. Simon and Schuster.
[49] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.

## Innovation at Work

The kind of sporadic interactions that drive innovation also happen at the office. But while they are essential for generating new ideas, they are hardly critical for most activities. Before the age of COVID-19, offices were used for both innovation and production. And they were used differently by different people. As the eminent Richard Hamming once observed:

> I noticed the following facts about people who work with the door open or the door closed. I notice that if you have the door to your office closed, you get more work done today and tomorrow, and you are more productive than most. But 10 years later somehow you don't quite know what problems are worth working on; all the hard work you do is sort of tangential in importance. He who works with the door open gets all kinds of interruptions, but he also occasionally gets clues as to what the world is and what might be important. Now I cannot prove the cause and effect sequence because you might say, "The closed door is symbolic of a closed mind." I don't know. But I can say there is a pretty good correlation between those who work with the doors open and those who ultimately do important things, although people who work with doors closed often work harder. Somehow they seem to work on slightly the wrong thing - not much, but enough that they miss fame.[50]
>
> – RICHARD HAMMING

It goes without saying that those who keep the door closed all day might as well work remotely. And that works well for many tasks, but not for innovation. As already noted, one way of thinking about what should and shouldn't be done remotely is through the lens of the technology lifecycle (Figure 1), which can be divided into two fundamentally different activities: exploration and execution. While frontier innovation requires exploration to make new discoveries, production does not.[51]

During the exploration phase, employees benefit from knowledge spillovers and the proximity to other creative people. But when a prototype is developed or a project becomes more clearly defined, operations become more standardized and routinized. And because knowledge spillovers become less important as a consequence, people might as well work from remote locations.

## The Next Wave of Offshoring

More and more activities will become offshorable as technology progresses. Before the dawn of the digital revolution, economists used to think of the tradable sector of the economy as the manufacturing sector, with non-manufacturing jobs deemed non-tradable. But the domain of tradable services has expanded enormously in recent decades, rendering old ways of thinking redundant.

[50] Hamming, R. (1986). You and Your Research [Transcript]. Bell Communications Research Colloquium Seminar.
[51] Frey, C.B. (2021). How Culture Gives the US an Innovation Edge Over China. *MIT Sloan Management Review*, 62(3).

In the new world of globalized digital labor, some jobs in just about every sector might be offshored. As Richard Baldwin has argued, recent advances in telepresence and telerobotics promise to transform many sectors as we know them.[52] This is even true of sectors that have been technologically stagnant in the past, like healthcare and education.

To be sure, many healthcare jobs are probably destined to be delivered in person for some time, and perhaps even forever. But as we noted in Technology at Work 5.0, telemedicine is now on the rise, and with a little imagination one can envision many medical services being performed by doctors who are located thousands of miles away. "Indeed, some surgery has already been performed by robots controlled by doctors via fiber-optic links."[53]

While most educational services are best delivered in person, they are also becoming increasingly expensive. Thus, in higher education, cheap digital delivery looks increasingly sensible, and has other clear advantages besides reducing inflated costs: in-person lectures cannot be paused or replayed.

That said, digital delivery will probably never fully replace in-person teaching in K-12 education, and that is where the vast majority of educational jobs are. Recent studies of the effect of school closures during the pandemic reinforces this view. Examining the initial eight-week shutdown of schools in the Netherlands, which has some of the fastest broadband in the world, Oxford's Per Engzell and co-authors found that, "The average learning loss is equivalent to a fifth of a school year, nearly exactly the same period that schools remained closed."[54] They also show that losses were "up to 60% larger among students from less-educated homes."[55] This speaks to the findings of a German study, showing that low-achievers "disproportionately replaced learning time with detrimental activities such as TV or computer games rather than with activities more conducive to child development."[56]

Services that cannot be delivered digitally, or can only be delivered digitally with poor quality, have one key characteristic: they are personal, meaning that face-to-face contact is either imperative or highly desirable. While a remote-controlled robot might be able to serve dinner at a restaurant, it is still not the same experience. However, face-to-face human contact is hardly critical for interactions with a telephone operator who arranges your conference call. Nor do you need to see the clerk who takes your airline reservation over the phone.[57] This is true of many other activities, including those performed by credit analysts, mathematical technicians, and editors.

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[52] Baldwin, R. (2019). *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*. Oxford University Press.
[53] Blinder, A. S. (2006). Offshoring: The Next Industrial Revolution? *Foreign Affairs*, March/April.
[54] Engzell, P., Frey, A., & Verhagen, M. D. (2020). Learning inequality during the COVID-19 pandemic. SocArXiv.
[55] Ibid.
[56] Grewenig, E., Lergetporer, P., Werner, K., Woessmann, L., & Zierow, L. (2020). COVID-19 and Educational Inequality: How School Closures Affect Low-and High-Achieving Students. CESifo Working Paper No. 8648.
[57] Blinder, A. S. (2009). How Many US Jobs Might be Offshorable? *World Economics*, 10(2), 41.

Thus, the critical divide between jobs that can be offshored and those that cannot is clearly no longer education. Many skilled types of work are now easily deliverable electronically with no loss in quality. Conversely, there are many jobs we think of as 'unskilled' which aren't tradable. The jobs of bus drivers and receptionists cannot be offshored, though they are becoming increasingly exposed to machine learning and advanced robotics.

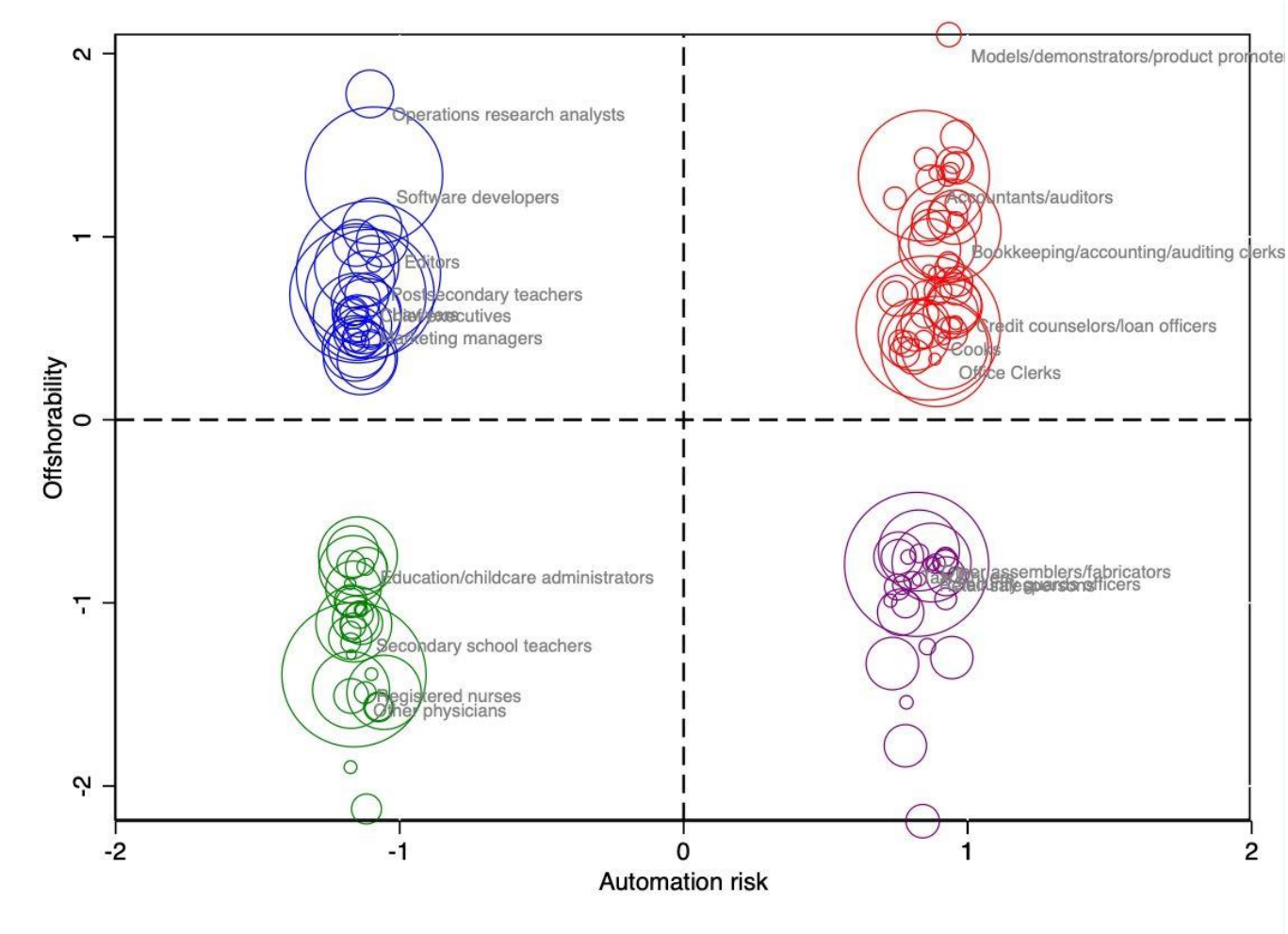
## The Offshoring-Automation Matrix

Many jobs that aren't offshorable are automatable. Indeed, recent years have seen some striking improvements in the capabilities of machines. In manufacturing, robots can now autonomously perform a relatively wide range of tasks — including welding, painting, and packaging. More importantly, the potential scope of automation goes far beyond manufacturing. According to my own work with Michael Osborne, first published in 2013, almost half of jobs in the United States are highly exposed to automation due to recent advances in artificial intelligence (AI) and mobile robotics.[58] As we highlighted in 2015 Citi GPS report Technology at Work, hardly any industry is left unaffected. Jobs in transportation, logistics, retail, finance, and a host of professional services and managerial occupations, are becoming increasingly automatable.

To assess the offshorability and automatability of jobs more systematically, we match our automatability index with a widely used offshorability index.[59] Figure 9 categorizes occupations according to their exposure to both trends. Overall, our estimates suggest that 41% of the U.S. workforce is safe from both offshoring and automation, while 8% of jobs (like those of bookkeepers, loan officers, and office clerks) can both be done by algorithms and sent abroad. The overlap, however, is limited: one-third of jobs are exposed to automation (but not to globalization), while another 18% are at risk of being offshored.

[58] Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, 114, 254-280.
[59] Acemoglu, D., & Autor, D. (2011). Skills, Tasks and Technologies: Implications for Employment and Earnings. In *Handbook of Labor Economics* (Vol. 4, pp. 1043-1171).

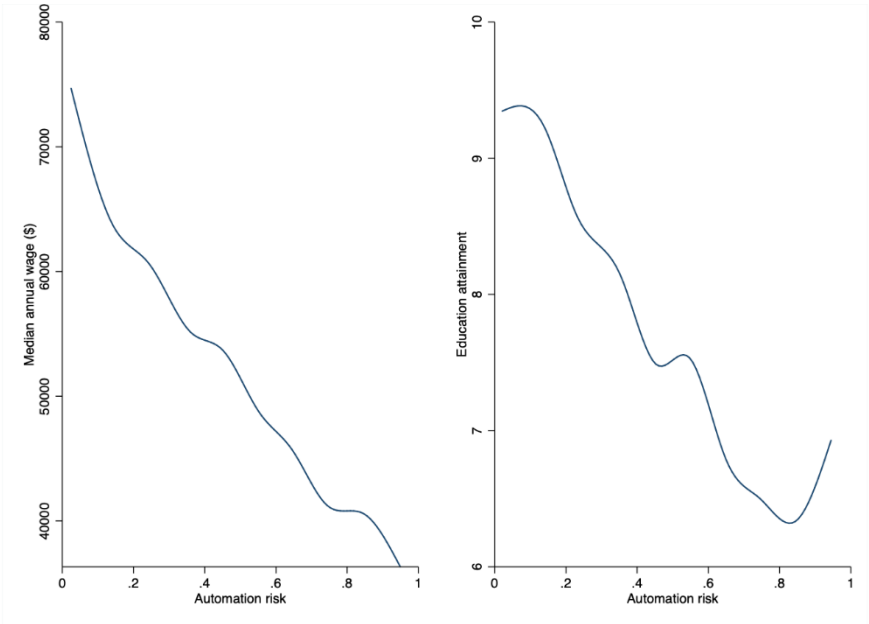
**Figure 9. Automation Risk and Offshorability**




Source: Frey and Osborne (2017), Acemoglu and Autor (2010), 2019 ACS 5-year Data, IPUMS USA

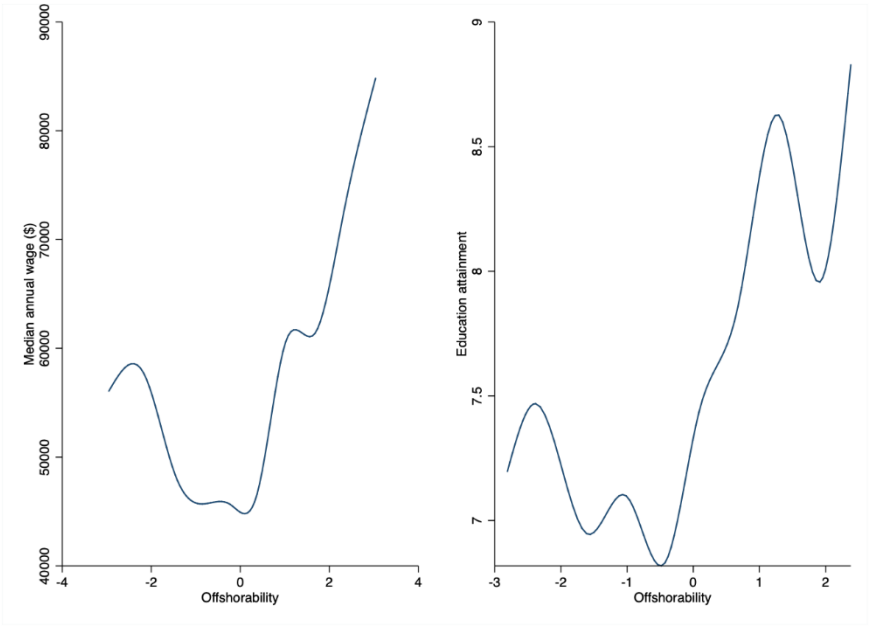
The key difference between jobs that can be automated, and those at risk of being offshored, is that automation is primarily confined to unskilled low-income jobs (Figure 10), like those of cashiers or assembly workers. Jobs that are offshorable, in contrast, tend to be relatively skilled high-income jobs (Figure 11), including those of software developers and editors.

**Figure 10. Automated Risk vs. Median Annual Wage (Left) and Automation Risk vs. Education Attainment (Right)**




Source: Frey and Osborne (2017), Occupational Employment and Wage Statistics, Bureau of Labor Statistics

**Figure 11. Offshorability vs. Median Annual Wage (Left) and Offshorability vs. Education Attainment (Right)**




Source: Acemoglu and Autor (2010), Occupation and Wage Statistics, Bureau of Labor Statistics

When we look at the industries that are highly exposed to offshoring, finance and insurance as well as professional services loom large, while sectors like accommodation, food services, transportation, and construction, are more exposed to automation (Figure 12). Across industries, the vast majority (70%) of the jobs exposed to both automation and offshoring are held by women (Figure 13), while among the occupations that are left relatively unaffected by either trend, 66% of jobs are held by men.[60] We further note that men are more at risk within the categories exposed to either offshoring or automation.

**Figure 12. Automation and Offshorability Risk by Industry**

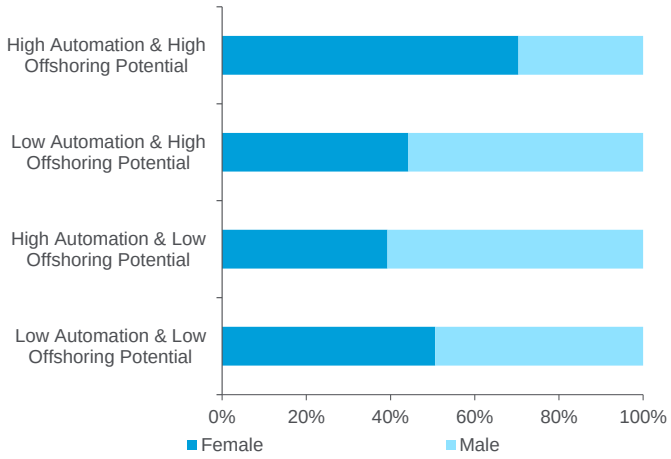
| Industry | High Automation Risk (%) | High Offshorability Risk (%) |
|---|---|---|
| Accommodation & Food Services | 70.33 | 8.42 |
| Administrative, Support, & Waste Management Services | 49.06 | 26.22 |
| Agriculture, Forestry, Fishing, & Hunting | 56.92 | 6.80 |
| Arts, Entertainment, & Recreation | 31.67 | 29.01 |
| Construction | 57.72 | 12.21 |
| Educational Service | 14.25 | 18.85 |
| Finance & Insurance | 40.12 | 62.34 |
| Health Care & Social Assistance | 23.15 | 11.62 |
| Information | 20.18 | 44.41 |
| Management of Companies & Enterprises | 30.79 | 56.31 |
| Manufacturing | 52.69 | 27.77 |
| Mining, Quarrying, & Oil and Gas Extraction | 38.46 | 24.59 |
| Other Services, Except Public Administration | 33.20 | 18.62 |
| Professional, Scientific, & Technical Services | 25.73 | 61.99 |
| Public Administration | 24.88 | 32.50 |
| Real Estate & Rental and Leasing | 71.16 | 20.46 |
| Retail Trade | 55.39 | 15.14 |
| Transportation & Warehousing | 64.80 | 14.21 |
| Utility | 31.11 | 27.00 |
| Wholesale Trade | 36.67 | 54.97 |

Source: Frey and Osborne (2017), Acemoglu and Autor (2010), 2019 ACS 5-year Data, IPUMS USA

Thus, overall, automation and offshoring affects different groups in the labor market. So it should be no surprise that cities will fare differently from these trends. As shown in Figure 15, less densely populated places are relatively exposed to automation. This finding is intuitive, since jobs that center on creativity and complex social interactions are particularly hard to automate, and interactive jobs are highly clustered. Denser cities, on the other hand, are more exposed to offshoring (Figure 16).

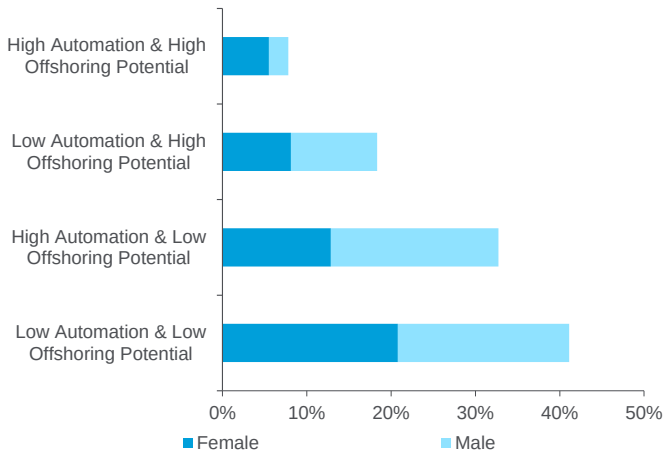
[60] While our estimates should not be taken to imply that all of those jobs necessarily will be offshored or automated, they do suggest that many occupations are potentially automatable and/or offshorable from a technological capabilities point of view.

**Figure 13. Employment Share with Categories**




Source: Frey and Osborne (2017), Acemoglu and Autor (2010), 2019 ACS 5-year Data, IPUMS USA

**Figure 14. Employment Share**



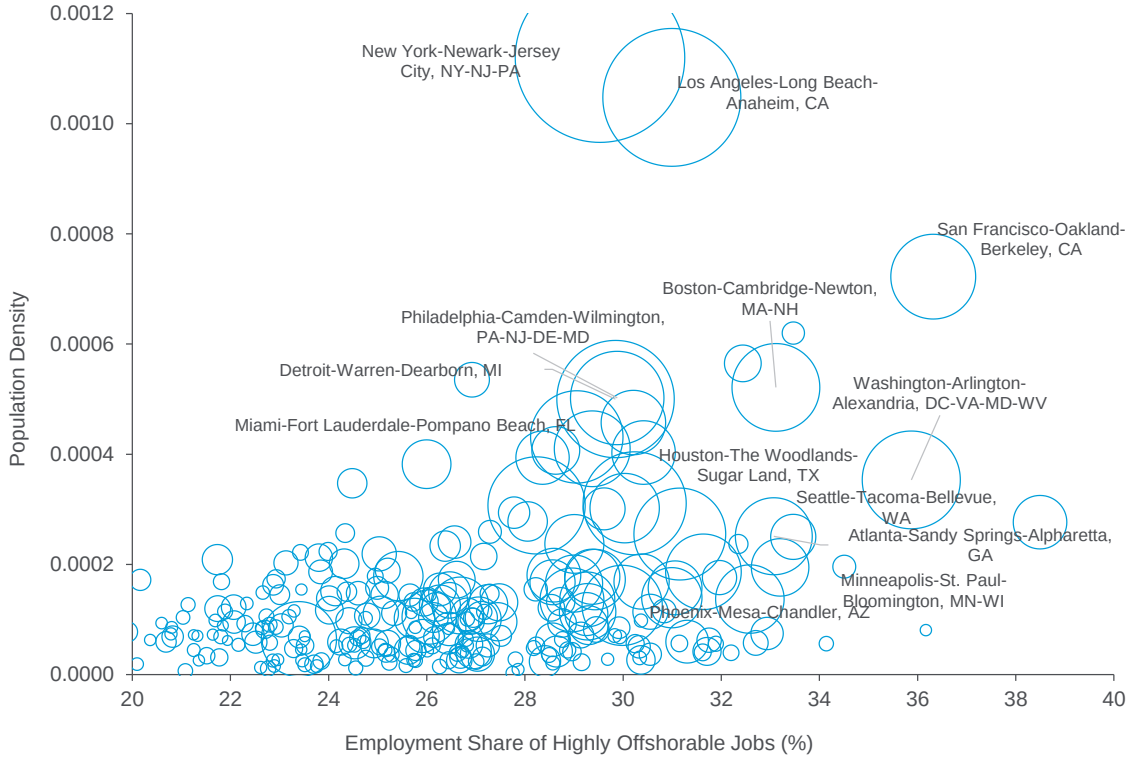

Source: Frey and Osborne (2017), Acemoglu and Autor (2010), 2019 ACS 5-year Data, IPUMS USA

However, the gradual shift towards a post-production society will, if anything, make cities more important. Jobs that involve originality, such as developing new ideas and artefacts, remain highly clustered in places like the Bay Area, Boston, Washington DC, Denver, and New York (Figure 15), simply because exploratory work benefits from knowledge spillovers. And because such activities are relatively unexposed to automation and offshoring, they will make up an ever-growing share of total employment, reinforcing the importance of cities, big and small.

**Figure 15. Employment Share of High Automate Jobs by Population Density**


Source: Frey and Osborne (2017), 2019 ACS 5-year Data, Metropolitan and Micropolitan Statistical Area Tables, U.S. Census Bureau

**Figure 16. Employment Share of High Offshorable Jobs by Population Density**

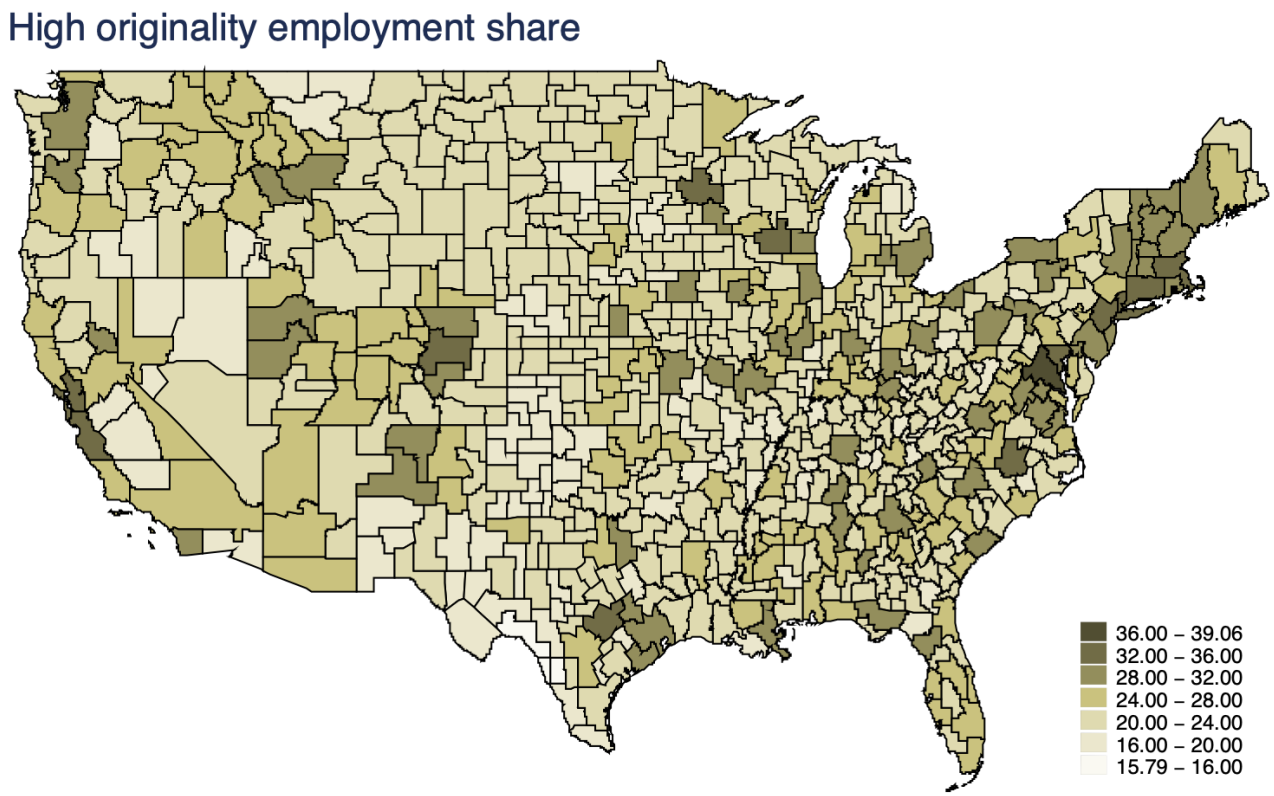



Source: Frey and Osborne (2017), 2019 ACS 5-year Data, Metropolitan and Micropolitan Statistical Area Tables, U.S. Census Bureau

Despite the proliferation of remote work technologies, denser places continue to experience higher levels of innovation.[61] And they produce more important discoveries. Studies show that walkable streets facilitate more serendipitous meetings and unconventional innovations, as do restaurants, cafes, and bars.[62] This, in turn, creates many local in-person service jobs: the economist Enrico Moretti estimates that one new tech job creates demand for five new non-tradable service jobs in a given city.[63] Thus, the clustering of jobs in knowledge industries reinforces the trend towards greater urbanization.

[61] Berkes, E., & Gaetani, R. (2019). The Geography of Unconventional Innovation. Rotman School of Management Working Paper, (3423143).
[62] Roche, M. P. (2020). Taking Innovation to the Streets: Microgeography, Physical Structure, and Innovation. *The Review of Economics and Statistics*, 102(5), 912-928.
[63] Moretti, E. (2010). Local Multipliers. *American Economic Review*, 100(2), 373-377.

**Figure 17. High Originality Employment Share**




Source: Autor, Dorn, and Hanson (2019), 2019 ACS 5-year Data, IPUMS USA, O*NET Online

Technological innovation, in other words, will continue to be the prime engine of new job creation. In Chapter 4, we turn to examining what can be done to spur innovation and create new types of work.

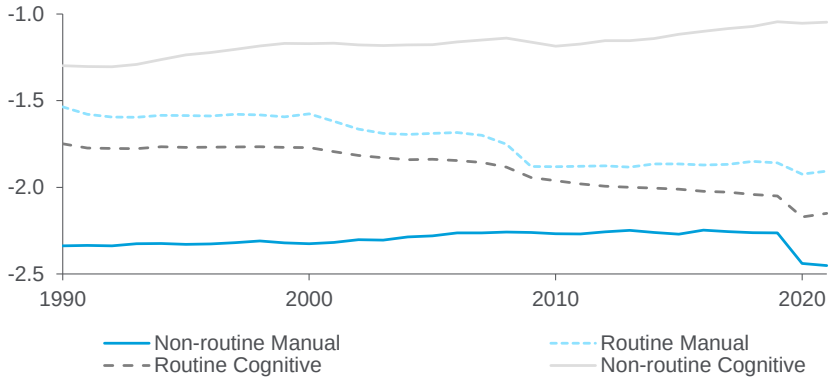
# Chapter 2: COVID-19 and Digitization

# Introduction

While the potential scope of automation has expanded rapidly in recent years, sluggish productivity growth suggests that new technologies are yet to be adopted.[64] But many think the COVID-19 pandemic will accelerate automation, including digitization, and there are indeed several channels through which this could happen.[65]

First, companies may prefer automation to rehiring. At least this has been the case after recent recessions. For example, routine jobs, which are easy to automate, were permanently eliminated during the Great Recession, while non-routine jobs rebounded thereafter (Figure 18).[66] The contraction following the onset of the pandemic has been even more dramatic, and this time around the potential scope of automation is much greater. It is estimated that 61% of furloughed jobs in Britain are in occupations that are at high risk of automation.[67]

**Figure 18. U.S. Employment Per Capita, logs**




Source: Citi Research

A second reason why automation might accelerate is that customers suffering income losses tend to switch to cheaper goods and services.[68] That is why fast food restaurants, like McDonalds, and general merchandise stores, like Walmart, gained market share when the recession took hold in 2008. The tendency of consumers to trade down creates a trap because goods and services of lower quality are typically produced with more automation technology.

Take supermarkets, for example. According to estimates by the economist Sérgio Rebelo, an upscale supermarket like Whole Foods employs six workers per million dollars of sales. Sam's Club, in contrast, employs only two workers per million dollars of sales.

[64] Goldin, I., Koutroumpis, P., Lafond, F., & Winkler, J. (2020). Why is Productivity slowing down? OMPTEC Working Paper No. 2020-1.
[65] Frey, C.B. (2020). Covid-19 will only increase automation anxiety. *Financial Times*.
[66] Jaimovich, N., & Siu, H. E. (2020). Job Polarization and Jobless Recoveries. *The Review of Economics and Statistics*, 102(1), 129-147.
[67] Fabian Society (2021). *Sharing the future: workers and technology in the 2020s*. Commission on Workers and Technology.
[68] Jaimovich, N., Rebelo, S., & Wong, A. (2019). Trading down and the business cycle. *Journal of Monetary Economics*, 102, 96-121.

Thus, every million dollars of sales that consumers divert from Whole Foods to Sam's Club leads to the loss of four jobs, which puts pressure on Whole Foods to reduce costs and automate.[69] This creates a vicious cycle: as consumers trade down they reduce the demand for labor which adds to the pains of the recession.

Restaurants are also likely to be affected. The number of employees per customer is much lower in a fast-food chain like Wendy's relative to upmarket restaurants. And new technologies offer the potential of reducing the labor intensity of restaurants more broadly. For example, in 2016, a new and almost fully automated restaurant chain called Eatsa opened. Customers ordered their food at an iPad kiosk. They then waited a few minutes in front of a giant vending machine that churned out the meals. At the other side of the machine, kitchen staff members cooked the food, but Eatsa did not employ any waiters. Eatsa didn't catch on before the pandemic.

But there are good reasons to believe that consumer preferences are changing in ways that favor automation. During the 1918 pandemic, concerns over the Spanish flu radically reduced trust and altered social interactions.[70] In a recent survey, 25% of respondents said they would continue to be wary of activities like eating out, even when the pandemic subsides. Another 12% said they will not return to pre-pandemic activities and will continue to socially distance.[71]

A third reason is that businesses will want to automate in order to become more resilient to future shocks of a similar nature. E-commerce has been given a boost by the pandemic, but in some countries pressure has been mounting on retailers of 'non-essential' goods to close online operations as warehouses remain less automated and highly crowded. For example, during the early days of the pandemic the GMB Union, a general trade union in the U.K., accused one retailer of "playing Russian roulette with people's lives", suggesting it should close its warehouses during the outbreak. In New York City, some Amazon warehouse workers in Staten Island walked off their jobs, as did Instacart's grocery delivery workers nationwide.[72]

The prime reason why warehouses still employ large swaths of the workforce is that order picking remains a largely manual process. Humans are still better at complex perception and manipulation tasks. But here, too, automation looks increasingly feasible. At the OpenAI lab in San Francisco, a robotic five-fingered hand called Dactyl can even twist and flip an alphabet block. While this is straightforward for most humans, the achievement lies in the fact that artificial intelligence allows Dactyl to learn new things on its own through trial and error. Warehouse automation today is probably where factory automation was in the 1980s[73] But the COVID-19 pandemic is likely to accelerate investment in warehouse automation to avoid future strikes and shutdowns.

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[69] Rebelo, S. (2017). Recessions Push People to Buy Cheap Things, Which Just Makes Everything Worse. *Harvard Business Review*.

[70] Aassve, A., Alfani, G., Gandolfi, F., & Le Moglie, M. (2021). Epidemics and Trust: The Case of the Spanish Flu. *Health Economics*, 3(4), 840-857.

[71] Barrero, J. M., Bloom, N., & Davis, S. J. (2020). Why Working From Home Will Stick. University of Chicago, Becker Friedman Institute for Economics Working Paper, (2020-174).

[72] Selyukh, A. & Bond, S. (2020). Amazon, Instacart Grocery Delivery Workers Demand Coronavirus Protection And Pay. National Public Radio.

[73] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.

Automation will surely happen at different speeds across industries, depending on labor costs, flexibility demands in production, and market volatility. In industries where demand is highly seasonal, it may still not be economical to invest in robots to meet peak demand as workers can be hired temporarily, which robots mostly cannot. But this is also gradually changing. In agriculture, companies like FarmWise now rent out robots to farms. Rather than sell robots directly to farmers, FarmWise sells its robotics services to farms, and charges farms roughly $200 per acre inspected and weeded.[74]

That said, adopting automation technology is for the most part a complex undertaking. And right now, the vast majority of companies lack the organizational capabilities to reap the benefit from the very latest technologies, like advanced AI-enabled robotics. This is why successful adoption is still so rare.[75] The U.S. Census Bureau's 2018 Annual Business Survey (ABS) showed that less than 3% of American companies had adopted machine-learning technology before the COVID-19 period. And while the adoption of some automation technologies has picked up since then, the acceleration has largely been confined to ready-to-use technologies that do not require complementary investments, organizational restructuring, and new expertise. As Matt Beane and Erik Brynjolfsson explain:

> Managers want systems with a relatively small physical footprint and proven capabilities that are easy to connect to power, pressurized air (for robotic grippers that rely on suction), and the existing IT infrastructure. Such plug-and-play systems can be rapidly set up to deliver results and rapidly reconfigured when things inevitably change. Examples among the companies we're studying include modular, computer-controlled conveyors; automatic guided vehicles (AGVs); and sorting machines. They can be shipped on a pallet or two and be set up over a weekend, in some cases by the vendor's remote technical staff. This has all been critical because COVID-19-driven demand for shipped, assembled, or packaged goods created holiday-level orders for many organizations more or less overnight.
>
> – MATT BEANE AND ERIK BRYNJOLFSSON[76]

Any automation project that is complicated has been a 'hard no' during the pandemic.[77] But as already noted, there are several reasons to believe that automation will pick up when the pandemic subsides, suggesting more is yet to come.

[74] Shieber, A. (2021). FarmWise plans to add autonomous crop dusting to its suite of robotic services. TechCrunch.
[75] Zolas, N., Kroff, Z., Brynjolfsson, E., McElheran, K., Beede, D. N., Buffington, C., Goldschlag, N., Foster, L., & Dinlersoz, E. (2021). Advanced Technologies Adoption and Use by US Firms: Evidence from the Annual Business Survey. NBER Working Paper No. 28290.
[76] Beane, M., & Brynjolfsson, E. (2020). Working With Robots in a Post-Pandemic World. *MIT Sloan Management Review*, 62(1), 1-5.
[77] Ibid.

While this could bring about a much needed productivity revival, it risks making advanced economies even more polarized. Throughout much of the twentieth century, the diffusion of work to the hinterland was perhaps the prime reason why economic growth was so widely shared. Not just in the United States but also across the Atlantic, convergence between regions was a stylized fact of growth during the postwar decades.[78] But this pattern came to an end in the 1980s.[79]

What happened? While there are many factors, one is surely the changing nature of production. New work is typically created in cities where entrepreneurs and innovators cluster as they benefit from knowledge spillovers.[80] Historically, convergence happened when a prototype had been developed, production scaled up, and operations standardized.[81] This is when it makes economic sense to relocate production to the hinterland, where housing and labor is cheap, prompting wages to rise in places lagging behind. New jobs and industries used to spread to other locations this way, and as long as cities did not generate new jobs at a faster rate than they diffused geographically, convergence followed.

The difference in the age of computers and advanced robotics is the following: when jobs become routinized and standardized, they no longer diffuse within advanced economies to the same extent. Instead, they are increasingly offshored to China or automated away. Consequently, flourishing cities in advanced economies have become hubs for innovation. But the rest is done abroad or by machines.[82]

Having discussed some of the reasons and impacts of an acceleration in automation, we asked Citi Research analysts around the world what changes were happening in their sectors as a result of the pandemic and how much of this change they expected to become permanent. We present their views on the growth of digitization in the following sectors: technology; travel; real estate; telecommunications; robotics; financials; consumer; health and wellness; and education.

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[78] Barro, R. J., & Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, 100(2), 223-251.
[79] Ganong, P., & Shoag, D. (2017). Why Has Regional Income Convergence in the U.S. Declined? *Journal of Urban Economics*, 102, 76-90.
[80] Jacobs, J. (1992). The death and life of great American cities. Vintage.
[81] Duranton, G., & Puga, D. (2001). Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products. *American Economic Review*, 91(5), 1454-1477.
[82] Frey, C. B. (2020). *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton University Press.

# How has the Pandemic Changed the Growth of Digitization in Different Sectors?

## Technology

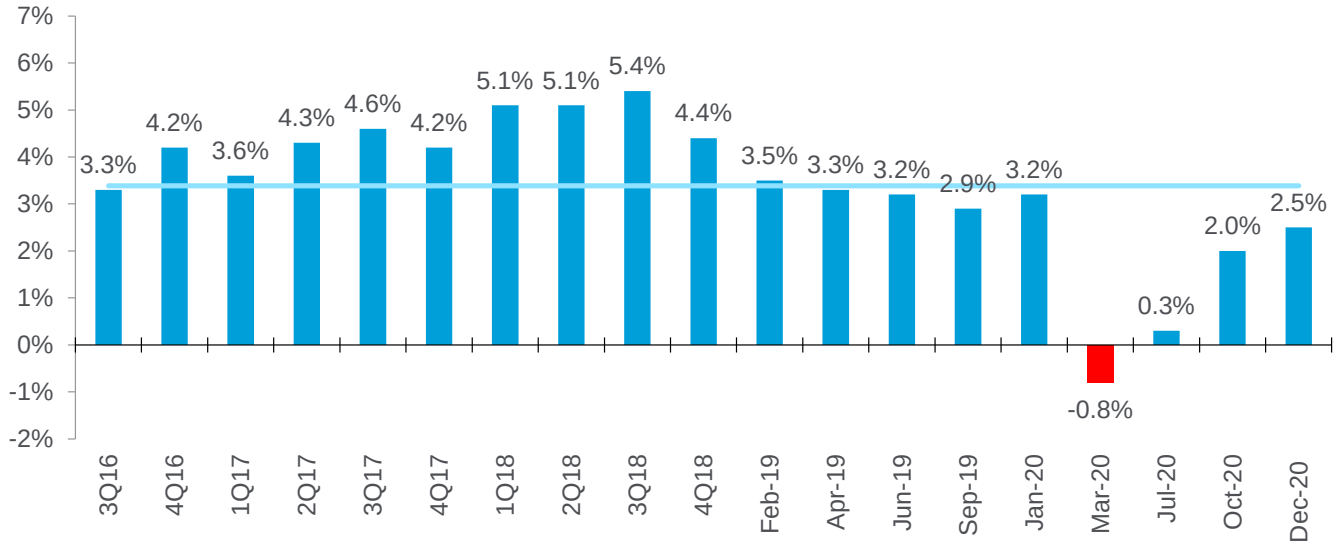
**Citi Research: Technology**
Surendra Goyal, CFA
Amit B Harchandani
Arthur Lai
Asiya Merchant, CFA
Ashwin Shirvaikar, CFA
Jim Suva, CPA

Digital Transformation is a secular trend for IT Services companies. Enterprises have wanted to be more digital for many years, but often adopted an incremental and piecemeal approach given the complexity and cost. Corporations also assumed they had time to adapt, but seminal events of 2020 — a global pandemic, disrupted supply chains, cybersecurity challenges — left many corporations behind. A rethinking of technologies and processes is accelerating transformation and an urgency is compressing schedules to roughly half the length seen pre-pandemic. Cloud is a key building block for transformations, but others include:

- digital customer experiences (CX) and user interface/user experience (UI/UX) design and development;
- analytics and artificial intelligence (AI);
- meeting the rise in regulations around data privacy and data security requirements;
- continued digitization of Business Process tasks, including Finance, Accounting, Procurement, and Human Resources;
- 5G deployments and over-the-top (OTP) services in telecoms and media;
- mobile commerce, direct-to-consumer (DTC), omni-channel and personalization in consumer;
- FinTech disruption in financial services;
- telemedicine, wearables, and connected devices in healthcare; and
- Industrial Internet-of-Things (IoT), Industry 4.0, and automation in manufacturing.

Lower maintenance spending on legacy systems can be reallocated towards digital solutions, but other areas allow for cost reductions: automation and robotics; cloud penetration; or vendor consolidation. Cloud deployments not only enhance agility and speed to market but also resiliency (e.g., secure remote working became a necessity, not a nice-to-have). We believe we are still in the early stages of the cloud journey, with only 20-40% of enterprise workloads currently in the cloud. A survey of Chief Investment Officers (CIOs) we conducted at the end of 2020 suggested that information technology (IT) budget expectations continue to rebound and are now close to pre-pandemic levels. In addition, Gartner forecasts industry revenue in IT services will grow by ~6% in both 2021 and 2022 and software spending by 8-10%.

**Figure 19. Global IT Budget Expectations Continue to Rebound from March 2020 Lows — Still Below 9-12 Months Ago**




Source: Citi Research

The growth in demand for digital services is, however, beginning to heighten the likelihood of possible supply side challenges. Multiple companies talked about increasing attrition and some have picked up hiring aggressively in anticipation of further attrition upticks. One leading IT services company saw quarterly annualized voluntary attrition of 16% in December 2020. Another has onboarded 100,000 people virtually in the last 12 months. With more balance between 'work from home' and 'work from the office', global recruiting helps, but for many IT service companies, workforce utilization is already at peak levels. Offshoring work to low-cost countries and the use of automation are part of the solution, but a scarcity of talent for new skills is also evident.

In IT hardware, the pandemic has likely caused a change in the growth trajectory of several subsectors — some positively, some negatively. Companies, workers, educators, and students have all made adjustments, which are likely only to occur in the early phases of the new normalcy post-pandemic. Fortunately, technology has helped society and education traverse this difficult time across the globe. But not all technology sub-sectors have benefited from changes caused by the pandemic.

On the positive side, there is likely a permanent upward inflection for personal computers (PCs). Prior to the pandemic the trend was one PC per household, shared by household members at home and an annual addressable market of 250 million PC units per year. With remote learning and 'work from home' now more acceptable, the trend has shifted from one PC per household to one PC per person. This equates to an annual demand for PC units above 300 million units. While many of these new PCs are lower quality Chromebooks, the childhood age for using a PC has dramatically shifted lower as households can no longer survive on one PC as a shared use device. Prior to the pandemic, the average life duration of a PC was stretching longer as families did not see a need for upgrades. However, with video conferences, power hungry apps, and higher daily use the average PC now has a stronger need for an upgrade. We believe PC demand will continue above pre-pandemic levels.

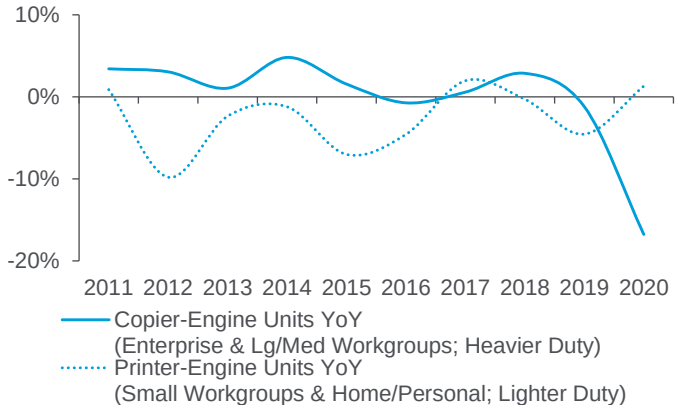
Figure 20. Citi PC Forecast

| Units in Millions | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021E |
|---|---|---|---|---|---|---|---|
| **WW PC SHIPMENTS (Units)** | | | | | | | |
| **Desktop** | **110.7** | **100.8** | **95.2** | **91.1** | **91.2** | **77.1** | **68.3** |
| % change year to year | -16% | -9% | -6% | -4% | 0% | -15% | -11% |
| % of total client units | 41% | 39% | 37% | 36% | 35% | 26% | 22% |
| **Portable** | **161.4** | **155.4** | **160.2** | **163.6** | **170.7** | **219.9** | **242.1** |
| % change year to year | -7% | -4% | 3% | 2% | 4% | 29% | 10% |
| % of total client units | 59% | 61% | 63% | 64% | 65% | 74% | 78% |
| **Total Client PCs** | **272.1** | **256.2** | **255.4** | **254.7** | **261.9** | **296.9** | **310.5** |
| % change year to year | (11%) | (6%) | (0%) | (0%) | 3% | 13% | 5% |
| **Tablets (including 2 in 1)** | **207.2** | **174.9** | **163.8** | **146.2** | **144.5** | **163.5** | **152.1** |
| % change year to year | (10%) | (16%) | (6%) | (11%) | (1%) | 13% | (7%) |
| Client PC + Tablets | **479.3** | **431.1** | **419.1** | **400.9** | **406.4** | **460.4** | **462.5** |
| % change year to year | (10%) | (10%) | (3%) | (4%) | 1% | 13% | 0% |

Source: Citi Research

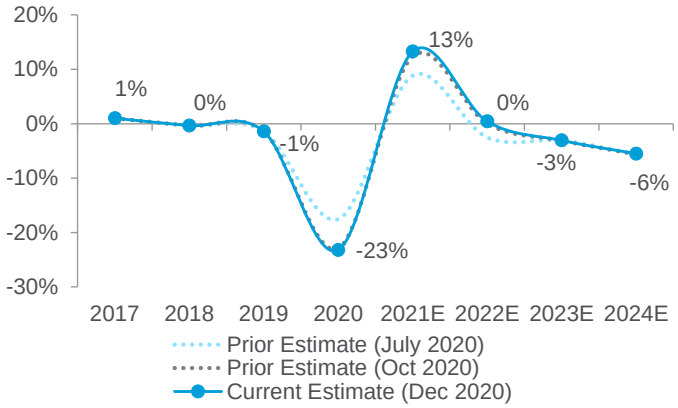
On the negative side, there is likely a permanent downward inflection for office printing. During the pandemic workers have been forced to into 'work from home' situations and in doing so have adapted to a 'print less' mentality. Digital editing has been around for decades but many were still in the habit of printing large documents at work to review and highlight in hard copy and this service was often viewed by employees as free. However, with employees at home and forced to use their personal printers, they are more conscious about ink and paper consumption and the associated costs of their actions and generally print less. We do not believe office printing will return to pre-pandemic levels.

Figure 21. Printer Growth by Primary Application




Source: IDC

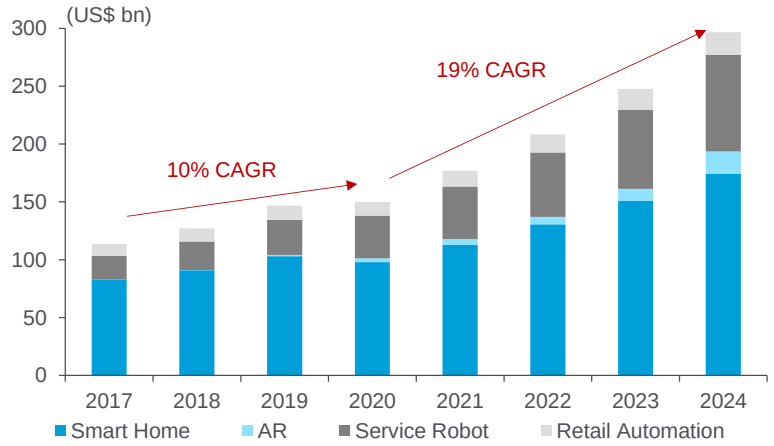
Figure 22. Printed Page Volume Declines (Enterprise Print Volume YoY)




Source: IDC

Pre-pandemic, advances in technology were leading to more contactless interactions between our physical and digital worlds. The pandemic accelerated this trend with concerns over actions such as touching elevator buttons, touch panels, and vending machines. In Beijing, hospitals have already deployed voice control-enabled elevators. Penetration is set to deepen for smart homes, service robots, and unmanned stores, which we see growing at double-digit compound annual growth rates (CAGRs) in the next five years. We estimate the global contactless economy will double between 2019 and 2024 to reach $300 billion. (See The US$300bn Contactless Economy)

**Figure 23. The Touchless Economy Impact**




Source: Strategy Analytics, MarketsandMarkets, Allied Market Research, Citi Research

Technological developments such as voice recognition, NLP (natural language processing), and computer vision allow users to interact with devices in a natural way via voice commands, gesture controls, and haptics. Voice assistant devices (VAD) have been growing fast — according to the International Data Corporation (IDC) smart speaker shipments had already reached 127 million in 2019. Many of these are used in homes, but VADs are likely to become integrated into car dashboards as part of the control system. New contact-free retail models are also being rolled out such as voice-ordering kiosks, unmanned stores (Just-Walk-Out Shopping such as Amazon Go) or facial-recognition payments, all of which increase convenience and save time. As technology continues to advance, touchless shopping will be a growing trend around the world.

**Figure 24. Key Components of a Touchless Economy**

| Applications | Comment |
|---|---|
| **Smart Home** | In the AIoT era, touchscreens, switches, and remote controls merge into the surroundings, and into wearables and devices. Ubiquitous UI interconnects multi-devices and users for various functions and applications. The physical interface is simplified and integrated into a unified dashboard. |
| **Augmented Reality** | Technological progress drives AR adoption. Improvements in 3D sensing, computer vision, and conversational UI significantly improve the user experience and the range of use cases. We expect the AR market to grow to an annual $20 billion in 2024, a 75% CAGR from 2019. |
| **Service Robot** | AI technology makes robots more intelligent and flexible, meaning they can perform more tasks. Adopting various sensing technologies, computer vision, and conversational AI allow robots to become more adaptable in the touchless economy. |
| **Retail Automation** | Unmanned stores and automatic checkouts are the ultimate touchless shopping experience, made possible by 3D sensing, computer vision, and AI algorithms. |

Source: Citi Research

**Citi Research: Technology**
Amit B Harchandani
Tyler Radke
Alicia Yap, CFA

## Uptake of New Technology Increased During the Pandemic

In the semiconductor industry, firms which provide multi-million-dollar lithography systems play a mission-critical role in the supply chain. Travel restrictions due to the COVID-19 pandemic meant that some customer support engineers could not visit their chipmaker customers' sites to help them keep their lithography machines up and running. To help customers remotely, the company developed an augmented reality (AR) solution using mixed reality headsets. This approach enabled subject matter experts to 'enter' the cleanrooms in customer fabs (factories) to complete service actions and troubleshoot issues. Another customer use case is the use of AR to facilitate installation of the latest state-of-the-art lithography systems at customer locations around the world, to make up for limited local installation experience.

Lastly, AR was used internally as well, for example to reduce in-person test run visits to the cleanrooms within its own factory. Just as remote PC fixes are commonplace in enterprises today, AR solutions could become more prevalent across many industries to provide remote technical solutions.

The pandemic also accelerated trends in software that have been underway for years, as the abrupt shift to 'work from home' forced organizations to rapidly adopt technologies such as e-signing, remote meetings/video conferencing, and e-commerce solutions.

In assessing the sustainability of the continued digitization trends, we broadly see two categories of companies:

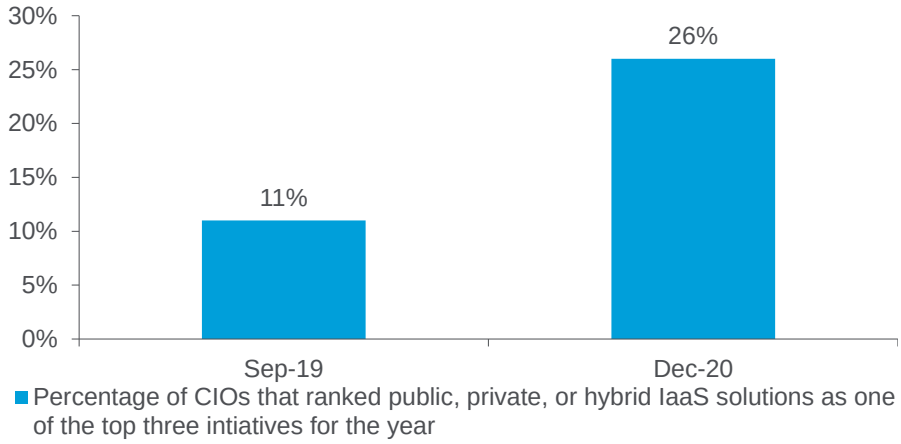
1. Those where COVID-19 accelerated and validated digitization trends leaving post-pandemic growth 'higher for longer' (such as e-signing and cloud adoption).

2. Companies that saw at least partial one-time benefits or pull forwards, and face headwinds as the pandemic eases (video conferencing, e-commerce to some extent).

As an example, video conference revenue growth significantly accelerated during the pandemic across the globe. Video conference platforms offer new ways of working, sharing and collaborating for modern enterprise and organizations. Education was also a big adopter of video conferencing as schooling switched to remote. Technology such as e-signing benefited from the shift to remote work and the shift to digital-based transactions (from paper) seems to be permanent, with the pandemic increasingly validating its capabilities and the power of the technology.

Finally, the pandemic drove significant increases in public cloud adoption for a variety of reasons. First, just from a matter of practicality, the lockdowns meant some organizations couldn't access onsite data centers, thus forcing them to look to public cloud as a way to run their business remotely. In addition, the shift to remote work and adoption of collaboration technology/remote desktops, exposed many of the shortcomings of non-cloud/ on-premise technology which generally suffered from performance degradation by remote work given the lack of scalability. We generally see the pandemic as having accelerated public cloud adoption plans that were underway potentially by as much as years in the enterprise software space. We note this is validated by the results of our most recent CIO Survey where the percentage of CIOs seeing Infrastructure-as-a-Service (IaaS) in the top three investment areas increased by ~2.5x from September 2019 levels to December 2020.

**Figure 25. Infrastructure as a Service (Cloud Technology) Has Become a Key Initiative**




Source: Citi Research

## Transport

**Citi Research: Transport**
Sathish B Sivakumar

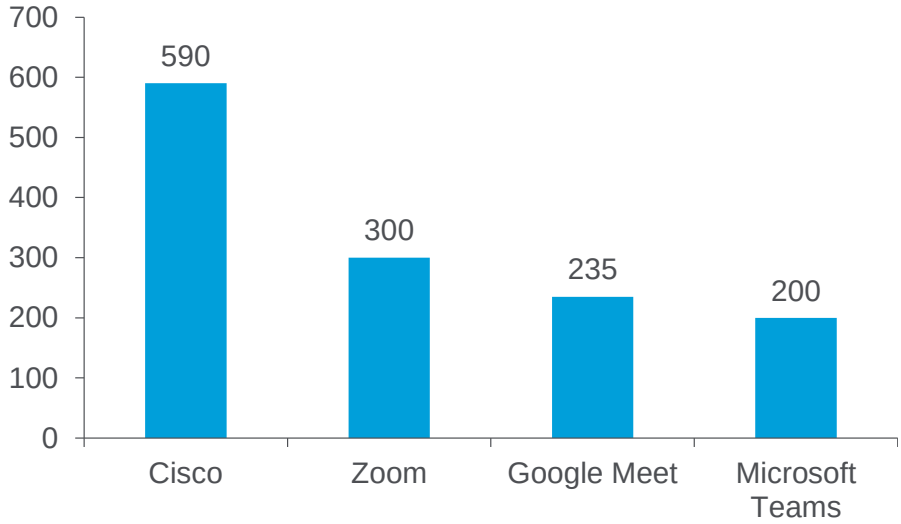
The uptake of virtual meetings has been significant since the beginning of the pandemic crisis as businesses scrambled to find new ways to maintain their business functions including both internal and clients meetings. Anecdotal evidence on the uptake of virtual conferences/ meetings can be seen in recent press comments:

"Cisco's Webex participants near 600 million as pandemic flares again." Source: ET

"Zoom surpasses 300 million daily meeting participants." Source: Reuters

"Teams has seen 200 million meeting participants in a single day, Google Meet has seen more than 235 million meeting participants." Source: VentureBeat

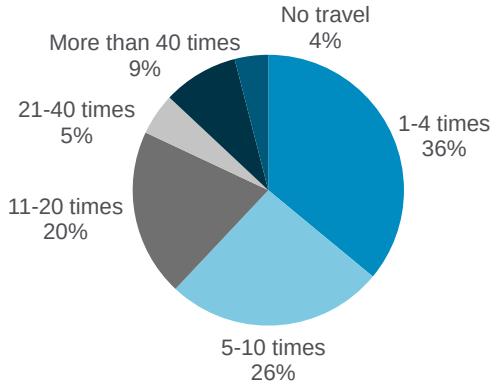
**Figure 26. Daily Meeting Participants (mn)**




Source: VentureBeat

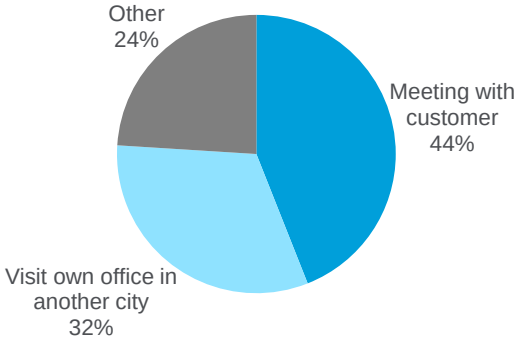
As the uptake of virtual meetings continues to expand and the acceptance of this medium as a business tool grows, there are two segments of the corporate traveler market who will be most affected: (1) the portion of the corporate travel market that travels more than five times per year; and (2) the corporate traveler who visits other offices.

**Figure 27. Frequency of European Corporate Traveler Business**




Source: Aeolus

**Figure 28. Purpose of Travel for European Corporate Travel**




Source: Aeolus

In our analysis, we've reduced the number of trips for travelers in the 'more than five times a year' category by 50% and the frequency of the 'visit own office' and 'other' categories also by 50%. Using these figures, we see corporate travel as being secularly impaired by 25% versus 2019 levels.

Pulling this forecast together with our previous analysis, a 1% reduction in corporate travel volumes impacting airline profitability by 10%, we believe the airline industry (even assuming some highly optimistic cost cutting and lower fuel costs) will struggle to remain profitable. In fact, we could see a scenario where the majority of long-haul airlines undergo a gradual nationalization process. This is on par with what is currently enjoyed in the Middle East; where destinations and jobs in the airline industry are largely controlled by the respective governments.

## Real Estate

**Citi Research: Real Estate**
Aaron Guy
Nicholas Jones

Digitization has and will continue to impact the real estate market in two main ways. First, the growth in online retail is driving significant changes to the type of real estate used, with store demand declining and logistics demand increasing. This is an ongoing trend over the past few years but is being accelerated by COVID-19. It is being constrained, however, by online retail capacity, including the online interface, the long-term nature of automation technology, and delivery logistics. Because of these constraints online sales in the U.K. were limited to around 35% at the COVID-19 peak, whereas before the pandemic, U.K. online retail adoption was amongst the highest in the world at around 15-20%.

Another area of digitalization that was accelerated during the pandemic was remote working, with almost 100% of many office markets shifting to 'work from home' for extended periods. While 'work from home' began decades ago, the technology to do so hadn't been tested on mass and new technologies have grown exponentially since COVID-19 in areas such as online meeting systems. This digitization has enabled another step-change in work practices akin, in our view, to innovations such as the 8-hour work day. It has also enabled a step-change in the way we work and live, including where we live.

This has the potential to significantly reallocate real estate value and therefore reshape cities and towns, as well as rural and holiday real estate.

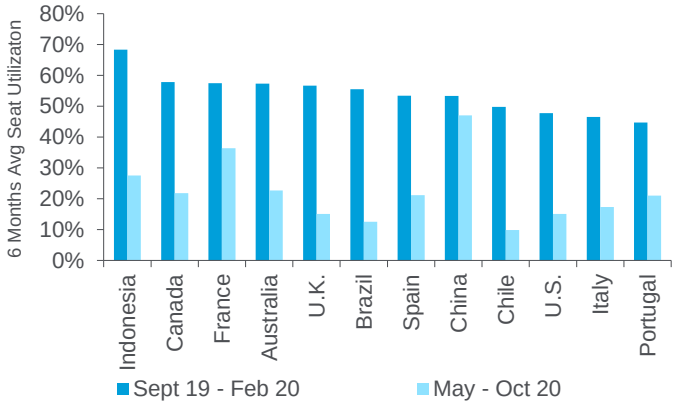
Before COVID-19, our research showed that (1) offices only utilized about 60% of their desks; (2) offices already had 10%-20% of space overcapacity; and (3) further capacity was left unutilized by staff holidays, sick days, and work outside the office (including meeting days). COVID-19 has in an instant created home offices (albeit many still not yet optimized for work), which has essentially increased 'office' space supply. Technology has enabled not just 'work from home' but the flexibility of 'work from anywhere' which could accelerate the pre-COVID-19 trend of outsourcing from central business districts (CBDs) to other regions or overseas.

Combined with research indicating a desire by employees and employers to continue working two days a week from home, office desk utilization could drop to around 45% as a result. Profit-focused companies could therefore reduce space, where we estimate that office desks in total can cost 20% to 50% of the staff cost. Initial research shows that its harder to maximize utility in smaller offices, which could drive a shift to overall less office space but higher quality and more centrally-serviced and technology-enabled smart offices. This value transfer could drive the re-allocation of significant amounts of office space to other uses. The increased utilization of residential real estate could permanently change the design of residential and shift residential preferences to the suburbs, out of town areas and extend holiday stays. Furthermore, the optimal office configuration as a result of a post-COVID-19 office is yet to be determined, but is likely to be significantly different from most of the current office stock, which could therefore accelerate obsolescence of existing office stock.

We also believe that employers will be collecting far more data on work intensity and 'work from home' behavior. In a quest for revenue growth and cost reductions, a future outcome of the increased digitization of work could be an opportunity to rationalize jobs currently assumed to be an 8-hour day if only 4 hours of actual productivity is measured from the data collected. This would further increase productivity and enable further worker flexibility.

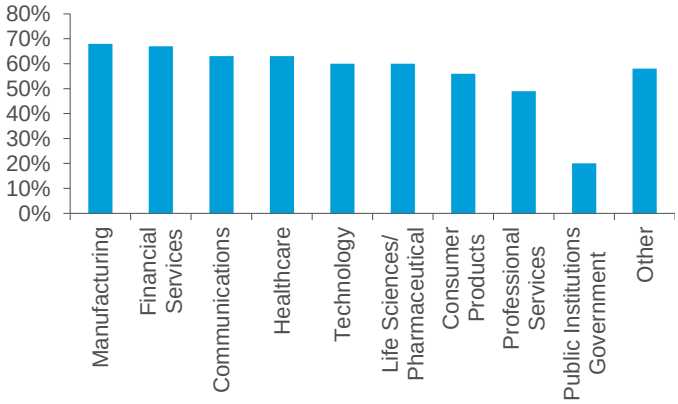
We believe the effects of the COVID-19-driven, technology-enabled 'work from home'/ 'work from anywhere' phenomenon on real estate are only just beginning. The resulting real estate value transfer will drive increased polarization of winners and losers as well as increase development opportunity and over time will likely evolve the face of real estate itself.

**Figure 29. Six-month Pre-and Post-COVID-19 Office Utilization**




Source: Citi Research, Citi Global Strategic Operations

**Figure 30. Office Utilization by Industry**




Source: Citi Research, JLL

Residential real estate has not been immune to digitization despite being one of the largest asset classes in the U.S. and one of the biggest purchases most people will ever make. Traffic to leading residential real estate platforms have increased throughout the pandemic. We view the spike in traffic as indicative of two trends: (1) de-urbanization as the population adapts to a new norm where remote working is more prevalent; and (2) increased engagement with digital solutions during the home buying process (e.g., virtual showing, virtual closings etc.). Accordingly, we look for these trends to be relatively sticky as more corporations adopt a hybrid approach to work and buyers and sellers find more convenience through digital solutions. Further, as home buyers and sellers opt for more convenient modes to transact real estate, internet buyers (iBuyers) will potentially see an increased willingness from home sellers to transact.

## Telecom

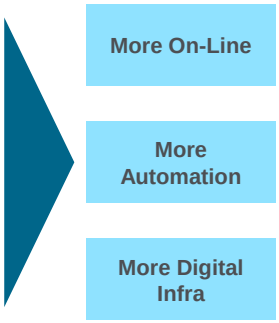
**Citi Research: Telecom**
Arthur Pineda

The reduction in workforce mobility had served to push companies to rethink their business models. One of the key changes that ensued was the push towards remote access. With the pandemic limiting individual mobility, institutions had pushed for greater remote access capabilities and with physical meetings replaced by virtual conferences. This translated to enhanced fixed broadband demand and importance, especially for emerging markets where penetration rates remained relatively low, with data users typically accessing the web via mobile services. Broadband access has become a basic necessity for remote function purposes during the pandemic. We expect demand for broadband to remain robust even post the pandemic. Companies appear likely to adopt hybrid working models as more companies indicate a permanent bias towards a partial remote work arrangements, even post-pandemic. The benefits of a hybrid model include a reduction in costly physical on-site footprints for companies and improved flexibility for workers.

Beyond just the broadband pipe connectivity, software/cloud/virtual platforms further developed with reduced public mobility. Commerce and gaming, for instance, have moved increasingly from physical to virtual (online gaming & online shopping). The adoption by corporates of hybrid virtual models or even fully virtual models necessitate greater investment in technology, platform and software services and digital infrastructure such as those provided by cloud services and data centers.

**Figure 31. Changes in Behavior/ Usage Pre- and Post-COVID-19**

| Category | Pre COVID-19 | Post COVID-19 |
|---|---|---|
| Work | Work at Office | Work From Home |
| | Offline Conference | Video Conference |
| Education | Study at School | Online Schooling |
| Play | Offline Play | Online Gaming |
| Shopping | Shopping Mall | Online Shopping |
| Manufacturing | Human Involvement | Automation |
| Infra | Highway/Road | MEC |
| | Railroad | Datacenter |




Source: Citi Research

Given the experience of physical disruption of labor amidst the pandemic, manufacturing activities are also increasingly moving towards automation and likely will be further enhanced with the development of 5G networks. This is supported by a survey from Citi Research's Innovation Lab on large industrials across Japan, Korea, China, and Taiwan, which indicated strong enterprise willingness and ongoing plans to invest in 5G-related solutions to drive efficiencies.

Proof of concept is already available. China's Quingdao Port for instance, one of the top ten busiest ports globally, has automated its operations with the help of 5G technologies. One of the key findings of the field trial suggests up to 70% of labor costs may be reduced when a harbor uses 5G automation.[83]

**Figure 32. Where Are Corporates Looking to Invest in a 5G World?**

| | Top 3 Most Critical IT Investments in the Next 2 Years | | | | |
|---|---|---|---|---|---|
| | Total | China | Japan | South Korea | Taiwan |
| Big Data Analytics | 51% | 57% | 43% | 58% | 43% |
| Access Network Technologies - 5G | 44% | 56% | 33% | 48% | 38% |
| Cybersecurity | 42% | 38% | 54% | 32% | 38% |
| Cloud System Migration | 42% | 38% | 53% | 35% | 35% |
| Data Centers | 34% | 38% | 32% | 32% | 33% |
| Managed IT Services | 30% | 26% | 28% | 40% | 30% |
| Virtualization Technologies | 29% | 24% | 31% | 30% | 33% |
| Traffic Offload and Backhaul | 17% | 13% | 16% | 17% | 28% |
| BSS/OSS Overhaul | 11% | 10% | 10% | 7% | 25% |

Source: Citi Research Innovation Lab

**Figure 33. What Benefits Do You Expect from Implementing 5G Technologies**

| | Perceived Benefits of 5G Implementation | | | | |
|---|---|---|---|---|---|
| | Total | China | Japan | South Korea | Taiwan |
| Higher Efficiency of Operations/Cost Saving | 50% | 44% | 49% | 52% | 64% |
| Internet of Things | 39% | 52% | 35% | 27% | 33% |
| Increased Productivity of Workforce | 39% | 35% | 42% | 42% | 36% |
| Reduce Our Operational Costs (OPEX) | 38% | 29% | 44% | 40% | 41% |
| Better Customer Experience | 35% | 40% | 34% | 32% | 31% |
| More Secured Operations | 32% | 28% | 33% | 37% | 31% |
| Incremental Revenues | 27% | 18% | 26% | 37% | 36% |
| Ability to Launch New Products Faster | 23% | 29% | 21% | 20% | 15% |
| Evolving Needs of My Business | 18% | 23% | 17% | 15% | 13% |

Source: Citi Research Innovation Lab

## Robotics

**Citi Research: Industrials**
Graeme McDonald
Martin Wilkie

Digitization in manufacturing automation is not a new theme, but historically it has been in 'digital silos' — within a product design (like CAD, or computer-aided design), or contained within production control, for example. The concept of the Industrial 'Internet-of-Things' (IIoT) emerged as part of the Industry 4.0 wave over the last decade to change this, and has significantly driven machine-to-machine communication. Three things are happening now that could significantly increase the growth rate of digitization:

1. Communication technologies like industrial 5G are beginning to emerge, substantially improving the communication capabilities (and so digitization) of industrial equipment.

2. There is a higher need for flexibility and adaptability in production and in the supply chain. This is partly driven by the COVID-19 pandemic, but arguably also global supply-disruptive issues like the U.S.-China tariffs.

[83] Ericsson, "Automated 5G smart factory and harbor in China", February 26, 2019

3. Data requirements of supply chains are increasing significantly as part of the introduction of non-financial reporting disclosure requirements in some jurisdictions.

While digitization is therefore not a new theme, we sense a tipping point driven by technology capabilities, post-COVID-19 needs for production flexibility, and data requirements from sustainability.

The annual Hannover Fair, once the world's largest automation fair but held virtually again in April 2021, highlighted the concept of the 'digital thread' bringing together all aspects of design and production. From a product perspective, this means the 'digital twin' of a product contains all the design and simulation models starting from early-stage concept and available all the way through to production and final product use. This therefore allows traceability and adaptability downstream. In the production process, this same 'digital twin' digitizes the process from sourcing to manufacturing to shipping.

Governments see the pandemic as a watershed opportunity for increasing digitization. The EU recovery stimulus from May 2020 includes a focus on the digital transition, and a World Bank report from December 2020 shows digital-centric, post-COVID-19 stimulus measures in countries and regions including the EU, China, South Korea, and the U.K. Corporates are also seeking to invest. A 2020 survey by Make UK, a manufacturing organization, showed that 71% of manufacturers believed that investment in the digital transition would increase over the next two years despite pandemic-led volume declines. Respondents cited IIoT as the most likely area of investment, followed by robotics, artificial intelligence, and additive manufacturing.

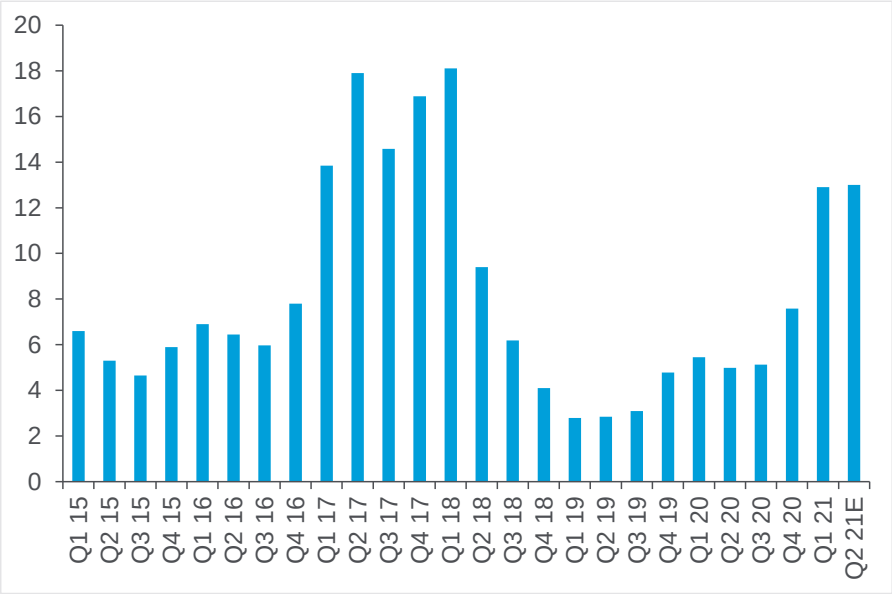
The pandemic has definitely raised the profile of robotics in general, especially in non-automotive industries. In early 2011, the Robotics Industry Association in the U.S. highlighted a number of new applications. For example, in the logistics industry, robots have been in greater demand not only to fulfil e-commerce orders but to comply with social distancing protocols. In food processing, some robot makers are seeing increased demand for more value-added processes such as food preparation, which helps improve food safety and hygiene.

Moreover, according to the CEO of Fanuc America, "companies have traditionally implemented automation to reduce cost, increase output and improve quality" but because of the pandemic "manufacturers are having to re-examine their supply chains to increase flexibility, minimize disruptions and move closer to customers." Some of these trends were already in place before the pandemic, such as the growing role of online shopping, but the need to invest in robotics and automate more processes (e.g., picking, packing, inspecting), has received an enormous boost especially as companies have had to deal with labor shortages, high turnover, and the need to improve workers' health and safety on the factory floor or in the warehouse. Separately, one consequence of the growing demand for warehouses, and logistics, and fulfilment centers is the expansion of the market for AMRs (autonomous mobile robots).

The auto industry has normally made up more than 50% of robot demand and even though orders from auto OEMs (original equipment manufacturers) and parts makers rose by 39% year-over-year in 2020, this ratio fell below 50% for the first time in the U.S. last year. Examples of faster growth areas included life sciences (+69%) and food and consumer goods (+56%). One of the implications of increasing demand for robots in non-automotive industries is the growth of smaller-sized robots, for example, with a payload of under 10kg.

One of the leading suppliers of components to makers of small-sized robots saw a sharp recovery in orders through the latter part of 2020, led by growth in China. The chart below shows their quarterly orders.

**Figure 34. Leading Supplier Small-sized Robot Orders**




Source: Citi Research, Company Reports

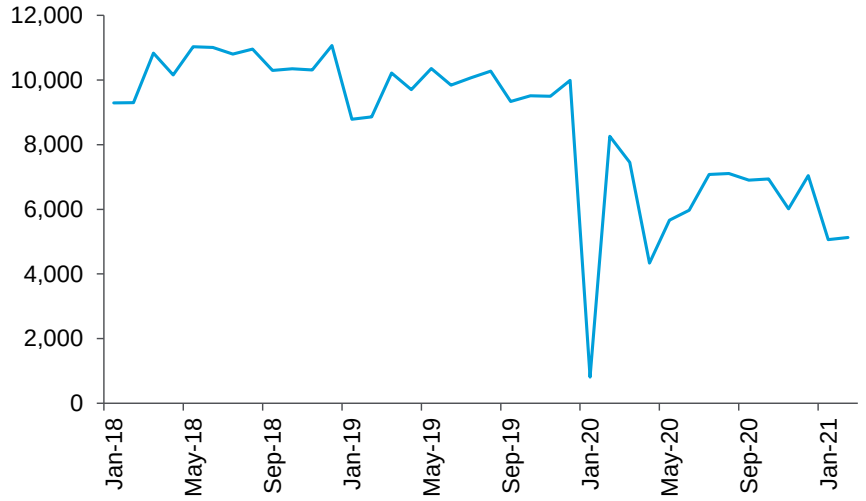
## Financials

**Citi Research: Banks & Insurance**
Ronit Ghose, CFA
Judy Zhang
James A Shuck
Michelle Ma, CFA

The COVID-19 pandemic and associated social distancing/safety requirements have been a bigger catalyst for digital transformation in banking and financial services than any development in the past decade. While the banking sector has faced its share of near-term impacts (e.g., increased market volatility, lower rates, and asset quality concerns), changes in human behavior, social/economic dislocation, and the acceleration of technological changes that predate the pandemic are likely to drive longer-term structural changes.

Social distancing and self-isolation measures introduced during the pandemic have led more individuals to turn to mobile devices to perform banking transactions, even among those who have been slow adopters. The pandemic is likely to break life-long habits and lead to increased digital use, especially among the older demographic cohort. Digital payments were already growing double digits in several markets prior to the COVID-19 pandemic —— the crisis has turbo-charged this trend, by the pandemic, with online payments and e-commerce growing rapidly, while contactless interfaces are booming offline. As a consequence, U.K. ATM cash withdrawals have recently been running at about half their pre-pandemic levels.

Figure 35. U.K. ATM Cash Withdrawals (£mn)



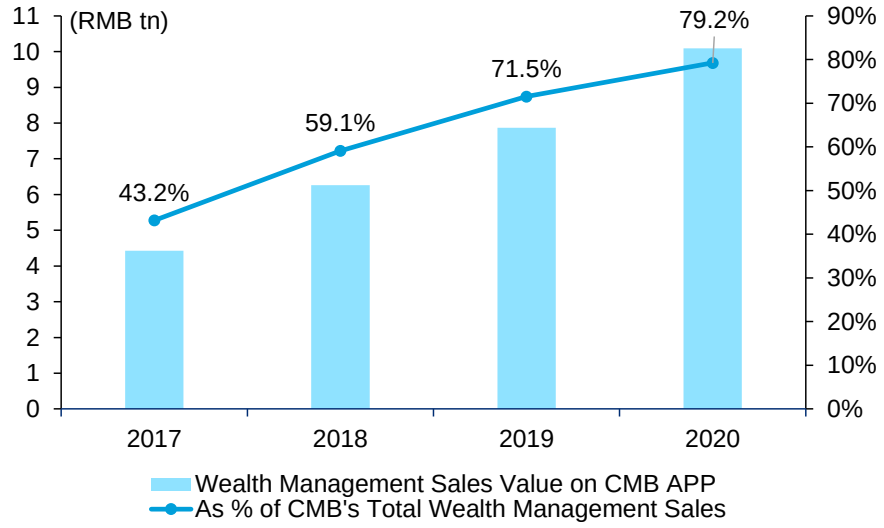

Source: LINK ATM Network, Citi Research

Banks will upgrade technology, making it easier to engage with customers, enabling more complicated banking transactions to be completed digitally, as well as employing AI to improve the effectiveness of digital call centers. In the U.S., banks are already seeing a decline in branch usage, which has led to a 20% decline in branch count over the past six years among those banks under coverage by Citi Research. The trend is similar across Europe over the recent decade, with Northern Europe at the forefront. The pandemic could help accelerate this trend globally. This will be positive for bank operating costs in the long term, but more spending and investment will be required in the near term to accelerate transformation.

While the cost to serve customers declines, increasing migration to digital is likely to put some pressure on banking product profit margins. This is especially the case in retail banking (e.g., brokerage and & wealth management, remittances, and foreign exchange) where customers have already been experimenting with newer FinTech channels that provide similar products at a fraction of the current cost via banking channels. Banks could be forced to revisit their business models and margins for these products to better compete in the digital world.

The COVID-19 pandemic was a wake-up call for banks in China to accelerate digitalization. The pandemic boosted user demand for easy, assessable, 24x7, and borderless banking services, not only for the younger generation, but for older banking customers. Commercial banks have been investing in FinTech with pledged IT budgets equal to between 1% and 3.5% of operating income. New technologies like machine learning, data mining, and smart contracts can simplify and reduce the cost of financial transactions. We believe FinTech can empower commercial banks to gain sustained competitive advantages via optimizing financial products, improving services, marketing, risk management, and channel strategy. Multiple banks have already expressed their intention to accelerate digital transformation in the post COVID-19 era to gain share. For example, 95% of China Merchants Bank (CMB) wealth management customers now use the CMB App and wealth management customers have grown 36% year-over-year.

Figure 36. Wealth Management Sales Value on CMB App




Source: Company Data, Citi Research

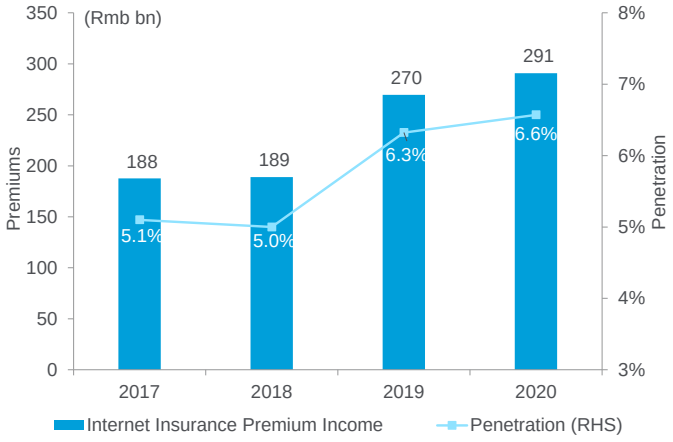
China is also seeing an uptick in demand for contactless money. The Bank for International Settlements (BIS) pinpointed that heightened public concern over the spread of the COVID-19 virus through cash, valid or not, could drive demand for a more flexible digitalized payment infrastructure, in which a central bank digital currency (CBDC) could play a vital role (see Citi GPS report Future of Money for more on CBDCs). China's electronic payment framework has been increasingly comprehensive thanks to two primary private payment systems (Alipay and WePay). But we see DCEP (Digital Currency Electronic Payment), China's newly introduced CBDC currently in retail pilot testing, as having a competitive edge in well-integrated payment methods, e.g., QR code and near-field communication (NFC), with its higher compatibility with offline payments, greater creditworthiness and security (as it is backed by the People's Bank of China), and better anonymity/data privacy.

As part of the pilot testing, one bank has pioneered the launch of CBDC-enabled ATMs, allowing customers to deposit and withdraw CBDC. In addition, the big six state-owned banks in China have started to promote CBDC wallets to retail customers, and the application scenarios of CBDC cover both online platforms and offline channels, including vending machines in the Shanghai Metro and Huijin Department Store in Shanghai.

Insurance is a data-rich industry and one that has been steadily digitalizing for many years. Prior to the COVID-19 pandemic, insurers had made some progress on the journey towards a 360-degree view of the customer across multiple distribution channels but this was set to take many years to be fully realized. The inability for agents to meet face to face with customers accelerated the digitalization process as it has become critical to be able to sell products on-line and integrate them into existing networks. Similarly, the crisis has highlighted the need to manage costs effectively and leading to more automation and customer self-service. Insurers are also upgrading IT systems more aggressively than before, and likely reallocating with travel & expense budgets. Insurers expect to spend more on technology investment in the coming year — upgrading legacy systems, refreshing and simplifying product ranges, and improving the use of data both for risk management and for cross-selling purposes. This journey started some time ago but it is certainly moving with more urgency now.

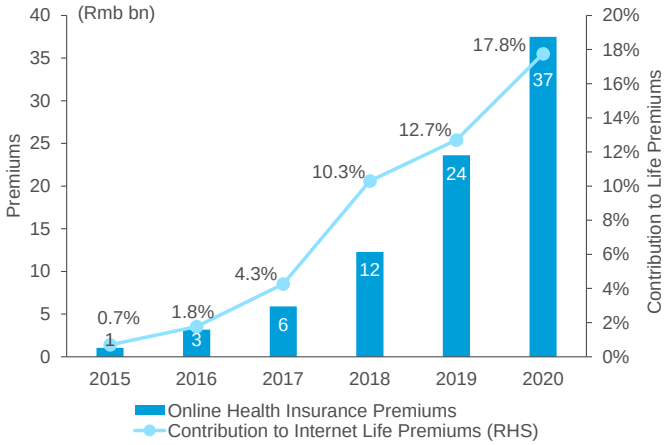
The pandemic has propelled the digitalization of the Chinese insurance industry further in multiple areas. First, regulators are holding a more open-minded attitude toward the virtual sale of insurance products. For example, the Insurance Authority of Hong Kong started issuing circulars in February 2020 allowing the digital distribution of more types of protective insurance products under sufficient upfront disclosure. Second, insurance companies are allocating more resources toward developing digital tools that improve operational efficiency and personnel management. Insurers are interviewing, recruiting, and training staff and agents with the help of AI and virtual meetings. Despite lockdowns and social distancing measures, all listed life insurers in China were able to maintain or even expand their agency workforce in the first half of 2020. Finally, customers who in the past relied heavily on face-to-face meetings for product education are also getting used to purchasing insurance products online, particularly more sophisticated health insurance products. The Internet insurance penetration rate in China climbed to 6.5% in 2020 as a result and health insurance as a proportion of total online life insurance premiums enhanced notably to 17.8% in 2020 from the 12.7% seen in 2019.

**Figure 37. China Internet Insurance Premium and Penetration**




Source: Citi Research

**Figure 38. China Internet Life Insurer's Health Insurance Premiums**




Source: Citi Research

## Consumer

**Citi Research: Consumer and Internet**
Paul Lejuez, CFA, CPA
Jason B Bazinet
Nicholas Jones
Nelson Cheung

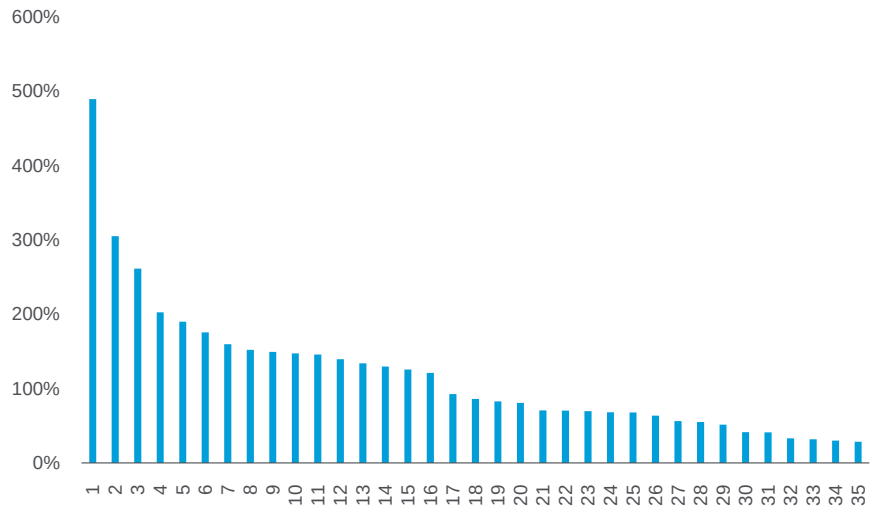
The pandemic drastically increased the number of shoppers who wanted to, or were forced to, shop online. Looking at the total amount of U.S. retail sales done online, we estimate that average e-commerce penetration increased from 18% of sales in 2019 to 29% of sales in 2020 across the 40 companies in Citi Research's U.S. Retail coverage group that have meaningful e-commerce businesses. Many shoppers turned to e-commerce as stores were either closed or had capacity restrictions during the pandemic and/or because they did not feel comfortable shopping inside stores.

While there will likely be some reduction in e-commerce penetration as vaccines are widely distributed and the economy opens up (including stores that may have been previously closed), we also believe the shift to e-commerce is secular versus cyclical. E-commerce has been consistently gaining share for years, and while there may be some instances where e-commerce penetration pulls back temporarily in 2021, longer-term penetration will continue to move higher.

As a result of 2020 events, many shoppers who did not feel comfortable shopping online prior to the pandemic may now feel differently and appreciate the ease and convenience of shopping online versus going to a store. We believe some categories (like apparel and home) may ultimately reach an e-commerce penetration level as high as 50%, while the food category is likely to remain lower on the penetration scale.

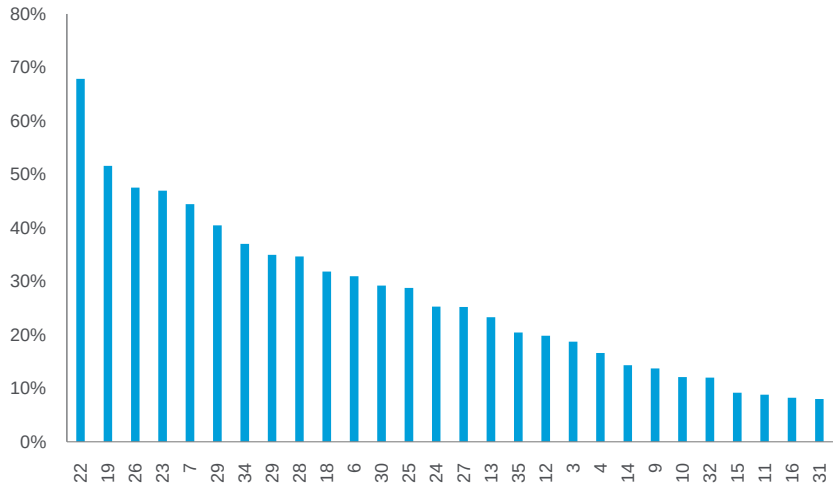
In Figure 39 and Figure 40 below, we show e-commerce growth in the first quarter of 2021 versus the first quarter of 2019 for the Citi Research U.S. Retail sector coverage universe and e-commerce penetration rates in the first quarter of 2021.

**Figure 39. E-commerce Growth 1Q21 vs. 1Q 19**




Note: Companies 1 through 36 represent companies under coverage by Citi Research U.S. Analyst teams. It excludes companies who do not have e-commerce or do not report e-commerce sales or e-commerce sales growth.
Source: Citi Research

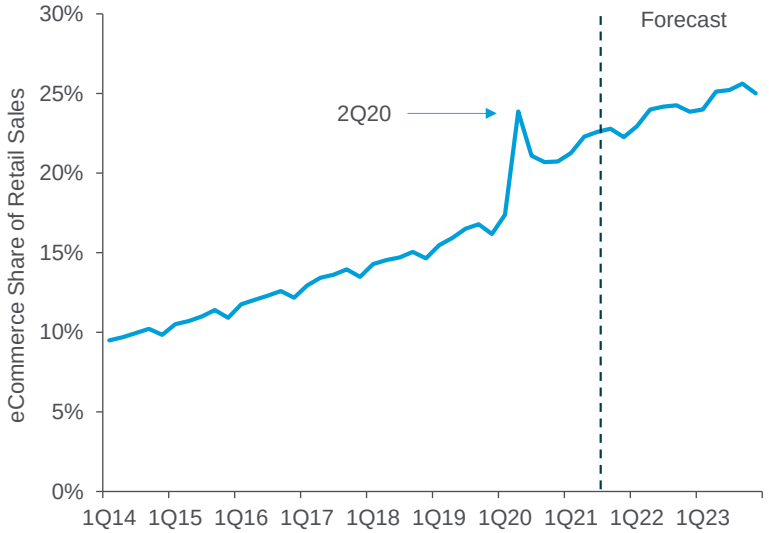
**Figure 40. E-commerce Penetration , or Companies Under Citi Research Coverage**




Note: Companies 1 through 36 represent companies under coverage by Citi Research U.S. Analyst teams. It excludes companies who do not have e-commerce or do not report e-commerce sales or e-commerce sales growth.
Source: Citi Research

The U.S. Census tracks total retail sales and e-commerce sales. Dividing total e-commerce sales by total retail sales (excluding autos and gasoline) gives us a measure of e-commerce penetration. Between the first quarter of 2014 and the first quarter of 2020, U.S. e-commerce penetration grew at a fairly predictable clip, adding 130 basis points of penetration per year. With COVID-19 fully underway in the second quarter of 2020, e-commerce penetration jumped 650 basis points over the first quarter of 2020. In effect, five years of e-commerce gains occurred in just one quarter. Since the second quarter 2020 peak, the U.S. Census has reported both third and fourth quarter data. Early indications suggest that some — but certainly not all — of the gains held. Going forward, we expect a similar cadence of e-commerce penetration, about 130 basis points of incremental penetration per year. This is not dissimilar to the cadence of e-commerce penetration prior to COVID-19. But, clearly, the growth is off a higher base.

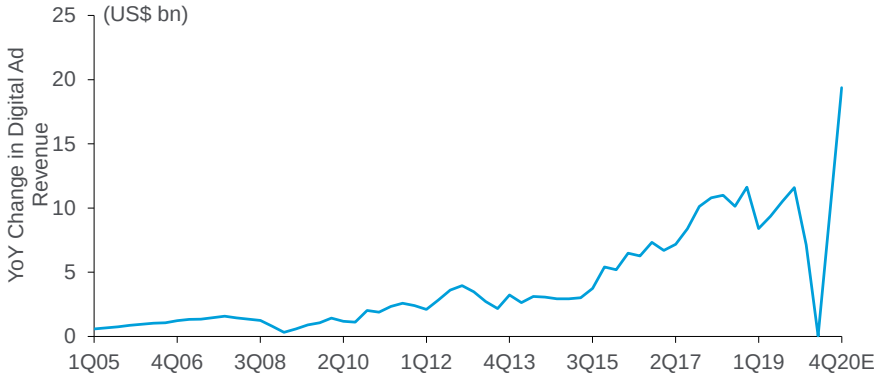
**Figure 41. E-commerce Share of Retail Sales Accelerated**




Source: Citi Research

If you aggregate the advertising (ad) revenue from the ten largest players in the Internet ad market, it's clear that COVID-19 caused a sharp acceleration in digital ads. In the fourth quarter of 2019, these ten firms generated $67 billion of ad revenue. While ad revenue dipped to $55 billion in the second quarter of 2020 — during the depths of the recession — digital ad revenue snapped back sharply reaching $87 billion in the fourth quarter of 2020. This addition of $20 billion in digital ad spending in the fourth quarter of 2020 versus a year earlier was nearly 2x the prior peak in year-over-year growth in spending.

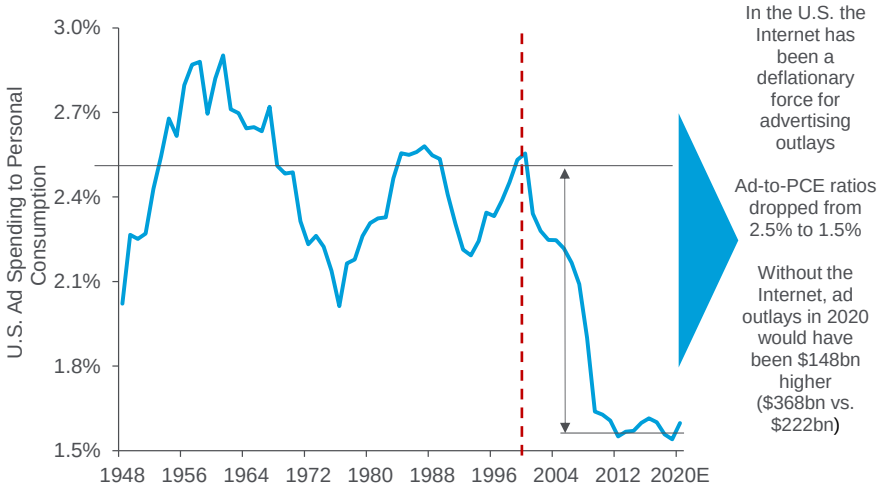
**Figure 42. Digital Ad Revenue Snapped Back Sharply in 4Q 2020**




Source: Citi Research

But, there is a slight rub. 2020 marked the second year in a row where the year-over-year change in digital ad spending moderated. In 2018, it peaked at over $43 billion of growth. In 2019, these 10 firms generated $40 billion of growth. And, in 2020, these same firms generated $36 billion of growth. Going forward the macro backdrop is apt to get better in 2021 and 2022 versus 2020 and e-commerce penetration will continue to rise, but an element of the digital ad bull case may not be true. There is no evidence, at least so far, that the U.S. economy is becoming more ad-centric. That is, when we divide total ad spending — across digital and non-digital formats — it represents a declining share of personal consumption. Indeed, since the rise of the Internet in 2000, ad-to-personal consumption expenditure (PCE) ratios fell from around 2.5% to just 1.5% in 2020. In short, digital ads are better. But, they are also cheaper than their non-digital counterparts (like TV, radio, print, and outdoor).

**Figure 43. The Internet Has Been a Deflationary Force for Advertising Outlay**



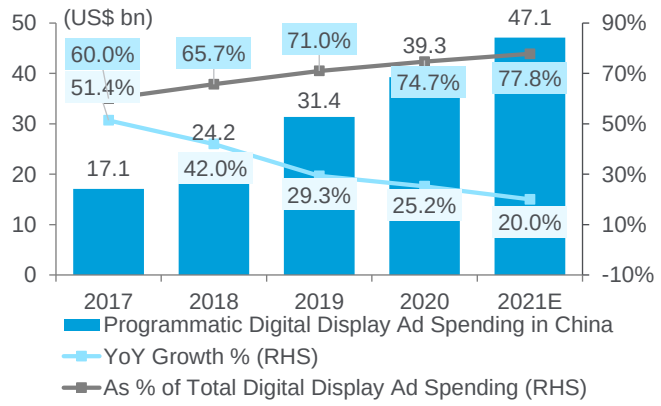

Source: Citi Research

According to data from eMarketer, programmatic digital display ad spending in China reached $39.3 billion in 2020, up 25.2% year-over-year, representing 74.7% of total digital display ad spending. This is up significantly from 60% of total digital display ad spending in 2017, indicating increasing penetration of programmatic ads in China.

eMarketer further expects programmatic digital display ad spending in China to grow 20%, reaching $47.1 billion in 2021, to 77.8% of total digital display ad spending. This compares to 85-90% share of programmatic digital display ad spending in the U.S., at $63.3 billion in 2020

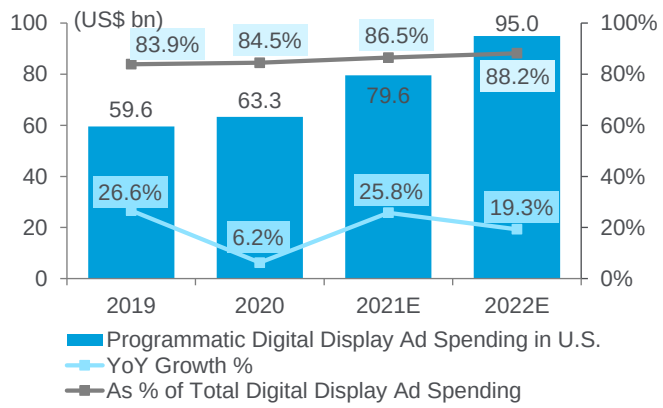
Management from a leading independent online marketing and enterprise data solutions provider in China recently indicated that only 10-15% of China's online ad market is currently fully automated, compared with over 50% in the U.S., offering significant room for programmatic advertising service providers to further penetrate into advertisers' wallet share.

**Figure 44. China: Programmatic Digital Display Ad Spending**




Source: eMarketer, Citi Research

**Figure 45. U.S.: Programmatic Digital Display Ad Spending**



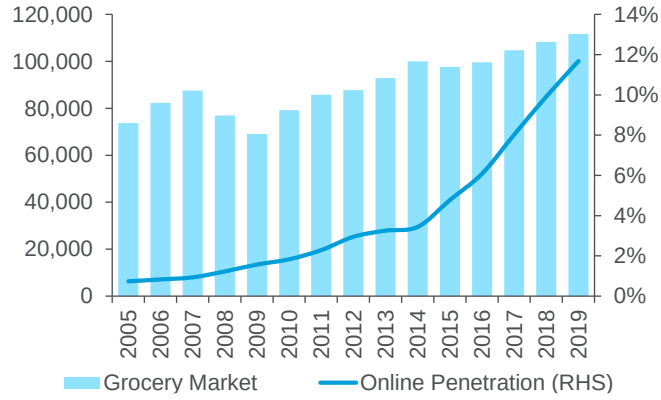

Source: eMarketer, Citi Research

**Citi Research: Consumer & Internet**
Nick Coulter
James Ainley
Alicia Yap, CFA

## Food

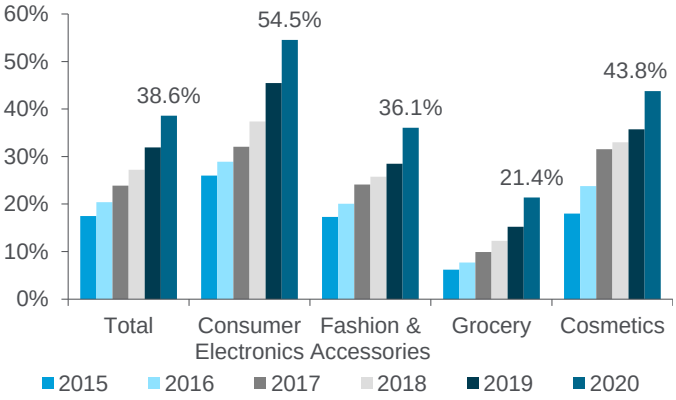
Pre-COVID-19, customers were already shifting towards online grocery delivery. In South Korea, online grocery grew at 30% CAGR over the five years to 2019, outperforming the broader e-commerce trend (~20% CAGR) and landing at 12% online grocery penetration in 2019 (Figure 46). In other markets, for example Japan, with its network of smaller grocery stores and customer preference for fresh produce often bought on the day, online grocery penetration was much lower at 2-3%, compared with broader retail e-commerce at around 15%. Online delivery was also growing much more slowly at an 11% CAGR.

**Figure 46. South Korean Online Grocery Shows 5-Yr CAGR of ~30% to Reach a Pre-COVID-19 Penetration of 12%**




Source: GlobalData, Citi Research

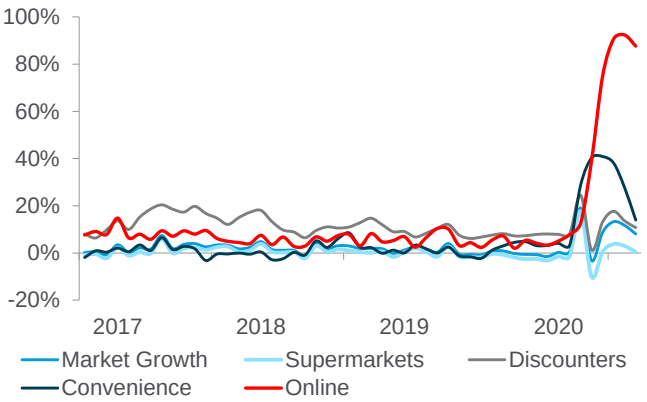
**Figure 47. South Korea E-commerce Penetration by Category**




Source: Kosis, Citi Research

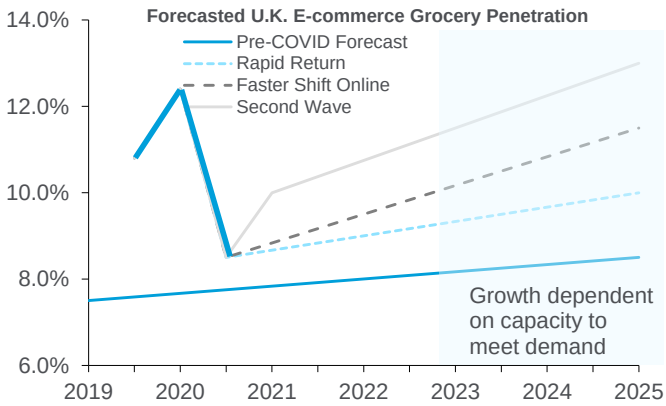
The pandemic forced a change in habits and catalyzed growth in grocery delivery across developed markets, even in historically lower growth markets like Japan. Developed grocery markets saw online growth rates of 75-125% during the COVID-19 crisis. In the U.K., penetration doubled from 6-7% to 12-13%. This trend is likely to only partially temper as economies reopen: almost all of the CEOs in grocery companies covered by Citi Research have acknowledged that higher levels of online grocery penetration are here to stay. One estimate predicts that 35-45% of the 75-125% growth in demand will be retained and this suggests that online penetration will be 2-4% higher than pre-COVID-19. If the same proportion of potential customers who could not get a delivery slot during the pandemic are retained, it would add a further 1%+ of growth. (Fig. 50)

**Figure 48. The COVID-19 Crisis Led to Significantly Higher Levels of Demand – and Supply for Online Grocery**




Source: Kantar Worldpanel (U.K. 4-week Grocery Data), Citi Research

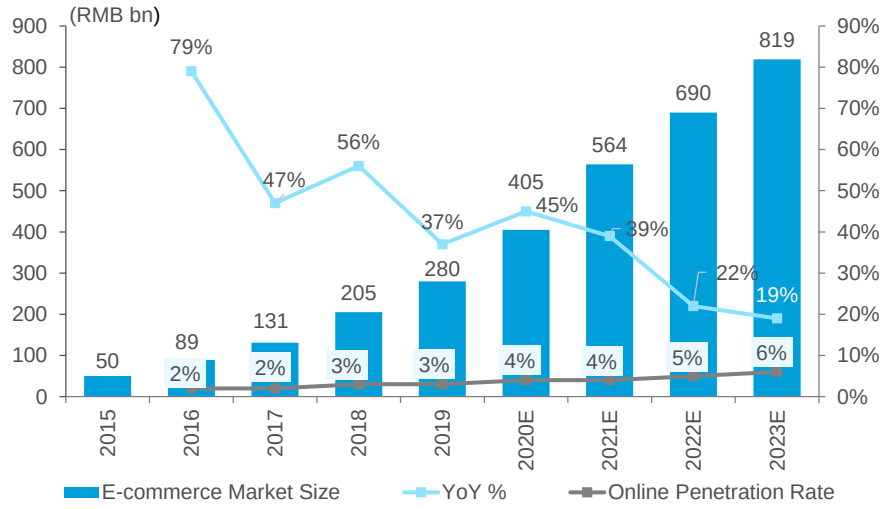
**Figure 49. Expectations are that Some of the Demand Will Stock Following the Crisis and that Penetration Will Accelerate Thereafter**




Source: Bain & Co., Citi Research

In China, data from iResearch shows an acceleration in online fresh produce buying. The fresh produce e-commerce penetration rate was 2.8% in 2019 and iResearch projects it will reach 4.4% in 2021, helped by e-commerce apps. According to Questmobile, monthly active users (MAUs) on fresh produce e-commerce apps increased from 53.1 million in May 2019 to 34.7 million in May 2020, while WeChat Mini Program users of fresh product e-commerce saw year-over-year growth of 66% to 88.5 million users in May 2020.

**Figure 50. China: Fresh Grocery E-commerce Market Size by Gross Merchandise Value (RMB bn)**

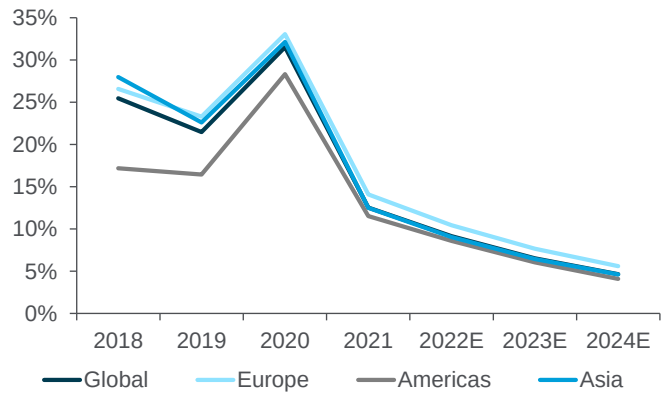



Source: iResearch, Citi Research

With many restaurants closed to dine-in customers over the last year, a clear winner from the pandemic has been online food delivery. According to Statista, the online platform-to-consumer market has seen its global revenues jump from $54 billion in 2019 to $71 billion in 2020 (+32%). This comes on the back of already strong growth in prior years, and while growth may slow in 2021, it seems the habits acquired through the past year will be likely to stick. The industry has evolved from one where online platforms connect restaurants which already offer their own delivery to a first-party delivery model where the food delivery company provides the logistics in return for a higher fee. This has allowed consumers to access a much broader range of cuisine, in turn spurring more growth. The next level of innovation will likely involve the use of that same logistics network to deliver an ever broader range of goods and services.

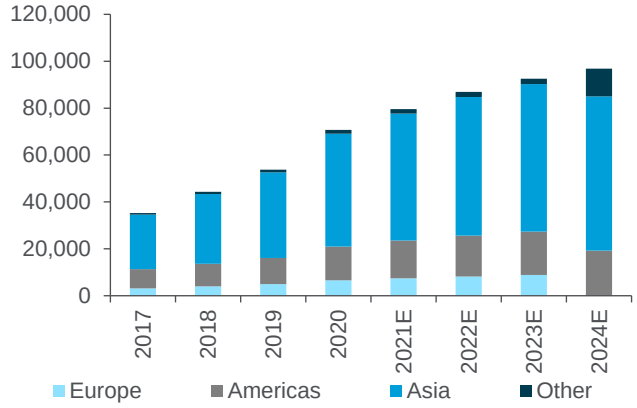
Growth appears to be strong around the world. We think developing markets, where income inequality is high, offer the most attractive opportunities for operators as the relatively lower cost of delivery can be more easily borne by wealthy consumers. In developed markets, where the gap between rich and poor is typically smaller, we see regulation putting upward pressure on driver costs which may make the offer less affordable for consumers and stunt growth.

Figure 51. Online Food Delivery Growth (%)




Source: Statista, Citi Research

Figure 52. Online Food Delivery Revenue ($m)




Source: Statista, Citi Research

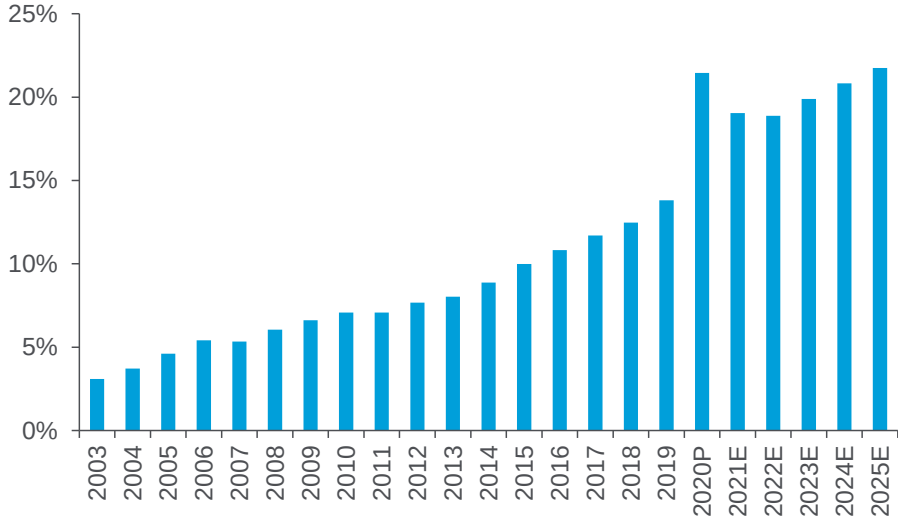
## Entertainment & Arts

**Citi Research**
James Ainley
**Citi Private Bank**
Suzanne Gyorgy

Online gambling participation has seen a step change during the pandemic, increasing from 14% of global gambling gross win (the amount a bookmaker or sportsbook wins before operating expenses) in 2019 to 21% of gross win in 2020, according to H2 Gambling Capital (H2GC) data. Between 2015 and 2019, the online market started to see strong growth, gaining 12% per year compared to offline gambling which saw just 1% growth. However, in 2020 the online market jumped by 20% while offline gambling declined by 30%. H2GC expects the offline market will rebound to pre-pandemic levels through 2021-22 and then revert to its long-term growth rate, but strong online growth is expected to continue from the higher 2020 base.

Europe is at the heart of this revolution with online penetration expected to have reached 38% in 2020, spurred on by more liberal regulation in most European markets. Online innovation is also a driver across betting and gaming markets. By contrast, online penetration is only about 8% in North America, held back by years of restrictive regulation on sports betting and online gambling. However this is changing. In 2018, the U.S. Supreme Court ruled in favor of sports betting and many U.S. states are now moving to allow sports betting and online gambling. Elsewhere in the world, restrictive regulation remains the main limiting factor.

**Figure 53. Global Online Gambling Penetration**




Source: H2GC, Citi Research

The art market has remained remarkably resilient in 2020-21 amid the turbulence brought on by the COVID-19 pandemic. Adaptability and innovation in response to the crisis by auction houses, art fairs, galleries and collectors allowed for rapid digitization and online sales. The overall art market shrank by 22% in 2020, from $64.4 billion in sales in 2019 to $50.1 billion, according to a report authored by art economist Clare McAndrew and published by Art Basel and UBS. The drop is far less than expected given the widespread global lockdown during the first half of 2020, with some 93% of galleries surveyed closed during the period and a number of auctions and art fairs cancelled or postponed. With art collectors at home and unable to travel, online sales soared, from $6 billion in 2019 to $12.4 billion in 2020, accounting for a full quarter of all sales by value in 2020.

While the world's three largest art markets, the United States, United Kingdom and Greater China (mainland China, Hong Kong and Taiwan) once again accounted for the majority of art sales, in 2020 Greater China surpassed the U.S. to become the world's largest auction market, accounting for 36% of public auction sales by value. This partly reflects the fact that China reopened and resumed in-person events much more quickly than the U.S. and U.K., but may also be a phenomenon that is here to stay for the near term.

Auction houses were quick to adapt to online-only formats and hybrid online/in-person livestreamed sales events, as well as shift to many clients' preference for private sales. International art fairs also went virtual, with online viewing rooms and a welcome side-effect, transparent pricing. Dealers reported reaching a wider audience and new collectors. Millennials are increasingly active in the art market — high net worth millennials were the highest spenders in 2020, with 30% having spent over $1 million versus 17% of Boomers, according to McAndrew.

Blockchain, NFTs (non-fungible tokens), and cryptocurrency are also revolutionizing the art industry, with Christie's setting an auction record of $69.3 million for a purely digital work of art by 'Beeple' (Mike Winkelmann) in March 2021. The NFT 'Beeple' sale attracted over 22 million on-line viewers logged in to witness the sale and brought 250 bidders previously not known to Christie's. Digital art and NFTs are a dynamic new medium for artists and is creating an exciting new market sector with alternative ways to own, view, trade, and pay for art.

Of course, with any new emerging market there will be booms and busts, critics and naysayers, but this is nothing new. Throughout art history, artists have pushed the boundaries from cave painters to abstract expressionist art, to Pop-art, video art, and now NFTs.

Technological advancement will surely be one of the lasting legacies of the pandemic on the art industry. On the other hand, there is no substitute for viewing art in person. As auctions, art fairs and galleries begin to resume in-person events and activities, and collectors and art professionals resume travel, we expect art transactions to increase throughout 2021 with the market returning to pre-pandemic levels. (See the Citi GPS report The Global Art Market and COVID-19: Innovating and Adapting.)

## Health and Wellbeing

**Citi Research: Health and Wellbeing**
Joanne Wuensch
Daniel Grosslight

As hospital procedures return to pre-pandemic normalization levels, we see digitization continuing to be relevant throughout the treatment process, including pre- and post-operative care. For example, during the pandemic virtual clinics and telemedicine was increasingly used for diabetes management. While physicians want to meet their patients (particularly new ones) in person, in a post-pandemic world subsequent follow up could be done via telehealth, particularly in rural areas or where there is a fair amount of commute time. Physicians were also able to run remote diagnostic procedures while trying to diagnose atrial fibrillation in patients. And use of continuous glucose monitors (CGMs), which allow glucose to be measured and communicated remotely, increased in the hospital setting under Emergency Use Authorization (EUA) from the U.S. Food and Drug Administration (FDA).

Another example of increased digitization is in the post-operative setting, where technology is developing to help track patients' progress. This allows physicians to get additional data they wouldn't necessarily pick up from a periodic follow-up visit. Case in point is the Mymobility app, which tracks patients following a knee replacement procedure. Combined, remote digital options can potentially free up time for physicians to treat more patients, and make access to physician care easier for patients. While many of these technologies were underway before the pandemic, their accelerated adoption is likely here to stay.

On the payment for and delivery of care, COVID-19 will be a watershed moment, in our view. We ultimately see COVID-19 as an accelerant for the adoption of virtual health, interoperable data systems, and provider analytics. Additionally, the financial strain put on health systems by the pandemic clearly shows how reliant providers are on the fee-for-service (FFS) model, despite the often-heralded march to value-based-care. We think this could be a wake-up call for health providers to move to more risk-based, capitated payment models, where providers are paid a fixed amount per patient for a prescribed time period by an insurer or physicians group.

Many providers were caught flat-footed at the start of the pandemic, with outmoded technology stacks and business models too reliant on FFS reimbursement. While provider investment in technology retrenched in 2020 as budgets were stretched (apart from telehealth), we think we will see an acceleration of the provider investment cycle in 2021. Healthcare technology (HealthTech) companies focusing on interoperability by leveraging cloud infrastructure, Application Programming Interfaces (APIs), and modular applications are positioned to benefit in this investment cycle.

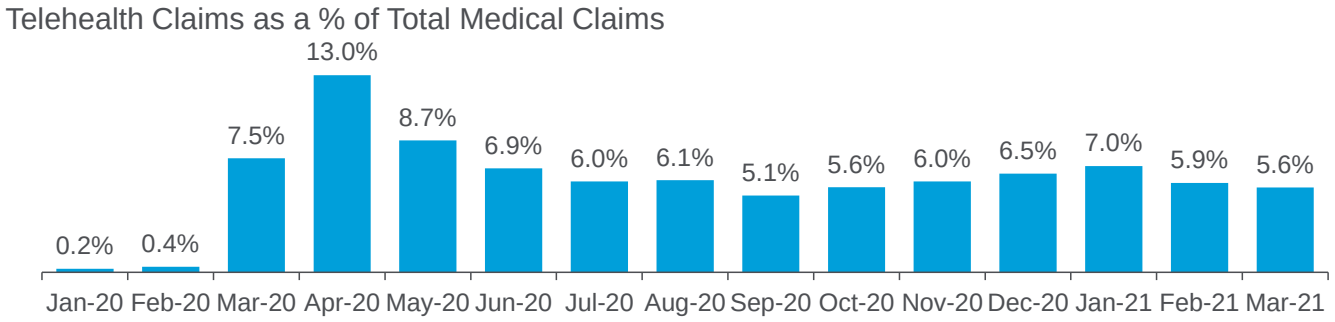
**Figure 54. Moving to Agile, Interoperable Data Analytics**

| | Current | Future |
|---|---|---|
| Data | • Clinical used for claims adjudication<br>• Data capture within the EHR (electronic health record) system. Lack of interoperability with outside vendor | • Integration of clinical, operational, and financial data to get comprehensive understanding of patient population<br>• Easy to share, aggregate, and analyze data among multiple vendors across various hospital systems |
| Analytics | • EHR analytics combined with patchwork of third-party and home-grown point solutions<br>• Most time spent cleaning and standardizing data rather than analysis | • Cloud-based, modular solutions with easy-to-use applications integrated with multiple vendors |
| Focus | • Compliance-driven<br>• Claims adjudication | • Outcomes-driven<br>• Hard ROI (return on investment) |

Source: Citi Research

The pandemic will fundamentally shift how care is delivered in the U.S., with virtual health becoming an important treatment modality across the care continuum. While utilization will certainly drop as COVID-19 concerns wane and as payers offer less generous reimbursement, we think that the shift to virtual care will be durable, as the pandemic has fundamentally changed payer, patient, and provider preferences. Many experts we have spoken with think that ~30% of all U.S. outpatient treatment visits will likely be conducted via virtual health. The biggest barrier to adoption remains uncertain reimbursement. During the pandemic, most payers (including Medicare) have reimbursed telehealth visits at parity with in-person visits. We think it is very likely this reimbursement is reduced post-pandemic (likely to 60-70% of in-person rates in our view). A recent survey of 1,594 physicians and healthcare professional found that 73% thought that low or no reimbursement will be a barrier to the continued use of virtual care after the pandemic.[84]

**Figure 55. While Telehealth Utilization Has Moderated, It Remains Significantly Higher than Pre-Pandemic**

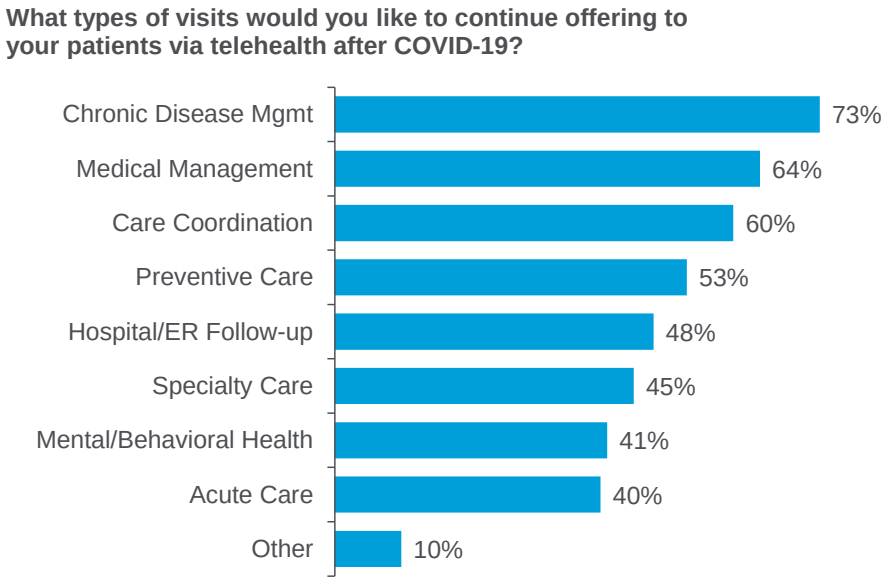



Source: Fair Health, Citi Research

[84] The COVID-19 Healthcare Coalition. (2020). Telehealth Impact Study: Physician Survey.

The next step in the evolution of virtual care is likely to be deeper integration with health plan benefit design and providers to effectively treat a broad-based set of conditions. We see virtual health as particularly well suited to treat behavioral health conditions, where the physical touch is less important, patients bear a disproportionate financial burden, timely intervention is critical, and social stigma may keep people from seeing a provider in person. Additionally, we think will see persistent high levels of virtual health utilization for chronic disease management, medical management, post-op follow-ups, and virtual-first primary care.

**Figure 56. Conditions Best Served by Telehealth**



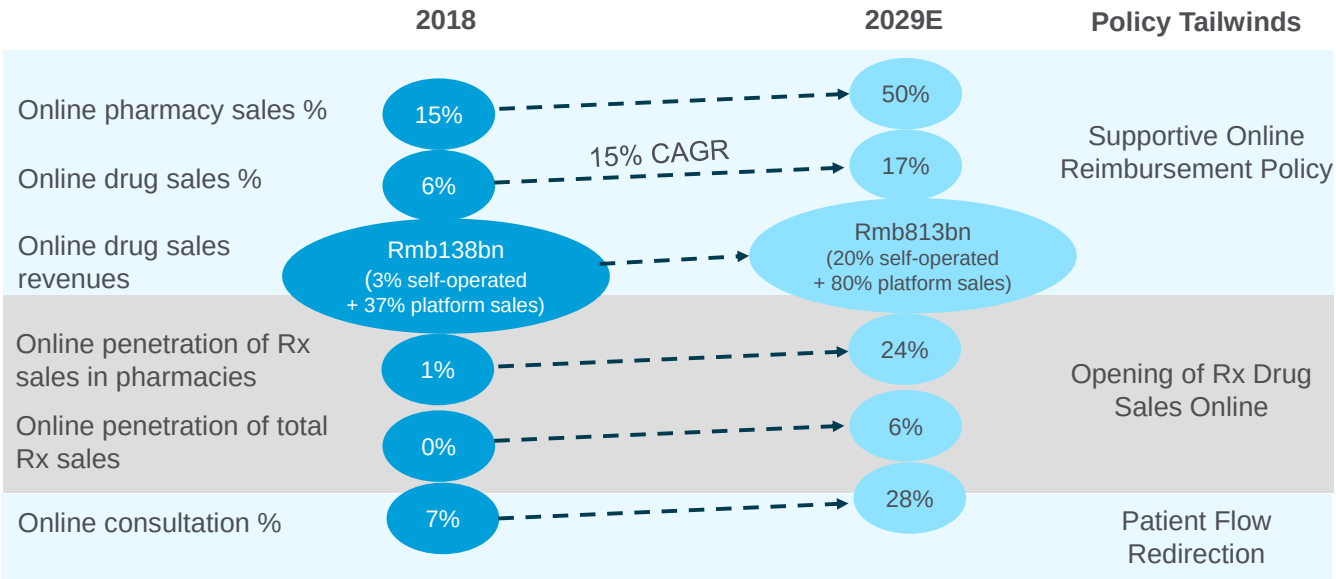

Source: COVID-19 Healthcare Coalition Telehealth Impact Study, survey of 1,594 physicians and other healthcare professionals, July-August 2020.

We see Big Tech getting bigger in healthcare, and will be most impactful in: (1) the migration of healthcare data to the cloud and embedding advanced analytics; (2) providing the front-end user interface to shop for and access care/prescriptions; (3) generic drug distribution; and (4) telehealth technology integration. While Amazon will be rolling out a telehealth solution this summer to the self-insured employer market, we do not think Big Tech will get into the direct provision of clinical care given the complexity of building a clinical network of care providers and lack of patient trust.

China's healthcare industry saw continued digitization growth post the COVID-19 outbreak with the help of policy breakthroughs and higher customer acceptance. We expect online medical consultation and drug sales growth could further accelerate in China, helped by policy tailwinds, such as the opening up of online prescription drug sales, prescription outflow, and supportive online medical reimbursement policies.

We estimate online drug sales could reach 17% of China's total drugs sales of Rmb813 billion (~$125bn) in 2029, from just 6% in 2018. In addition, online pharmacy sales could increase to 50% of total China pharmacy sales in 2029 from 15% in 2018. Based on an online survey we conducted with 3,867 respondents aged 18-80 in China from tier-1-5 cities on their attitudes to online healthcare, we believe online healthcare is likely to be sticky, as 75% respondents agree they will continue using online pharmacy/ online consultation post COVID-19.

**Figure 57. Online Medical Consultation and Drug Sales Growth in China Could Further Accelerate**




Note: Online drug sales % equals online drug sales as a % of total drug sales in China. Online pharmacy sales % equals online pharmacy sales as a % of online + offline pharmacy sales.
Source: Citi Research, Ministry of Commerce

Other areas in healthcare and wellbeing have also benefited from digitization. The real revolution in the digitization of fitness came in the mid 2010's when technology advancements consigned the makeshift rusty basement gym to history. Digital fitness platforms and connected equipment have enabled a truly engaging fitness experience capable of maintaining user interest at home over substantially longer periods of time. The pandemic has driven significant growth in a number of digital products and services.

According to the International Health, Racquet & Sportsclub Association (IHRSA), 68% of Americans that used an online fitness service during the pandemic plan to continue using it. We view this as an epiphany moment, not a temporary phenomenon, driving a paradigm shift towards 'fitness anywhere'.

Traditional fitness facilities have been forced to quickly adapt and embrace digital fitness, leading to the advancement of the hybrid fitness facility (offering both a physical site and digital fitness), which is steadily becoming an expectation of consumers. The pandemic has put rocket fuel in the digital fitness industry, evidenced by the proliferation of new, connected technologies and enhanced by network effects that increase the value as the popularity of the offering increases.

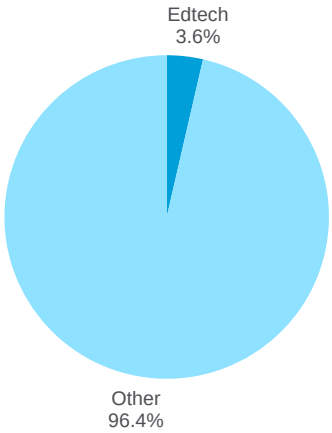
Sports more broadly have embraced e-sports and we have seen virtual racing events take off. In March 2020 we saw Formula 1 racing drivers taking on e-sports racing drivers on game consoles in 'Not the Grand Prix', permissioned by F1. Then in December 2020, the first Union Cycliste Internationale (UCI)-sanctioned world cycling event occurred on a virtual racing platform followed by the hybrid real-virtual triathlon at the Arena Games in March 2021. The pandemic has sprung these events to center stage and while traditional formats will continue to dominate, we expect digital sports to play a more prominent role.

## Education

**Citi Research Education Sector**
Thomas A Singlehurst, CFA

Based on the work conducted as part of our Education-focused series of Citi GPS reports, we think the pandemic has had a material impact on the pace of digitization of the education industry. (See the Citi GPS report Education: Fast Forward to the Future - Accelerating Edtech Adoption in a Post-COVID-19.) Before looking at the impact of the pandemic, however, we should consider the landscape pre-COVID and a key point here is that the global education market, while significant (worth about $6 trillion globally in 2019 and growing at a decent mid-single-digit clip) is strikingly underpenetrated in terms of digital technologies. Indeed, HolonIQ estimates that digital spending through educational technology (edtech) accounted for just 2.6% of global education spending in 2019 and only 3.6% in 2020.

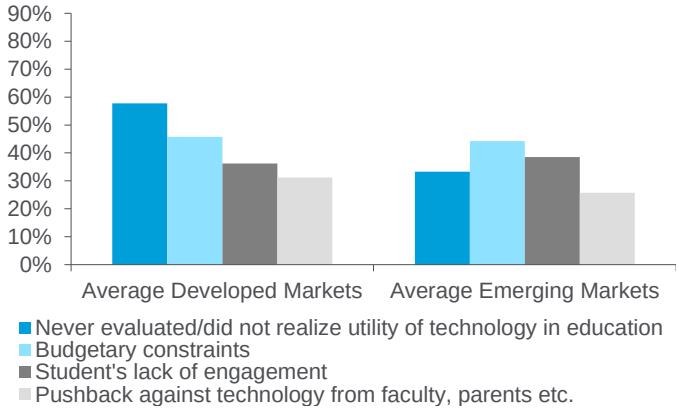
**Figure 58. Edtech Spend as a Proportion of Worldwide Education Spend, 2020**




Source: HolonIQ

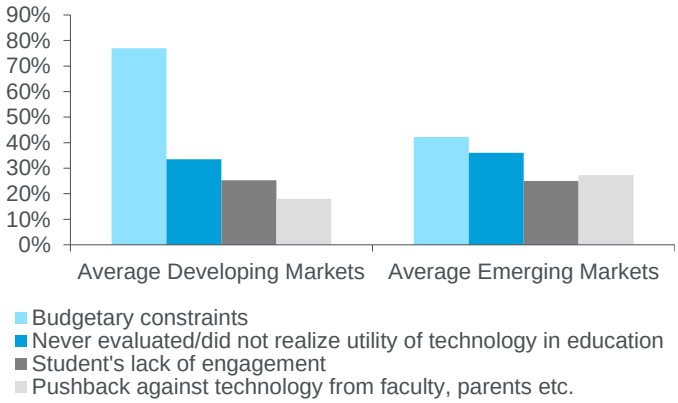
When we look at the reasons for this, we discover a variety of explanations. Some of this clearly relates to pressure on budgets — technology based solutions, for all their promise, are not always cheaper than analog alternatives to implement. But a lot of the inertia can be attributed to a lack of interest in technology-based solutions or indeed active pushback based on historic preferences or indeed political motivations.

**Figure 59. Universities: Why Do You Say Your Institution Has Underinvested in Online Learning/Edtech? Select All that Apply**




Source: Citi Research

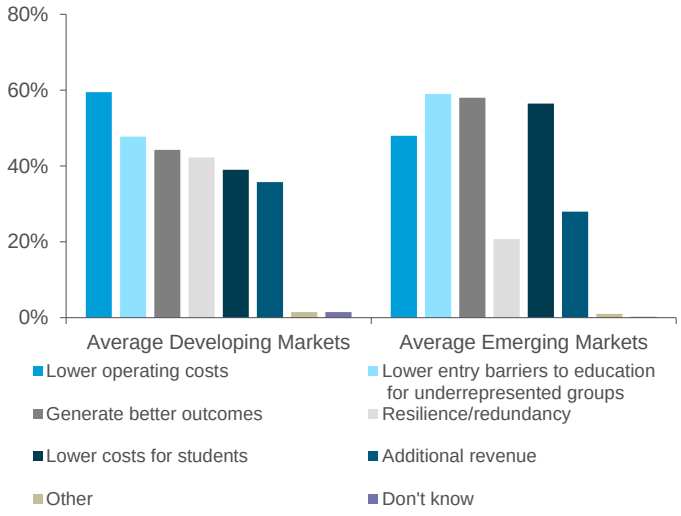
**Figure 60. K-12: Why Do You Say Your Institution Has Underinvested in Online Learning/Edtech? Select All that Apply**




Source: Citi Research

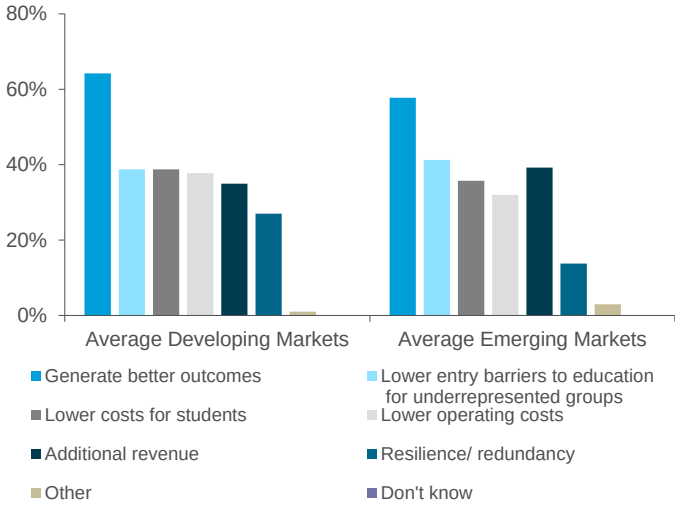
In this context, we think the impact of the COVID-19 pandemic has been nothing short of seismic for the global education industry. The sudden forced move to online learning from March 2020 has resulted in a full scale re-appraisal of the role technology can play and its importance. Some of this is a function of necessity – a more rounded appreciation of the role online can play as a form of redundancy when in-person teaching is not available. However, we detect a broader recognition of some of the other benefits edtech can play longer term not only as a way of reducing costs but also broadening access and delivering better outcomes.

**Figure 61. Universities: What Do You Hope to Achieve by Increasing Spend on Online Learning/Edtech? Select All that Apply**




Source: Citi Research

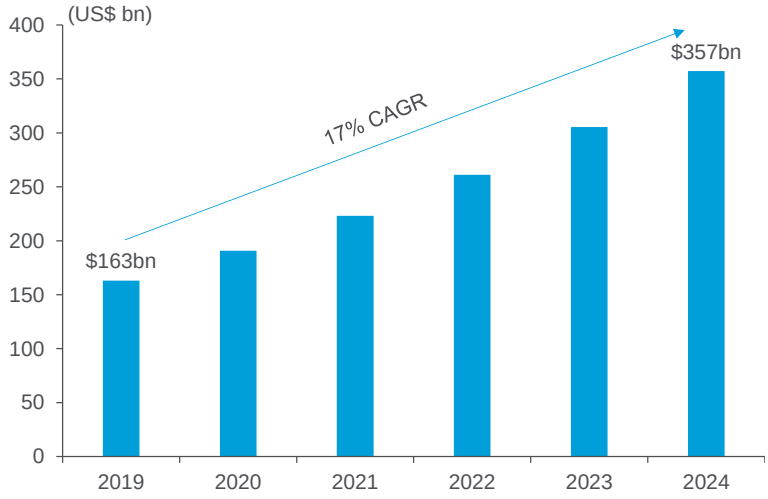
**Figure 62. K-12: What Do You Hope to Achieve by Increasing Spend on Online Learning/Edtech? Select All that Apply**




Source: Citi Research

In practical terms, we think this change in perception will be associated with a material acceleration in the level of spend on technology in an educational setting. We forecast worldwide edtech spend will more than double to about $360 billion by 2024 from around $160 billion in 2019, implying an compound average growth rate (CAGR) of around 17% per year.

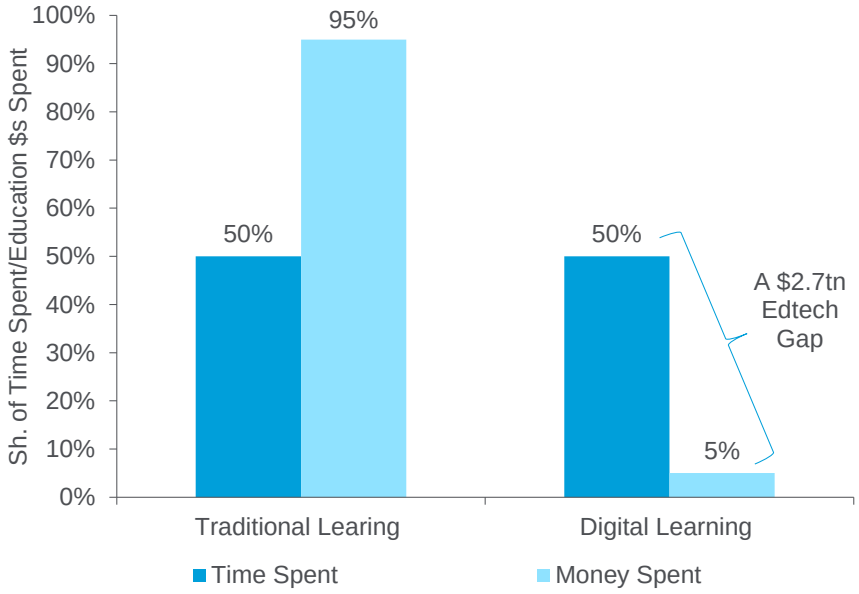
**Figure 63. Worldwide Edtech Spend to Grow at 17% Compound Annual Growth Rate**




Source: HolongIQ (2019 edtech actual), Citi Research

What is more, we think this could even be conservative. We note that even if spend on edtech is to double, this would still leave it at barely 5% of global spend on education. This compares to the proportion of learning done online, which we estimate to expand to 50% based on our survey work. This gap between the amount of time spent on online learning relative to the amount of money spent on technology drives a potential 'edtech gap' that could be equivalent to $2.7 trillion per year.

**Figure 64. Sizing the Edtech Opportunity Gap Using Time Spent vs. Money Spent**




Source: Citi Research

We think the pandemic has been transformative in terms of perceptions of the role played by digital/technology in education and, in due course, will also be transformative to actual spending patterns, with major implications for policy makers, educators, and the (largely private but still small) companies that serve this exciting and dynamic market.

# Chapter 3: Fiscal Policy – From Life Preservers to Stimulus

# Fiscal Policy: From Life Preservers to Stimulus

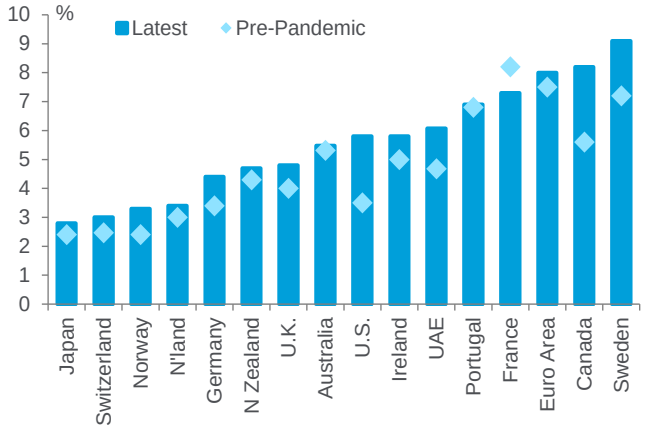
**Igor Cesarec**
Citi Global Economics

In this chapter, we analyze how fiscal policy can impact labor markets and the future of jobs. We first look at the 'life-preservers' that were put in place to support jobs and workers during the pandemic and their consequences. We next focus on the labor market impact of fiscal policies intended to stimulate growth as the economy emerges from the pandemic, which include investment in infrastructure, green technology and the digital economy. Given the rising importance of green infrastructure to meet new net zero targets, we then examine the substitution from brown to green jobs. Finally, we look at jobs from digital infrastructure. As previous chapters have shown, the pandemic has accelerated digitization, but it has also highlighted a digital divide within societies that needs to be tackled.

## Impact of the Pandemic on Labor Markets

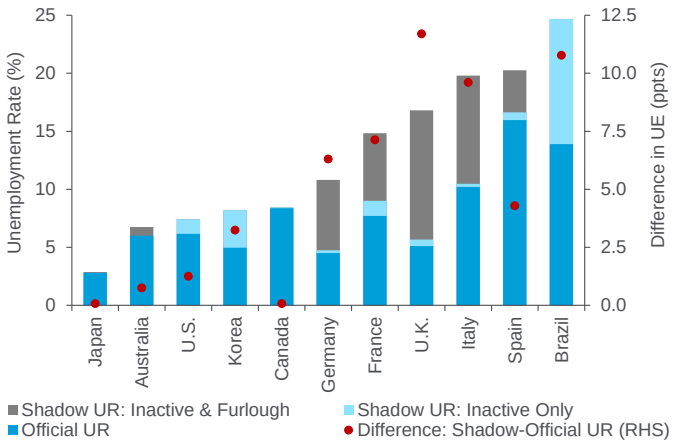
The COVID-19 pandemic remains disruptive to the global economy and continues to have a profound impact on jobs and workers. Lockdowns, working from home, and social distancing measures have changed how people work, which workers want to and are able to work, as well as what type of jobs are available to them. This continues to be the case even as vaccination programs are underway and economies tread the path to recovery.

**Figure 65. Advanced Economies: Unemployment Rate (%)**




Source: National Statistical Agencies, Citi Research

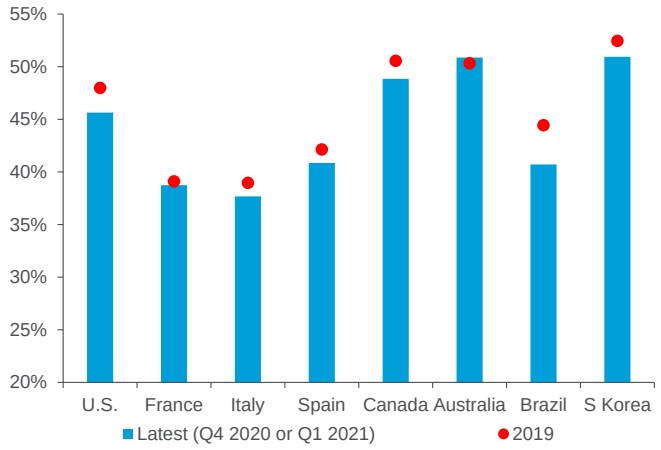
**Figure 66. Quarterly Unemployment Rate Shadow vs. Official (1Q21)**




Source: National Statistical Agencies, Citi Research

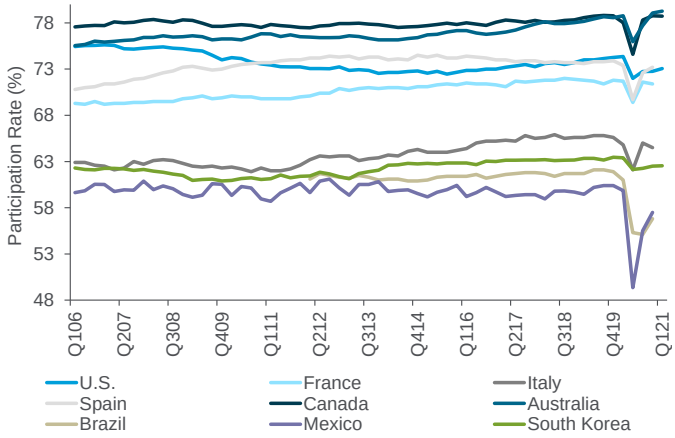
While unemployment rates globally remain elevated (Figure 65 and Figure 66), they still do not show the full extent of the pandemic's adverse impact on labor markets. Citi's shadow unemployment rate, which corrects for pandemic-specific anomalies, continues to run high and show there is still ample slack in global labor markets (Figure 66). Employment levels in most economies are still below pre-pandemic levels (Figure 67) as labor force participation is only gradually recovering in all economies considered except for Canada and Australia (Figure 68).

**Figure 67. Select Economies: Employment-Population Ratio, Latest vs. 2019**




Source: Eurostat, Haver Analytics, National Statistical Agencies, Citi Research

**Figure 68. Select Economies: Labor Force Participation Rate, 2006-2021**




Source: National Statistical Agencies, Citi Research

# Fiscal Policy Continues to Support Labor Markets During the Pandemic

Due to restrictions and the collapse in demand, many workers did not work during the pandemic, which made support from national governments paramount in supporting their incomes. Fiscal policies came in many different forms, with some designed to directly support workers and employers. Two of the most important policies implemented have been job retention schemes ('short-time work' schemes and wage subsidies) and expanded unemployment insurance programs, but included other measures such as social security payment holidays, selective tax cuts, limitations on layoffs, interest-free loans, and public job creation.

These policies have helped with efforts to contain the spread of the virus and have been instrumental in supporting workers' incomes and livelihoods. Overall, fiscal policies helped ensure labor market outcomes that were — while still dire in absolute terms — better than what was initially expected.

We now analyze the two main types of fiscal support for labor markets that governments adopted globally following the COVID-19 outbreak: job retention schemes and expanded unemployment insurance. Both types of policies share a common goal of supporting workers' incomes during the pandemic, but differed in their approaches to achieving that goal.

## Job Retention Schemes: Intended to Preserve Worker-Employer Match

Job retention schemes were designed by governments to keep workers employed with their pre-pandemic employers and ensure they received an income even if they worked reduced or no hours, while alleviating firms' labor costs. In general, job retention schemes have taken the form of either short-time work programs (where the government pays the workers for the hours not worked) or wage subsidy programs (where the government subsidizes earnings for workers on reduced hours).

The OECD estimates that job retention programs helped support a total of 50 million jobs during the pandemic through May 2020 in its member countries and helped reduce layoffs.[85] Several countries had short-time work programs before the pandemic (e.g., Germany, France, Italy, Japan, and Canada), whereas others created them specifically to tackle the labor market consequences of the pandemic (e.g., the U.K. and Australia). Countries with existing short-time work programs typically expanded them through a combination of widening access to the schemes, increasing their generosity, extending time coverage of programs, and including previously excluded workers (e.g., part-time or non-permanent workers).

## Design and Extent of Use of Job Retention Schemes Varied Globally

In the U.S., employers — in particular small businesses — have been incentivized to retain workers on their payroll through the Paycheck Protection Program (PPP) administered by the Small Business Administration. The payments from PPP are loans which would be forgiven under certain conditions. The government secured $349 billion for PPP under the Coronavirus Aid, Relief, and Economic Security (CARES) Act in March 2020, with an additional $321 billion in April 2020. The Consolidated Appropriations Act in December 2020 included $302 billion for a second round of PPP loans. There are no direct statistics on how many jobs the program has saved, but empirical estimates[86] show that the PPP increased U.S. employment by between 1.4 million and 3.2 million jobs (0.9%-2.0% of total pre-pandemic employment) in the first wave of the pandemic through June 2020. However, we must note that PPP funds could go towards other business expenses by firms, not just workers' wages. In addition to PPP, the CARES Act also included an Employee Retention Credit, a refundable tax credit against payroll taxes to employers required to shut down, with an estimated cost of $55 billion.

In the U.K., a job retention scheme was set up in which employers can reclaim up to 80% of their employees' wages from the government initially through the end of June 2021, up to a maximum of £2,500 per employee per month. Employers continue to pay National Insurance and pension contributions for the hours the employee did not work. The scheme cost £65 billion and was subsequently extended twice. The extension from November 2020 through March 2021 cost £2.6 billion and the latest extension from April 2021 through September 2021 is expected to cost £7 billion. As of April 2021, the cumulative number of furloughed jobs totaled 11.2 million, which is 34.1% of pre-pandemic employment in the U.K.

Australia introduced the "JobKeeper" scheme, which ensured continued employment of furloughed workers. It provided a wage subsidy and likely helped contain the rise of the unemployment rate in Australia. The program is estimated by the government to have cost A$88 billion (4.4% of GDP) in 2020 with 3.2 million workers using it (25% of employment).

[85] OECD (2020). Job retention schemes during the COVID-19 lockdown and beyond, OECD Tackling coronavirus (COVID-19)
[86] Autor et al. (2020). An Evaluation of the Paycheck Protection Program Using Administrative Payroll Microdata. MIT Working Paper.

**Figure 69. Select Economies: Job Retention Schemes At-a-Glance**

| | | Amount Spent | % of GDP | Jobs Saved | % of Employment |
|---|---|---|---|---|---|
| U.S. | Paycheck Protection Program | $972bn | 4.5% | 1.4mn-3.2mn | 0.9%-2.0% |
| U.K. | | £74.6bn | 3.4% | 11.2mn | 34.1% |
| Australia | JobKeeper | A$88bn | 4.4% | 3.2mn | 25% |
| Germany | Kurzarbeit | €37bn | 1.1% | 6mn | 13.1% |
| France | Activité Partielle | €38bn | 1.6% | 8.4mn | 33% |
| Italy | Cassa integrazione | €35bn | 2.0% | 7.2mn | 31% |
| Spain | ERTE | €32.4bn | 2.6% | 3.6mn | 18% |

Source: OECD, National Statistical Agencies, Citi Research

Germany had a pre-existing scheme of short-time work ("Kurzarbeit") prior to the pandemic, but lowered access thresholds, raised replacement rates, and extended the maximum duration of the program from 12 to 24 months during the pandemic. Instead of laying workers off, employers reduce their hours and the government pays the worker 60-80% of their wage for the hours not worked (while the employer still pays full wages for hours worked). The program is estimated to cost €37 billion (1.1% of 2020 GDP) over 2020 and 2021. At its peak in April 2020, 6 million workers used the scheme (13.1% of pre-pandemic employment), but this has since dropped to 2-3 million.

France broadened access to its "Activité Partielle" program of short-time work with a replacement rate of 70% (an indemnity paid for time away from work of the worker's gross hourly wage), subject to a cap. The scheme was extended from six to 12 months. The government spent an estimated €31 billion in the first round of the program, and subsequently an additional €7 billion. A total of 8.4 million workers, or 33% of the workforce, were on the furlough program at its peak.

Italy allocated €35 billion in 2020 for various programs supporting work, preserving employment, and supporting incomes. It extended its pre-existing fund, which supplemented earnings and enabled short-time work, and implemented a freeze on layoffs. An 80% replacement rate (subject to a cap) was used in the short-time work program, which initially lasted for nine weeks, but later extended for an additional 18 weeks. An estimated 31% of workers (7.2 million in total) used the scheme at its peak.

Spain expanded its furlough scheme "ERTE" for an estimated cost of €28 billion. The government has simplified the scheme and eliminated conditions for access such as a requirement for prior minimum contributions or a reduction of accumulated entitlement. In addition, firms that maintained employment under ERTE are exempt from paying social security contributions for workers who are laid off (€7.7 billion cost). Approximately 3.6 million workers, or 18% of the workforce, used the furlough scheme at its peak.

European countries relied much more heavily on job retention schemes to preserve jobs (Figure 69). This resulted in smaller increases in the unemployment rate (Figure 65). In the U.S., use of the PPP in order to keep workers in their jobs was limited. Instead, the U.S. relied much more heavily on supplementing unemployment insurance, as detailed below. This led to a much higher increase in unemployment rates in the U.S. compared to pre-pandemic levels.

## Expanded Unemployment Insurance

An alternative fiscal approach to supporting labor markets during the pandemic does not tie the support to job retention. The policy does not require workers to remain employed (even if working no hours), but rather allows for separation from the employer and provides support through unemployment benefits, which are typically expanded by the government. These expanded benefits included wider access to benefits, extending in the duration of eligibility, and increasing the level of benefits. A similar policy that does not require job retention provides unconditional cash transfers, which are received regardless of employment status, but are usually subject to an income cap.

### Expanding employment insurance and providing cash transfers was extensively used during the pandemic in the U.S.

Expanded unemployment insurance was extensively used by the U.S., which significantly expanded and supplemented its existing joint federal/state Unemployment Insurance program. The CARES Act, implemented in March 2020, extended unemployment insurance by 13 weeks, increased benefits by up to $600 per week for four months, and expanded eligibility requirements at an estimated cost of $270 billion. At expiration in July 2020, an executive order allocated a further $44 billion to unemployment benefits from the Disaster Relief Fund. Subsequently, the Consolidated Appropriations Act in December 2020 restored the expired program but lowered the top-up benefits to $300 per week and lengthened the maximum period for receiving unemployment insurance to 50 weeks, at an estimated cost of $119 billion. The American Rescue Plan of March 2021 extended these through September 2021, at an estimated cost of $203 billion.

In addition, the U.S. government provided direct payments to individuals under a certain income threshold, in three rounds. The cost was cost $293 billion for the first round in March 2020, $164 billion for the December 2020 payments, and $411 billion for the March 2021 round.

**Figure 70. Select Economies: Unemployment Insurance Extensions and Other Cash Transfer Policies**

| | | Amount Spent | % of GDP |
|---|---|---|---|
| U.S. | UI expansion | $636bn | 3.0% |
| | Direct cash transfers | $868bn | 4.0% |
| Australia | JobSeeker | A$14.2bn | 0.7% |
| Germany | UI expansion | €7.7bn | 0.2% |
| France | UI expansion | €0.5bn | 0.0% |
| Italy | UI expansion | €10.3bn | 0.6% |
| Spain | Various | €13bn | 1.0% |

Source: National Statistical Agencies, Citi Research

### Europe and Australia spent less on unemployment insurance expansion than job retention schemes

Most European countries enacted only limited expansions of their existing unemployment benefit programs due to the pandemic. This could be due to the fact that many decided to favor the above-mentioned job retention schemes and saw limited need to boost already-robust unemployment insurance schemes.

The amounts spent on changes to unemployment benefit programs were therefore smaller than those spent on job retention schemes (Figure 70). Germany added €7.7 billion for unemployment benefits in its supplementary 2020 budget and France extended replacement income for the unemployed at a total cost of €0.5 billion. Italy enacted measures to support income of laid off workers and the self-employed by extending its unemployment insurance mechanism for at a cost of €10.3 billion. Spain provided support for self-employed workers (which cost €6.5 billion), introduced a new means-tested Minimum Income Scheme (€3 billion), and provided benefits for workers who have exhausted unemployment insurance (€0.2 billion). There was also an exemption of social security contributions in place for the self-employed who received the benefits (€3.3 billion).

Australia also spent a smaller amount on its unemployment benefit expansion than on its job retention program. The "JobSeeker" program implemented a top-up for individuals receiving unemployment benefits and was worth around A$14.2 billion (0.75% of GDP) in 2020.

## Impact of Different Policies on Labor Markets as the Economy Emerges from the Pandemic

The two main types of fiscal policy used to support labor markets during the pandemic will have different effects on current and future employment. This is because job retention schemes are designed to keep workers in their jobs whereas unemployment benefit expansions and cash transfer are not. The key tradeoff that determines how the labor market responds to the re-opening of the economy is between (1) the speed, ease, and cost of returning people to work, and (2) the flexibility of the workforce.

### Preserving the Worker-Employer Relationship Means Easier Re-opening

By design, job retention programs have kept workers attached to their jobs throughout the pandemic, which makes worker recall more straightforward. Businesses that re-open, even if partially, already have a pool of employees that they can draw upon and do not need to go through potentially lengthy hiring processes, which speeds up the re-opening. As workers are likely to retain most of the firm-specific human capital required for performing the job, there are limited costs involved with training workers. While firms can recall workers that they laid off from unemployment, it is less likely that they will be able or willing to return to work for the same firm than if they had remained employed through a job retention scheme. The worker might have moved or found work elsewhere in the meantime.

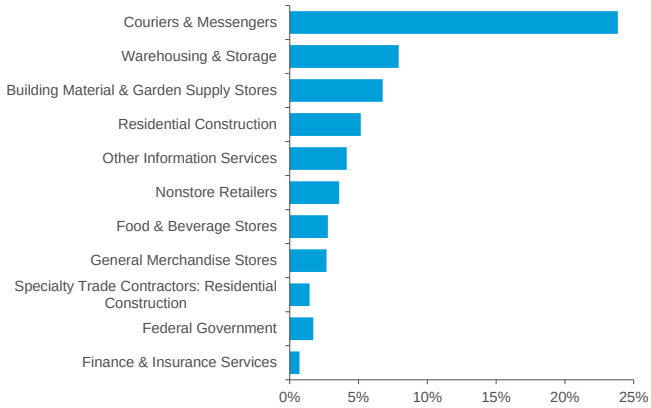
We expect firms will find it more difficult to ramp up operations in economies which put limited job retention programs in place and instead relied on supporting workers through enhanced unemployment benefits. These economies could also incur higher costs than those which put extensive job retention schemes in place.

### Structural Changes to the Economy Shift Labor Demand

The post-pandemic economy is likely to look different from the pre-pandemic one. Behavioral shifts such as a decline in corporate travel, and the rise of an e-commerce/contactless economy, automation, and partial remote work arrangements at the workplace are likely to persist even after the pandemic. This will lead to long-term changes in the labor market. Employment in some sectors experienced strong demand during the first wave of the pandemic, and these occupations have an increased likelihood of remaining in high demand post-pandemic.

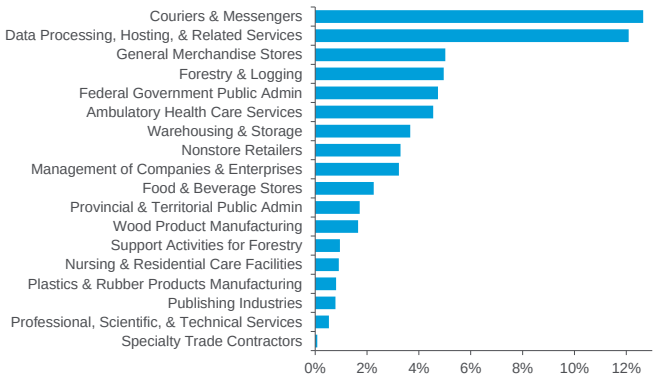
There is already evidence of these shifts. In the U.S., there are 11 sectors in which employment is now higher than before the pandemic, with a total of 760,000 jobs (0.6% of the total workforce) added in these sectors, even though overall U.S. employment is still down by more than 5% from pre-pandemic levels (Figure 71). Similarly, in Canada there are 18 sectors with higher employment compared to before the pandemic, for a total of 102,000 jobs (0.6% of the total workforce), despite the overall employment being down more than 7% from pre-pandemic levels (Figure 72). These are workers that inevitably shifted sectors to follow the labor demand in the economy. Demand for some occupations may never fully recover as an estimated 32-42% of COVID-19 related layoffs could be permanent.[87] This structural shift in labor demand is more easily met if labor supply is more flexible.

**Figure 71. U.S.: Sectors with Positive Work Growth, Mar 2021 vs. Jan 2020**




Source: Bureau of Labor Statistics, Citi Research

**Figure 72. Canada: Sectors with Positive Work Growth, Jan 2021 vs. Jan 2020**




Source: Statistics Canada, Citi Research

## Not Incentivizing Workers to Stay in Jobs During the Pandemic Could Increase Labor Market Flexibility

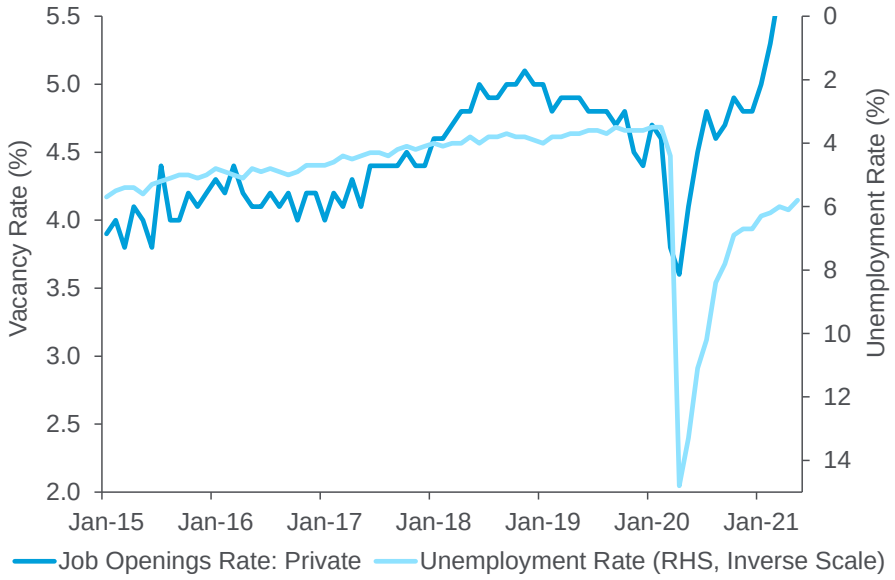
Job retention programs might artificially keep jobs in place that will eventually need to be eliminated due to structural changes in the economy. In contrast, economies that did not rely on job retention programs extensively but rather allowed worker-employer separation and then supported workers through enhanced unemployment benefits, will likely have a more flexible labor supply and therefore find it easier to adapt to structural changes in the post-pandemic world. Coming out of the pandemic, workers will not be tied to firms in which there might be limited long-term prospects, instead they may employment and be flexible enough to change occupations to follow increased labor demand in certain sectors.

There is already evidence of the lack of labor market flexibility impairing the recovery. While overall global labor markets remain slack, there are reports of labor shortages in some sectors. In the U.S., the job vacancy rate is spiking while unemployment rate remains well above pre-pandemic levels (Figure 73). Low labor market flexibility could slow down the necessary re-training efforts of workers and therefore exacerbate structural unemployment, which can keep the unemployment rate higher for longer and therefore have long-term effects on workers' income, consumption, wages, and skills development.

[87] Barrero, J. M., Bloom, N., & Davis, S. J. (2020). COVID-19 Is Also a Reallocation Shock. University of Chicago, Becker Friedman Institute for Economics Working Paper, (2020-59).

Extended unemployment benefits can also help workers find jobs that are better suited to their skills and improve the worker-job match quality.[88] Since the effect is higher on those who are more likely to be liquidity constrained, such as women, minorities, and workers with lower educational attainment, these programs can help alleviate labor market inequality exacerbated by the pandemic.

**Figure 73. U.S.: Vacancy Rates vs. Unemployment Rate**




Source: Bureau of Labor Statistics, Citi Research

## Other Economic Effects Separate the Two Approaches

Beyond the tradeoff between the ease of retuning people to work and having a flexible workforce, there are other distinctions and macroeconomic effects between these two types of fiscal support programs. Job retention schemes tend to be more generous than unemployment benefits, especially for those with no minimum hour requirements. They also offer more security, which decrease the motive for precautionary savings, both of which should be more supportive of aggregate demand.

However, unemployment benefits are better-targeted and cover those in need of financial assistance. Coverage in job retention schemes might be spotty; they may not cover certain segments of the workforce such as part-time and occasional workers, or those not making contributions. Enhancements to unemployment benefits tend to be easier for governments to implement administratively than through job retention programs, especially if the latter are started from scratch. Job retention schemes not only support jobs that may need to be eliminated, but they have the potential to support jobs which would have been retained anyway, which is wasteful and is another downside of those programs.

As governments' fiscal policies move from 'life-preservers' to stimulus, these will also have the potential to shape the future of labor markets. We turn to this topic next.

[88] Farooq, A., Kugler, A., & Muratori, U. (2020). Do Unemployment Insurance Benefits Improve Match Quality? Evidence from Recent U.S. Recessions. NBER Working Paper No. 27574.

# Post-Pandemic Fiscal Stimulus: How Many and What Kinds of Jobs Will It Create?

## Fiscal Stimulus: How is it Different?

The term 'fiscal stimulus' has been used quite loosely, we use a more precise definition in this report. In particular, we refer to policies that go beyond supporting jobs that would be lost due to the pandemic or supporting incomes, but instead give an extra boost to the economy and create new jobs.

While fiscal policies to support labor markets and fiscal stimulus policies have the same starting point — an increase in government outlays, which could be in the form of either direct spending or transfers — they have different goals and approaches.

Fiscal 'life preservers' are aimed at 'weathering the storm' and minimizing damage to the economy during the pandemic. The timeliness of their impact was therefore important. Fiscal stimulus policies are intended to 'put wind in the sails' of the economy as it emerges from recession — spurring growth, improving productivity, and lifting potential output. As such, the benefits of these policies typically take longer to implement and are designed to have a medium-to-longer-term impact. While they also include transfers, there is typically an emphasis on government investment, which can include spending on infrastructure, education & research, healthcare, and housing.

A prime example of past fiscal stimulus is the American Recovery and Reinvestment Act of 2009, which the U.S. enacted in the wake of the Global Financial Crisis. There have been several fiscal stimulus packages either proposed or enacted as the global economy treads the path out of the pandemic-induced recession in 2021. Here, we focus on two: (1) the proposed American Jobs Plan in the U.S.; and (2) the recently approved NextGenEU plan.

## The American Jobs Plan Proposal Features $2.3 Trillion in Spending Over 8 Years

The American Jobs Plan was proposed by the Biden administration in March 2021. It differs from some of the other pandemic-era fiscal policies such as the CARES Act of 2020 and the American Rescue Plan of 2021 as it is not intended to alleviate the economic strain of the pandemic but rather to simulate medium and longer-term growth in the economy mainly through investment into infrastructure, green technologies, health, and housing.

The proposal is projected to cost just under $2.3 trillion (10.7% of U.S. GDP) with $621 billion earmarked for transportation, $418 billion for housing and construction, and $938 billion on other categories, including health and R&D (see Figure 74).

**Figure 74. American Jobs Plan At-a-Glance ($ Billion)**

| | | | |
|---|---|---|---|
| **TOTAL** | **$ 2,288** | | |
| **Transportation** | **$ 621** | **Essential services** | **$ 311** |
| Electric Vehicles | $ 174 | Broadband | $ 100 |
| Roads & Bridges | $ 115 | Water Infrastructure | $ 111 |
| Public Transit | $ 85 | Electric Grid | $ 100 |
| Railroads | $ 80 | **Other** | **$ 938** |
| Transportation Climate Defense | $ 50 | Manufacturing | $ 150 |
| Airports | $ 25 | R&D | $ 244 |
| Ports, Ferries, Waterways | $ 17 | Worker Development & Protection | $ 98 |
| Other Transportation | $ 75 | Medicaid home & Community-based C | $ 400 |
| **Housing and construction** | **$ 418** | Other | $ 46 |
| School Construction | $ 100 | | |
| Housing Upgrades | $ 213 | | |
| Public Housing Construction | $ 40 | | |
| Childcare Facilities | $ 25 | | |
| Other Buildings | $ 40 | | |

Source: The White House, Citi Research

## NextGenEU Plan to Spend €750 Billion by 2027

The NextGenEU plan was approved by the European Union (EU) Council in December 2020 with its main component, the Recovery and Resilience Facility (RRF), voted through the EU Parliament in February 2021. The plan is unprecedented as it is the first time the EU is redistributing resources over a time period and not just across countries. The plan rests on six pillars:

- Green transition
- Digital transformation
- Smart, sustainable, and inclusive growth (including economic cohesion, jobs, productivity, competitiveness, research & development, and innovation)
- Social and territorial cohesion
- Health and economic, social and institutional resilience
- Policies for the next generation (including education and skills)

As such, it is largely forward looking and differs markedly from fiscal policies focused on alleviating the immediate impact of the pandemic on the economy. The plan does not replace national fiscal policies of EU member states, but rather complements them.

The NextGenEU plan will cost €750 billion (5.4% of EU-27 GDP). Its centerpiece, the RRF, will disburse a total of €672.5 billion (€312.5 billion in grants and €360 billion in loans) for investment projects across the above-mentioned six pillars in member states. A minimum of 37% of the RRF (€249 billion) should be spent on programs in the green transition pillar and at least 20% (€135 billion) on the digital transformation pillar, though member states can allocate a higher proportion to programs in those pillars if they choose. Another €47.5 billion will go towards crisis response and crisis repair measures through the REACT-EU program, and €30 billion will go towards other programs (Figure 75).

Figure 75. NextGenEU At-a-Glance (€ Billion)

| | |
|---|---|
| TOTAL | € 750 |
| Recovery and Resilience Facility (RRF) | € 672.5 |
| of which, loans | € 360.0 |
| of which, grants | € 312.5 |
| ReactEU | € 47.5 |
| Horizon Europe | € 5.0 |
| InvestEU | € 5.6 |
| Rural Development | € 7.5 |
| Just Transition Funds (JTF) | € 10.0 |
| RescEU | € 1.9 |

Source: European Commission, Citi Research

NextGenEU will be financed via EU borrowing, unlike the EU Budget which is primarily financed by member states' contributions. However, the European Commission is planning to put forward proposals to help repay the borrowing, using revenue linked to a carbon border adjustment mechanism, a digital levy, and the EU Emissions Trading System (proposals forthcoming in June 2021), as well as new sources of revenue such as a Financial Transaction Tax, a financial contribution linked to the corporate sector, and a new common corporate tax base (proposals in by June 2024).

## How Many and What Types of Jobs Will Be Created?

Fiscal stimulus policies have several macroeconomic effects and boost growth to varying degrees, depending on the form they take. The degree of the impact is typically measured using fiscal multipliers — a measure of the change in gross domestic product (GDP) for each dollar of fiscal policy enacted. However, here we focus on one macroeconomic effect of fiscal policy in particular: job creation. We are therefore interested in the employment multiplier, which measures a related but separate concept: the number of jobs created for each dollar of fiscal policy put in place.

## Employment Multiplier Estimates Range between 8 and 51 Jobs Created for a Year per $1 Million of Fiscal Spending

Estimates of the employment multiplier vary across studies, depending on the methodology and fiscal stimulus analyzed. Generally for the U.S., they find effects that are statistically significant and economically sizable: $1 million of fiscal stimulus creates on average between 8 and 51 job-years, e.g.one job is created that lasts for one year, with the majority of estimates in the 10-33 range (Figure 76).

**Figure 76. Employment Multiplier Estimates from Academic Literature**

| Study | Country | ARRA or Not | Estimate (job-years / $1mn) | Confidence Interval |
|---|---|---|---|---|
| Chodorow-Reich et al. (2012) | U.S. | ARRA | 38 | [12, 64] |
| Conley and Dupor (2013) | U.S. | ARRA | 8 | [-1, 16] |
| Dube, Kaplan and Zipperer (2014) | U.S. | ARRA | 33 | [17, 48] |
| Dupor and McCrory (2018) | U.S. | ARRA | 19 | |
| Dupor and Mekhari (2016) | U.S. | ARRA | 10 | [5, 15] |
| Feyrer and Sacerdote (2012) | U.S. | ARRA | 20 | [7, 32] |
| Wilson (2012) | U.S. | ARRA | 18 | [6, 29] |
| Adelino, Cunha and Ferreira (2017) | U.S. | Non-ARRA | 51 | |
| Bucheim and Watzinger (2017) | Germany | Non-ARRA | 40 | [2, 78] |
| Shoag (2016) | U.S. | Non-ARRA | 29 | [13, 45] |
| Suárez, Serrato, and Wingender (2016) | U.S. | Non-ARRA | 33 | [4, 62] |
| Alloza and Sanz (2019) | Spain | Non-ARRA | 6 | |
| Pollin and Garrett-Peltier (2007) | U.S. | Non-ARRA | 9-20 | |

Source: Chodorow-Reich (2019). Geographic Cross-Sectional Fiscal Spending Multipliers: What Have We Learned? *American Economic Journal: Economic Policy* 2019, 11(2): 1–34.

A number of studies rely on the analysis of the American Recovery and Reinvestment Act of 2009 (ARRA). These are likely to be a useful guide to what the employment multipliers might be for the currently proposed American Jobs Plan legislation in the U.S. While certainly not identical, the two plans do share characteristics such as the focus on infrastructure, technology, green manufacturing, healthcare, and education. Moreover, both share a similar macroeconomic backdrop: these policies are being put in place in the wake of historic economic downturns (The Global Financial Crisis and the COVID-19 pandemic) and face monetary policy that is at the zero lower bound and reliant on asset purchases. This is important because evidence shows that fiscal policy is more effective when the economy is in a recession[89] and when the zero lower bound is binding.[90]

Estimates of the employment multiplier derived from non-ARRA studies are largely in line with the ARRA-based estimates. While employment multipliers could be different in Europe than in the U.S. due to structural differences in the respective labor markets, there is a limited number of estimates derived from European data that could be used to assess the impact of the NextGenEU program on jobs in Europe (Figure 76). We therefore use the same multipliers for Europe as for the U.S.

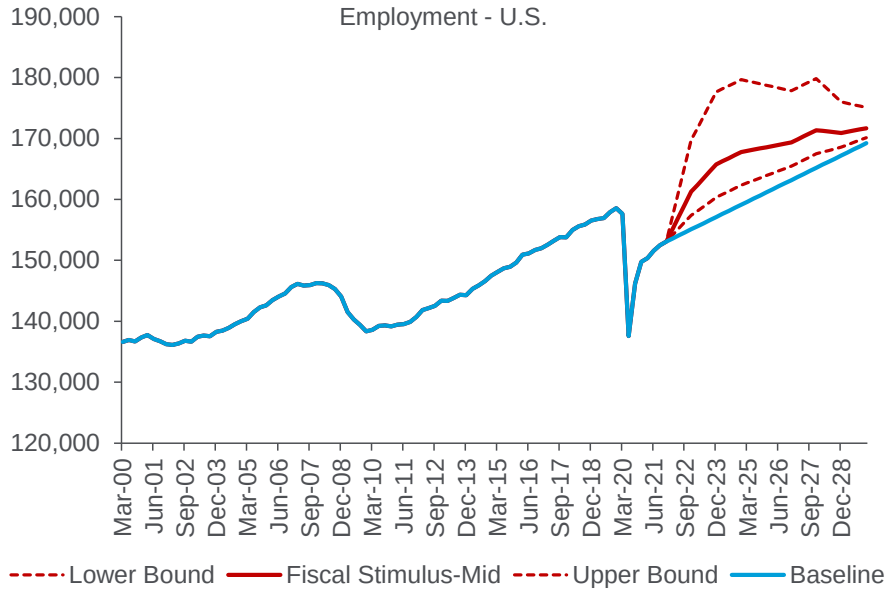
[89] Auerbach, A. J., & Gorodnichenko, Y. (2012). Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*. 4 (2), 1-27.
[90] Christiano, L., Eichenbaum, M., & Rebelo, S. (2011). Why Is the Government Spending Multiplier Large? *Journal of Political Economy*, 199 (1), 78-121.

## The American Jobs Plan and NextGenEU Could Create and Sustain an Average of 6 Million Jobs in the U.S. and 2.3 Million Jobs in the EU

Using the employment multiplier estimates, we can project the expected impact of the fiscal stimulus plans on employment in the U.S. and in the EU. The American Jobs Plan, if enacted as proposed by the Biden administration, has the potential to create a total of 49.5 million job-years. This translates into creating more than 6 million jobs that could be sustained for the eight-year duration of the plan.[91] This is economically large: employment in the U.S. would be on average 4% higher each year over the eight years of the plan than what it would have been without the fiscal stimulus. This would ensure a faster return to the pre-pandemic level and trendline of employment (Figure 77).[92]

These projections are based on the assumption that the American Jobs Plan spending starts in 2022 and is phased over eight years, with Citi forecasting the following dynamics: 12.5% of the total in 2022, 17.5% in each 2023 and 2024, 15% in 2025, 12.5% in each 2026 and 2027, 7.5% in 2028 and 5% in 2029. The caveat is that there is considerable uncertainty about the dynamics of the investment spending.

**Figure 77. Projected Path of Employment in the U.S., With and Without Fiscal Stimulus ('000s)**




Source: Bureau of Labor Statistics, Citi Research

NextGenEU plan could create a total of 16.1 million job-years in the EU, which means it would create 2.3 million jobs on average that could be sustained for the seven year duration of the program. It would increase employment in the EU by approximately 1% during each of the seven years of the program compared to the counterfactual of no fiscal stimulus. This is smaller than in the U.S., but still

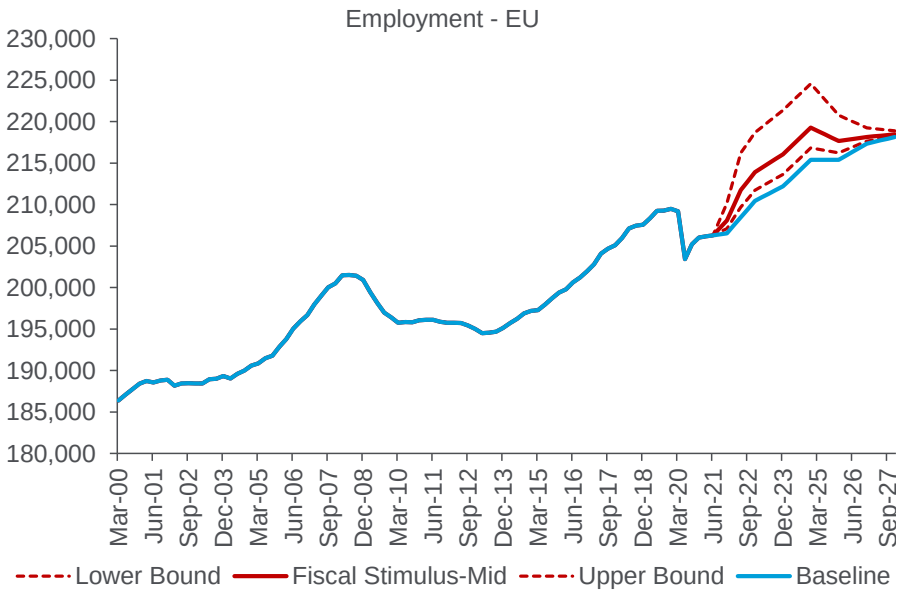
[91] We use the average employment multiplier across available studies of 21.5 job-years per $1 million spent for the 'mid' scenario. We use the lowest estimate of 8 for the lower bound and highest estimate of 51 for the upper bound.

[92] The plan will be paid by raising taxes, which could weigh on job creation. However, tax increases are spread out over 15 years and typically have smaller fiscal multipliers than investment. We therefore leave out these effects from our calculation as they are likely to be small.

economically large. The stimulus is likely to boost the recovery of the European labor markets (Figure 78).

NextGenEU has a somewhat faster timeline with an impact already in the second half of 2021. Citi's assumptions underlying the calculation for the European Union is that the funds will be disbursed as follows: 9.5% of the total in 2021, 21.5% in 2022, 24% in each 2023 and 2024, 14% in 2025, 5% in 2026 and 2% in 2027.

**Figure 78. Projected Path of Employment in the EU, With and Without Fiscal Stimulus ('000s)**




Source: Eurostat, Citi Research

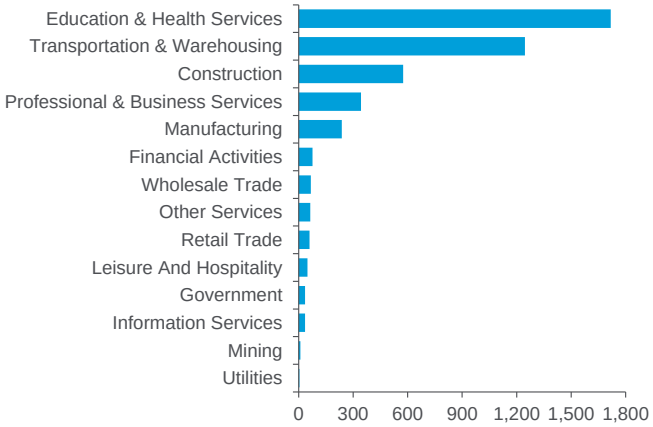
## U.S. Fiscal Stimulus Likely to Create Jobs in Education & Health Services, Transportation & Warehousing, and Construction

Another important aspect of job creation through fiscal stimulus is what sectors might disproportionately benefit from the policy. With the caveat in mind that details of the American Jobs Plan are still subject to change, we assume an equal proportion (25%) is spent on each of the following areas: transportation, education, healthcare and green infrastructure.

Using estimates of the employment multipliers by sector, we conclude that the education & health services sector, transportation & warehousing sector and the construction sector are most likely to benefit from fiscal stimulus (Figure 79).[93] In these sectors, employment could be up by 7%, 22% and 8%, respectively, on average over the duration of fiscal spending. Employment would be up by less than 2% over the course of the plan in other sectors (Figure 80).

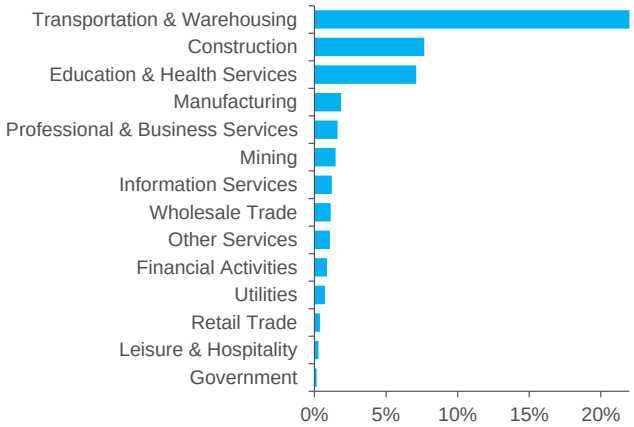
[93] This study has a slightly lower estimated overall employment multiplier, so that the total number of jobs created and sustained in the U.S. comes out to 4.5 million vs. 6.1 million that we calculated using the average multiplier from all studies.

**Figure 79. Jobs Created by the American Jobs Plan by Sector ('000s)**




Source: Bureau of Labor Statistics, Pollin and Garrett-Peltier (2007), Citi Research

**Figure 80. Jobs Created by the American Jobs Plan by Sector (Share of Pre-Pandemic Employment in the Sector)**




Source: Bureau of Labor Statistics, Pollin and Garrett-Peltier (2007), Citi Research

Fiscal stimulus policies such as the American Jobs Plan in the U.S. and NextGenEU in Europe aim to increase future productivity and thereby potential output by broadly investing in infrastructure. This has the potential to create and sustain jobs in the millions over the coming decade as the plans are being implemented. In addition to reinvigorating sluggish labor markets and supporting the post-pandemic recovery path of the global economy, both policies include a focus shifting toward green infrastructure and green jobs. We turn to this area next.

## Green Jobs

**Citi Global Insights**
Lara Ouvaroff

As we emerge from the COVID-19 crisis, there is an exceptional opportunity for policy to tackle climate change and boost green jobs. With global attention increasingly centered on climate factors and commitments to net zero developing across much of the world, there appears to be growing momentum behind efforts to a greener future.

An immense exploration is underway into how, as a global population, we can actively and practically implement policies and principles at both national and local levels across individual industries. There is a particular emphasis on the transition of 'old economy' staples into part of the greener economy, with the departure from fossil fuels into renewables perhaps the most evident. With this development comes the creation of a broad variety of new green jobs and retraining opportunities for the current workforce.

In this section, we look at where these roles are likely to be found and what training is required — either by the public or private sector — in order to fill them. Approximately 70% of the world's economies now hold net-zero commitments and numerous individual corporates and businesses have made similar assurances. Focus on the sustainability of supply chains is also becoming increasingly common. The establishment of many government initiatives will results in a greener workforce but there will be a transition process to get there.

## United States

Although the U.S. is still shy of a full commitment to net zero by 2050, the Biden administration showed its intentions in addressing climate change, by signing an executive order to reinstate the U.S. to the Paris Agreement within hours of the January 2021 presidential inauguration. He also stressed climate change-related employment opportunities in his proposed U.S. recovery effort. Though the political process may reduce some of the strength of the proposal, the intention from the executive branch seems clear —- in building back the U.S. economy from recession, there is a real opportunity to do so with green intent.

In order to support the efforts to achieve net zero, the energy workforce is set to triple by 2050. A recent report from Princeton University titled Net Zero America, highlights net-zero pathways throughout the 2020s as supporting an average of 3 million energy jobs (a net increase of 500,000 to 1 million jobs versus a business-as-usual scenario), with a net wage increase of $30-$40 billion for the same time period.[94] Some even more optimistic estimates see up to 4.5 million new jobs, including across the construction of new, necessary infrastructure.[95]

Under a net zero 2050 scenario, oil sector jobs are expected to fall by 60-95% from their current level of ~800,000, which make up about one-third of all jobs in the energy workforce.[96] In aggregate, however, the number of fossil fuel-related roles will be more than offset by an increase in employment across low-carbon sectors, most significantly by opportunities within solar, wind, and the electric grid. Currently employing 350,000 people, the Princeton study forecast by 2050 the solar sector will comprise between a third and a half of energy-related jobs in net zero scenarios, followed by electric grid providing around a third of roles and the wind sector comprising 10-25% of energy-related jobs.[97]

With almost a quarter of coal related jobs having been eliminated since 2016, the green transition proposed by the Biden administration could present new employment opportunities for these same individuals, albeit with salary implications.[98] Though the transformation and growth of the green economy will create millions of jobs, many of which are to be found across solar and wind, there is debate as to whether these jobs can match the compensation of those in traditional energy industries, especially for more senior positions.

### Many of the new green industry jobs are construction heavy with an estimated 53% of solar workers expected to be in construction and 33% in wind.

Due to the construction-heavy nature of many of the new green industry jobs, the green transition involves an increase in demand for workers from a variety of education and training backgrounds; across solar, an estimated 53% of workers are anticipated to be in construction with the number closer to 33% for wind.

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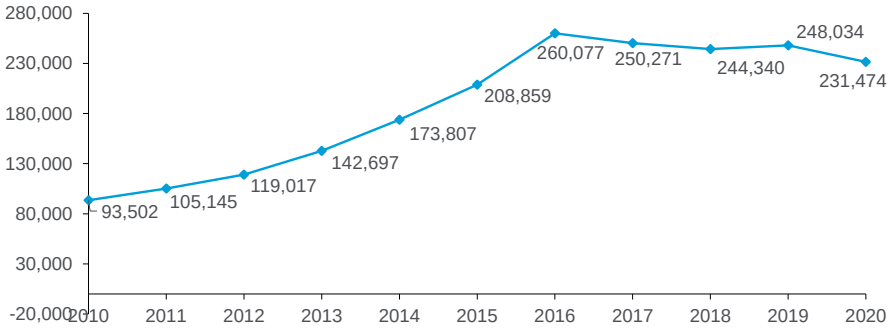
[94] Larson et al. (2020). Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Interim report, Princeton University.
[95] Richards, H. (2021). Biden's clean energy plan: Job creator or killer?
[96] Larson et al. (2020). Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Interim report, Princeton University.
[97] Ibid.
[98] Kuykendall, T. (2020). US coal jobs down 24% from the start of Trump administration to last quarter. S&P Global Market Intelligence

Though initially employment in clean energy looks attractive, the new green opportunities are not as fiscally lucrative as their previous energy employment at higher levels of seniority, with estimates of average solar installation job paying around $45,000 annually (2019 Bureau of Labor Statistics), versus upwards to $80,000 for coal, oil and gas workers.[99] There is further debate regarding the longevity of these new green positions. The largest solar power plant in the U.S. created will create around 600 jobs during its construction, but will require just 12 permanent operations and maintenance roles after the completion of the initial build.[100]

Despite potentially less lucrative opportunities towards the top of the solar industry, solar is a key area of renewable energy growth and employment. Solar jobs steadily increased between 2010 and 2016, rising nearly 3x and significantly faster than overall U.S. job growth in that period, though growth has flattened since. Solar-related jobs increased in 31 states in 2019, led by Florida and followed by Georgia, Utah, New York, and Texas.

**Figure 81. U.S. Solar Workforce, 2010-2020**




Source: The Solar Foundation[101]

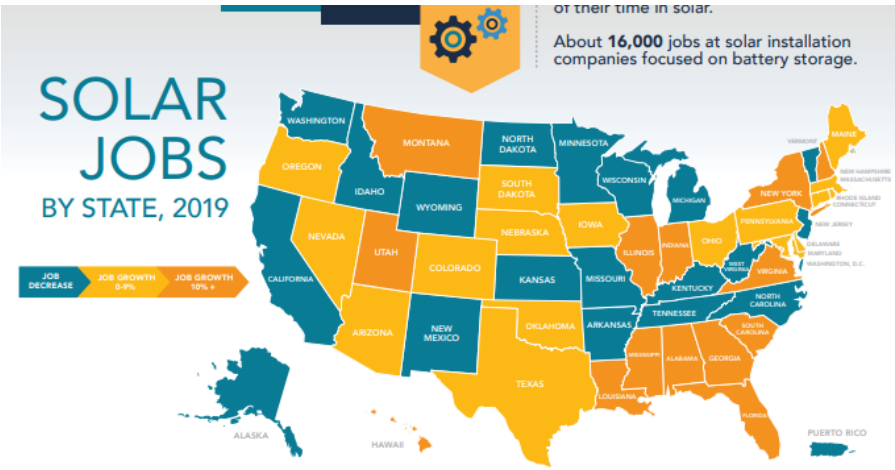
## Growing Renewable Jobs is Important in States Such as Wyoming

Progress on growing jobs in the renewables sector is vital in coal-rich states such as Wyoming, where 16 working mines produce almost 40% of coal production in the U.S. The green transition and the move towards net zero creates a real threat to the almost 15,000 people employed in Wyoming's fossil fuel industry. Despite the coal sector losing 761 jobs last year, wind is providing an alternative employment avenue and a source of significant tax revenue for the state.[102] Almost $8 billion of potential resources could flow into the state if proposed wind projects, go ahead.[103] Excluding projects in planning stages — if only wind projects currently in permitting or construction come to fruition — the Centre for Energy Economics and Public Policy estimates approximately $7.1 billion of inflows and 4,700 new jobs as the result.[104]

[99] Richards, H. (2021). Biden's clean energy plan: Job creator or killer?
[100] Carpenter, S. (2021). The Challenge Facing Biden's Green Jobs Agenda? Green Jobs. *Forbes.*
[101] The Solar Foundation (2021). National Solar Jobs Census.
[102] Searcey D. (2021). Wyoming Coal Country Pivots, Reluctantly, to Wind Farms. *The New York Times.*
[103] Erickson, C. (2019). New wind projects could generate thousands of jobs, billions in revenue. *Casper Star Tribune.*
[104] Cook, B. & Godby, R. (2019). Estimating the Impact of State Taxation Policies on the Cost of Wind Development in the West.

Currently the U.S. only receives 7.3% of its energy from wind power. However, with the construction of wind farms such as the one proposed by PacifiCorp, which is doubling the capacity of Wyoming's wind production, the U.S. Energy Information Administration forecasts 38% of America's electric needs (up from 19% currently) will come from renewable sources.[105][106]

**Figure 82. Solar Jobs by State, 2019**




Source: The Solar Foundation

## United Kingdom

The current U.K. government has advocated for recovery efforts in response to the COVID-19 crisis to be framed with a green lens, and has issued a number of new policy directives supporting the green economy. In November 2020, the government launched a new Green Jobs Taskforce with the specific directive to formalize efforts in establishing permanent, high quality green roles by 2030 as the country transitions to a low-carbon economy. The ambition is to create two million green jobs over the next decade with 700,000 of them being newly created jobs as part of the effort to reach net zero emissions by 2050.[107]

In the March 2021 budget, the Chancellor of the Exchequer outlined further provisions to support the U.K. economy through green policies. These included £20 million towards improving offshore wind developments; £68 million to fund a long-duration energy storage prototype competition; and £4 million for a biomass feedstocks program, which aims to identify how forest products can be used for energy.[108] Employment in the offshore wind sector is expected rise almost three-fold by 2030 from its current level of 11,000, reflecting the U.K's commitment to generating a third of all the United Kingdom's energy and all of residential energy from wind sources within the next decade.[109]

[105] U.S. Energy Information Administration (2021). Wind explained: Electricity generation from wind.
[106] Outcalt, C. (2020). Wyoming Confronts Its Wind-Powered Destiny. *WIRED*.
[107] U.K. Government (2020). UK government launches taskforce to support drive for 2 million green jobs by 2030.
[108] U.K. Government (2021). Budget 2021: What you need to know.
[109] Sheppard, D. & Hook, L. (2019). UK aims to draw third of electricity supplies from offshore wind. *Financial Times*.

In September 2020, the government outlined its new 'Green Recovery Challenge Fund' which provisioned £40 million for local conservation projects, a budget that has now doubled to £80 million. Alongside its environmental impact through the reduction of biodiversity loss, the Fund is expected to create and protect a collective 5,000 jobs in England.[110][111] Much of this activity is to strengthen the U.K.'s low-carbon industry, where the government estimates there are already 460,000 jobs.[112] Progress in meeting these targets will require action from a number of industries.

For shipbuilders and marine engineers, restructuring occupations towards a greener objective means refocusing on offshore renewable energy, including construction, supply and maintenance of offshore wind farms. The U.K. has its own ambitious target to generate all residential electricity in homes to be powered from offshore wind by 2030, allowing for the sector to support 60,000 jobs both directly and indirectly.[113] With Prime Minister, Boris Johnson, stating "as Saudi Arabia is to oil, the U.K. is to wind – a place of almost limitless resource", it is hardly surprising to see U.K.-based shipbuilders diversifying to produce a range of renewable-based energy products including turbines for offshore wind farms, with a number of individual farms able to generate sufficient power to support approximately 100,000 homes annually.[114][115]

What is evident, as the national government highlights, is the importance of local authorities and governments in implementing a number of these proposed policies and programs. The Local Government Association (LGA) estimates that in conjunction with central government support, the U.K. could create almost 700,000 new jobs this decade, and a further 488,000 by 2050.[116]

In their analysis the LGA highlight that a cluster of new roles (28% of them) will be situated in Yorkshire and Humber, and the North West. The LGA further estimates that of the jobs created by 2030, nearly half will be in low-carbon electricity generation and heating, 21% in energy efficiency product installations, 14% in the manufacturing of low-emission vehicles and related infrastructure, 11% in alternative fuel production, and 9% in low-carbon services (IT, legal, financial).[117]

One potential area for job creation is the U.K.'s Zero Carbon Humber project, a partnership of 12 companies and organizations, aiming to create the world's first net-zero industrial cluster by 2040. It plans to use carbon capture and storage, renewable energy, and hydrogen to decarbonize the region, sustaining 55,000 jobs and creating 'thousands' of new roles as a result.[118]

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[110] U.K. Government (2020). Government's £40 million Green Recovery Challenge Fund opens for applications.
[111] U.K. Government (2020). £80 million fund for green jobs and new national parks to kick start green recovery.
[112] U.K. Government (2020). PM: A New Deal for Britain.
[113] Elgot, J., Harvey, F., & Ambrose, J. (2020) Boris Johnson to unveil plan to power all UK homes with wind by 2030. *The Guardian*.
[114] Harrabin, R. (2020). Boris Johnson: Wind Farms could power every home by 2030. BBC News.
[115] Harland & Wolff. Ormonde Offshore Wind Farm.
[116] Local Government Association. Local green jobs – accelerating a sustainable economic recovery.
[117] George, S. (2020). UK 'capable of creating 700,000 new green jobs by 2030'. edie.
[118] Wheeler, S. (2021). Why industrial clusters can be the heard of the green revolution.

The challenge that the U.K. faces, much like other global economies, is the retraining of labor from areas likely to be forced into transition in order to reach wider environmental commitments. Though some job losses in high emission industries — such as the estimated 1 in 6 U.K. auto jobs at risk (~25,000) with the end of the furlough scheme — can initially be attributed to the COVID-19 crisis, it is environmental concerns that may restrict the amount of government support available to these industries as they attempt to build back. For example, YouGov polling found that "more than half of British adults believe taxpayer's money should only be used for low-polluting or electric vehicles."[119][120]

The New Economics Foundation (NEF) estimates that close to 70,000 jobs were at risk across the aviation industry as a result of COVID-19, with at least 17,000 aviation workers, plus a potential 14,000 additional workers across their supply chains, needing to permanently transition into alternative industries should there be stagnation across aviation for five years.[121] Though COVID-19 has had a clear impact on the industry, pressures to address carbon emissions have, in part, resulted in a hesitation to return to what was standard activity.

## Europe

For much of Europe the move to a greener economy has been in motion for a number of years. Governmental policy has been supportive in directing economies towards a more sustainable future, advocating that "the vast majority of workers simply need to increase and modify their skill set."[122] An additional 700,000 jobs could potentially be created in the EU alone through a set of primarily technological changes across key sectors such as motor vehicles and waste management.[123] The European Commission's Employment and Social Developments in Europe (ESDE) report refers to 'greenable' jobs as those that will be affected by the transition towards a greener economy and highlights the significant rise in the number of greenable roles between 2006 and 2016 (over 12 million), with up to 40% of all jobs likely to be affected by greening in Europe. Within that, it's the Green Enhanced Skills jobs, which fall into the categorization of developing skills and applying them to current roles such as EV electricians, which are growing at the most rapid pace.[124]

There are clear examples of restructuring occupations across Europe from more traditional manufacturing and industrial roles to those which encompass the greener ambitions of both governments and companies. This kind of redirection of employment can be seen across industries and countries.

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[119] Campbell, P. (2020). One in 6 UK auto jobs at risk once furlough ends, says trade body. *Financial Times*.
[120] Topham, G. (2020). UK car industry 'could lose one in six jobs due to Covid-19 crisis'. *The Guardian*.
[121] Chapman, A. & Wheatley, H. (2020). Crisis support to aviation and the right to retrain. New Economics Foundation.
[122] The European Centre for the Development of Vocational Training (Cedefop) (2010). Skills for green jobs. European Synthesis Report.
[123] European Commission (2018). Impacts of circular economy policies on the labour market. Study by Cambridge Econometrics, Trinomics and ICF.
[124] European Commission (2019). Towards a greener future: employment and social impacts of climate change policies. Employment and Social Developments in Europe (ESDE) 2019. Chapter 5, 172-174.

In Germany and France, car manufactures have retrained staff in hybrid technologies to produce EV or hybrid vehicles.[125] In Estonia, the emphasis has been on education, with higher education programs designed to highlight the importance of reducing pollution across supply chains.[126] In some areas, financial incentives have driven the change in skill accumulation. In Spain, by 2016, over 60,000 people had received training under a system where employers who offer training receive reductions in social security contributions; more than double the number in 2009.[127] Europe has been successful in reshaping the narrative for rebuilding the economy with a clear emphasis on the restructuring of current roles to be more adaptable to future, more sustainable, requirements.

## Global Context

The green transition provides numerous employment opportunities, and working towards a 2°C target could create up to 18 million jobs globally in contrast to a business as usual scenario, according to the International Labour Organizaton (ILO).[128] An area of particular note is electricity production, with the net creation of almost 2.5 million jobs more than offsetting the expected 400,000 fuel based electricity job losses. However, many of these roles are likely to be regionally disparate in their benefits with a number of these newer, greener roles concentrated in the Americas, APAC and Europe, with net employment losses anticipated in the Middle East and Africa (300,000 and 350,000 respectively).[129] Developing nations require support in retraining and establishing their own renewable industries and offsetting job losses due to the transition away from traditional energy sources.

Government policy is accelerating the green transition, such as mandates for electric cars. Around 14% of global new car sales in 2025 are forecast to be electric. By 2030, Citi Research estimates electric vehicle penetration in China and Europe to reach 47% and 42%, respectively with the U.S. forecast to hit 28%. India has embarked on ambitious new climate friendly policies, with an attempt to generate 175 gigawatts of renewable electricity by 2022 (or half its energy production); in part resulting in 25,481 new roles created between 2017 and 2018 in across solar and wind.[130]

Private companies can also play a role. A waste management company in Bangladesh created over 16,000 new jobs for people with lower socio-economic backgrounds through a program based on composting waste from Dhaka's markets[131]. Innovation and adaptability of programs need not require vast amounts of investments, but identifying opportunities to increases sustainability within

[125] The European Centre for the Development of Vocational Training (Cedefop) (2010). Skills for green jobs. European Synthesis Report.
[126] Ibid.
[127] The European Centre for the Development of Vocational Training (Cedefob) (2015). Green skills and innovation for inclusive growth, Cedefop reference series 100
[128] International Labour Office (2018). World Employment and Social Outlook: Greening with Jobs. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_628654.pdf
[129] Ibid.
[130] Ibid.
[131] Mondal, A. H., Iqbal, Z., & Mehedi, S. (2011). Skills for green jobs in Bangladesh. Final Report. International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-dhaka/documents/publication/wcms_157249.pdf

processes will be material in achieving climate goals, both domestically and internationally.

# Digital Jobs

**Citi Global Insights**
Amy Thompson

"Broadband internet is the new electricity," according to the Biden administration.[132] As the world becomes more digital, a strong digital infrastructure becomes as important as traditional infrastructure. The COVID-19 pandemic has brought into focus the imperative to ensure high-speed access for all. The White House comments are also a reference to the Rural Electrification Act, which not only brought electricity to the U.S. but also created jobs for electricians in the midst of the Great depression as they fitted out the nation's buildings for electricity. Like electrification, rolling out upgraded and more widespread digital infrastructure will create jobs — and those jobs are especially needed against the backdrop of high unemployment brought on by the pandemic.

At the end of 2020, the EU announced NextGenEU, a fiscal stimulus package worth €750 million. More than 50% of this will support what the European Commission calls 'modernization', including the digital transition. On a country level, Germany proposed spending over 20% of funds for its recovery and resilience plan on digitalization, including €3 billion on 'digitalization of the economy and infrastructure'. In the U.S., the Biden administration's proposed American Jobs Plan, a $2.3 trillion infrastructure package, includes $100 billion to connect all Americans by building out infrastructure and reducing the cost of broadband access.

## Jobs Created by Upgrading Digital Infrastructure

Upgrading digital infrastructure creates three categories of jobs:

- **Delivering enhanced connectivity:** To deliver enhanced connectivity, countries must look to provide universal fiber[133] access and scaled up 5G coverage. This creates jobs both from the infrastructure rollout, such as jobs laying fiber in the ground, to supporting customers with the transition to higher-speed connectivity.
- **Utilizing enhanced connectivity:** Utilizing this enhanced connectivity will accelerate the growth of the Internet of Things (IoT) as an increasing number of industries turn to digital solutions. As the IoT grows, the jobs of the future will look very different to jobs performed today.
- **Derivative jobs:** These jobs emerge as the newly employed spend more, which increases demand for goods and services.

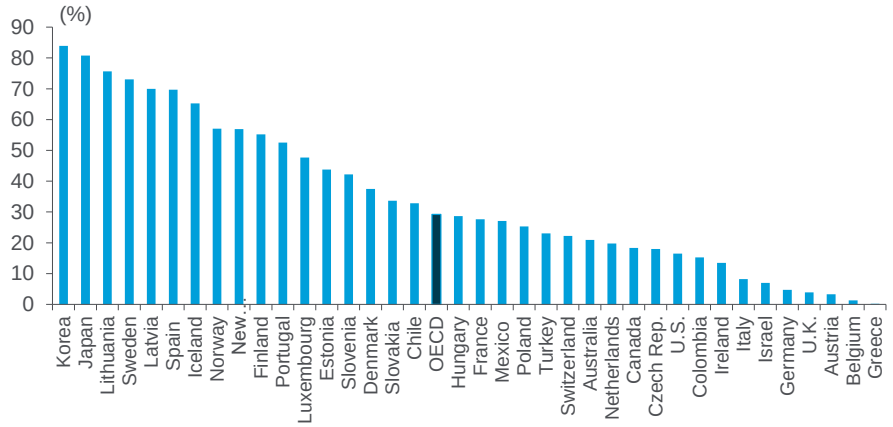
## Delivering Enhanced Connectivity Creates Traditional Infrastructure Jobs

Across the 37 member countries of the OECD, 29% of broadband contracts are fiber contracts with huge geographical variation in the availability of fiber broadband both within and between countries (Figure 83). The U.K. has targeted 85% of properties to have fiber broadband access by 2025, compared with just 4% in mid-2020. In the U.S., The Federal Communications Commission (FCC) estimates that

[132] The White House (2021). Fact Sheet: The American Jobs Plan.
[133] Fiber broadband is an Internet connection which uses fiber optic cables instead of traditional copper cables. This is beneficial as (1) fiber is able to handle higher use volumes without degrading; and (2) fiber offers greater reliability and faster Internet speeds.

at the current pace of fiber rollout, 50% of Americans would still not have fiber broadband access by 2025. However, in light of the 2021 Infrastructure Bill, Citi expects availability to now reach 60% of households by 2025. At the other end of the spectrum, fiber broadband penetration is high in countries like South Korea and Japan, at 84% and 81%, respectively.

**Figure 83. Percentage of Fiber Broadband Connections Varies by Country (June 2020)**

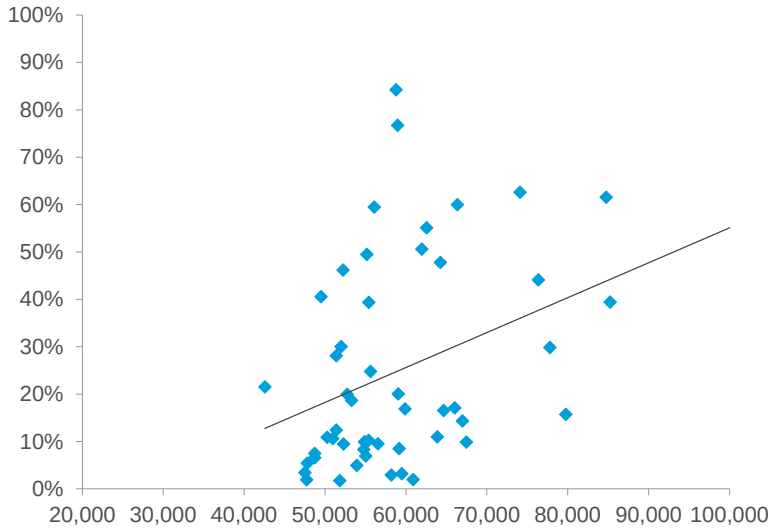



Source: OECD

There are also regional disparities in the rollout of fiber broadband. In the U.S. Only 3% of properties in Montana have access to fiber broadband, due in part to the state's low population density and its low average wage (average private wages are < $45,000/year). However, in New York, 62% of properties have access to fiber broadband as the average private wage is > $72,000 per year.

Figure 84 shows the link between average salary and fiber rollout is not anecdotal with a weakly positive correlation between the availability of fiber broadband and higher average salaries across the U.S. This indicates a possible digital divide due to regional disparity, and rolling out fiber across the country presents an opportunity to level up by reducing this difference between states.

**Figure 84. Availability of Fiber is Weakly Correlated with Higher Average Salaries**




Source: Statista, Broadband Now

The pandemic has accelerated already growing demand for Internet access. In the U.K., up to 2019, demand was already at 40% per year and expected to outstrip supply capabilities of a mixed fiber/copper system between 2030 and 2040. Increased reliance on Internet connectivity during the pandemic has likely brought forward this time horizon. Increased demand and unequal availability creates a strong case for accelerated fiber rollout.

## Fiber Rollout Creates Demographically and Geographically Diverse Employment Opportunities

Under the first category of jobs, 'delivering enhanced connectivity,' jobs are created in three categories: (1) engineer roles; (2) construction roles; and (3) distribution and customer service roles.

Engineer roles are skilled jobs which require training. In the U.S., Verizon job advertisements state that prospective Cell Site engineers who will maintain telecoms equipment in the field should have 3+ years of experience and a technical degree in electronics or telecommunication. Being skilled jobs, telecoms engineer roles are high-quality jobs and command a high salary: the median salary of a traditional infrastructure worker in the construction industry without a college degree in the U.S. is $38,835, while in telecoms still without a college degree, it is $57,266 (i.e., 47% higher).[134]

Construction accounts for many of the jobs created in the fiber broadband rollout. To take a recent example: in December 2020, the U.K. provider Openreach announced the recruitment of 2,500 new engineers and estimated their construction partners would create a further 2,800 jobs.[135] Research shows that between 60% and 80% of the work involved is in digging up and repaving the road.[136] This work does not require telecoms-specific training and creates jobs for those with existing skills.

Customers require support in transitioning to fiber. In the U.K., the Gigabit Take-Up Advisory Group (GigaTAG) was launched in August 2020 to understand the barriers to fiber adoption and propose solutions. Their inaugural report notes that despite the availability of Fiber to the Cabinet (FTTC) fiber broadband service for some time in the U.K., 30% of customers still rely on basic broadband.[137] Supporting the transition to fiber and educating consumers about its benefits is, therefore, a significant task. Jobs targeting increasing adoption levels will be created in both sales and customer service.

A 2012 report on the economic impact of broadband for the International Telecommunication Union observed that ~50% of the jobs created by the Broadband Stimulus Bill in the U.S. were in communications, construction, and equipment with the remaining in ancillary services (e.g., distribution) and higher in the value chain (e.g., metal products and electrical engineering).[138] Jobs created higher in the value chain span a broad spectrum of technology firms, including: (1) OEM device manufacturers; (2) infrastructure equipment manufacturers; and (3) content and application developers.

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[134] Bradley, N. (2012). Installing fibre-optic cables underground. Beyond Broadband.
[135] BBC (2012) Openreach creating 5,300 new jobs to speed fibre rollout.
[136] Bradley, N. (2012). Installing fibre-optic cables underground. Beyond Broadband.
[137] GigaTAG (2020). Gigabit Take-Up Advisory Group: Interim Report.
[138] International Telecommunication Union (2012). Impact of Broadband on the Economy. Broadband Series.

Jobs are also created as an externality to infrastructure investment. Historically, additional jobs have been created by the rollout of improved digital infrastructure: the same ITU report categorizes jobs gained by the creation of new business services and jobs gained as a result of new economic activity.[139] Overall, full-fiber rollout could boost productivity by £59 billion by 2025 in the U.K., according to research from the Centre for Economic and Business Research (Cebr) and could bring 500,000 people back to the workforce by 2038.[140]

5G can be used to deliver connectivity for rural areas where fiber rollout is not commercially viable. According to the Institute for Civil Engineers (ICE) in the U.K., it could cost as much as £45,000 to connect a single rural property to the fiber network. Rolling out 5G does not require the same volume of terrestrial infrastructure, making it a lower-cost solution to providing coverage in rural areas.

### 5G Presents a Second Opportunity to Enhance Connectivity.

As of February 2021, 30% of countries, representing 1,366 cities, have started to rollout their 5G infrastructure.[141] Ericsson forecast that by 2026 there will be 3.5 billion 5G subscriptions, accounting for 40% of all mobile subscriptions.[142] This compares with just 0.5% of phones shipped in 2019 that had 5G capabilities.

To support this growth in subscriptions while meeting regulatory requirements, there will need to be a huge increase in infrastructure. In rural areas, towers will be needed while urban settings will make use of rooftop sites. Towers and rooftop sites both host active equipment, including antennae and base transceiver stations, to receive, process, and transmit data to end-users. A 2017 estimate for the U.K. said that 400,000 additional 5G towers would be required to network rural areas.[143]

The work needed to facilitate the required growth again differs geographically. Even just across Europe, inCITES Consulting's European 5G Readiness Index records an over 40-point variation in the overall score between the most prepared country (Finland) and the least (Bosnia and Herzegovina).[144] At the level of infrastructure and technology preparedness, the difference is even greater at almost 48 points.

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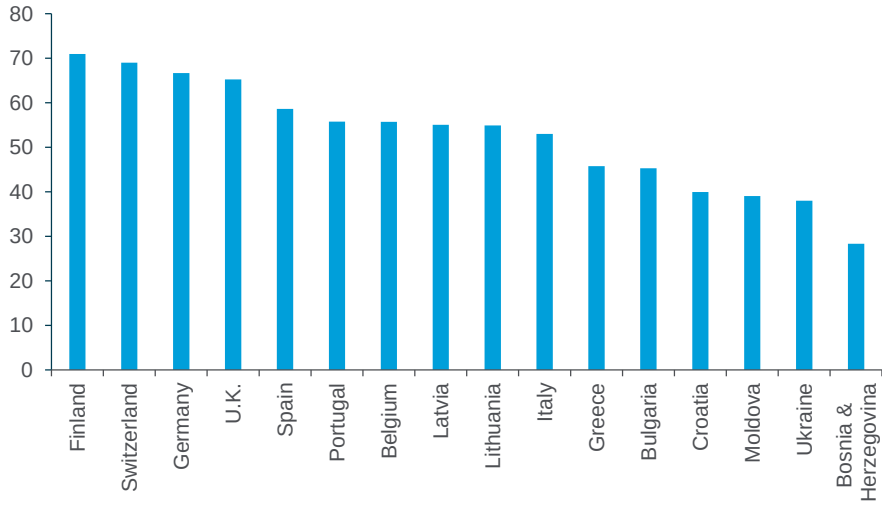
[139] Ibid.
[140] Centre for Economics and Business Research data on the Openreach website.
[141] VIAVI Solutions (2021). The State of 5G: 5G Deployments Surge Despite Global Pandemic.
[142] Ericsson (2020). Ericsson Mobility Report. pdf
[143] Knapton, S. (2017) 400,000 extra phone masts needed to bring 5g network to rural Britain. *The Telegraph*.
[144] inCITES Consulting (2020). Europe 5G Readiness Index: Assessing Europe's readiness to deploy and adopt 5G.

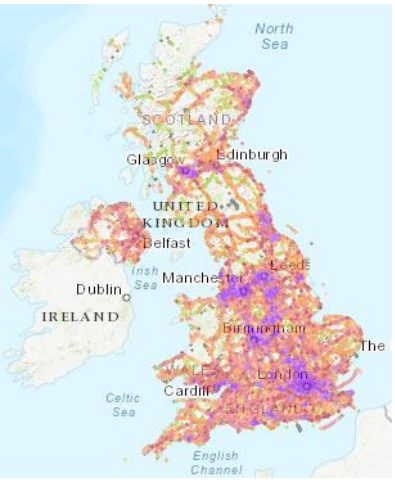
**Figure 85. 5G Readiness Index**




Source: inCITES Consulting

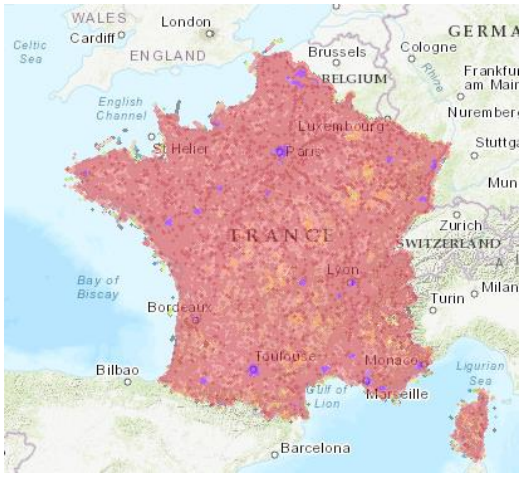
A heat map of England and Wales demonstrates the scale of the existing 5G rollout. Many of the areas of no coverage are rural areas, for example much of the North of England and parts of Wales. The two maps of the U.K. and of France clearly demonstrate that there is scope to extend the rollout of 5G, since only a small percentage of the country is marked as having 5G access (in purple).[145]

**Figure 86. 5G Rollout Is Clustered Around Cities in the U.K.**




Note: 5G is noted in purple vs. 4G in red
Source: nperf

**Figure 87. The Same is True of France**




Note: 5G is noted in purple vs. 4G in red
Source: nperf

Not only is the current level of infrastructure significantly less for 5G than its predecessor, but comprehensive 5G coverage will require more stations because 5G wavelengths have a range of around 1,000 feed — about 2% that of 4G. 5G signal can also be blocked by anything in its path, including trees. Active sites will therefore need to be significantly more prevalent in the built environment than the infrastructure required for previous generations.

[145] nperf. 5G coverage map worldwide.

Tower technicians will be required to install and maintain this significant number of towers. At the beginning of 2020, the U.S. Federal Communications Commission (FCC) Commissioner announced the full deployment of 5G would require 20,000 more tower climbers and telecom technicians.[146] As well as creating new jobs, there is also a need to upskill those already working in telecoms with training in 5G specific installation and maintenance practices. From the rollout of 5G, its use, and externalities, IHS Markit estimates 22 million jobs stand to be created globally by 2035.[147] This includes jobs across the 5G value chain, from OEM device manufacturers to network operators and infrastructure component manufacturers to content and application developers.

With enhanced connectivity in place through both 5G and fiber rollout, there are significant steps forward that can be made in digitalizing a whole range of sectors. We noted in the Citi GPS report Technology at Work v4.0 that manufacturers have come to see 5G as the enabler of the IoT because it circumvents the need for hardwired Ethernet connections, which can be expensive and time-consuming to install. With the advent of 5G, IoT connectivity will become more affordable.

## Utilizing Connectivity: The Internet of Things

GSMA Intelligence forecasts the number of IoT connections will double from 12 billion in 2019 to 24 billion in 2025.[148] Energy, healthcare, manufacturing, and retail will be the key drivers of this growth with around half of business executives in these sectors claiming to have IOT connectivity in their businesses, according to Forbes Intel survey.[149] It is difficult to accurately split the growth of IoT by sector, but the following indicates the distribution of the opportunity. By 2025, various forecasts estimate the IoT market in global healthcare will reach $534 billion[150], in energy management systems the figure is closer to around $10 billion[151] and in manufacturing just over $50 billion.[152]

Although many worry that IoT-facilitated automation will have undesirable consequences for the labor market, we expect new opportunities to arise. Many IoT devices will need installation and maintenance, such as smart meters for gas and electricity consumption, which automatically provide readings to utilities providers. Growth in the installed base of devices will redesign the labor landscape, creating jobs that did not previously exist. These include field sensor technicians to install and maintain agricultural sensors, household smart-meter and autonomous vehicle maintenance engineers, and telehealth installers.

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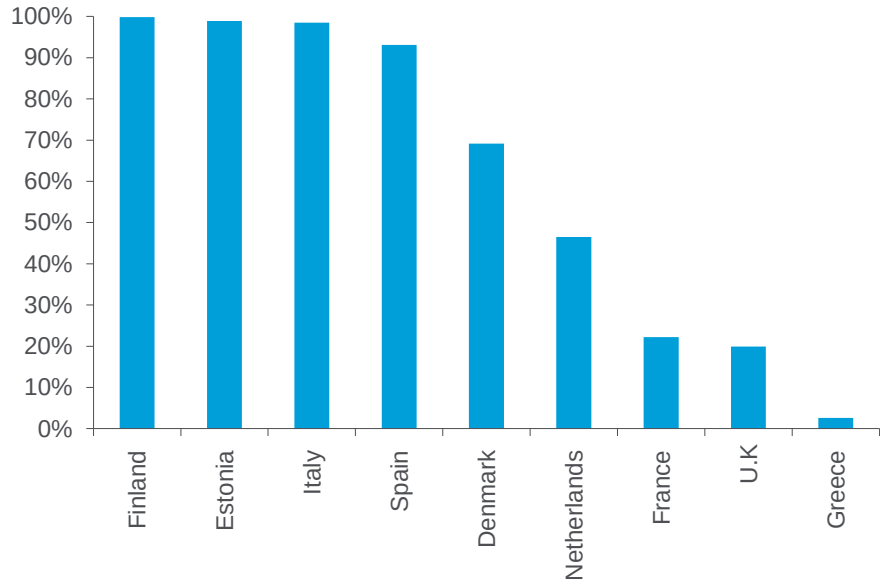
[146] Horowitz, J. (2020). U.S. Senate committee tackles shortage of 5G tower climbers. VentureBeat.
[147] IHS Markit (2019). The 5G Economy: How 5G will contribute to the global economy.
[148] GSMA Intelligence (2020). IoT connections update: impact of Covid-19 on our forecast.
[149] *Forbes* (2018). How IoT is Impacting 7 Key Industries Today.
[150] Grand View Research (2019). IoT in Healthcare Market Worth $534.3 Billion By 2025.
[151] Digiteum (2019). Internet of Things Energy Management: 5 Ways IoT Helps Save Energy.
[152] MarketsandMarkets (2020). IoT in Manufacturing Market

## Case Study: IoT in the Home

Many IoT devices in the home are plug-and-play devices like smart kettles, but smart meters are a notable exception. In the U.S., 75% of electricity consumers had smart meters installed by the end of 2019, up from 47% in 2017.[153] However, rollout is not uniform across the states: Washington has the highest penetration rate at 97% while in New York and West Virginia, only 1% of premises had smart meters fitted, according to 2016 data.[154] Similarly in Europe, as of 2018, only 34.2% of properties had electricity smart meters and for gas the figure was even lower, at 14.04%, but the figures vary by country (Figure 88)[155].

Hence, in some countries, there is an opportunity to create jobs to accelerate the rollout of smart meters. To install both gas and electricity smart meters in one property takes an engineer around three hours (1.5 hours each). In the U.K., at the end of 2020 there were 23.6 million smart meters fitted, compared with a target of 50 million under the U.K. Smart Metering Programme.[156] That leaves almost 26 million meters still to be fitted, or equivalent of about 39 million hours of manpower to fit the remaining meters.

**Figure 88. Select Economies: Progress Installing Smart Meters**




Source: Build Up EU

Other devices connected to the IoT will doubtless enter the home, from thermostats that recognize you are approaching home and automatically switch on your heating, to doors that open in response to facial recognition. Beyond smart meter rollout, installing and configuring devices like these will create jobs of the future.

[153] Cooper, A., & Shuster, M. (2021). Electric Company Smart Meter Deployments: Foundation for a smart Grid (2021 Update), The Edison Foundation: Institute for Electric Innovation.
[154] U.S. Energy Information Administration (2017). Nearly half of all U.S. electricity customers have smart meters.
[155] Tounquet, F., & Alaton, C. (2020). Benchmarking smart metering deployment in the EU-28. European Commission.
[156] Department for Business, Energy & Industrial Strategy (2021). Smart Meter Statistics in Great Britain: Quarterly Report to end December 2020.

# Chapter 4: Inventing the Future

# Inventing the Future

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While place is becoming more important, the success of different geographies is not destiny. Governments and policymakers can do a lot to boost innovation and new job creation as many production tasks are offshored and automated away, as discussed in Chapters 1 and 2. Fiscal policies discussed in Chapter 3 will help transition economies, but many of the jobs involved with upgrading infrastructure, including in green and digital industries, are one-off in nature. In this chapter, we explore how governments and corporates need to invent the future of work over a longer time horizon.

Countries and cities trade with one another for the same reasons that people and companies trade. They do so to exploit their comparative advantages. Some of these advantages are 'natural' and cannot be created: Texas, Russia, and Saudi Arabia all sit on massive oil deposits, and nature has made the Seychelles and the Amalfi Coast more attractive tourist destinations than Alaska.

But while policymakers cannot do much about these natural advantages, they are becoming less important in modern knowledge-based economies. For example, we cannot explain the rise of Silicon Valley on the basis of its geography. As the name suggests, it has more to do with silicon than with any natural advantage. To be sure, after Pearl Harbor, its location on the west coast was one of the reasons for military investment in the region, but this was also true of many other places, including Los Angeles.[157] Its success had much more to do with man-made advantages, including the absence of enforceable non-competes, which facilitates job-hopping and innovation, the proximity of Stanford University, and the early success of Hewlett & Packard.[158]

Importantly, such man-made advantages can change over time, often in response to new technologies. As noted, recent technological change means that all sorts of production tasks are becoming increasingly automatable and offshorable. Thus, the comparative advantage of rich nations lies firmly in the early stages of the product lifecycle — that is, in the domain of innovation and exploration (Figure 1).

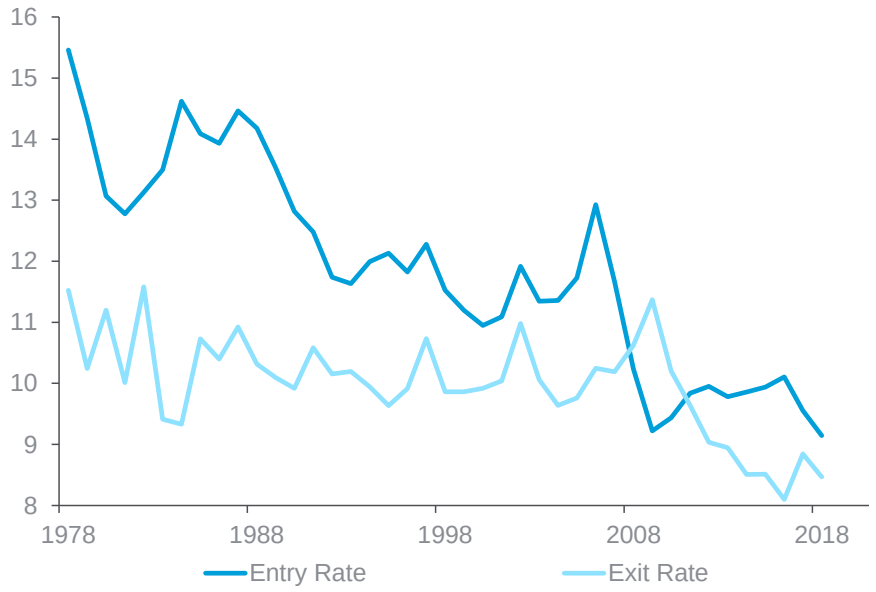
The costs of exploring and experimenting play an important role in entrepreneurship, which is ultimately what creates new goods and services, and thus new types of work. And those costs have been dramatically reduced by the Internet, open-source software, and the cloud. Huge fixed investments in IT infrastructure, servers, and other hardware are no longer required for new companies to set up. Much can be rented from cloud computing providers. Thus, the cost of setting up a new company has fallen from around $5 million a decade ago to less than $50,000 today.[159]

[157] O'Mara, M. (2020). *The Code: Silicon Valley and the Remaking of America*. Penguin Books.
[158] Berger, T., & Frey, C. B. (2017). Regional technological dynamism and noncompete clauses: Evidence from a natural experiment. *Journal of Regional Science*, 57(4), 655-668.
[159] Kerr, W. R., Nanda, R., & Rhodes-Kropf, M. (2014). Entrepreneurship as experimentation. *Journal of Economic Perspectives*, 28(3), 25-48.

## Restarting Startups

As new technologies lower the barriers to exploration, it opens the door for many more new companies to be established.[160] It is therefore somewhat puzzling that U.S. business dynamism has faltered. Startups, which drive the commercialization of new ideas, have been declining in the world's most dynamic economy since the late 1970s (Figure 89). Even the high-tech sector has seen business dynamism decline, beginning in the 2000s.[161]

**Figure 89. U.S. Percent of Establishments**




Source: Business Dynamics Statistics, U.S. Census Bureau

Part of the reason is the growing market power of incumbents.[162] As noted, in the early stages of the product lifecycle, exploration and innovation is essential to product development. Then, when a prototype has been established, innovation efforts tend to shift towards automation and incremental improvements of the production process to cut costs.

Eventually, however, the low-hanging fruits will have been picked and the opportunities to achieve further efficiency gains will diminish. Thus, the marginal return to political lobbying for protection from competition will at some point exceed the marginal return to innovating to improve efficiency.[163] It is no coincidence that companies with more political connections tend to be less innovative and take out fewer patents.[164] Studies show that while politically connected firms grow in employment and revenues, they also have lower productivity growth, which is

[160] Ibid.
[161] Decker, R., Haltiwanger, J., Jarmin, R., & Miranda, J. (2014). The Role of Entrepreneurship in US Job Creation and Economic Dynamism. *Journal of Economic Perspectives*, 28(3), 3-24.
[162] Philippon, T. (2019). *The Great Reversal: How America Gave Up on Free Markets*. Harvard University Press.
[163] Frey, C. B. (2021). How Behemoth Companies Quash Innovation. *MIT Technology Review*, 124(2
[164] Akcigit, U., Baslandze, S., & Lotti, F. (2018). Connecting to Power: Political Connections, Innovation, and Firm Dynamics. NBER Working Paper No. 25136.

"consistent with the view that political connections help firms remove particular market frictions or block competition, as opposed to help them push the productivity and technology frontiers."[165]

To be sure, much innovation still takes place in R&D labs in large companies, and much productivity growth has unquestionably come from incremental product and process improvements in large firms.[166] But while such improvements are important, it is breakthrough inventions that lay the foundations for them. "You can improve a cassette player in terms of design and function, but eventually you need a radical innovation to create a CD player or you arrive at a dead end."[167] Breakthrough inventions, a recent study by Lingfei Wu and collaborators shows, are more likely to come from individual inventors or smaller teams.[168] Large teams and organizations are less likely to get everyone on board in pursuit of an unconventional hypothesis. As Jeff Bezos once put it, "If you can't feed a team with two pizzas, it's too large."

Large teams, like large movie studios, typically generate sequels rather than new narratives. Corporate hierarchies that function by command and control are good at bringing about incremental improvements, such as making production processes run more efficiently — a recent paper did indeed find that most productivity growth has come from quality improvements by incumbents.[169] However, sequels eventually run into diminishing returns, and incumbents are unlikely to pursue disruptive technologies that threaten their revenues from old technologies, as Harvard's Clayton Christenson famously observed.[170] Kodak's unwillingness to push into digital photography is a classic example. More broadly, careful analysis by the economists Ufuk Akcigit and William Kerr shows that young firms generate more radical innovations with larger spillovers.[171] Indeed, none of the major hardware companies became leading software and internet companies.

## Competition and Innovation

COVID-19 has if anything led to greater market concentration and more powerful incumbents.[172] But the concern predates the pandemic. As the economist Thomas Philippon has shown in some detail, since the 2000s business dynamism has declined dramatically and productivity growth has faltered, while business spending on lobbying has skyrocketed and market concentration has risen across many sectors of the economy.[173] In a separate study, Philippon and Germán Gutiérrez show that recent "regulations have a negative impact on small firms, especially in

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[165] Ibid.
[166] Garcia- Macia, D., Hsieh, C. T., & Klenow, P. J. (2019). How Destructive Is Innovation? *Econometrica*, 87(5), 1507-1541.
[167] Frey, C. B. (2021). How Culture Gives the US an Innovation Edge Over China. *MIT Sloan Management Review*, 62(3).
[168] Wu, L., Wang, D., & Evans, J. A. (2019). Large teams develop and small teams disrupt science and technology. *Nature*, 566(7744), 378-382.
[169] Garcia- Macia, D., Hsieh, C. T., & Klenow, P. J. (2019). How Destructive Is Innovation? *Econometrica*, 87(5), 1507-1541.
[170] Christensen, C. M. (2013). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business Review Press.
[171] Akcigit, U., & Kerr, W. R. (2018). Growth through Heterogeneous Innovations. *Journal of Political Economy*, 126(4), 1374-1443.
[172] Frey, C. B. (2021). How Behemoth Companies Quash Innovation. *MIT Technology Review*, 124(2).
[173] Philippon, T. (2019). *The Great Reversal: How America Gave Up on Free Markets.* Harvard University Press.

industries with high lobbying expenditures".[174] They also show that those regulations boost incumbent profits, suggesting that regulatory capture, i.e., the influence of business on regulations, has increased in recent years.

Of course, such concerns aren't new. Joseph Schumpeter correctly foresaw that the limits to progress aren't technological, but political and cultural. A mature economy, he reckoned, would be more regulated and less flexible, so that in the political long-run, technological progress would come to an end. In a similar vein, Mancur Olson famously argued that as special interest groups accumulate over time, the ability of vested interests to hinder the spread of new technologies can lead to stagnation.[175] The reason why free trade is valuable, according to Olson, is less because of gains from specialization than the fact that it undercuts distributional coalitions (i.e., special interest groups that influence policies in their favor). That is why open economies tend to be more dynamic and innovative over the long run.

One way of halting the economic equivalent of atherosclerosis is to enlarge economic jurisdictions. This has been a virtue of the U.S. Constitution, which guarantees free trade between state, and it explains the success of the European Single Market. Indeed, the prime reason why Britain was overtaken by Germany and France in the postwar years is that its protectionist policies and decision to stay outside the European Economic Community helped protect unproductive incumbents and stifled innovation.[176] In this light, the recent trend towards greater protectionism is worrying.

In the first ten months of 2020, as the pandemic took off, G20 members undertook 1,371 policy interventions, of which 1,067 harmed trading partners, a recent report by the Centre for Economic Policy Research finds.[177] And many countries are now reassessing trade dependence more broadly. As Phil Hogan, the European Union's Commissioner for Trade, recently said, "We need to think about how to ensure the EU's strategic autonomy".[178] Whatever this means in practice, it is important that governments continue to embrace openness to trade and free markets to support competition and innovation.

## Patent Reform

Another worrying trend is the striking increase in patent litigation and related costs, which appears to negatively affect entrepreneurship and innovation. For example, studies show that venture capital, which is a major funding source for entrepreneurial activity, becomes harder to obtain in a highly litigious patent environment.[179]

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[174] Gutiérrez, G., & Philippon, T. (2019). The Failure of Free Entry. NBER Working Paper No. 26001.
[175] Olson, M. (2008). *The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities*. Yale University Press.
[176] Crafts, N. (2018). *Forging Ahead, Falling Behind and Fighting Back: British Economic Growth from the Industrial Revolution to the Financial Crisis*. Cambridge University Press.
[177] Evenett, S., & Fritz, J. (2020). *Collateral Damage: Cross-Border Fallout from Pandemic Policy Overdrive*. The 26th Global Trade Alert Report. Global Trade Alert.
[178] Cited in Irwin, D. (2020). The pandemic adds momentum to the deglobalization trend. VoxEU.
[179] [179] Kiebzak, S., Rafert, G., & Tucker, C. E. (2016). The effect of patent litigation and patent assertion entities on entrepreneurial activity. *Research Policy*, 45(1), 218-231.

Patent litigation also increases the cost of debt funding for innovating firms. Companies' capacity to borrow partly depends on the collateral value of their assets. And as intangible assets — like new technologies and brands — constitute an ever increasing share of companies' asset values, intellectual property rights could act as collateral, at least in theory.[180] However, an increasingly litigious patent environment makes this less likely to happen. For example, while companies with cited patents receive higher stock market valuations, our research show that they receive lower credit ratings.[181] Theoretically, from a creditor's perspective, the potential costs of patent lawsuits could outweigh their economic benefits. That is because creditors do not share the upside of the firm's investments. Relative to shareholders, they are more concerned about the downside, such as patent litigation incurring substantial losses on creditors.[182]

At the same time, a larger patent portfolio is associated with a higher credit rating. This implies that portfolio size effects exist, "meaning that firms with a larger patent portfolio are better able to settle disputes through cross-licensing agreements, without resorting to patent lawsuits".[183] Larger patent portfolios, in other words, provide insurance against potential future lawsuits. The rise of strategic patenting has created a litigious patent environment, which might lead corporate lenders to refrain from financing innovation. "As companies need to devote substantial financial resources to build and uphold a large patent portfolio as insurance to tap into credit markets, innovation may suffer as a consequence."[184]

Thus, in short, patent reform is urgently needed. For example, a progressive tax that increases with the size of companies' patent portfolios beyond a certain threshold might be one way of mitigating the rise of strategic patenting without making innovation costlier for new companies with smaller patent portfolios. Another approach would be simply to increase renewal fees for larger companies, or alternatively, reintroduce the requirement that companies must use the patents they hold in production after a specified number of years. This would serve to increase the cost of strategic patenting and lower the cost of capital for innovating companies. It would also lower the barriers to entry for new companies more broadly, as they would not need a license for a patent that is not in use.

## Jumpstarting R&D

Besides reducing barriers to entry for new companies, governments should invest more directly in science and innovation. As we all know, basic research discoveries are applicable to a broader set of industries and therefore often have greater social value. Because the social gains from basic research are much larger than the private gains, private-profit opportunities alone are not likely to draw as much resources into basic research as is socially desirable, leading to underinvestment unless supplementary public investment is made.[185]

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[180] Frey, C. B. (2013). *Intellectual Property Rights and the Financing of Technological Innovation: Public Policy and the Efficiency of Capital Markets*. Edward Elgar Publishing.
[181] Frey, C. B., Neuhäusler, P., & Blind, K. (2020). Patents and corporate credit risk. *Industrial and Corporate Change*, 29(2), 289-308.
[182] Ibid.
[183] Ibid.
[184] Ibid.
[185] Nelson, R. R. (1959). The Simple Economics of Basic Scientific Research. *Journal of Political Economy*, 67(3), 297-306.

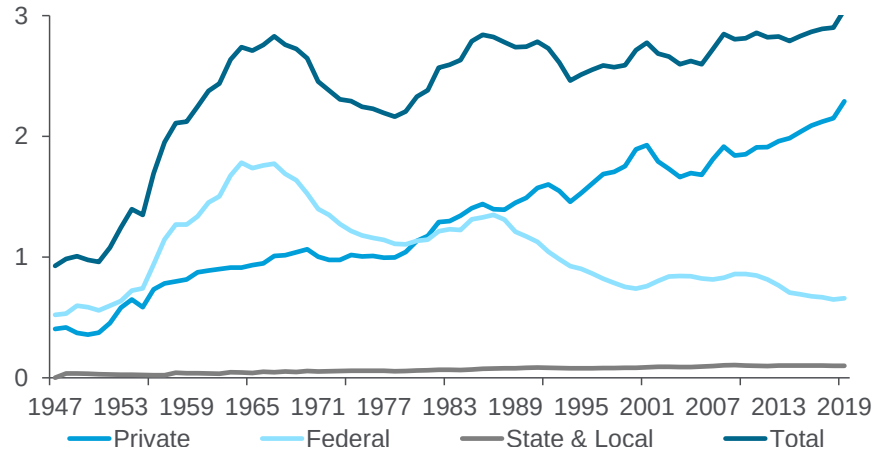
In fact, empirical studies suggest that the socially optimal level of R&D investment — which produces the highest rate of economic growth — is two to four times greater than actual spending.[186] And underinvestment is especially acute in basic research, which generates the greatest spillovers.[187]

Today, however, most public R&D is military R&D in the U.S., the U.K., and France. In the U.S., federal spending on the National Science Foundation, or on R&D tax credits, is less than one-tenth of federal spending on defense-related R&D.[188]

Whether the impact of government-funded R&D on private R&D is positive or negative is ultimately an empirical question. It depends on whether there is crowding out or crowding in. For example, if skilled engineers are in short supply, crowding out may occur. The best available evidence, however, shows that increases in government-funded R&D increases privately-funded R&D expenditures. On average, across all OECD countries, it is estimated that a 10% increase in defense R&D results in a 4% increase in private R&D.[189]

These findings, however, should not be taken to imply that government-funded R&D should focus on defense R&D. In fact, as already noted, other types of public R&D are likely to generate greater spillovers. As shown in Figure 90, while overall R&D spending has been flat since the 1960s, federal spending on R&D has steadily fallen. This decline was offset by an increase in private R&D, which tends to focus more on applied rather than basic research.

**Figure 90. Federal and Non-federal Research & Development, % of GDP**




Source: Bureau of Economic Analysis

What's more, the organization of discovery matters hugely. In a recent study of 65 million journal articles, patents, and software products, Lingfei Wu and collaborators found that large teams typically build on existing ideas and designs, whereas their smaller counterparts tend to come up with ideas and inventions that disrupt earlier ones.

[186] Bloom, N., Schankerman, M., & Van Reenen, J. (2013). Identifying Technology Spillovers and Product Market Rivalry. *Econometrica*, 81(4), 1347-1393.
[187] Akcigit, U., Hanley, D., & Serrano-Velarde, N. (2013). Back to Basics: Basic Research Spillovers, Innovation Policy and Growth. NBER Working Paper No. 19473.
[188] Moretti, E., Steinwender, C., & Van Reenen, J. (2019). The intellectual spoils of war: How government spending on defence research benefits the private sector. VoxEU.
[189] Ibid.

Unlike solo inventors, larger teams must reach a consensus, making individual team members less willing to stand out or risk interfering with other members' insights. They also face greater coordination and communication challenges, which makes it harder to get everyone on board in pursuit of an unconventional idea.[190] Taken together, these findings imply that governments and science foundations should make more resources available for basic research in general, and for research done by smaller teams in particular.

## Education

Without an expansion of the number of people engaged in innovation, however, more spending on research could just translate into higher wages. In other words, more spending must be accompanied by an expansion of the workforce engaged in innovation.

Throughout history, universities have been key suppliers of workers in science and technology. Indeed, studies show that individuals growing up around a technical university are much more likely to become inventors.[191] As noted in the Citi GPS Disruptive Innovations IV: "it is not a coincidence that most of the regional clusters mentioned above are located close to universities and research centers such the Boston Route 128 corridor which has MIT and Harvard on its doorstep… In Europe, Stockholm is ranked as being one of the most important tech hubs and has some of the fastest growing start-ups, [where Kista Science City has] become an important cluster for ICT companies and research… It is also home to two universities – the Royal Institute of Technology (KTH) and Stockholm University. Currently there are over 6,800 university students studying ICT courses at the Kista campuses 2019 and a total of 24,000 employees that work in the ICT sector." Thus, in short, expanding the number of universities, and the number of students they enroll, is likely to have significant spillovers on local innovation.

As is well-known, there is much scope for increasing enrollment in STEM subjects, especially among women. Even though women with STEM jobs earn 33% more than comparable women in non-STEM jobs, women still make up a small share of the STEM workforce. Strikingly, women fill close to half of all jobs in the U.S. economy, but they hold less than 25% of STEM jobs.[192] The under-representation of women is particularly pronounced in the math-intensive science fields, like engineering, computer science, and physical science.[193]

As noted in the Citi GPS report Education: Fast Forward to the Future, a worrying trend is that U.S. federal and state grants per student have declined after peaking in 2011. This trend must be reversed, and more grants should focus on women in STEM in particular. Such efforts will be critical to improve diversity in science and technology. And improving diversity is not a zero-sum game: innovation flourishes in diverse environments, which ultimately benefits everyone.

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[190] Wu, L., Wang, D., & Evans, J. A. (2019). Large teams develop and small teams disrupt science and technology. Nature, 566(7744), 378-382.
[191] Toivanen, O., & Väänänen, L. (2016). Education and Invention. *The Review of Economics and Statistics*, 98(2), 382-396.
[192] This, in turn, is related to influences by "family, teachers, culture, stereotypes, and role models throughout the schooling process." See Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). Women in STEM: A Gender Gap to Innovation. Economics and Statistics Administration Issue Brief 04-11.
[193] Kahn, S., & Ginther, D. (2017). Women and STEM. NBER Working Paper No. 23525.

## Immigration

Expanding the labor force engaged in discovery through education, however, will inevitably take time. A more immediate way of doing so is through immigration, which has been a prime driver of technological dynamism and the flow of ideas throughout history.[194] For example, America benefited enormously from the influx of Jewish émigrés from Nazi Germany during World War II. Careful studies show that patenting and innovation accelerated wherever they settled.[195] And they were not the exception but the norm. A recent study found that immigration has been an important source of American innovation for the past 130 years.[196] Economists have also found that immigrants have an 80% higher startup rate than U.S.-born individuals and play outsized roles in U.S. high-growth entrepreneurship. They do not just start smaller companies, but companies of every size.[197]

A common objection is that sending countries might lose out from immigration. However, while the loss of skilled people in less-developed countries raises concerns over brain drain and their future development prospects, emigrants often create important connections to global sources of knowledge, and others return home with new knowledge and skills, further driving innovation and entrepreneurship. A well-known example is the Indian diaspora, which has been key to the success of Bangalore's thriving IT cluster. Immigration, it turns out, is not a zero-sum game: it can be hugely beneficial for the sending and receiving countries alike.[198] Thus, in the interest of boosting innovation and entrepreneurship, the barriers to immigration and free movement that have been introduced during the pandemic must be reversed when it subsides.

## The Lost Einsteins

The best way of increasing the pool of inventors, however, may not be through immigration but by exposing more people to innovation. Indeed, in a recent study, Alexander Bell and collaborators show that kids who are exposed to innovation early in life are much more likely to patent later on. Those with parents who are inventors, and even those who just grow up in a city with a greater abundance of patentees, are much more likely to become inventors themselves.[199]

Right now, however, most innovation policy focuses on supporting people who have already decided to become inventors. As Anton Howes has pointed out, just about everything policymakers worry about when promoting innovation, from the patent system to funding basic science, is in a sense downstream of it. If people are not exposed to innovation at some point in life, they won't become inventors.

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[194] Goldin, I., Cameron, G., & Balarajan, M. (2011). *Exceptional People: How Migration Shaped Our World and Will Define Our Future*. Princeton University Press.
[195] Moser, P., Voena, A., & Waldinger, F. (2014). German Jewish Émigrés and US Invention. *American Economic Review*, 104(10), 3222-3255.
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The main reason that most people never innovate doesn't have to do with the patent system but the very simple reason that it never occurs to them.[200] Indeed, you already have to be an inventor for intellectual property to matter to you or particular sources of funding to be a concern.[201]

To boost innovation, policies are needed to increase the potential pool of inventors. Most kids leaving school without having been exposed to innovation, results in many 'lost Einsteins'.[202] Even a small increase in the number of people who decide to become inventors could have a much greater effect than minor tweaks of incentive structures that only affect the small fraction of the workforce that is already inventing. The United States and other nations would do well to transform their educational systems not just to prepare kids for jobs that already exist, but by exposing them to inventors and thereby increase the chances that they create innovations later in life.

## Innovation for Jobs

To be sure, education is far from a panacea, especially as many high-education jobs are becoming offshorable. Nor is the bulk of the population going to become inventors. But even a modest increase in innovation and entrepreneurship from current levels could have a sizeable impact on people's employment prospects. Indeed, most jobs that people in advanced economies have today did not even exist in 1950. Those jobs had to be invented.

To what extent future innovations will create new jobs or simply replace old ones depends on policy choices. Governments can do their part to incentivize businesses to develop technologies that create new jobs, instead of focusing on inventing technologies that replace workers. For example, as Daron Acemoglu and co-authors have shown, the U.S. tax code currently favors automation at the expense of employment. While effective labor taxes stands around 28.5%, the effective tax rate on capital invested in equipment, machines and software has fallen to around 5%, following a series tax laws enacted from 2002 under the George W. Bush administration up to the Obama and Trump administrations. It is estimated that eliminating the capital bias in the tax code could increase the number of people employed by 6.5% and boost labor's share of national income share by 1.1 percentage points.[203]

[200] Howes, A. (2021). Age of Invention: Upstream, Downstream.
[201] Ibid.
[202] Bell, A., Chetty, R., Jaravel, X., Petkova, N., & Van Reenen, J. (2018). Lost Einsteins: who becomes an inventor in America? (No. 522). Centre for Economic Performance, London School of Economics and Political Science.
[203] Acemoglu, D., Manera, A., & Restrepo, P. (2020). Does the US Tax Code Favor Automation? NBER Working Paper No. 27052.

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## IMPORTANT DISCLOSURES

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## Key Insights regarding the Future of Work

LABOR MARKET

The post-industrial society was characterized by the movement of manufacturing jobs to lower cost locations and a rise in service-related jobs. / We are now moving into a post-production society where both goods and services are increasingly produced abroad or by machines.

INNOVATION

In the Citi GPS report Technology at Work v5.0, we found that 52% of U.S. jobs could in principle be done remotely, but just because a job can be done remotely doesn't mean it should be, especially creative jobs. / Face-to-face environments which generate sporadic encounters, social networks, and knowledge spillovers via population density are all important factors in fostering innovation.

POLICY

Despite new technologies that lower the barriers to starting a business, new start-ups are struggling to take off due to the power of incumbents, patent litigation, and lack of spending on R&D. / To offset automation and offshoring, rich nations need to put policies in place that increase their competitive advantage in innovation and exploration.