



TECHNOLOGY AT WORK v5.0

A New World of Remote Work

Citi GPS: Global Perspectives & Solutions

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TECHNOLOGY AT WORK v5.0

A New World of Remote Work

Kathleen Boyle, CFA
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And just like that, working from home is a real thing. With the coronavirus spreading, and lockdowns ordered, many office workers suddenly became ‘work from homers’. If you were lucky, you grabbed a few things off your desk on your last day in the office in case you had to work on your laptop from the dining room for a few days. But that turned into a couple of weeks and then a few months. At some point you realized one or two things about working from home – you needed a proper chair and an extra monitor. You also missed your commute as it signified the end of your working day. Now, work and life blend together and somehow it always feels like Tuesday. And that’s before the extra stresses of home schooling, all-the-time family time, and the weekly strategic battle to find a pack of toilet paper.

As lockdowns are slowly lifted and the threat of COVID-19 lessens, questions are being asked around what the work environment will look like post-COVID-19. For some, there’s no question about returning to the workplace. But the workplace is going to be very different in an environment of social distancing. For others, working from home was unexpectedly refreshing and enhanced productivity. In fact, Gallup found three in five U.S. workers who have been doing their jobs from home during the COVID-19 pandemic would prefer to continue to work remotely as much as possible, once restrictions have lifted.

The COVID-19 pandemic was able to accelerate the shift to remote working as the digital world is finally at a stage where it can support technology like virtual meetings. The digital revolution enabled telework and the upcoming roll out of 5G will drive telerobotics and augmented and virtual reality (AR/VR), leading to increased automation globally. Improved virtual and telepresence could also shift the development path for emerging markets, away from a manufacturing-led growth model (like China) more to a service-led growth model (like India).

But the sudden shift to remote work has also highlighted inequalities in the workforce. Jobs which can be done remotely tend to be higher paying jobs and those that require physical presence tend to be lower paying/lower education jobs. This means the pandemic lockdowns have disproportionately affected incomes for those in lower paying jobs which couldn’t switch to remote work. The biggest takeaway from the report is we need to innovate to increase our resilience to further disruptions and avoid the societal disruptions caused by the recent lockdowns.

The report also focuses on trends we see accelerating due to the COVID-19 crisis. The adoption of education technology (edtech) should get a boost as the pandemic is likely to shift attitudes towards increasing edtech spend with schools needing to teach remotely. The value of connectivity has increased during the pandemic and telecom network infrastructure has enabled functions such as eHealth and Big Data & Monitoring. And the rapid shift to work from home has been a catalyst for next-generation software focused on productivity & collaboration.

Business travel is likely to decline as virtual meetings replace face-to-face ones and in turn adversely affect the airline and travel industry. As corporates rethink office space, we look at the debate over the role of cities and real estate. Finally, a silver lining from remote working — air pollution has declined and we look at the positive environmental effects of saying from home one day a week.

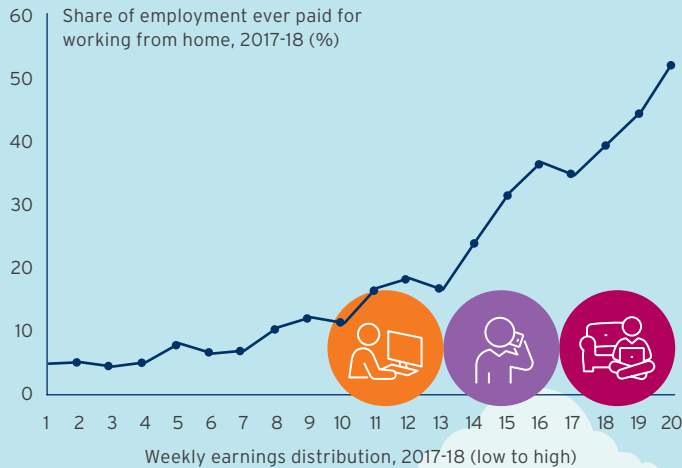
Most importantly, we hope you and your families remain safe and healthy throughout this difficult time.

THE NEW NORMAL OF REMOTE WORK

24% OF OCCUPATIONS IN THE U.S. CAN BE PERFORMED REMOTELY – AND THEY EMPLOY 52% OF THE U.S. WORKFORCE.

But less than 1 in 10 of the bottom half of earners can work from home versus 1 in 2 of the higher earners.

Source: American Time Use Survey



JOBS WHICH CAN BE DONE REMOTELY ALSO CORRELATE TO THE HIGHEST EARNINGS JOBS.

This mirrors the idea of skills-biased technological change where advances in technology have favored skilled workers.

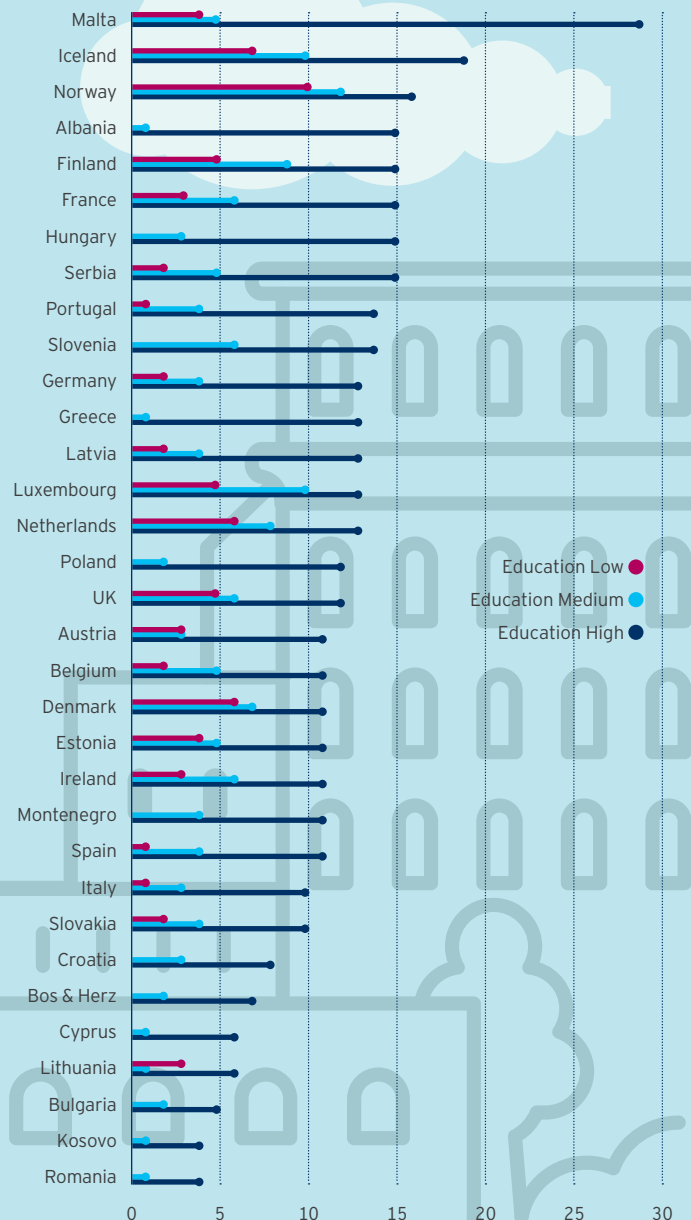
Source: American Time Use Survey



In Europe, remote working is also more common in skilled occupations.

Remote Working by Skill Group in Europe, 2018

Source: Eurostat



Aged 25-64 working from home almost every day, 2018 (%)



KEY INDUSTRIES DRIVING THE SHIFT TO VIRTUAL OFFICES INCLUDE EDUCATION TECHNOLOGY, TELECOM SERVICES, AND SOFTWARE.



The COVID-19 pandemic will accelerate how the education industry perceives education technology

Growth in EdTech could exceed the 12.5% annual growth rate expected to 2025



Work from home raises the importance of telecom connectivity

Increased performance of telecom networks could drive advanced capabilities including eHealth and Big Data and Monitoring



Work from home and dispersed teams will increase the adoption of next-generation productivity and collaboration software capabilities

These capabilities are a mixture of 'communications-centric' and 'deliverable-centric' swim lanes

A PERMANENT INCREASE IN TELEWORK HAS A LARGE EFFECT ON CORPORATE TRAVEL, REAL ESTATE, AND CLIMATE CHANGE.



Air pollution levels are down globally due to declines in industrial action and transportation

If 52% of the U.S. workforce work at home for one day a week, they will be saving 20 million tonnes of CO₂ which is equivalent to 4.3 million passenger cars NOT driven in one year.



A virus-driven recession is likely to cause a short-term, painful rent and value decline in office markets

But we expect the benefits of cities will continue to drive new job growth, office evolution and continued space demand.



We see corporate travel as being secularly impaired by 25% vs. 2019 levels

A 1% impact on corporate travel volumes, has a 10% impact on airline profits.



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Citi's Take

Throughout the pandemic, business leaders were forced make quick decisions with sometimes limited and rapidly changing information. Citi continues to be affected in almost every region by COVID-19. As a global organization, senior leaders were able to take lessons learned in the early stages of the outbreak in Asia to devise contingency plans as the pandemic threat moved across regions and eventually the globe. One simple philosophy dominated all decisions — the safety of Citi employees was the primary concern.

As we move to the next chapter, we wanted to share how Citi is looking at the 'Future of Work' in a practical sense. In May, Jane Fraser, President of Citigroup and head of Citi's Crisis Management Team, shared the essay below with all employees after pondering the impact of this pandemic on our culture and life at work at Citi. We also reached out to Diane Arber, Head of Human Resources for Citi's Institutional Clients Group to highlight on the clear set of principles they've developed to drive the return to the office.

An Ode to the Office



Jane Fraser

President of Citi, CEO of Global Consumer Banking

Several big tech firms announced they would have many, if not most, of their employees working for home once the pandemic is over. I had a very visceral reaction to the idea of not being back together eventually, as did Mike Corbat and many of us on his team. And apparently we're not alone. I read an external survey that said most people want to return to the workplace, but with increased flexibility and critical changes to workspaces—changes that are well underway in Citi sites.

So let's be clear, we do indeed intend for most of us to return to our offices and sites when the pandemic is over. For sure, many of us will have more flexibility to work at home, and we will work differently in the office using all the new digital tools to collaborate and to serve our clients better. Our workspaces will be different to prioritize safety. But at the end of the day, being physically together is better for our culture and well-being, not just for our productivity. So yes, while we've proven we can operate efficiently remotely, our experience at Citi is about so much more than that.

So consider this a brief ode to the office, and those facets of our culture that we cannot afford to lose in the long run...

Collegiality and belonging. The minute you walk into one of our branches during one of their morning huddles, or into a deal team brainstorming, or an agile team at work together around the whiteboards, you feel it. The spirit. The sense of team. Shawn Feeney in Markets put it best: "What attracts people to Citi as an employer and keeps us here is the collegiality. We work with outstanding people who are not only technically strong in their areas of expertise but are also caring, witty and a lot of fun to be around. After a number of months of WFH, the absence of it is beginning to sting." With the overwhelming majority of us now working from home, many for the first time, we're deprived of that daily "fix" of collegiality, camaraderie and sense of belonging to Citi, whether it's in a staff meeting or a surprise encounter in the cafeteria. We also want our new joiners to experience the camaraderie and sense of belonging to Citi that comes from being physically together.

Apprenticeship. In many parts of our business, we operate an apprenticeship model—banking, wealth management, the trading floor... the list goes on. I strongly suspect that our career development will be impaired if we were to move more permanently to the work-from-home models touted by some of these tech giants. Whether it is listening in on conversations with clients, witnessing the execution of a big trade, watching a debate among senior colleagues and how our ideas and advice evolve, or getting that in-the-moment feedback, there is much we learn from simply being around those with more or diverse experience.

So many intangibles. The idea that is sparked from the unexpected conversation in the elevator or Town Square. The added understanding that comes when a colleague hangs back after a meeting and asks for a clarification they were reluctant to address in front of a group. The benefit you get when a colleague overhears you on the phone and proactively or simply unexpectedly offers advice on an issue challenging you. The laughs you have in the middle of a massive project or client deliverable that just make the load feel lighter and more worthwhile. As much as we try, it's just not the same when we're remote.

So for these, and for so many more reasons, we will come back into our offices when it is safe to do so because it is a better model for our bank and for our culture. And when the time is right to launch Phase 2, it will be for a more sizeable group so we can get the buzz back in our buildings. Simply put, we are better together.

Now & Future: Plans to Return to the Office, or Not

The biggest surprise to us during the lockdown period was that almost ALL jobs in the Institutional Clients Group can be done from home. But was also learned that connecting with video matters and collaboration tools are really important.

Citi's HR Operating Committee has developed a clear set of principles to drive the return to the office.

- **Your health and safety come first:** Both at home and in the office, your health and well-being is and will remain our top priority.
- **We will use data, not dates, to drive decisions:** Any decisions about returning to the office will be dependent on data, including local medical data. We are not, nor will we be, focused on hitting specific dates.
- **Working does not require you to be in the office:** The vast majority of our people are working remotely and are doing so very effectively. We suspect many of us will continue to work remotely more regularly in order to accommodate social distancing in the office.
- **Our pace of returning to the workplace will be slow and measured:** We are in no rush given the effectiveness of our remote work. As colleagues left the office, our firm had to make quick decisions. On our way back to the office, we have the ability to be deliberately slower and focused on important details such as colleagues' transportation needs, where we sit, and how we manage common areas.
- **One approach won't fit all:** The timing and ways we come back to the office will vary based on location, office setup, resources and medical guidance. For high risk or vulnerable colleagues, we will continue to take extra precautions. For those with family and childcare needs, we will remain flexible.



Diane Arber
Head of Human Resources, Citi Institutional
Clients Group

- **We will continue to innovate our way of working:** We will also focus on the longer term, strategic shift that will outlive this pandemic, such as designing future ways of working to enable us to engage effectively with each other and our clients.
- **Finally, we will make the most of now:** We will continue to innovate and support our colleagues and managers as they lead teams remotely and engage clients in new ways—understanding that this situation will continue for longer than we initially expected.

Based on the set of principles we've developed, Citi's leadership team is focusing on four workstreams focused on the Future of Work

- **Work Arrangements:** How we work and where we work including reviewing Flexible schedules, Time-off, and Rotation Schedules.
- **Learning, Performance, and Engagement:** Employees around the world are working remotely, and this is new for most of our colleagues. While tech and data security choices can be confusing, the real threat to productivity and innovation is the human element. We are looking at Remote Boot Camps to learn and share what's working best and challenges to address. Managers at every level need to re-imagine the way they work. There's a shift in what it means to supervise, coach, comfort, and learn in today's context.
- **Recruiting:** To include an on-demand virtual onboarding for all new joiners focused Citi's culture, footprint and people. Resources will include a New Employee Experience Degreed Plan and a New Joiner Checklist.
- **Well Being:** Ensure employees' are supported through benefits and wellness initiatives as we transition into new way of working arrangements.

A New World of Remote Work: Introduction



Carl Benedikt Frey
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113 of 483 occupations examined can be performed remotely — and they employ 52% of the U.S. workforce

The threat of another high-fatality influenza pandemic will continue to loom large. Driving much of the concern, beyond the immediate consequences of COVID-19, is the fear that the next pandemic could become as deadly as the 1918 influenza pandemic which killed between 50 and 100 million people globally. That influenza pandemic, which swept the globe towards the end of World War I, was much deadlier than the war itself.

The strategies available to governments in 1918 to control the outbreak were limited: legal changes mandating staggered business hours to avoid rush-hour crowding was one of the key measures taken. In its aftermath, Royal S. Copeland, the Health Commissioner of New York City, told *The New York Times*, “All along, my greatest anxiety was over the matter of transportation. After all, there is not so much danger over theaters and churches; people who are sick do not go much to the theater or to church. But sick people go to work.” The most dangerous place, he explained, was the subway, but not much could be done there, besides trying to distribute the crowds and making sure there was ventilation in the cars.¹

This time around, public transportation should have been less of a concern. Many jobs can be done remotely thanks to advances in digital technology. When U.K. Prime Minister Boris Johnson tested positive for COVID-19 and self-isolated, he made clear that he could still continue to work “thanks to the wizard of modern technology.” More broadly, rapid penetration of broadband in the home, a new generation of powerful laptops, cheaper and better IP telephony, more robust VPN software, online collaboration tools like Slack and Google Docs, and videoconferencing tools like Zoom, have powered the rise of telecommuting. And there are new technologies on the horizon. In the not too distant future, with the adoption of 5G, both telepresence and telerobotics will become increasingly good substitutes for face-to-face interactions.

Yet despite the ability of many citizens to work from home in the current pandemic, transportation systems have again come under pressure. In the U.K., on Tuesday March 24th, the day after Boris Johnson announced a lockdown to curb the spread of the coronavirus, pictures emerged showing workers in London crowding into Tube carriages, despite warnings that people should keep two meters (6ft) away from each other. As the death rate rose by 87 in just that one day, Matt Hancock, Secretary of State for Health and Social Care, urged people to “Only go to your job if you cannot work from home.”² However, there is no real consensus on which jobs those are. What’s missing is a concept of which jobs are essential, and which can or cannot be done remotely. In this report, we aim to bridge that gap. Examining 483 occupations, we find that 113 of these can be performed remotely. These occupations also employ the bulk of the U.S. workforce: 52% of workers are employed in occupations that could be performed at distance in a time of crisis (Chapter 5). Needless to say, the same occupations can also be done remotely in the U.K. and in other advanced economies.

¹ Epidemic Lessons Against Next Time, *The New York Times*, Nov 17, 1918.

² <https://www.bbc.co.uk/news/uk-52022417>

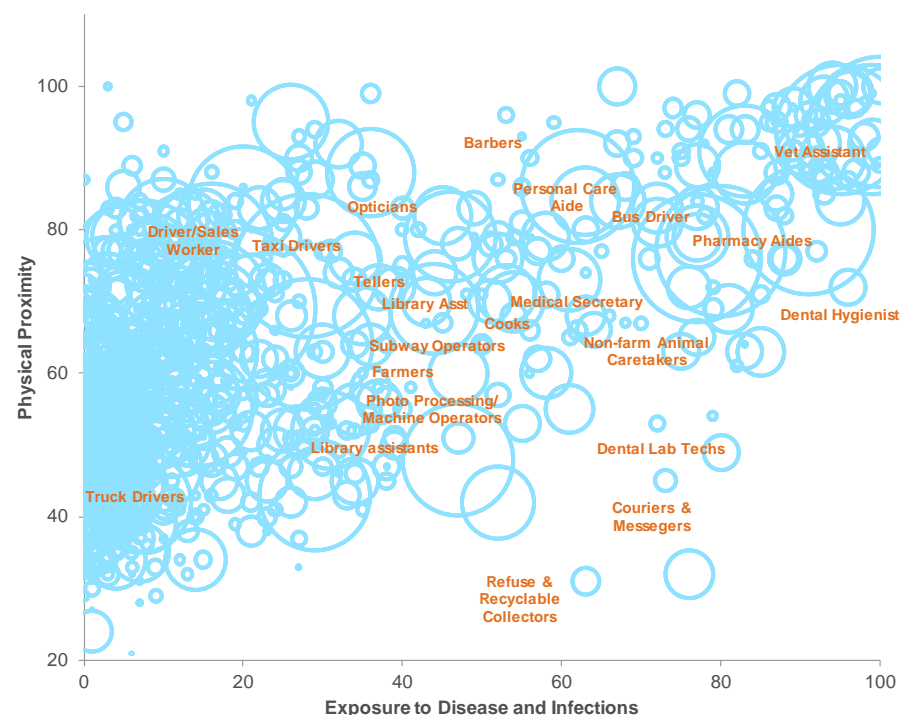
From Physical to Virtual Interconnectedness

COVID-19 has made it abundantly clear just how interconnected our economies are. Before the Industrial Revolution, most people worked from their homes producing the goods and food they needed. There was hardly any distinction between the home, the firm, and the farm. It was only as markets integrated that people and local economies began to specialize and trade the way Adam Smith postulated in *The Wealth of Nations*. Consequently, people and economies became much more productive, but also more dependent on each other. It also meant more people were suddenly clustered closely together on the factory floor where disease could spread rapidly, and often did.

Interactiveness has increased throughout the 20th century, not only in the workplace but also in social functions, making cities more susceptible to pandemics

However, as production became more standardized and automated, factories began moving out of the cities where housing was much cheaper. What was left in the cities was a set of interactive sales and service jobs which grew rapidly in numbers. Indeed, there is compelling evidence that the interactiveness of employment increased consistently throughout the twentieth century.³ These interactions did not just occur at the workplace but also increasingly in stores, bars, restaurants, and theaters, making cities fertile grounds for spreading disease. It is hardly a coincidence that large cities were the worst affected by the influenza pandemic of 1918-19. In times of pandemics, the interactiveness of employment matters greatly, because, as Figure 1 shows, occupations involving greater proximity to other people are much more exposed to disease of various kinds.

Figure 1. Proximity and Disease Exposure Across Occupations



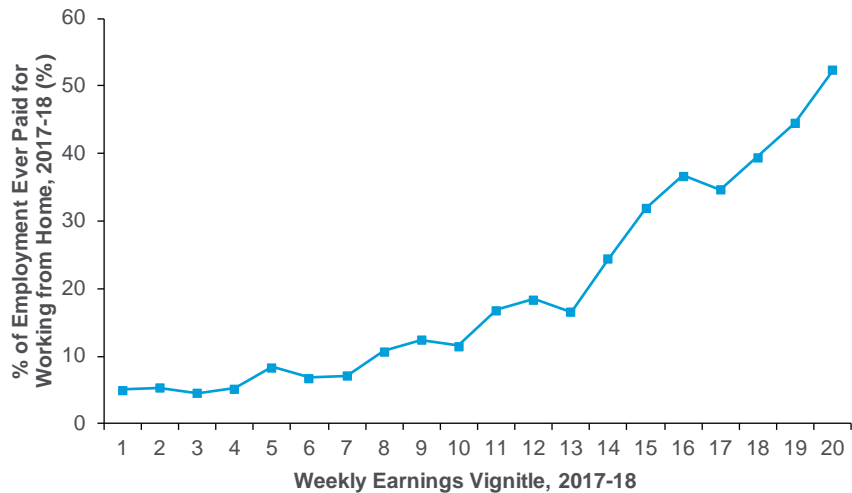
Source: National Center for O*NET Development. O*NET OnLine. Retrieved March 27, 2020, from <https://www.onetonline.org/>

³ Michaels, G., Rauch, F., & Redding, S. J. (2019). Task Specialization in US Cities from 1880 to 2000. *Journal of the European Economic Association*, 17(3), 754-798.

Because lower income workers are less likely that higher income worker to be in an occupation that can work remotely, pandemics will exacerbate inequality in the labor market

Today, however, interactiveness does not always require physical proximity. Some interactions still require face-to-face meetings, but many interactions can be done electronically or virtually. The occupations highlighted in Figure 1 are all jobs we found can be done remotely (see Chapter 5). And jobs that can be performed remotely are, needless to say, have less exposure to viruses and disease. What's more, these jobs also pay better. As we show later, being able to work remotely is a privilege that's largely confined to people in high-income jobs. This finding speaks to a large volume of literature on what economists call "skill-biased technological change", which shows digital technologies have increased the demand for college educated workers and increased their wages. These jobs are also less exposed to policies like social distancing and lockdown, meaning the people in them will see less severe income losses in times of pandemics. As Figure 2 shows, less than one-in-ten of those in the bottom half of earners say they can work from home, whereas one-in-two say they can work from home at the higher end. Without cash transfers to those at the lower end of the wage distribution (who also have less savings), the coronavirus will exacerbate inequality in the labor market with long-lasting and potentially devastating social consequences.

Figure 2. Share of Employment Ever Paid for Working from Home (%), 2017-2018



Source: American Time Use Survey

The COVID-19 Experiment

COVID-19 is creating enormous societal disruptions but also new opportunities to experiment, both for business and for governments

The key message of this report is simple: COVID-19 is creating enormous societal disruptions but also new opportunities to experiment, both for business and for governments. The pandemic has made clear we need to innovate to become more resilient to future shocks. For example, countries have sick pay to allow the sick to stay at home, but during pandemics we also want more healthy people to stay at home. Supporting those who can work from home, and help them find meaningful work, will be critical to the future resilience of nations. One way forward could be to subsidize services performed on freelancing and crowdsourcing platforms like Upwork or Mechanical Turk. People could help labelling images to create better training datasets for artificial intelligence (AI) algorithms, they could take surveys, or perform many other clerical tasks. Others could be paid to take online courses on response issues critical to pandemics, or other topics deemed vital. This would help boost aggregate demand (at a time when many low-paying, in-person service jobs at stores and restaurant are closed down) by raising incomes and supporting critical human capital investment to lift future productivity growth.

On the business side, there will be plenty of forced experimentation with virtual offices, which could actually help boost productivity growth over the long run. One case in point is to look at the strike by London Underground workers in February 2014. The shutdown closed some, but not all, Tube lines forcing Londoners to rethink their commutes to and from work. Such experimentation turned out to have fruitful and lasting consequences. In a recent paper, the economists Shaun Larcom, Ferdinand Rauch, and Tim Willems found about 5% of commuters stuck to their new route even after normal service resumed. Short-term disruption prompted them to rethink their routines.⁴ And while the vast majority (95%) only suffered from travel disruptions, the benefits to the 5% who changed their route were long lasting, exceeding the short-term costs produced by the strike.

It goes without saying the COVID-19 pandemic presents a far greater disruption than the London Tube strike. The short-run economic costs will be immense, not to mention the staggering number of lives lost. But as businesses are forced to rethink their routines and work processes, they will inevitably have to experiment with new technologies, accelerating trends in business organization that were already underway. Many big banks were quick to ban all travel. Technology companies like Facebook, Google, Twitter, and Amazon have all implemented remote working policies for jobs around the globe. Twitter has even made working from home mandatory for all its workers. Meanwhile, with Milan and Paris fashion weeks curtailed, Armani decided to stream the show for its autumn/winter collection without an on-site audience.

We are by no means suggesting all of these changes will be permanent, but as the strike on the London Underground permanently changed the commuting routes of a minority, the COVID-19 experience will leave a lasting mark on how some businesses organize. And even if this turns out to be a minority, the long-run economic benefits could be vast. Where firms and managers were able to switch to remote work temporarily, without productivity and innovation suffering, the future case for teleworking will look strong. In any event, investors are betting it will. While markets have tumbled, share prices of Slack, a corporate-messaging platform, and Zoom, which makes videoconferencing software, skyrocketed during the lockdowns. Looking back, some small firms might even be left wondering what the point of paying for an office was if they can economize on office space and let their employees work from the comfort of their home. Writing in 1997, Frances Cairncross may well have been right in thinking that, “In half a century’s time, it may well seem extraordinary that millions of people once trooped from one building (their home) to another (their office) each morning, only to reverse the procedure each evening... Commuting wastes time and building capacity. One building — the home — often stands empty all day; another — the office — usually stands empty all night. All this may strike our grandchildren as bizarre.”⁵

The big difference this time around is there is not just a technological pull towards telecommuting, but also an economic and political push. In the U.S., the Trump Administration announced it will expand Medicare telehealth coverage, allowing its beneficiaries to gain access to a wider range of healthcare services without having to travel to a healthcare facility. “The Trump Administration is taking swift and bold action to give patients greater access to care through telehealth during the COVID-19 outbreak,” said Administrator Seema Verma.

⁴ Larcom, S., Rauch, F., & Willems, T. (2017). The benefits of forced experimentation: striking evidence from the London underground network. *The Quarterly Journal of Economics*, 132(4), 2019-2055.

⁵ Cairncross, F. (1997). The death of distance: how the communications revolution will change our lives (No. C20-21). Harvard Business School.

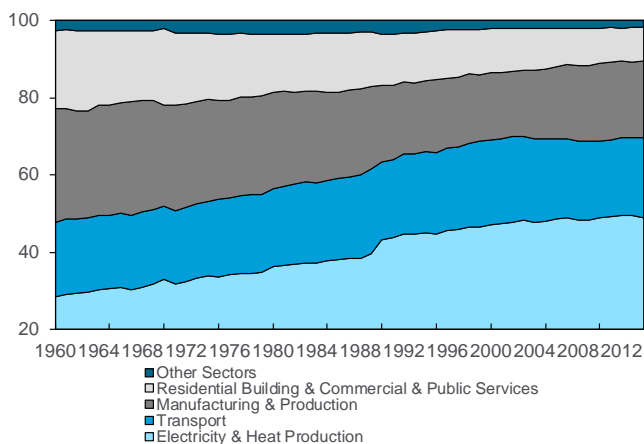
Telecommuting could reduce carbon emissions from transportation, although offsets also exist as people move further away from work and travel more for other reasons

“These changes allow seniors to communicate with their doctors without having to travel to a healthcare facility so that they can limit risk of exposure and spread of this virus. Clinicians on the frontlines will now have greater flexibility to safely treat our beneficiaries.”⁶

Another reason we might see a stronger political push for telecommuting is climate change. As Figure 3 and Figure 4 show, transportation accounts for 21% of carbon dioxide emissions globally and 33% of emissions in the United States.

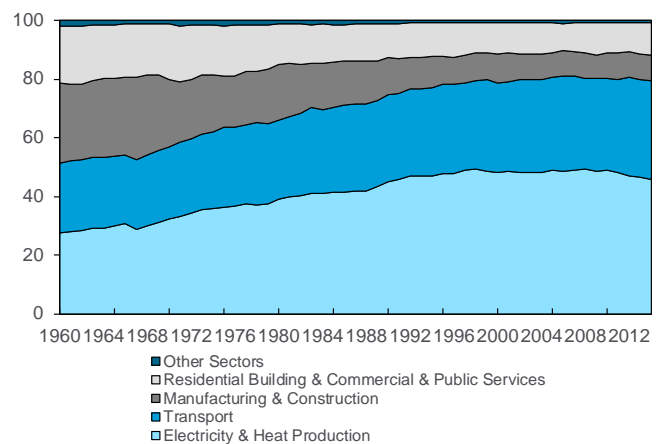
Understanding how virtual offices will impact on the carbon footprint requires more careful analysis. In some cases telecommuting might actually increase business travel. If most employees work from home, scattered across locations, and some activities are still poorly managed at a distance, all employees will have longer commutes when they do meet. The opportunity to telecommute might prompt workers to live farther away from the workplace, thus offsetting some of the work trip reductions on telecommuting days with longer commuting trips on non-telecommuting days. What’s more, the time saved on telecommuting might be redistributed to travel for other purposes. Indeed, studies show that telecommuters make more trips for meals, shopping, and other social trips on days they work remotely.⁷ Telecommuters also spend more time on shopping trips, business trips, and various types of personal travel than non-telecommuters.⁸ And there is no reason to think the impact will be uniform across locations: it might vary across metropolitan areas of different sizes, with different levels of density, with differently developed public transportation systems. Telecommuting might provide a complement to personal travel in some places, but have a substitution effect in others.⁹ As we will argue, the impact of COVID-19 on economic behavior is unlikely to be uniform across geographies.

Figure 3. CO₂ Emissions by Sector or Source, World (%)



Source: <https://ourworldindata.org/grapher/carbon-dioxide-co2-emissions-by-sector-or-source>

Figure 4. CO₂ Emissions by Sector or Source, U.S. (%)



Source: <https://ourworldindata.org/grapher/carbon-dioxide-co2-emissions-by-sector-or-source?country=USA>

⁶ <https://www.cms.gov/newsroom/press-releases/president-trump-expands-telehealth-benefits-medicare-beneficiaries-during-covid-19-outbreak>.

⁷ Balepur, P. N., Varma, K. V., & Mokhtarian, P. L. (1998). Transportation impacts of center-based telecommuting: Interim findings from the Neighborhood Telecenters Project. *Transportation*, 25(3), 287-306.

⁸ Zhu, P., Wang, L., Jiang, Y., & Zhou, J. (2018). Metropolitan size and the impacts of telecommuting on personal travel. *Transportation*, 45(2), 385-414.

⁹ Zhu, P. (2012) Are telecommuting and personal travel complements or substitutes? *Annals of Regional Science* 48(2): 619-639.

Are Cities Dying?

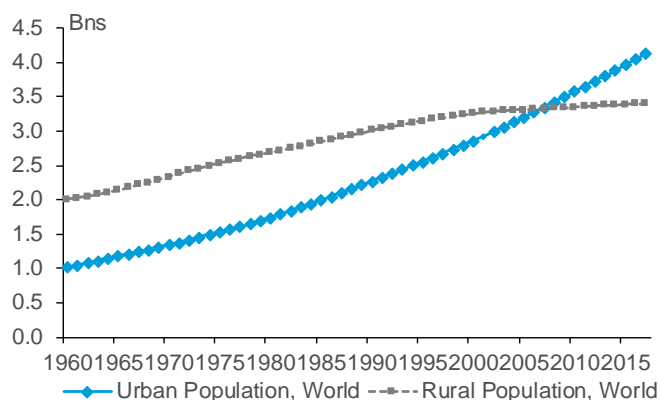
Historically, cities attracted industry as they were either close to inputs, close to where a finished good was consumed, or at a central spot in between

Urban history is replete with examples of industries clustering to reduce transportation costs, which as George Kingsley Zipf noted, often caused industries to locate close to where inputs are first produced, at the point where the finished good is consumed, or at a central spot in between. It is not a coincidence that Pittsburgh, which specializes in steel production, is sitting on a mountain of coal. And Chicago became the meatpacking city because cows and pigs came through there as they travelled from the agrarian west to markets on the east coast. Yet as transportation costs declined rapidly over the course of the twentieth century, urbanization continued to accelerate, suggesting that transportation costs had ceased to be the prime force shaping patterns of agglomeration. Instead, urbanization continued as jobs became increasingly interactive and there were only poor substitutes for face-to-face contact.

The ICT revolution seemed like the end of cities as jobs could most back to the home...but urbanization has continued

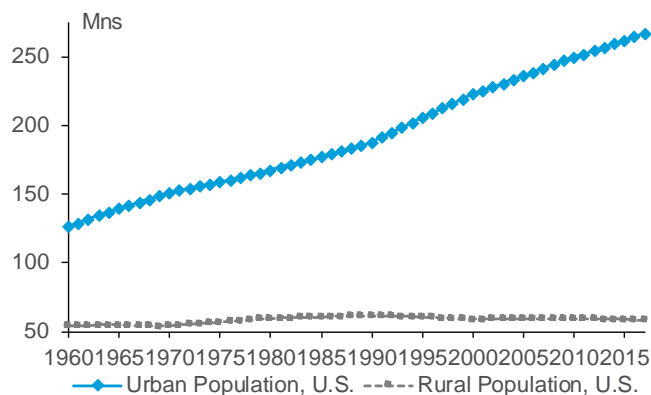
Thus, when the information & communications technology (ICT) revolution first took off, professional seers like Alvin Toffler argued face-to-face contact would become obsolete. The new production system, he suggested, “could shift literally millions of jobs out of the factories and offices into where they came from originally: the home.” This, in turn, he suggested, would mean the end of cities. Why buy an expensive apartment in Manhattan when you can telecommute from your countryside cottage? Yet so far, the 21st century hasn’t seen a reversal of the rapid urbanization over the 19th and 20th centuries. On the contrary, urbanization has steadily continued, even in the U.S. (Figure 6). And since 2007, there are more people living in cities than in rural areas globally (Figure 5).

Figure 5. Number of People Living in Urban and Rural Areas, World



Source: <https://ourworldindata.org/grapher/urban-and-rural-population>

Figure 6. Number of People Living in Urban and Rural Areas, U.S.



Source: <https://ourworldindata.org/grapher/urban-and-rural-population>

Predicting the future of work requires a framework for understanding the costs and benefits of various types of human interaction and urban life. Offices and cities will only cease to exist if their benefits are being diminished (as Toffler argued), or if the costs of agglomeration reach new heights. It depends on whether face-to-face interaction can be supplanted by its digital competitors. And it depends on the costs of cities, which have historically included health costs, pollution, congestion, crime, and social problems. Even if digital technologies reduce the need for face-to-face interaction, technologies that reduce pollution (like self-driving electric cars) or congestion (like drones) might push in the other direction.

Digital technologies are becoming increasingly good substitute for face-to-face interactions

Cities continue to provide social networks that constitute huts for innovation and consumption

Although COVID-19 likely accelerated the move to remote work, it may also increase inequality



Robert Garlick
Head of Citi Research, EMEA

To shed some light on these issues, we begin by examining how the costs of moving goods, people, and ideas have shifted the fortunes of countries and regions since the Industrial Revolution. With telepresence and telerobotics, we argue digital technologies are becoming increasingly good substitutes for face-to face interactions. As more services can be done remotely, countries with a combination of cheap labor, good digital infrastructure, and good institutions for higher education, are likely to be the main beneficiaries. In Chapter 2, we review the implications for economic development. We argue that as manufacturing employment is declining across the board, and many services are becoming exportable due to advances in digital technology, the future growth model for the developing world will look more like the path India has taken, rather than the manufacturing-led model of China.

In Chapter 3, we turn to the implications for economic geography. The key takeaway here is even though more activities can be performed virtually, nobody lives in cyberspace. Cities provide social networks that constitute hubs for innovation and consumption, and they will continue to perform those functions. However, virtual offices and advances in machine learning will reduce the need for many in-person interactions, leading to a somewhat diminished role for cities. In our age of information overload, where many walk around with the world's knowledge in their pockets, cities provide a critical function by matching people and filtering down the most important ideas through human interaction. Some of these functions, we suspect, will be taken over by AI algorithms, which are already primarily used for filtering and matching.

In Chapter 4, we examine the staggering differences in patterns and attitudes towards remote work across countries. We explore various explanations for these differences, including skills, digital infrastructure, policy and regulation, and cultural dimensions like embeddedness and trust. We emphasize that the shift towards remote work will happen at different speeds across countries. In Chapter 5, we explore how the social disruptions from COVID-19 might speed up remote work and thereby exacerbate inequality. In contrast to financial crises, which tend to reduce inequality, we show how pandemics can increase inequality, especially in the labor market. We argue this will have long-lasting social consequences if left unchecked.

Sector Implications

COVID-19 is likely to accelerate a number of the trends we have covered in previous [Technology at Work](#) publications, including: the impact on jobs of growing robotics, automation, and AI; re-shoring into developed economies; pre-mature industrialization in emerging economies; the growth of e-commerce, digital money and digital healthcare; and job opportunities in technology, healthcare, education, and green infrastructure. In this report however our focus is the potential impact of technology on remote working and learning.

In addition to remote working, digital technologies will enable a secular shift to remote learning. We explore the potential for significant new disruptions within the education sector in Chapter 6. "The rush to online learning happened almost overnight", noted 2U Inc. recently who believe "when done right, as our recent Gallop study proves, online can be as good, or even better, than the campus." Edtech can improve education's stagnant productivity, personalize outcomes, and lower cost. Like back-up solutions for corporate offices, educational institutions now have to have an effective plan B, such as flipped classrooms, digital courseware, or blended learning solutions. These are not bleeding-edge solutions — while greater investment will aid new innovation, the pandemic is actually forcing mass adoption of existing technologies.

Digital technologies will enable a secular shift to edtech, enabled by digital infrastructure

Although the scope and size of the global economic shock from COVID-19 has been beyond anything we have experienced — the worst contraction in the U.K. in 300 years — it would have been worse without the digital infrastructure making telework possible. The proliferation of broadband over dial-up is one factor in telework being an option today. Early attempts at virtual meetings were between frustrating and impossible. Video conferencing technology today become ubiquitous, cloud computing has been transformative, and 5G will aid connectivity further. As scientist and science fiction writer Arthur C Clark predicted in 1964 when business can be conducted independent of distance “men will no longer commute, they will communicate.” Chapter 7 discusses how telecommunications have fared in this crisis, but a digital divide still exists — 3 billion people in emerging economies may still be unconnected by 2023 and intra-country levels of digital literacy can vary significantly.

New software tools will drive collaboration and productivity in the digital workspace

One certainty is technology solutions will be invented to solve new problems. It was only 25 years ago that most businesses started to introduce email, and now colleagues often email when sitting next to each other in the office. Since then accelerating forces of mobility, SaaS, cloud, and machine learning have aided communication (between people or devices), adoption, and compute power. With remote work increasing outcome accountability, a boom in data analytics will aid in measurement and reporting. All technology-enabled human interactions generate metadata that previously did not exist and provides new lifeblood for AI. Chapter 8 discusses the next wave of innovation in new communication and work deliverable tools which will help drive collaboration and productivity in the digital workspace. In the future augmented and virtual reality will further these trends. We briefly touch on rising security and privacy concerns that come with digitization and have addressed these more fully our May 2019 Citi GPS report [Managing Cyber Risk with Human Intelligence](#).

One of the biggest debates on the impact of telework is around real estate — newspaper headlines talk about both the demise and the resurgence of the office. We look at both side of the arguments in Chapter 9 and also at derivative implications for urban versus rural house prices. When a medium one bedroom apartment in San Francisco rents for \$3,500 per month, or Americans spend 5 billion hours per year in traffic jams, it is not surprising that some are looking for alternative solutions. A study by Stanford University in 2017 found the average worker would accept 8% less pay for the option of working from home, saving them travel costs and commute time.

Some corporates will look at remote working as a cost saving opportunity while others highlight the importance of being physically together for culture, social capital, apprenticeship, and well-being. We include an ‘Ode to the Office’ from Jane Fraser, President of Citi. In a recent Financial Times article Lucy Kellaway also noted the office “gave me routine, structure, amusement, purpose, many friends and a refuge in times of trouble. It was where I went to pass my days. My office was my rock,” but that is it was “overcrowded, full of distractions, encouraged presenteeism” and “easy to waste a whole day in dull meetings.” Near term many are longing to get back to the office post lockdown and longer term even if previous cultural norms can be broken some employees will still fear missing out (FOMO) or being forgotten (athazagoraphobia).

There is less debate surrounding some corporate travel being substituted for virtual meetings. These have been battle tested-during the pandemic and offer cost savings for employers and time savings for employees. We conclude in Chapter 10 that telework will structurally reduce corporate travel by 25%, with negative knock on implications for airlines, airports, hotels, and taxis.

An important derivative implication from increased telework is a significant positive effect on climate change. In Chapter 11 we estimate CO₂ emissions in the U.S. could be reduced by 20 million tons per year (the equivalent of 4.3 million passenger cars) for each day workers who can work from home do so. There are extra CO₂ savings from aviation and office emissions. This is important on many levels with air pollution alone estimated by the World Health Organization (WHO) to be responsible for some 7 million deaths each year. In addition, road accidents are one of the top 10 causes of death and reduced commuting travel could save lives.

Has COVID-19 ushered in a new future of work? Opinions will differ widely across job roles, cultures, generations, and personal situations (e.g., family, digital access, urban density, commute times). But the pandemic brought about the biggest work experiment in history, accelerated digital trends, and has opened up new habits, possibilities, and thinking. The answer is likely for employers to give their talent the choice. Let them experiment and innovate. A combination of choice and technological process means we are unlikely to go back to norms at the start of this year/decade. In Chapter 5 we estimate the remote work possibilities frontier in the Financial Services industry is over 80% and in a recent Bloomberg survey “97% of analysts, 94% of fund managers, and 80% of traders asked said they want to work from home in the future at least some of the time.” While this report explores some negative derivative sector implications of a tipping point in flexible working, overall a happier and healthier workforce can help motivation and productivity and be a win-win for both employers and employees.

Chapter 1: The Great Unbundling: From Steam Power to Telerobotics

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Before the Industrial Revolution, the world economy was a patchwork of city-level economies with the majority of workers derived their living off the land

As the cost of goods fell, markets became more integrated and merchants became middlemen

From time to time, technology shocks have shifted the locus of economic activity. As the economist Richard Baldwin has shown, we have seen two different phases of globalization, and are about to witness a third, as technology has caused three costs to plummet in sequence.¹⁰ First, the cost of moving goods fell sharply thanks to steam power. Then, we saw the cost of moving ideas decline with the spread of information & communication technology (ICT). And more recently, face-to-face costs have plummeted in many jobs thanks to digital technology. This implies greater opportunities for remote work, which as we shall see, could reshape the global economy.

To better understand the enormous impacts digital technology will have on our productive systems, however, it is instructive to begin by looking back. In the pre-globalization world, before steamships had become sufficiently energy efficient to carry goods enormous distances at low cost, the world economy was little more than a patchwork of city-level economies. Production and consumption were bundled together. While there was long-distance trade, it was mostly confined to luxury goods. High transportation costs meant that any good which had to be transported over long distances was expensive. Consequently, the global economy remained highly localized with production and consumption occurring in fixed locations. Families typically worked and lived under one roof and produced what they needed themselves. The rural industries were merely an off-season activity. In the winter, when there wasn't much agricultural work to be done, farmers engaged in spinning and weaving. In his traveler accounts, Daniel Defoe (best known for his imaginative novel *Robinson Crusoe*) describes the manufacturer as someone who has cows grazing on the land around his home. Part of his living was derived from the land, which also ensured his independence. In this so-called domestic system, the household, the farm, and the firm were often one. In England, only around 30 percent of workers were wage earners in early eighteenth-century. Most people worked for themselves at their own pace surrounded by their families.¹¹ And any surplus they produced was sold to households nearby.

Steam Power and the First Unbundling

Things started to change as the cost of moving goods fell. As markets became more integrated, merchants became an indispensable middleman for many artisans, who could suddenly sell their goods across the country or even abroad. The merchant often needed to take part in the process of finishing the goods, and for this purpose he had to employ workers, and thus gradually became a manufacturer. Larger industrial undertakings required more capital, which few independent artisans had. Aware of this, the manufacturers began to provide the tools for production. Artisans, in other words, gradually lost ownership of the means of production as well as their autonomy over the pace of work, and came to form what Karl Marx would call a working class. And so, the slow but relentless divorce between capital and labor that took off during the Industrial Revolution began.¹²

¹⁰ Baldwin, R. (2016). *The Great Convergence*. Harvard University Press.

¹¹ Frey, C.B. (2019). *The Technology Trap: Capital, Labor and Power in the Age of Automation*. Princeton University Press.

¹² Frey, C.B. (2019). *The Technology Trap: Capital, Labor and Power in the Age of Automation*. Princeton University Press.

The Industrial Revolution started as a local phenomenon in Britain, but it was soon felt outside its borders as transportation technologies improved. Of particular importance was the invention of the railroad and the steam ship. By 1821 there were 188 steamers operating in England. And around that time, a series of inventions culminated in George Stephenson's Rocket — the steam locomotive that was used for the first public and fully steam-powered railroad between Liverpool and Manchester in 1830.

Not long after the first railroad began operating, steam changed ocean travel forever. In 1838, Isambard Kingdom Brunel's Great Western became the first ocean steamship to cross the Atlantic, though it took many decades for steam to displace sail simply because longer journeys required ships to carry vast amounts of coal as cargo. It was not until the end of the century that the coal requirements of steam engines became sufficiently low for steamships to cover the distance between China and England.

The advent of the steamship lowered international shipping costs steadily and led to 'globalization's first unbundling — the separation of production and consumption

With the costs of international shipping falling steadily, more and more people could buy faraway goods. In England, a middle class emerged that could afford bread baked with American wheat, enjoy sipping Chinese tea, which they had previously only read about in Jane Austen's novels, and sweeten it with Jamaican sugar. The economic historians Kevin O'Rourke and Jeffrey Williamson date the beginning of this process to the 1820s. But while shipping got cheaper, the costs of moving ideas and people did not fall much. The consequence was the separation of production and consumption that led to "globalization's first unbundling."¹³ In the industrial West, where the Industrial Revolution first took off and spread, early industrialization fostered additional innovation, which remained highly localized. This helped the West to pull ahead of the rest: the resulting growth differences compounded over time, leading to what economic historians have called the "Great Divergence."¹⁴ This divergence was the result of a combination of low trade costs and high communication costs.

The ICT Revolution and the Second Unbundling

The ICT Revolution in the 1990s enabled companies to move production offshore and restructure their supply chains

Things changed again around 1990 when ICT became sufficiently sophisticated to allow rich-nation companies to unbundle their factories and ship routine production activities abroad, together with advanced manufacturing capabilities. Indeed, for all processes to run smoothly, companies in advanced economies sent their marketing, managerial, and technical know-how along with the production capabilities that were moved offshore. Rather than just goods crossing borders, entire factories were now moving across countries. Offshoring increased efficiency gains, but the ICT revolution was about much more. Arguably its greatest virtue was to enable companies in the industrial West to restructure their supply chains in ways that made it possible to effectively combine cheap labor in countries like China with highly skilled tech work at home.

¹³ Baldwin, R (2006). Globalisation: The Great Unbundling(s), Economic Council of Finland 20(3): 5-47.

¹⁴ Pomeranz, K. (2009). The great divergence: China, Europe, and the making of the modern world economy. Princeton University Press.

This second unbundling redrew the international boundaries of knowledge

Before the 1990s, companies had to choose between relying on high-tech and high wages in rich countries or using low-tech and low wages in poorer nations. The iPhone is just one of many examples: product development takes place in the United States, but production is located in China. This would not have been possible without radically improved communications technology, allowing companies to coordinate complex activities at distance. The ICT Revolution caused what Baldwin has called the “second unbundling”, which redrew the international boundaries of knowledge.¹⁵

But why was the knowledge transfer so concentrated to a few countries like China? The reason is that the cost of moving people, while falling, remained relatively high as the cost of moving goods and ideas diminished. Even though airplane fares declined, this is not the only cost of moving people. As the wages of managers and technicians continued to rise rapidly, so did the opportunity cost of travel. The high cost of moving people, and the need for managers to visit production facilities on a regular basis, led offshoring companies to cluster production in a few locations, mostly in East Asia.

Telerobotics and the Next Unbundling

In 2004, Thomas Friedman argued that location was becoming irrelevant

In *The World Is Flat*, published in 2004, Thomas Friedman famously argued that location was becoming irrelevant: “My bottom line is this: Open-source is an important flattener because it makes available for free many tools, from software to encyclopedias, that millions of people around the world would have had to buy in order to use, and because open-source network associations with their open borders and come-one-come-all approach can challenge hierarchical structures with a horizontal model of innovation... The net result of this convergence was the creation of a global, Web-enabled playing field that allows for multiple forms of collaboration, the sharing of knowledge, and work in real time, without regard to geography, distance, or in the near future, even language.... That is what I mean when I say the world has been flattened.”¹⁶

Others argued innovation and education created relationship-based activities so location was relevant

Not everyone agreed. In a critical review, the economist Ed Leamer responded: “In his “flat” world, your wages are set in Shanghai. In fact, most of the footloose relationship-free jobs in apparel and footwear and consumer electronics departed the United States several decades ago, and few U.S. workers today feel the force of Chinese and Indian competition, notwithstanding the alarming anecdotes about the outsourcing of intellectual services. Of course, standardization, mechanization, and computerization all work to increase the number of footloose tasks, but innovation and education work in the opposite direction, creating relationship-based activities like the writing of this review.”¹⁷

Who was right? So far, history has been kinder to Leamer's assessment. But new technologies loom on the horizon with the potential to “flatten the world”, even if not to the extent that Friedman envisioned.

¹⁵ Baldwin, R. (2016). *The Great Convergence*. Harvard University Press; Baldwin, R. (2019). *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*. Oxford University Press.

¹⁶ Friedman, T. L. (2005). *The World is Flat: A Brief History of the Twenty-first Century*. Macmillan.

¹⁷ Leamer, E. E. (2007). A Flat World, a Level Playing Field, a Small World After all, or None of the Above? A review of Thomas L Friedman's *The World is Flat*. *Journal of Economic Literature*, 45(1), 83-126.

The third unbundling is underway as face-to-face costs are plunging through digital technologies

As we shall see, a third unbundling is underway as face-to-face costs are plunging the way coordination costs have since the 1990s. It is true, as technology sceptics like Robert Gordon have pointed out, that airplanes, trains, and cars have barely become faster over recent decades (though they have become a lot safer).¹⁸ But as digital technologies get better, they will reduce the need for some travel altogether.

Collaborative platforms already help facilitate teleworking including telemedicine

We are already seeing an accelerating trend towards remote work as companies are reorganizing themselves to facilitate telecommuting. This is made possible by collaborative platforms like Business Skype, Slack, and Trello, which make teamwork easier to organize at a distance. But in recent years, things have gone even further. A new key technology is called “telepresence” and is already widely used by banks, professional service companies, and even governments. Start-ups and multinationals alike are beginning to use augmented reality (AR) and virtual reality (VR) to improve remote collaboration. Going forward, these technologies will redefine how corporations work.

Today, there is plenty of experimentation going on, especially in telemedicine. As Ann Mond Johnson, CEO of the American Telemedicine Association (ATA), puts it, “What telehealth can do is help both the clinicians as well as the consumer have access to service without actually getting exposed to the virus. It mitigates the risk. So in that regard it’s incredibly valuable.”¹⁹ At Thomas Jefferson University Hospital in Philadelphia, for example, patients arriving with COVID-19 symptoms get a mask and an iPad. The patient can then use their iPad to video chat with a remotely-located nurse practitioner who can evaluate their symptoms and determine next steps, avoiding any face-to-face interactions.

With 5G, telerobotics could mean humans can operate machines from remote locations

To be sure, reducing in-person interaction is not just about having better technology for virtual meetings. There are many services where a human worker needs to be in front of a machine to get the job done. But digital technology may be changing even that, especially as 5G is being rolled out. With 5G, technologies like “telerobotics” could eventually become good substitutes for people traveling to provide manual services, too. Telesurgery and drone operations are two examples where telerobots are already being controlled at distance. Given the expansion of bandwidth, and the reduction in latency that will come with 5G, it seems only a matter of time until a rapidly growing set of in-person interactions can be performed at distance.

¹⁸ Gordon, R. J. (2017). The rise and fall of American growth: The US standard of living since the civil war. Princeton University Press.

¹⁹ <https://abcnews.go.com/Health/telemedicine-moment-patients-make-growing-industry/story?id=69738388>

Chapter 2: The Death of Distance and the Future of Development

Digital technologies have created new opportunities for high-skilled advanced-economy workers, but have also disproportionately benefited workers from developing countries

Virtual immigration and telecommuting are likely to significantly expand the scope of tasks than can be done at distance in developing countries

Digital technologies are likely to favor countries specializing in tradable services vs. manufacturing goods

In 2000, Frances Cairncross argued the ICT Revolution would help the developing world catch up with the West. “Companies will be free to locate many screen-based activities wherever they can find the best bargain of skills and productivity. Developing countries will increasingly perform on-line services — including monitoring security screens, inputting data from forms, running help-lines, and writing software code — and sell them to the rich industrial countries that generally produce such services domestically”, she confidently predicted.²⁰ She was right. The Internet, it is true, is a two-way street and not everything is produced where labor is cheapest. Digital technologies have clearly created many new opportunities for highly skilled advanced-economy workers whose competitive advantage is based on creativity and know-how, rather than on low wages. But recent studies show online platforms with standardized information have benefited workers from developing countries disproportionately.²¹

While many services are already provided online, virtual immigration and telecommuting are likely to significantly expand the scope of tasks than can be done at distance in developing countries. Plenty of both menial and professional tasks will be possible to perform remotely at lower cost. Salaries in the West are often a dozen times what they are in developing countries. An accountant in the U.S. earns roughly twenty times the salary of her Chinese counterpart. Thus, a company in the U.S. could even hire several Chinese accountants instead and still save on labor costs. At the higher end of the skill distribution, a Japanese engineer could repair a Toyota in Ethiopia controlling a robot remotely. But since labor costs in Ethiopia are much lower, the reverse seems more likely. And at the low end of the skill spectrum, hotel rooms in Stockholm could be cleaned by robots controlled by a worker in Mexico City.²² And a truck in Germany could be driven remotely by a worker in Vietnam (leaving national security concerns aside).

The consequences for both economic geography and growth models are likely to be significant. And in terms of economic development, it is likely to favor countries specializing in tradable services rather than in manufacturing goods. Indeed, most evidence suggests industrialization no longer provides the path to prosperity it once did. As we showed in [Technology at Work 2.0](#), peak manufacturing employment has continuously fallen over the course of the twentieth century as production processes have become increasingly automated. Even in the factory of the world — China — manufacturing employment has already taken a hit. Between its peak in 2013 and 2017, China’s manufacturing employment share fell from 19.3 percent to 17.5 percent. Around 12.5 million production jobs vanished in only four years as robot adoption accelerated and jobs moved to low-wage nations.

As I have argued in my book *The Technology Trap*, China is now facing a dilemma similar to that of America in the 1980s, when U.S. corporations were left with the choice of either moving production offshore or automating to remain competitive.

²⁰ Cairncross, F. (2000). *The Death of Distance 2.0*. London: Texere.

²¹ Agrawal, A., Lacetera, N., & Lyons, E. (2016). Does standardized information in online markets disproportionately benefit job applicants from less developed countries?. *Journal of International Economics*, 103, 1-12.

²² Baldwin, R. (2019). *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*. Oxford University Press.

Like the U.S., China has clearly settled for automation, making its intent to accelerate robot adoption explicit in its five-year plan in order to prevent production from moving to countries like Thailand and Vietnam. The rapidly falling cost of automation is making this strategy increasingly feasible: according to our estimates, the payback period for a robot in the Chinese auto industry has already fallen below two years.²³

Look to India, not China

The Indian model of service-led growth is more likely to become the norm vs. the China manufacturing model throughout the developing world

Since the pathbreaking work of William Arthur Lewis, development economists think of the manufacturing industry as a stepping stone to middle-income status.²⁴ But as the economist Dani Rodrik has shown, developing countries are now running out of manufacturing jobs earlier and at much lower levels of GDP per capita, especially when pitched against early Western industrializers.²⁵ This means the China model will become even harder to replicate. Instead, as we shall see, the Indian model of service-led growth is more likely to become the norm throughout the developing world.

India's middle class has grown with the unbundling of services as the country has attracted outsourced call centers, as well as a host of so-called business process outsourcing (BPO) activities, including many back-office jobs like accounting, payroll, human resources, and various legal and IT services. As the economists Barry Eichengreen and Poonam Gupta have pointed out, service sector growth typically comes in two waves. First, when an economy moves from low-income into middle-income status, various informal services grow rapidly. In the second stage, when it moves beyond middle-income, it shifts into more skilled types of services like information technology, accounting, and finance.²⁶ India, however, is an outlier in that it has already moved into the second wave, which economists commonly associate with more advanced knowledge-driven economies.

India's geography, infrastructure, and educational system all favored services over manufacturing

India's strong focus on services is due to a combination of factors. First, the traditional manufacturing path faced a number of serious constraints, including poor transportation, infrastructure, and geography in terms of distance from manufacturing hubs like Germany, Japan, and the U.S. This left it relatively sheltered from international competition, but it also made it hard to integrate into global value chains. Second, while India is behind in vocational training and skills, its educational policy has long favored high-quality universities. This, in turn, has favored services over manufacturing.

²³ Frey, C. B. et al. (2016). Technology at Work 2.0, Citi GPS.

²⁴ Lewis, W. A. (1954). Economic development with unlimited supplies of labour. The Manchester School, 22(2), 139-191.

²⁵ Rodrik, D. (2016). Premature Deindustrialization. Journal of Economic Growth, 21(1), 1-33.

²⁶ Eichengreen, B., & Gupta, P. (2013). The two waves of service-sector growth. Oxford Economic Papers, 65(1), 96-123.

India was also helped by having a literate population with good English-language communication skills

Third, India has a literate population with good English-language communication skills. It is hardly a coincidence that the top three nations hiring telemigrants are advanced English-speaking countries (the U.S., Australia, and Britain), while the biggest sources of telemigrants were the Philippines, India, and Bangladesh.²⁷ As Ed Leamer points out, “linguistic and cultural barriers that make it difficult to exchange thoughts between people located far from each other in the cultural landscape. In that kind of world, there would be specialized cultural services (e.g., plays and newspapers and legal services) made by locals for locals. These couldn't be shipped very far because the messages would melt away to meaninglessness if the content were shipped over great distances to unreceptive cultures.”²⁸

Speaking the same language certainly does not reduce all cultural barriers to zero, but it lowers them, and thus the cost of communication and coordination. Even for the trade of physical goods, language matters. It is true that studies show that the Internet has increased cross-border trade in physical goods by reducing the cost of international communication.²⁹ But studies also show that online trade gives a comparative advantage to English-language countries.³⁰ It is hardly a coincidence that the introduction of machine translation for Spanish-speaking Latin America on an online marketplace increased exports on the platform by 10.9%.³¹

Exporting the Service-led Growth Model

The Philippines is also following a service-led growth model

To be sure, the service-led model is not just an Indian story. In the Philippines, for example, the special economic zones set up in 1995 have provided tax incentives for call center operators. Though these measures were intended to attract call centers, the clustering of talent also attracted multinationals interested in setting up shared services offices to reduce their wage bills. Companies like Accenture, Dell, Oracle, and JP Morgan now cluster near Manila. In addition to BPO activities, freelancing is booming in the Philippines, with most work being lined up work via platforms such as Upwork.com, Freelancer.com, or Shutterstock.com.³²

²⁷ Baldwin, R., & Forslid, R. (2020). Globotics and development: When manufacturing is jobless and services are tradable. NBER Working Paper 26731.

²⁸ Leamer, E. E. (2007). A Flat World, a Level Playing Field, a Small World After all, or None of the Above? A review of Thomas L Friedman's *The World is Flat*. *Journal of Economic Literature*, 45(1), 83-126.

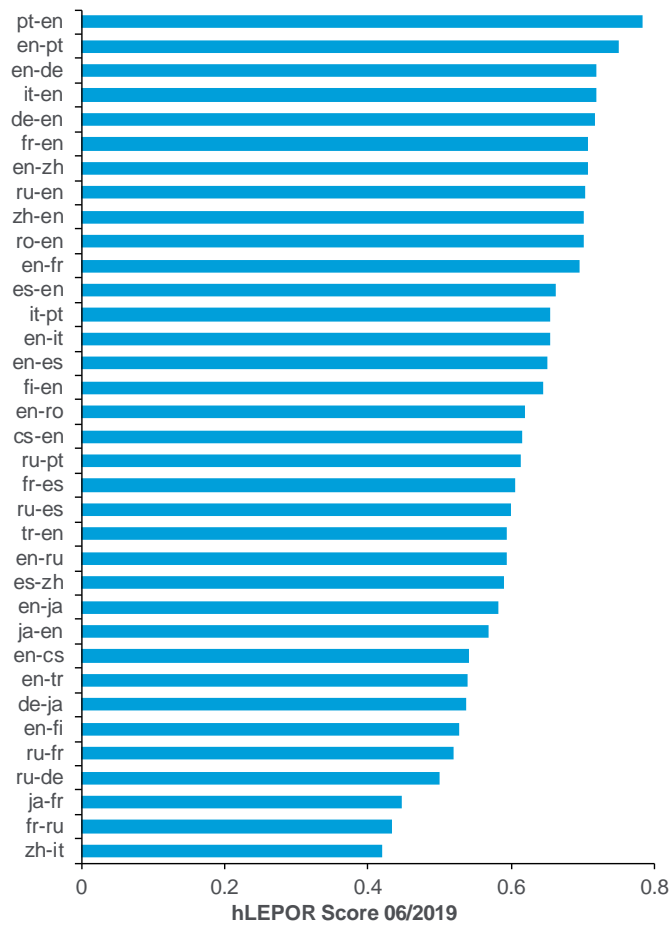
²⁹ Freund, C. L., & Weinhold, D. (2004). The effect of the Internet on international trade. *Journal of International Economics*, 62(1), 171-189.

³⁰ Gomez-Herrera, E., Martens, B., & Turlea, G. (2014). The drivers and impediments for cross-border e-commerce in the EU. *Information Economics and Policy*, 28, 83-96.

³¹ Brynjolfsson, E., Hui, X., & Liu, M. (2019). Does machine translation affect international trade? Evidence from a large digital platform. *Management Science*, 65(12), 5449-5460.

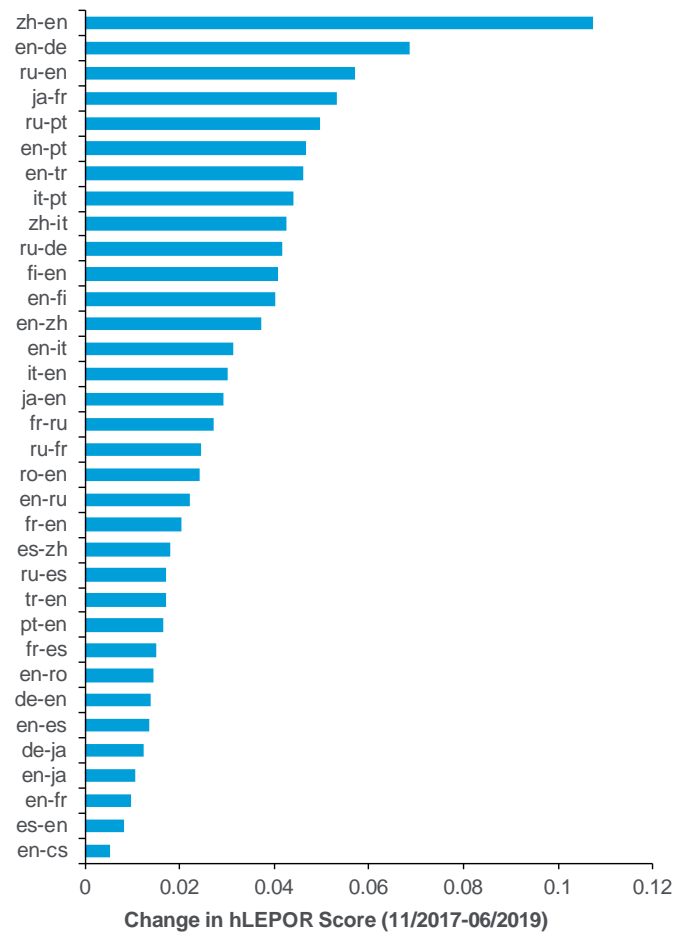
³² Baldwin, R., & Forslid, R. (2020). Globotics and development: When manufacturing is jobless and services are tradable. NBER Working Paper 26731.

Figure 7. Machine Translation Performance, Ranking by Language



Source: Stanford HAI, Artificial Intelligence Index Report 2019

Figure 8. Machine Translation Performance, Improvement



Source: Stanford HAI, Artificial Intelligence Index Report 2019

Improvements in machine translation could mean BPO services will no longer need to be clustered in English-speaking countries

As machine translation improves, however, there is less reason for BPO services to cluster in English-speaking countries. Figure 7 and Figure 8 look at the performance of machine translation using the hLEPOR evaluation metric, which measures the difference from a human reference translation. hLEPOR scores of 0.7 implies close to human-level quality with just a couple of mistakes per sentence. Portuguese-English and English-Portuguese are pairs with the highest hLEPOR score (Figure 7), but the fastest improvement was for Chinese-to-English, followed by English-to-German (Figure 8). That said, machine translation still lags human performance, even though commonly used benchmarks, which focus on single sentences rather than more complex longer paragraphs, favor machine translators.³³ But important progress is being made. One major challenge has been the translation of rare words for which there is little data. But machine learning researchers have found ways of circumventing this problem by dividing words into subunits.

³³ See Mitchell, M. (2019). Artificial Intelligence: A Guide for Thinking Humans. Penguin UK.

Even incremental improvements in machine translation error rates could increase the global supply of service workers

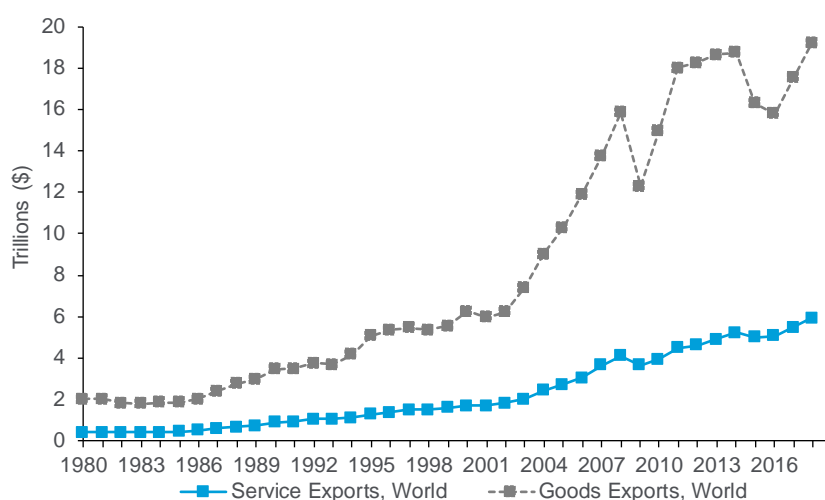
The manufacturing industry is increasingly releasing labor vs. the service sector which see steadily growing employment

In 2016, Google researchers found that using “word-units” and neural networks collectively reduced translation error rates by 60 percent.³⁴ It is important to remember that machine translation doesn’t need to be perfect in order to be useful. Even incremental improvements can increase the global supply of service workers. There are about a billion people who could sell services in English through online platforms today. With the help of even imperfect machine translation that number could easily double, allowing businesses to tap into new pools of talent.

The Future of Productivity in Services

Historically, the virtue of manufacturing for economic development has been threefold: manufacturing goods are tradable, the manufacturing sector is highly productive, and it used to be capable of absorbing a significant share of low-skilled workers. But, as we have seen, while the manufacturing sector continues to be highly productive, it is increasingly releasing labor rather than absorbing it. Service employment, in contrast, has been steadily growing. What’s more, service exports are now growing faster than the export of goods (Figure 9). The problem has been that many services have remained technologically stagnant. This led economists to question whether service-led growth can provide a feasible way forward for the developing world. It still takes four people to play a quartet, as the economist William Baumol famously pointed out. However, many services have or are being cured from Baumol’s disease. In the U.S., services are estimated to have accounted for over 70 percent of labor productivity growth as the ICT revolution prompted a productivity revival in the late 1990s.³⁵

Figure 9. World Service vs. Goods Exports, 1960-2018



Source: <https://data.worldbank.org/indicator/BX.GSR.NFSV.CD>

³⁴ Frey, C.B. (2019). The Technology Trap: Capital, Labor and Power in the Age of Automation. Princeton University Press.

³⁵ Triplett, J. E., & Bosworth, B. P. (2004). Productivity in the US services sector: new sources of economic growth. Brookings Institution Press.

Even delivery services can now be performed at a distance which offers the potential for a more broad-based productivity revival. After retail witnessed very rapid productivity growth in the 1990s, companies soon ran into bottlenecks. Goods still needed to be shipped from the factory to the warehouse, then to the retail store, and finally to the ultimate buyer. And freight trucking turned out to be a highly unproductive activity. Delivery drivers still had to cope with congested streets, look for parking spaces, and ring doorbells. To work around this, many companies are now experimenting with drones (which can bypass congested streets) for delivery.³⁶

In 2018, for example, Amazon took out a patent for a delivery drone that can respond to human gestures. The technology will address the issue of how “flying robots might interact with human bystanders and customers waiting on their doorsteps. Depending on a person’s gestures — a welcoming thumbs up, shouting or frantic arm waving — the drone can adjust its behavior, according to the patent. The machine could release the package it’s carrying, alter its flight path to avoid crashing, [and] ask humans a question or abort the delivery, the patent says.”³⁷

Productivity gains from service automation can be significant

Case studies also show productivity gains from service automation can be significant. For example, when the U.K. mobile communications provider Telefónica O2 deployed 160 robots to process 500,000 transactions each month, the estimated three-year return on investment was over 650 percent.³⁸ Robotic process automation (RPA), as it is called, is also being adopted in some developing countries like call centers in the Philippines, which increasingly leverage chatbots, machine learning, and natural language processing.³⁹ And more sophisticated algorithms will aid call center operations in the near future. Indeed, in 2018, Google announced it is building AI technology to increase productivity in call centers. “Virtual agents will answer the phone when a customer calls. If a customer request involves something the algorithm cannot yet do, he or she will automatically be rerouted to a human agent. Another algorithm then analyzes these conversations to identify patterns in the data, which in turn helps improve the capabilities of the virtual agent.”⁴⁰

Some service jobs will be automation via technology, but many, especially professional service jobs, are exceedingly hard to fully automate or do remotely

To be sure, some service jobs are likely to be automated away and will thus release workers rather than absorbing more of them. But as we show in [Technology at Work 1.0](#), most professional service jobs remain exceedingly hard to fully automate. Instead, healthcare professionals, engineers, lawyers, and consultants are finding themselves augmented by automation technologies. These occupations are likely to continue to experience steady employment growth while being aided by more advanced machine learning tools. And they are also increasingly possible to do remotely.

³⁶ Frey, C.B. (2019). *The Technology Trap: Capital, Labor and Power in the Age of Automation*. Princeton University Press.

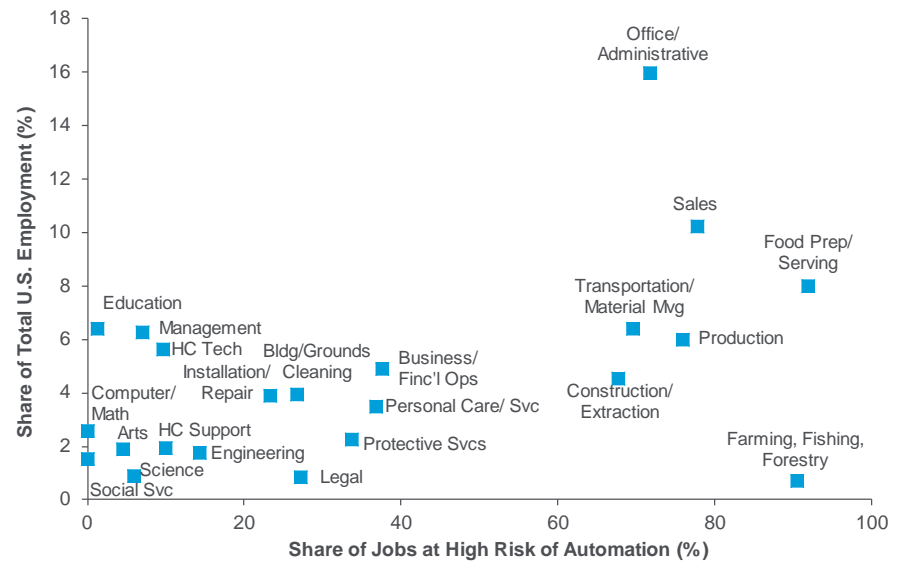
³⁷ Ibid.

³⁸ Lacity, M., & Willcocks, L. (2015). What knowledge workers stand to gain from automation. *Harvard Business Review*, 19(6).

³⁹ Baldwin, R., & Forslid, R. (2020). Globotics and development: When manufacturing is jobless and services are tradable. NBER Working Paper 26731.

⁴⁰ Frey, C.B. (2019). *The Technology Trap: Capital, Labor and Power in the Age of Automation*. Princeton University Press.

Figure 10. Jobs at Risk of Automation by Economic Sector



Source: 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.

Chapter 3: The Agglomeration

The proximity of firms and inventors affects how well knowledge travels to support further innovation and economic growth...cities are critical here for the exchange of ideas

96% of new product innovations occur in metropolitan areas, and almost half of all new innovations happen in just four cities

Proximity to the best and the brightest is essential for those who want to stay ahead of the curve

The economies of the most prosperous cities of the world have grown rich through service exports. Rather than making them obsolete, the ICT Revolution has allowed cities like New York to export financial innovations to the rest of the world. Because of highly localized economies of scale, these cities provide the engine of modern growth. Urban theorists, like the eminent Jane Jacobs, have rightly emphasized that the proximity of firms and inventors affects how well knowledge travels to support further innovation and economic growth.⁴¹ The exchange of ideas about new technologies is facilitated by cities, providing the necessary proximity for innovators to interact. As Harvard's Edward Glaeser has argued, smart people move to cities and make each other smarter. And this is also reflected in their wages. People who move to cities do not earn the urban wage premium immediately. They do so gradually, which suggests that they benefit from knowledge spillovers where they work and live.⁴²

This also helps explain why knowledge industries are so clustered. In the United States, finance is done in New York City, where most banks cluster on Wall Street. Most software innovation is happening in Silicon Valley and Seattle. Biotech is clustered in San Diego and Boston. Country music is made in Nashville. And movies are made in Hollywood. Studies show that in the U.S., about 96 percent of new product innovations occur in metropolitan areas, and almost half of all new innovations happen in just four cities: New York, Los Angeles, Boston and San Francisco.⁴³

Cities and Innovation

Because there are so many ideas out there, being close to the people with the best ideas provides an essential filtering mechanism. What's more, all ideas aren't accessible through books and the Internet immediately. For innovators who want to be first, and companies that want to be early adopters, published ideas are often old news. Proximity to the best and the brightest, in other words, is essential for those who want to stay ahead of the curve. And one idea often leads to another, which has historically made cities fertile places for experimentation. As Edward Glaeser and Joshua Gottlieb write, "The role of cities in creating chains of innovations can be seen historically in events like the Florentine Renaissance, where the architect Brunelleschi developed linear perspective, which was then used in low relief sculpture by his friend Donatello, then in painting by Masaccio, and passed to his student Filippo Lippi and others. Urban intellectual connections create agglomeration economies and help us to understand why skilled cities are so successful, but they also remind us that many intellectual revolutions involve small numbers of connected inventors."⁴⁴

⁴¹ Jacobs, J. (2016). *The Economy of Cities*. Vintage.

⁴² Glaeser, E. L., & Mare, D. C. (2001). Cities and skills. *Journal of Labor Economics*, 19(2), 316-342.

⁴³ Audretsch, D. B., & Feldman, M. P. (1996). R&D spillovers and the geography of innovation and production. *The American economic review*, 86(3), 630-640.

⁴⁴ Glaeser, E. L., & Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of economic literature*, 47(4), 983-1028.

Knowledge flows are visible in patent data with patents more likely to cite previous patents that are geographically proximate...showing ideas filter down in cities

Other examples are not hard to come by. The inventor Gustaf Dalén met with Gustaf de Laval only to find out that his device to measure the level of fat in milk had already been invented. This, however, inspired him to a series of follow-on inventions that led to the formation of AGA AB (which was integrated into Linde AG in 2000).⁴⁵ And more broadly, the collaborative nature of innovation, and the role of cities in facilitating interactions, may be relevant to explain events in economic history, such as the Industrial Revolution. Several innovations were produced by interactions between geographically proximate inventors. For example, the idea behind Richard Arkwright's water frame came from John Kay, who was working on a similar machine with his neighbor, the inventor Thomas Highs. And the James Watt steam engine, which powered much of the Industrial Revolution, came out of early collaborations in Glasgow with John Robison and Joseph Black, and later on with Matthew Boulton and William Murdoch in Birmingham.⁴⁶

Agglomeration theories that emphasize innovation and idea transmission treat cities and human capital as complements. When people know more, they have more knowledge that can be transmitted. And more skilled people are more likely to become innovators. But while the existence of knowledge flows was recognized in early work of Alfred Marshall, their extent remains hard to measure. As Paul Krugman puts it, "knowledge flows are invisible; they leave no paper trail by which they may be measured and tracked."⁴⁷ However, they do actually leave some trails. Knowledge flows are visible in patent data, and more specifically in patent citations, which link the invention to previous patented inventions. Economists have shown that patents are more likely to cite previous patents that are geographically proximate, providing evidence that ideas are often filtered down within cities.⁴⁸ In principle, everyone could just read the patent online, but they seem more likely to know about local inventions, suggesting that in-person interactions are important to innovation.

A number of studies have since provided additional compelling evidence in favor of this view. One study, for example, looked at the effects of the abrupt cancellation of the 2012 American Political Science Association annual meeting due to Hurricane Isaac. This made it possible to compare the extent of new collaboration among those scheduled but unable to attend relative to those who attended the conference in previous years as well as political science conventions that weren't cancelled the same year. Estimating the effect of cancellation on new collaboration, they find that cancelling the conference reduced the probability potential attendees collaborate by 16%. And the strongest effect was among potential collaborators who didn't live in the same place.⁴⁹

⁴⁵ Gårdlund, T (1993), *Misslyckandets genier*, Norstedts, Stockholm.

⁴⁶ Glaeser, E. L., & Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of economic literature*, 47(4), 983-1028.

⁴⁷ Krugman, P. (1991). *Geography and trade*. Cambridge: M.I.T. Press.

⁴⁸ Jaffe, A. B., Trajtenberg, M., & Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics*, 108(3), 577-598.

⁴⁹ Campos, R., Leon, F., & McQuillin, B. (2018). Lost in the storm: the academic collaborations that went missing in Hurricane ISSAC. *The Economic Journal*, 128(610), 995-1018.

Even very short in-person interactions can lead to lasting collaborations

Even very short in-person interactions can lead to lasting collaborations. In a field experiment with attendees of a Harvard Medical School research symposium, researchers were required to participate in a 90-minute brainstorming with other participants. The attendees were randomized into different rooms. Being in the same room, the researchers found, increased the probability that any two attendees submitted a joint grant proposal by 75%.⁵⁰

Innovation clusters benefit from the declining cost of distance because it allows them to reach global markets

In her seminal account of Silicon Valley, AnnaLee Saxenian also observes the importance of in-person interactions for progress and innovation: “In Silicon Valley a myriad of forums bring together individuals from different firms and industries, from public and private sectors, and from financial, educational, and training institutions. These gatherings, both formal and informal, enable individuals — often determined competitors — to discuss common problems, debate solutions, and define the shared identities that enable an industrial community to transcend the interests of independent firms. Only such an industrial community can create and recreate regional advantage in today’s competitive global economy.”⁵¹

So far, innovation clusters like Silicon Valley or Bangalore have greatly benefited from the declining cost of distance because it allows them to reach global markets. A software developed in the Valley can be marketed in Manila. The same highly localized economies of scale have also benefited Wall Street, allowing it to export financial innovations to places like Singapore and Hong Kong. But imagine that a new technology (like telepresence) emerges, which makes in-person interaction obsolete. What will happen?

It is noteworthy that even if telepresence remains an imperfect substitute for face-to-face interactions, there might still be good economic (and environmental) reasons to use it. In Silicon Valley the cost of operating a firm in a tech-hub has increased enormously as the influx of skilled workers has driven up the cost of housing. As *The Economist* recently put it, “The technology industry, which has disrupted nearly all other sectors, is disrupting itself. The communications tools and virtual workplaces that Valley firms have pioneered let teams work productively across cities and time zones without ever meeting one another in person.”⁵²

Studies have found employees who work from home are more productive

Of course, a key concern is that productivity will suffer if more work is done remotely. However, a work from home experiment at Ctrip, a 16,000 employee, NASDAQ-listed Chinese travel agency, suggests the opposite. Call center employees were randomly assigned to either work remotely from home or in the office over a period of 9 months. Working from home, they found, increased performance (calls per minute) by 13 percent: about 9 percent was due to fewer breaks and sick-days and 4 percent could be attributed to a quieter working environment. What’s more, home workers reported improved work satisfaction and the company experienced less turnover as consequence. This astounding success prompted Ctrip to rollout the remote working option for the entire company. Over half of its employees switched, which led to the gains from home work to almost double to 22 percent.

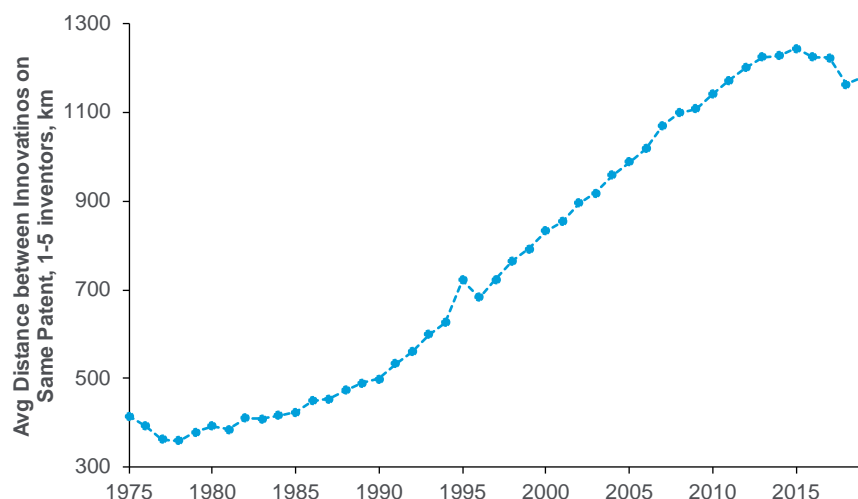
⁵⁰ Boudreau, K. J., Brady, T., Ganguli, I., Gaule, P., Guinan, E., Hollenberg, A., & Lakhani, K. R. (2017). A field experiment on search costs and the formation of scientific collaborations. *Review of Economics and Statistics*, 99(4), 565-576.

⁵¹ Saxenian, A. (1996). *Regional advantage*. Harvard University Press.

⁵² <https://www.economist.com/briefing/2018/09/01/silicon-valley-is-changing-and-its-lead-over-other-tech-hubs-narrowing>

It goes without saying that some activities are better done remotely than others, and running a call center cannot be compared to developing a new software or vaccine. However, as we shall see, since the introduction of the World Wide Web, even innovation is increasingly happening at distance (Figure 11).

Figure 11. Average Distance Between Inventors on the Same Patent (1 to 5 Inventors)



Source: <https://www.patentsview.org/web/#viz/comparisons&cmp=all/state/numDesc/2019>

Innovation and the Internet

The Internet and virtual connectivity led to more collaborative innovations

What happens to innovation when the cost of distance is radically reduced? We can look back to the 1990s, when companies were first connected over the Internet to find some answers. First, the Internet made inventors more aware of other inventors' work. When two companies were connected in cyberspace, patents from inventors in one company were more likely to cite patents by inventors from the other firm. But more importantly, virtual connectivity facilitated more collaborative innovations: inventors in the connected firms were more likely to jointly take out patents. The Internet didn't boost the number of solo-inventors or geographically clustered inventor teams. It facilitated collaboration across locations.⁵³

People who lived in less innovative regions benefited from the Internet

The emergence of the virtual world also led to a slowdown in the concentration of innovation activity. Comparing the growth of regional patenting between 2000 and 2005, to the pre-Internet era of 1990 to 1995, the economists Chris Forman, Avi Goldfarb, and Shane Greenstein show that the Internet served to slow the growing geographic clustering of patenting. Their findings also suggest that people who already lived in innovative places in the 1990s didn't benefit as much from their newly found interconnectedness, probably because they already had access to good collaborators locally. The prime beneficiaries were people in less innovative regions who suddenly gained access to a pool of knowledge workers in other locations.⁵⁴

⁵³ Forman, C., & Zeebroeck, N. V. (2012). From wires to partners: How the Internet has fostered R&D collaborations within firms. *Management science*, 58(8), 1549-1568; Forman, C. C., & van Zeebroeck, N. (2019, October 01). Digital technology adoption and knowledge flows within firms: Can the Internet overcome geographic and technological distance? *Research policy*, 48(8), 1-16.

⁵⁴ Forman, C., Goldfarb, A., & Greenstein, S. (2014). Information technology and the distribution of inventive activity. In *The Changing Frontier: Rethinking Science and Innovation Policy* (pp. 169-196). University of Chicago Press.

However, unconventional ideas and innovations are still more likely to happen in cities

The game changer could be machine learning, which could solve the problem of how to filter ideas down the best ideas from face-to-face interactions and make cities less attractive

Having the tools to sift through all the knowledge on the Internet could lead to even higher productivity

Some cities emerged for the purpose of consumption rather than for production reasons

However, some inventions are more important than others, and the more path-breaking discoveries still happen in cities. As the economists Enrico Berkes and Ruben Gaetani put it, “unconventional ideas are more likely to emerge when people interact in a dense and technologically diverse environment.” To identify unconventional ideas, they study atypical citation patterns. Specifically, they show that while a greater amount of innovation actually happens in suburbs, cities produce far more unconventional innovations. These innovations require a greater diversity of inventors and have a more disruptive economic impact. The creation of unconventional ideas, they argue, requires two innovators from different fields to combine their knowledge. But people from different backgrounds cannot interact in a formal environment, like R&D departments or companies, so they need another channel that only cities provide.⁵⁵

In this light, it looks unlikely that we will ever see the end of cities. But as we have seen, the Internet has already slowed down the concentration of innovation activity and new technologies that substitute for face-to-face interactions are on the horizon. Information technologies, to be sure, have given inventors access to more information and knowledge than they could possibly process, and being around smart people helps filter down the best ideas. But in the future, machine learning might help solve that problem. Indeed, much machine learning comes down to some kind of filtering or matching, whether it is a movie recommendation on Netflix, a book recommendation on Amazon, or an algorithm matching people on a dating app. We might well end up having the perfect dating app for inventors, and with improvements in telepresence, this would be a powerful tool for innovation at distance. Or we may end up having a recommendation engine that flags up key inventions depending on an inventor's interests and field of work. Thus, over time, AI algorithms could partly take over the matching and filtering function of cities.

This would surely give a significant boost to productivity. The Internet has given innovators access to more knowledge than they can process, which might help explain why productivity has so far failed to accelerate despite more and more people having access to the world's knowledge online. What they need now are new tools to pick out the relevant knowledge for their inventive pursuits. AI will eventually provide these tools, and as algorithms get better, innovation and productivity growth will take off.

Consumption Cities

Not all cities are innovation hubs, however. Some cities emerged for the purpose of consumption rather than for production reasons. In its early days, for example, Los Angeles was the place to which prosperous Midwestern retirees came to enjoy the climate. The Social Security Act of 1935 also meant that more citizens who reached retirement age could suddenly enjoy a life of leisure, which caused a massive boom in the American Sun Belt, with the construction of retirement homes, golf courses, and shopping centers, and retirement cities like Sun City, Arizona.

Urban amenities, such as a thriving arts scene, can probably also explain much of the appeal of cities like Berlin. But most evidence shows that consumer amenities are not the primary force driving urban concentration. If agglomeration was primarily driven by amenities, we would expect real wages should be lower in big cities, and this is not the case. The opposite is true.

⁵⁵ Berkes, E., & Gaetani, R. (2019). Income segregation and rise of the knowledge economy. Available at SSRN 3423136.

Following COVID-19, we are likely to see more service automation in restaurants and shops, making face-to-face interactions unnecessary

That said, the wage premium for living in large urban areas has declined overtime, probably because cities have become more pleasant places to live with lower rates of crime and less pollution.⁵⁶

Many of the consumption possibilities that cities offer, however, are increasingly moving online, like music and entertainment. Other services, like Deliveroo, and advances in drone technology, will make it increasingly feasible to substitute a meal at a restaurant for a meal at home. Following the COVID-19 lockdown, and the closure of bars, restaurants, and shops, it doesn't seem far-fetched that we will see more service automation as a consequence, making many face-to-face interactions unnecessary.

Here is one example. When we examined the exposure of service jobs to automaton in a recent study, we asked a group of AI experts to label 70 occupations as either automatable or non-automatable on the basis of the tasks they entail.⁵⁷ This gave us what AI researchers call a training data set. While the task descriptions for each occupation were unique, our database also provided a set of common features. Based on these features, we developed an AI algorithm that was able to learn about the characteristics of automatable occupations, allowing it to predict the exposure to automation of another 632 occupations.

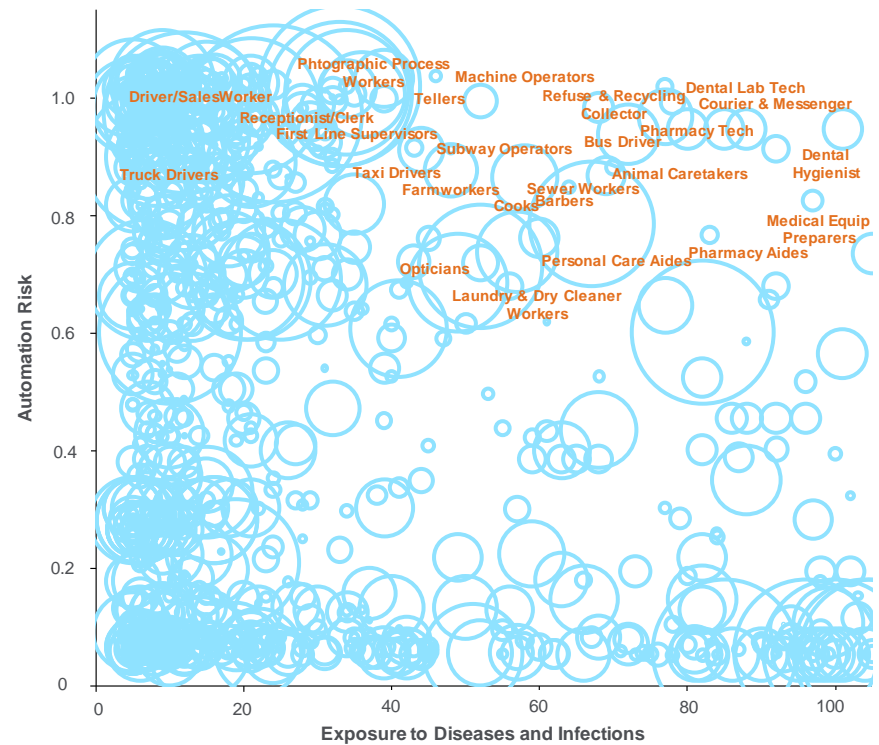
While the AI experts were convinced that the work of waiters and waitresses was non-automatable, our algorithm found that we were wrong. It predicted that waiters are susceptible to automation by analyzing the similarities between the jobs of waiters and other jobs in a more comprehensive manner than any human could. And the prediction turned out to be right. Three years later, in 2016, a new and almost fully automated restaurant chain called Eatsa opened, where customers order their food at an iPad kiosk. They then wait a few minutes in front of a large vending machine that churns out their meal.

So far, few restaurants have adopted self-service technology, probably because most customers prefer human interaction. And to be sure, people will continue to prefer waiters and waitresses to robots in most settings. Still, during shorter lunchbreaks, for example, it is likely that COVID-19 will spur the demand for more automated restaurants along with a host of automated delivery and transportation services. Food safety will probably continue to be on people's minds for some time to come. And many people may want to avoid certain types of in-person interactions. As we will discuss in greater detail in Chapter 5, pandemics have historically reduced trust between people, paving the way for an acceleration of automation. As Figure 12 shows, there are many delivery and in-person service jobs that lend themselves to automation.

⁵⁶ Glaeser, E. L., & Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of Economic Literature*, 47(4), 983-1028.

⁵⁷ 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.

Figure 12. Automation and Disease Exposure of the Workforce, 2019



Source: Own analysis based on 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.

Nobody Lives in Cyberspace

Many services will remain non-automatable, however, and as Mark Lemley notes, “No one is in cyberspace.” Even as more things are moving online, offline options still matter. For example, one study found that when a Walmart or Barnes & Noble opened offline in a city, people tended to substitute away from purchasing books on Amazon.⁵⁸ Thus, offline retail affects online purchasing: online sales at women’s clothing retailers, to take another example, are lower in places with many offline women’s clothing stores.⁵⁹

In other words, digital technologies are not making consumption cities obsolete. The simple reason is that online behavior is social, and social networks tend to be local. Despite the cost of transmitting information across vast distances being almost zero, the vast majority of most people’s email comes from people who work in the same building or live in the same home. In many ways, digital technologies and cities will remain complements.

Digital technologies are not making
consumption cities obsolete

⁵⁸ Forman, C., Ghose, A., & Wiesenfeld, B. (2008). Examining the relationship between reviews and sales: The role of reviewer identity disclosure in electronic markets. *Information systems research*, 19(3), 291-313.

⁵⁹ Brynjolfsson, E., Hu, Y., & Rahman, M. S. (2009). Battle of the retail channels: How product selection and geography drive cross-channel competition. *Management Science*, 55(11), 1755-1765.

For example, a recent study that looked at the online crowdfunding of music found that musicians' early funding typically comes from local supporters who the musicians knew before they joined the crowdfunding platform. However, as a musician gains prominence online, the later funding often comes from strangers at distant locations.⁶⁰

The bottom line is that distance isn't dead, but it matters less than it used to. One study nicely summarizes the matter. Comparing cross-border sales on an online marketplace with other data on international trade, Andreas Lendle and co-authors found that distance does predict both online and offline trade flows. But it matters a lot less on an online marketplace.⁶¹ Looking forward, with telepresence and telerobotic becoming more widespread, this trend is likely to continue in services as well.

⁶⁰ Agrawal, A., Catalini, C., & Goldfarb, A. (2015). Crowdfunding: Geography, social networks, and the timing of investment decisions. *Journal of Economics & Management Strategy*, 24(2), 253-274.

⁶¹ Lendle, A., Olarreaga, M., Schropp, S., & Vézina, P. L. (2016). There goes gravity: eBay and the death of distance. *The Economic Journal*, 126(591), 406-441.

Chapter 4: A Divided World of Remote Work

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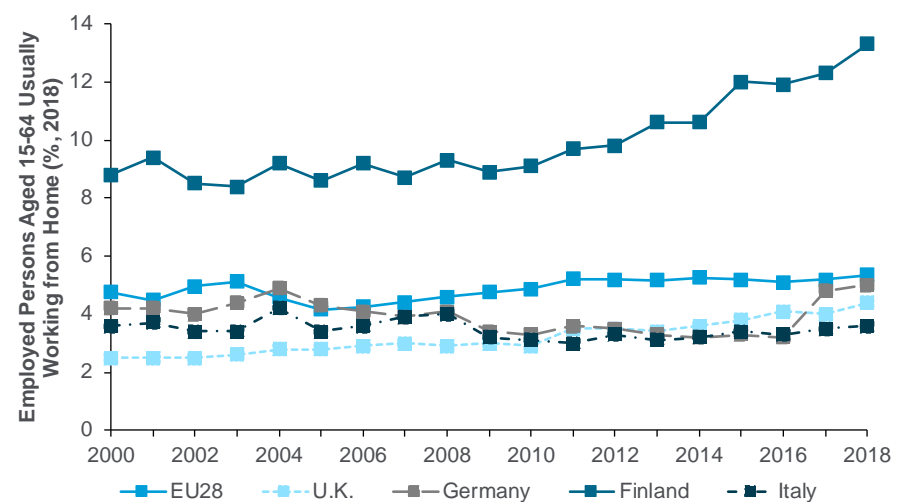
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Remote work has been around for a long time, first being mentioned in the 1970s

The modern era of computing began with the invention of the ENIAC, which was the first electronic computer, developed at the University of Pennsylvania in 1946. The limited communication between computers, however, retrained their effect on the economy. It was only with the ascent of the Internet that low-cost, commercial, computer-to-computer communication became possible at mass scale. Much of it built on key inventions developed through U.S. military funding in the 1960s and 1970s, but it was only when privatization occurred in the 1990s that the Internet gave a significant boost to productivity and changed the working lives of millions of people forever.

Like ICT, remote work is nothing new. The term telework can be traced back to Jack Nilles's 1975 analysis of the expanding information industry in the state of California.⁶² At the time, the main focus was on the use of telecommunications to reduce commuting time, which had become a major issue in large metropolitan areas like Los Angeles. The simple idea was to relocate the workplace away from the premises of the employer to the home, allowing employees to avoid the long hours of commuting and to increase productivity. New technologies, like computers and improved communications technology, Nilles argued, allowed for more decentralization of operations. Beginning in the 1990s, with the spread of the World Wide Web and the Internet, electronic mail and teleconferences increasingly made his vision feasible. And eventually, smaller and lighter wireless devices, like laptops, iPads, and smartphones enabled people to work not just from home, but from just about anywhere. But as shown in Figure 13, remote work has not really taken off in Europe as a whole, although some countries, like Finland, have seen rapid growth in the number of employees working from home.

Figure 13. Percentage of Workforce that Works from Home in Europe, 1990-2018



Source: Eurostat

⁶² Nilles, J. (1975). Telecommunications and organizational decentralization. IEEE Transactions on Communications, 23(10), 1142-1147.

It has gained traction lately through a combination of 'technology pull' and 'economic push' as companies realize ensuring continuity when disaster strikes is a key to success

The forced nature of remote working during the current pandemic could prompt some businesses to find more productive ways to operate

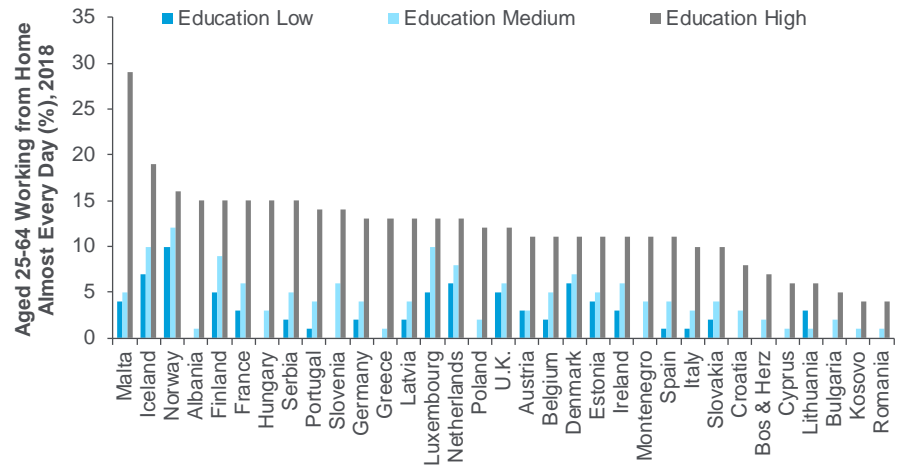
What's different this time around? As we have seen, technologies like telepresence and telerobotics mean more and more jobs can be done remotely. However, the potential scope for remote work has steadily expanded since the 1970s. In other words, a "technological pull" towards telecommuting has existed for some time. The key difference this time around is that an economic push also looks more imminent. Companies have belatedly begun to realize that in order to become more resilient to events like COVID-19, they must have structures in place that allow the company to operate even when people are unable to gather at the office. The success of companies, it is now widely understood, goes not just to those who can reduce costs, attract talent, and develop great products, but also those that can ensure continuity when disaster strikes.

On the one hand, firms are now all too well aware of the disruptive effects a pandemic can have, and they will want to be ready for the next one. Resilience to such shocks will require managers to think through how their company can switch to telework in a time of crisis in a more frictionless manner. But it is also likely telecommuting is going to become more prominent permanently. As already noted, during the strike at the London Underground in 2014, people were forced to find new routes to work. And such forced experimentation led to some people finding better routes to which they stuck, leading to significant long-run benefits. In similar fashion, forced experimentation with telecommuting could prompt some businesses to find more productive ways of doing things.

The Geography of Telecommuting

The shift towards telework, however, won't happen uniformly across nations. As shown in Figure 14, large differences across countries already exist. This is in part due to patterns of sectoral specialization. Countries specialized in activities that are not yet technically or physically possible to do at distance will naturally have fewer people engaged in telecommuting, *ceteris paribus*. The jobs which cannot be performed remotely broadly fall into one of two categories. In some jobs, the worker needs to be at a specific work location to be able to perform it. For example, child care workers, dentists, and hairdressers are jobs that cannot be done from a remote location. They provide in-person services. Other jobs that are hard to do remotely are those where the worker has to be physically close to his or her work unit. Factory workers, for example, must work from the factory, regardless of where that factory is, while a proofreader or editor can work virtually anywhere. An editor does not have to work from the publisher's offices or printing plant.

Figure 14. Remote Work by Skill Group in Europe, 2018



Source: Eurostat

Indeed, telework is rare in sectors which require the employee to work at a fixed location in order to perform job-related tasks, like assembly and other production tasks in manufacturing. Sectors with greater ICT dependence and where the key tools used are portable, show a larger incidence. Data for the Netherlands, where remote work is most common, shows telework is most prevalent in information and communication (42%), financial and insurance activities (36%) as well as professional, scientific and technical activities (28%).⁶³ Thus, unsurprisingly, skilled jobs that require higher levels of education are more likely to be done remotely. As Figure 14 makes clear, in every country remote work is more common in skilled occupations.

Digital Infrastructure

Digital infrastructure is key in facilitating remote work

Besides having a skilled workforce, the availability of critical digital infrastructure plays a key role in facilitating remote work. A 2015 survey among 1,027 teleworkers in Sweden found technical problems are among the main barriers for telecommuting. Asked if they had encountered any obstacles while working remotely, 63% said that they had encountered difficulties accessing their company's IT system and 56% reported problems when participating in virtual meetings.⁶⁴ Such problems will make employers reluctant to adopt telecommuting in their own companies. A study among employers in Belgium found that a majority of employers feared facing higher costs associated with improved ICT infrastructure, but also the loss of managerial control resulting from remote work. These concerns, they found, were particularly widespread among small & medium enterprises (SMEs).⁶⁵

⁶³ See Gschwind, L., & Vargas, O. (2019). Telework and its effects in Europe. In Telework in the 21st Century. Edward Elgar Publishing.

⁶⁴ See *ibid.*

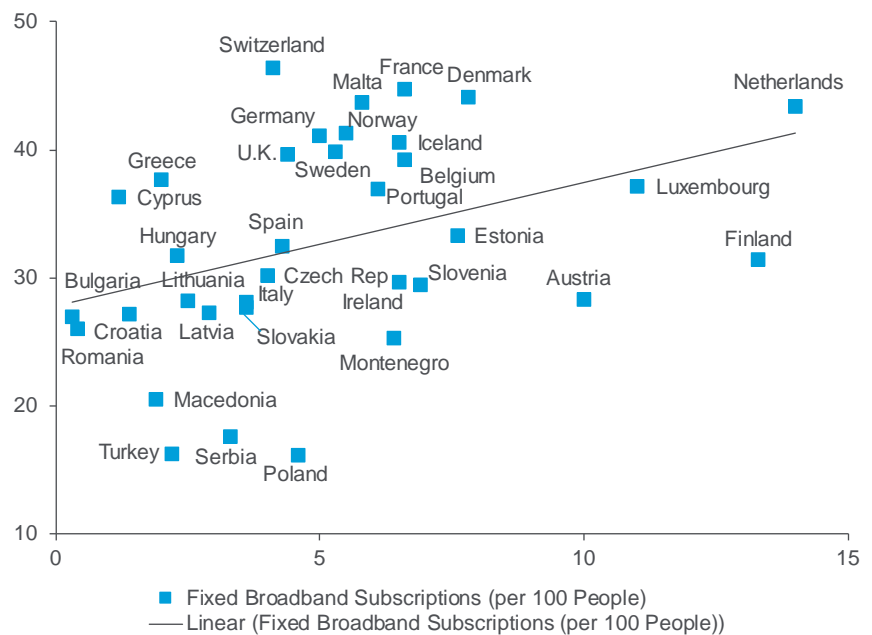
⁶⁵ Walrave, M., & De Bie, M. (2005). Teleworking@ home or close to home. Attitudes towards and experiences with teleworking. Survey in Flanders, The Netherlands, Italy, Ireland & Greece.

The shift to remote work during the COVID-19 outbreak led to new heights of Internet use

Digital infrastructure greatly matters, especially when many companies switch to remote work at the same time, which we saw recently. The digital infrastructure of all countries is generally accustomed to peak activity at specific times of the day, like in the evening when people get home from work. So the massive shift to remote work during the COVID-19 outbreak naturally led to new heights of Internet use and congestion.

What's more, most citizens have broadband plans with much lower capacity than they have at work, so when many people use a single Wi-Fi network to stream movies and do video conferencing at the same time, the result can be slowness. As The New York Times reported on March 16: "Use of bandwidth-hogging apps and games has already shot up in places where the coronavirus has taken hold. In Italy, housebound youngsters playing PC games in large part pushed up Internet traffic over one local landline network, Telecom Italia SpA, more than 90 percent compared with traffic in February, said Francesca Valagussa, a company spokeswoman. And in parts of Europe last week, traffic to WebEx, a videoconferencing service run by Cisco, soared as much as 80 percent, the company said."⁶⁶

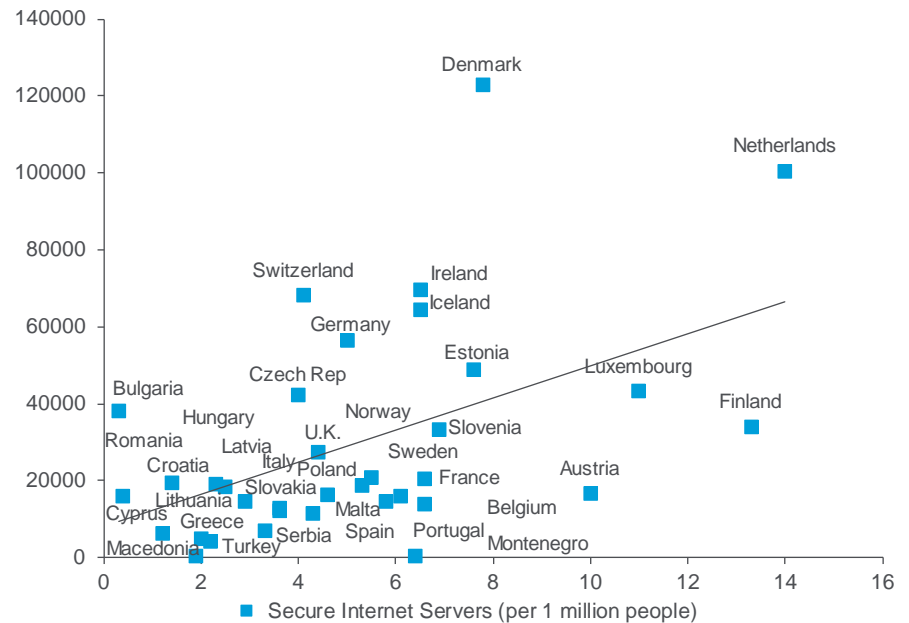
Figure 15. Remote Work Share and Fixed Broadband Subscriptions in Europe, 2018



Source: Eurostat

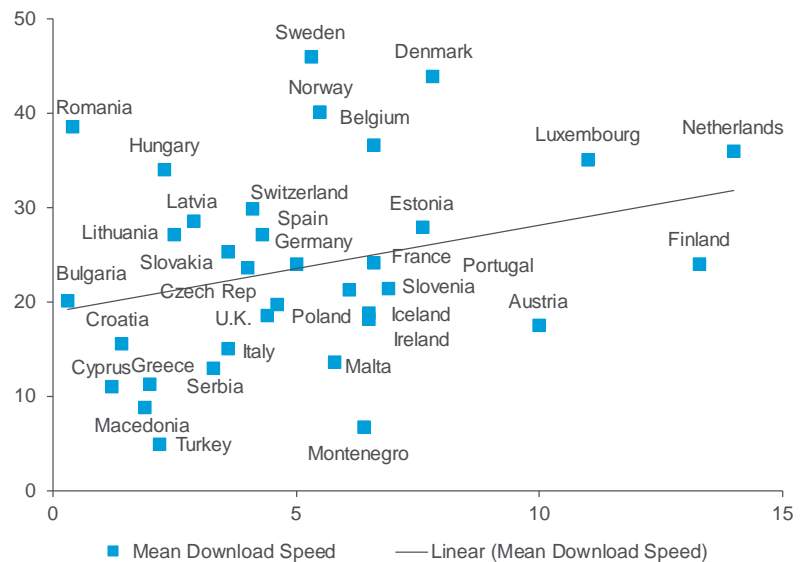
⁶⁶ <https://www.nytimes.com/2020/03/16/technology/coronavirus-working-from-home-internet.html>

Figure 16. Remote Work Share and Secure Internet Servers in Europe, 2018



Source: Eurostat

Figure 17. Remote Work Share and Broadband Speed in Europe, 2018



Source: Eurostat

There is a strong correlation between the readiness of a countries' digital infrastructure and the share of its population engaged in remote work

The experiences of companies during the pandemic will differ across countries depending on the available infrastructure on the national level. And this experience is likely to shape their willingness to adopt remote work policies more broadly going forward. As shown in Figure 15, there is a strong correlation between the readiness of countries' digital infrastructure and the share of its population engaged in remote work.

Whether we look at average broadband speed, the fixed number of broadband subscriptions by 100 people, or the number of secure internet servers per million people, the pattern is the same. Countries with better digital infrastructure have more people working from home.

Policy and Regulation

Regulations, like HIPAA in the U.S., has hindered expansion of some telework

Policy and regulatory barriers will also affect how rapidly companies in different countries switch to more flexible work models. One reason the promise of telemedicine has failed to materialize in the U.S., for example, is the Health Insurance Portability and Accountability Act (HIPAA), which was passed in 1996 and designed to provide patients with stronger privacy protections. It was implemented in the early days of the Web and well before the rapid growth of smartphones, video conferencing, and real-time messaging. Many of the most widely-used communication tools today, are not HIPAA-compliant, meaning citizens are unable to use many apps and services to get the care they need. But change might be underway. The U.S. Department of Health & Human Services (HHS) recently announced a “notice of enforcement discretion” for health care professionals who use digital technologies that aren’t compliant with HIPAA, allowing them to use FaceTime, Google Hangouts, Skype, etc. to speak to patients and assess symptoms. While it has taken a pandemic for this to happen, Congress could take steps to permanently boost telemedicine if the experiment is successful. This would be particularly important to the wellbeing of rural patients with limited access to nearby health care facilities.⁶⁷

In other domains, however, the U.S. government has been more willing to promote remote work well before COVID-19. In 1999, the 106th Congress passed the National Telecommuting and Air Quality Act, which aimed at encouraging the use of telecommuting in order to reduce emissions and air pollution, and established a pilot emission credit trading programs in five large metropolitan areas (Washington D.C., Los Angeles, Philadelphia, Houston, and Denver). Since then, telecommuting programs have been adopted by more employers, and policies encouraging such programs have been put in place at the local as well as the federal levels.

Regulatory barriers to workplace flexibility vary across countries and regions

Meanwhile, in Europe, comparative studies on regulatory barriers to workplace flexibility reveal a split across the continent. As a recent report by the International Labor Organization (ILO) aptly summarizes: “The Nordic countries, Sweden and Denmark in particular, are found to combine generous social security for parents and the elderly with a regulatory framework and working culture that allows for flexible coordination between paid work and private life. Southern and Eastern European countries, such as Greece, Italy, Portugal, Spain and the Czech Republic, Hungary, Poland and Slovakia are characterized by a lower level of formal flexibility and an emphasis on presenteeism. Central European countries, most prominently Germany, fall in between those two poles.”⁶⁸

Patterns of telework, in other words, are highly intertwined with many contextual political and regulatory factors. The U.K., for example, has moved to promote telework more broadly. Since 2014, all U.K. employees have the right to request flexible working arrangements (including working from home), subject to a qualification period of two years.

⁶⁷ <https://thehill.com/opinion/technology/489075-how-to-unlock-telemedicine-on-such-a-large-scale>

⁶⁸ Gschwind, L., & Vargas, O. (2019). Telework and its effects in Europe. In Telework in the 21st Century. Edward Elgar Publishing.

Before 2014, this right was only available to carers, like the parents of young children. That said, employers aren't obliged to accept requests for flexible working, but they are required to give due consideration to requests for flexible work made by their employees.

Article 3 of the European Framework Agreement on Telework of 2002 also makes clear that the employees and the employer can only introduce telework by mutual agreement. In other words, on the European level, there is no right to telework and there is no obligation to do telework. Unless telework is part of the initial job description, the worker may accept or refuse any remote working offer made by the employer. Conversely, if an employee wishes to opt for telecommuting, the employer has the right to accept or refuse this request.

Finland has the second highest share of remote work after being promoted through several government programs starting in 2006

Some countries, however, have made a stronger push towards telework than others. In Finland, which has the second highest share of remote work in Europe, it has been high on the national agenda for quite some time, and is actively promoted through several government programs. In 2006, when the Finnish government made the decision to promote telework, the key objectives was to “improve the quality of working life, increase productivity and promote ecological and sustainable ways of working.”⁶⁹ An employer guide for telecommuting was published the next year by the Finnish Ministry of Employment, to help businesses achieve these goals.

Culture and Norms

The role of culture in shaping economic outcomes has received growing attention in recent years. By culture, we mean “those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation.”⁷⁰ Culture, it is true, has many dimensions, but one that has received much attention among economists is trust. The reason is simple. As the Nobel laureate Kenneth Arrow once noted, “Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time.”⁷¹

Trust is an important element of remote working

In the context of remote working arrangement, trust is particularly important since it is harder for the employer to monitor production at distance. But as Adam Henderson of Millennial Mindset aptly puts it, “If you can't trust your employees to work flexibly, why hire them in the first place?” At the same time, it must be recognized that levels of trust between people will vary both within and across companies. There is even a significant variation in levels of trust across countries. To measure trust, we use the World Value Survey (WVS), which asks questions like: “Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?” Figure 18 plots their answers against the share of the working population who work remotely, showing that telecommuting is much more common in countries reporting higher levels of trust.

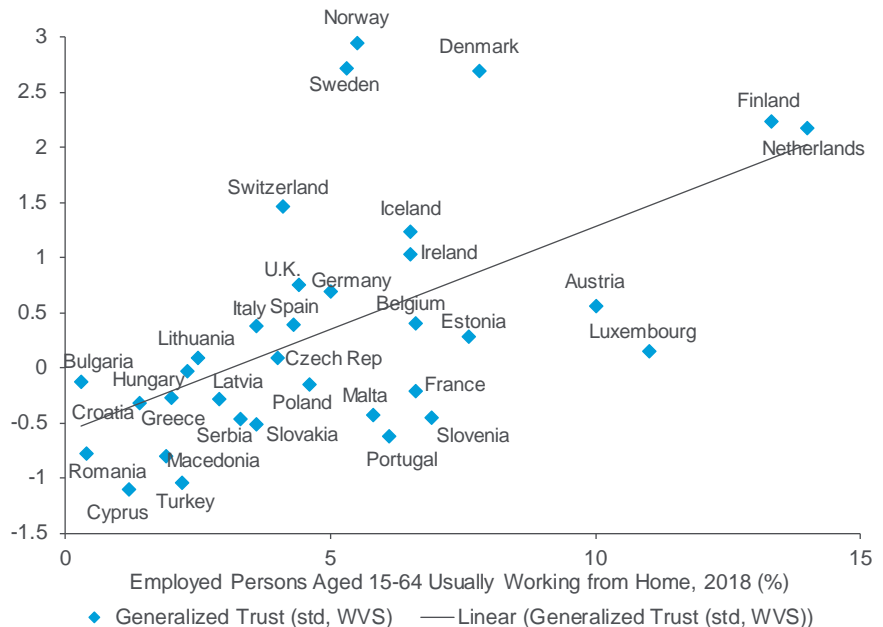
⁶⁹ Ibid.

⁷⁰ Guiso, L., Sapienza, P., & Zingales, L. (2006). Does culture affect economic outcomes?. *Journal of Economic Perspectives*, 20(2), 23-48.

⁷¹ Arrow, K., 1972, Gifts and Exchanges, *Philosophy and Public Affairs*, (1), 343-362.

While such correlations shall not be taken as causal evidence, academic studies have provided suggestive evidence of a causal impact of trust on entrepreneurship, among other things. And culture tends to be highly persistent, leaving countries with low levels of trust at a significant disadvantage over the medium term.⁷²

Figure 18. Remote Work Share and Reported Levels of Trust in Europe, 2018



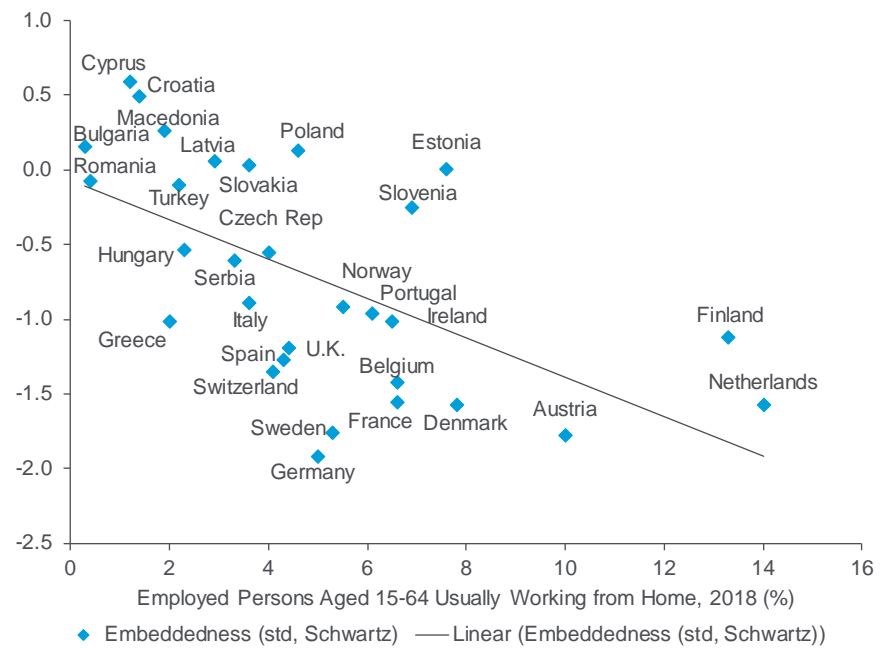
Source: Eurostat, World Value Survey

Countries with more embedded culture report much lower levels of remote work

Other dimensions of culture are likely to matter, too. For example, the social psychologist Shalom H. Schwartz has argued that people's embeddedness (in terms of their focus on sustaining the social order, avoiding change, and retaining tradition) differs significantly across countries. Embeddedness cultures value tradition, security, and obedience. People in such cultures are living or working more closely with others and conformance with group norms is regarded as highly important. This is likely to contribute to lower demand for flexible work arrangements. Figure 19 shows that such a link exists: countries with a more embedded culture report much lower levels of remote work.

⁷² In a different context, Nathan Nunn and Leonard Wantchekon have shown that large that current differences in trust levels within Africa can be traced back to the transatlantic and Indian Ocean slave trades. People whose ancestors were heavily raided during the slave trade, they find, are more mistrusting today

Figure 19. Remote Work Share and Reported Levels of Embeddedness in Europe, 2018



Source: Eurostat, World Value Survey

Pandemics affect social trust and COVID-19 could reduce social trust in place severely affected by the virus

Looking forward, it is also possible that COVID-19 will reduce social trust in places that were severely affected by it, which might serve to counteract a shift towards remote work. Indeed, a recent study found that the 1918 influenza pandemic had a larger negative impact on trust where mortality rates were higher. "An increase in influenza mortality of one death per thousand resulted in a 1.4 percentage point decrease in trust."⁷³ And because trust is essential to economic growth more broadly, it could also have long-lasting economic consequences, well beyond inhibiting a shift towards more widespread telecommuting.

⁷³ Aassve, A., Alfani, G., Gandolfi, F., & Moglie, M. L. (2020). Epidemics and Trust: The Case of the Spanish Flu (No. 661).

Chapter 5: COVID-19, Remote Work, and Inequality

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Our analysis found 113 occupations which can be performed at a distance, employing 52% of the U.S. workforce

In *The Great Leveller*, the historian Walter Scheidel argues the historical trend has always been towards rising economic inequality.⁷⁴ The only events which have reduced inequality, he suggests, are the four horsemen of catastrophe — war, revolution, plague, and famine. COVID-19 will surely have reduced inequality in the short-run. Because assets are disproportionately owned by the wealthy, they take more of a hit when markets plummet. But the labor market is a different story. Because the Black Death carried away 40% percent of Europe's population, it increased the bargaining power of the survivors, which led to the abolishment of serfdom and rising wages in the West. Mercifully, however, COVID-19 is not as deadly, so a similar levelling is not expected. What's more, the income from jobs that can be performed at distance is relatively shielded from social distancing and lockdown, and these jobs are typically high-paying ones. As we shall see, COVID-19 has created a wedge between high-paying jobs, which can be done remotely, and the rest, exacerbating already existing income disparities in the labor market.

How Many Jobs Can Be Performed Remotely?

To assess whether a job can be one remotely, Jonathan Dingel and Brent Neiman used responses to two Occupational Information Network (O*NET) surveys covering “work context” and “generalized work activities.” For example, if an occupation requires daily “work outdoors”, a job was deemed to be hard to do remotely.⁷⁵ Instead, we take a more straightforward approach, using the American Time Use Survey, which asks people if they actually work from home across 483 occupations. We identified occupations that can be done remotely as those having some respondents reporting that they already work from home 3 days or more per week. This left us with 113 occupations which can be performed at distance, employing 52% of the U.S. workforce (Figure 20). We call this the “remote work possibilities frontier” to emphasize that this figure is an upper limit on the number of jobs that can be done remotely with state-of-the-art technology. We also emphasize that this number will grow as telepresence and telerobotics becomes more pervasive.

⁷⁴ Scheidel, W. (2018). *The great leveler: Violence and the history of inequality from the stone age to the twenty-first century*. Princeton University Press.

⁷⁵ Dingel, J and B Neiman (2020), “How Many Jobs Can be Done at Home?”, Covid Economics: Vetted and Real-Time Papers 1: 16-24.

Figure 20. Twenty Jobs that Can Be Done Remotely

Rank	Occupation	Rank	Occupations
1	Statisticians	11	Insurance claims & policy processing clerks
2	Training & development specialists	12	Medical records & health information technicians
3	Business operations specialists, all other	13	Software developers: applications & systems software
4	Miscellaneous community & social service specialists, including health educators & community health workers	14	Postsecondary teachers
5	Editors	15	Computer programmers
6	Architectural & engineering managers	16	Musicians, singers, & related workers
7	Urban & regional planners	17	Sales representatives, services, all other
8	Real estate brokers & sales agents	18	Appraisers & assessors of real estate
9	Miscellaneous legal support workers	19	Other teachers & instructors
10	Claims adjusters, appraisers, examiners, & investigators	20	Word processors & typists

Source: American Time Use Survey

Knowing which jobs can be done remotely provides an indication of the resilience of a country's workforce during a lockdown

However, because a job can be done remotely, does by no means imply that it should be done remotely during normal times. As we have seen, for some activities, in-person interaction is still more productive. Nonetheless, having an idea about what percentage of jobs can be done remotely is helpful, because it provides an indication of the resilience of a country's workforce to policies like social distancing and lockdown. What's more, knowing what jobs that can be done remotely helps prioritizing when public transportation is overcrowded. Indeed, even since the lockdown in the U.K., pictures have regularly emerged showing workers in London crowding into Tube carriages, leading Health Secretary Matt Hancock to urge people to "Only go to your job if you cannot work from home."⁷⁶

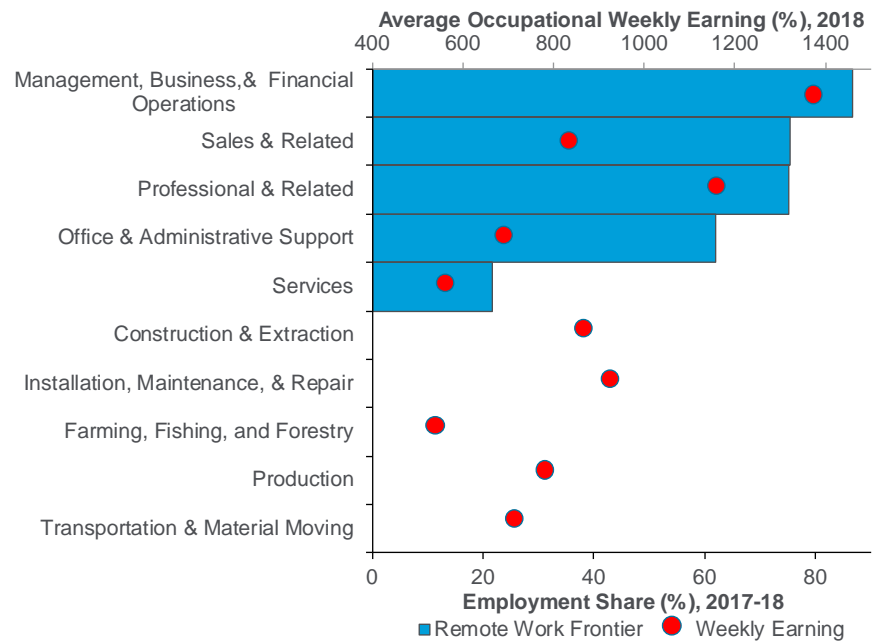
Inequality and Remote Work

Low income jobs tend to be in-person and are more affected in a time of social distancing than high income jobs, which more likely can be done remotely

Figure 21 and Figure 22 show the percentage of work that can be done at distance by major occupational categories and industries. They reveal a noteworthy pattern: at a time of social distancing, like the one we are experiencing now, high income workers will be less affected as they can continue to work remotely. The jobs of waiters, receptionists, hairdressers, fitness trainers, and other in-person type of services, which tend to be less well paid, will be more adversely affected. People in these jobs are more likely to suffer significant income losses due to social distancing policies, or will find themselves more exposed to the virus, putting their own lives and family at risk. The highest percentage of jobs that can be performed remotely relate to management, business, and financial operations, which also report the highest earnings. Looking at industries, we find that over 80% of finance jobs, and over 60% of jobs in information, education, and professional and business services, can be done remotely. These findings also speak to recent events: as already noted, Big Tech and large banks were among the first to make remote work optional or even mandatory as the spread of the virus accelerated in Europe and the United States.

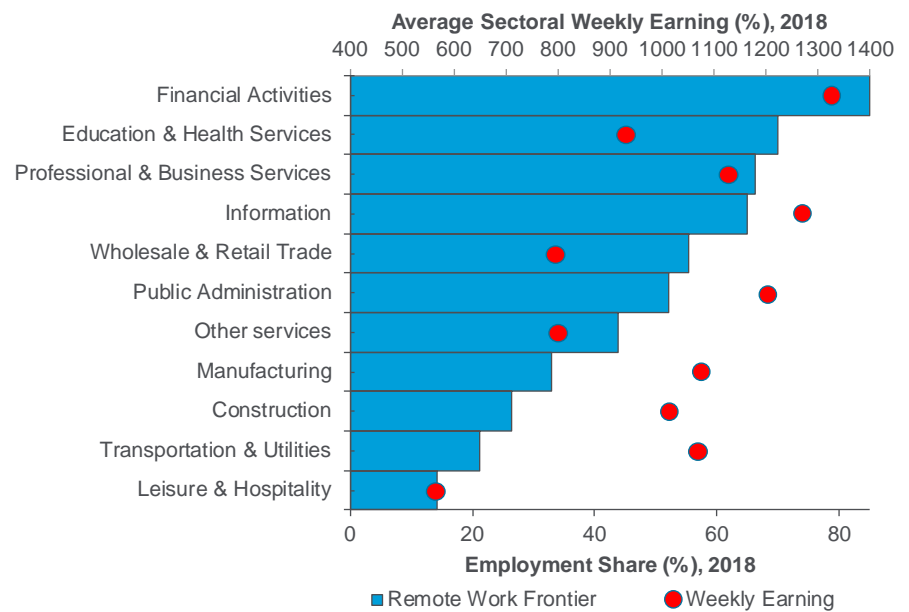
⁷⁶ <https://www.bbc.co.uk/news/uk-52022417>

Figure 21. Percentage of Jobs that Can Be Performed Remotely by Occupational Category



Source: American Time Use Survey

Figure 22. Percentage of Jobs that Can Be Performed Remotely by Industry



Source: American Time Use Survey

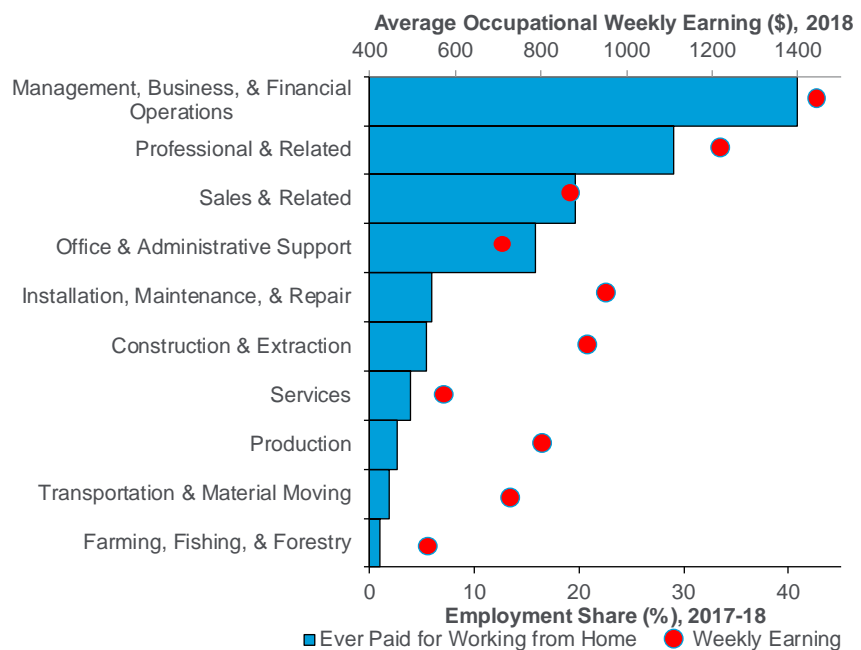
40% of workers in management, business and finance operations reported having worked from home, compared to less than 4% in transportation, material moving and production

These findings mirror an extensive literature on skill-biased technological change, showing that advances in technology have favored skilled workers.

Figure 23 Figure 24 show the percentage of workers who report they had been paid to work from home in 2017-2018, before COVID-19 struck. These workers, it must be emphasized, had only worked at home at some point during the year. Reassuringly, the overall pattern looks similar to our analysis of the “remote work possibilities frontier” in Figure 21 and Figure 22. A staggering 40% of workers in management, business and finance operations reported having worked from home, compared to less than 4% in transportation, material moving and production. Across industries, leisure activities and hospitality reported the lowest percentage of employees working from home.

These findings mirror an extensive literature on skill-biased technological change, showing that advances in technology throughout the twentieth century have favored skilled workers. This process has seemingly accelerated since the ICT revolution of the 1980s and 1990s, and is reflected in the rapid relative wage increases among individuals with a college degree across OECD countries. In the context of the Internet, there is also compelling evidence that broadband diffusion disproportionately benefited skilled workers.⁷⁷ These workers, we find, are also less exposed when pandemics strike.

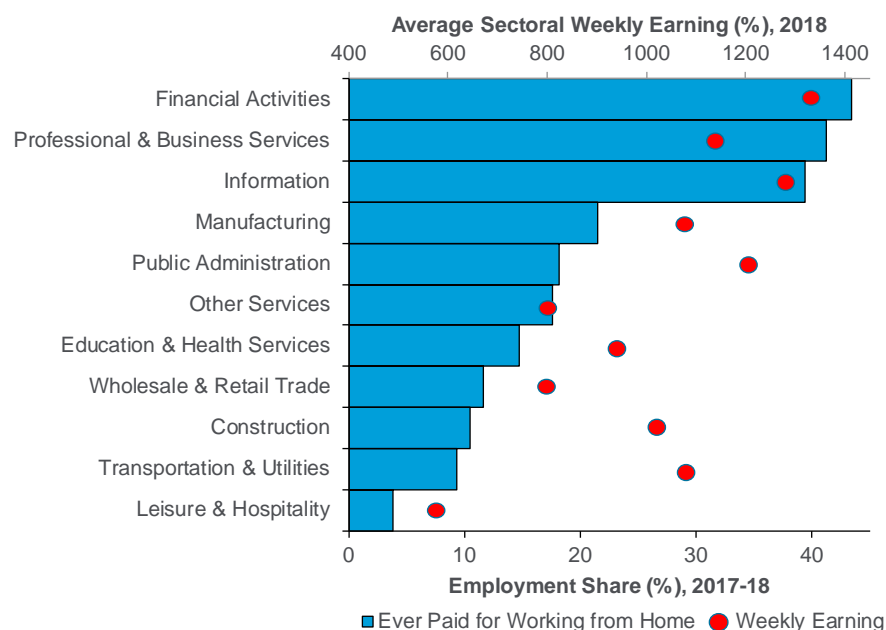
Figure 23. Percentage of People Reporting to Have Worked at Home by Occupational Category



Source: American Time Use Survey

⁷⁷ Akerman, A., Gaarder, I., & Mogstad, M. (2015). The skill complementarity of broadband internet. *The Quarterly Journal of Economics*, 130(4), 1781-1824.

Figure 24. Percentage of People Reporting to Have Worked at Home by Industry



Source: American Time Use Survey

Our findings are also similar to those of the Resolution Foundation. In the British context, they estimate that sectors already heavily affected by the pandemic have typical weekly pay of £320, relative to £455 for the economy as a whole. These include retail, hotels and restaurants, airlines, travel operators, cleaning, arts and entertainment, as well as personal services like hairdressing. They also find that people in the most at-risk sectors in Britain have less to fall back on, “being around 25 per cent more likely than average to live in families with no savings at all.”⁷⁸

Remote Work and Regional Polarization

There is a strong link between the share of jobs which can be done remotely and the average income across U.S. cities

Finally, and unsurprisingly, we note that there is a strong link between the share of jobs which can be done remotely and average income across U.S. cities (Figure 25). High-income cities like San Francisco also have among the highest share of jobs which can be done remotely. More broadly, the income of people in wealthy coastal areas is relatively protected as more jobs in those places can continue to be performed during a pandemic. What’s more, as the Brookings Institution notes, “Because broadband infrastructure can be both expensive and technically challenging in rural areas, residents suffer the consequences of being digitally invisible in the information economy.”⁷⁹

A digital divide between urban and rural will also likely exacerbate already growing regional inequality

This digital divide will exacerbate already growing regional inequality. Indeed, the past three decades have already been characterized by departure from the general pattern of regional convergence: for most of the 1900s places with lower incomes were catching up with richer ones.

⁷⁸ Resolution Foundation (2020). Doing what it takes: Protecting firms and families from the economic impact of coronavirus. March, 2020.

⁷⁹ Turne-Lee, N. (2020). From Rural Digital Divides to Local Solutions. Brookings Institution. <https://www.brookings.edu/longform/from-rural-digital-divides-to-local-solutions/>

As Robert Barro and Xavier Sala-i-Martin famously showed there was speedy income convergence across American regions over the century preceding the computer age. But in a paper titled “Why Has Regional Income Convergence in the U.S. Declined?,” the Harvard University economists Peter Ganong and Daniel Shoag argue that historically, this pattern broke down in the 1980s. Computer-related jobs clustering in skilled cities in combination with stricter land-use regulations seems to have disrupted the convergence trend.

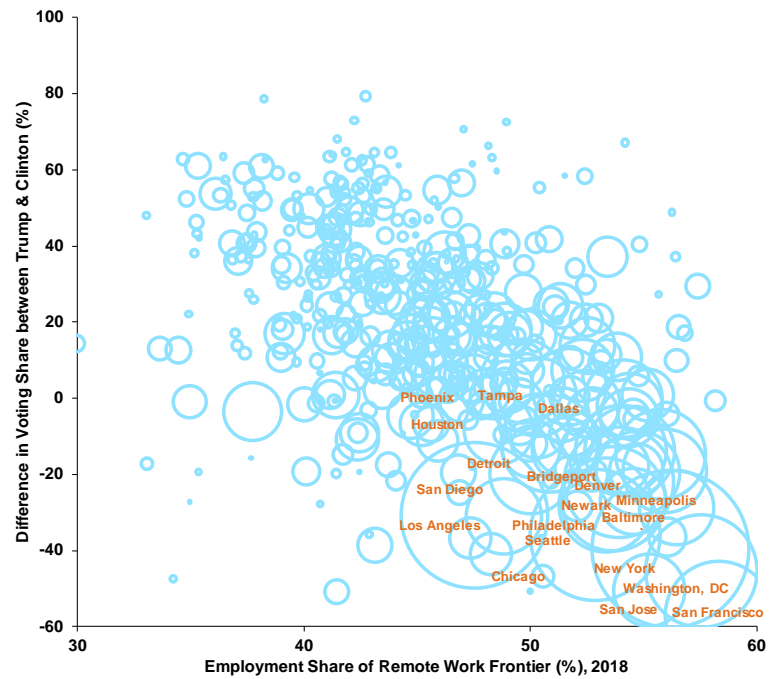
As shown in Figure 25, COVID-19 is set to accelerate regional income disparities. And with the U.S. Presidential election coming up on November 3, 2020, it is noteworthy that the places where President Donald Trump has his electoral base rank relatively low in jobs that can be done remotely. Cities where more people voted for Trump relative to Hillary Clinton (Figure 26) as well as where Trump made the largest gains relative to Mitt Romney’s result in 2012 (Figure 27), are more exposed to the restrictions on movement and travel to curb the spread of the virus. This might also explain why Trump is particularly keen for the lockdown to come to an end.

Figure 25. Percentage of Jobs that Can Be Performed Remotely and Average Income Across U.S. Cities



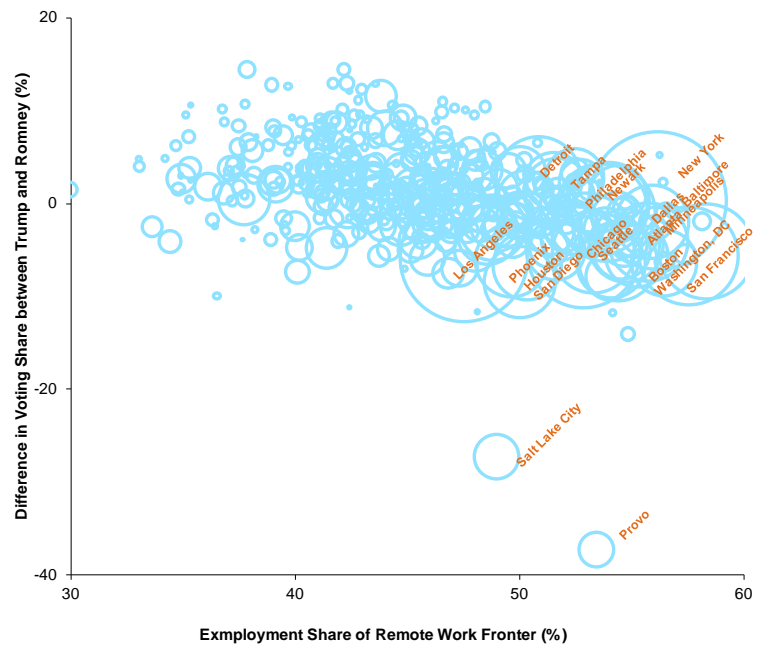
Source: American Time Use Survey

Figure 26. Percentage of Jobs that Can Be Performed Remotely and the Trump-Clinton Vote Share Difference Across U.S. Cities



Source: American Time Use Survey

Figure 27. Percentage of Jobs that Can Be Performed Remotely and the Trump-Romney Vote Share Difference Across U.S. Cities



Source: American Time Use Survey

Chapter 6: Educational Services

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Europe Media & Education Team

Post the pandemic, all educational institutions are looking to shore up their technology offerings and there is a positive acceleration in perception of edtech

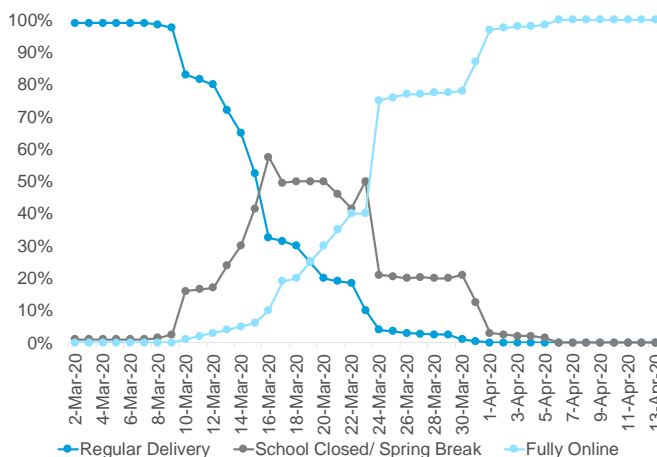
The previous chapters have focused on telework, but a similar sizeable shift could take place within education. Education technology (edtech) can improve education's stagnant productivity, personalize outcomes, and lower cost. While greater investment will aid innovation, the pandemic is forcing mass adoption of technology solutions that already exist today.

The pandemic and an economic downturn will have wide-ranging implications for the educational services industry. While we don't believe current events will structurally impair the value proposition offered by quality on-campus university education, with an uncertain timeline for reopenings, there are likely to be calls for tuition discounts/waivers. Managing liquidity will be key in the near term and current events may well prove to be an existential crisis for some institutions.

Within these constraints we believe all educational institutions are looking to shore up their technology offerings, with a key focus on student engagement in the near term and over the longer term, as a solution to persistent issues such as improving productivity and outcomes. This is all likely to accelerate the change in how the industry perceives spend on edtech resources, for the better.

In our most recent Citi GPS report [Education: Power to the People](#), we highlighted seven areas of focus for investors in Educational Services. They included (1) Private K-12; (2) Supplemental Services in Emerging Markets; (3) Higher Education Infrastructure in China; (4) University Services; (5) English Language Learning in China; (6) Edtech; and (7) Professional Training. We believe current events reinforce the importance of some of these themes including University Services and Edtech.

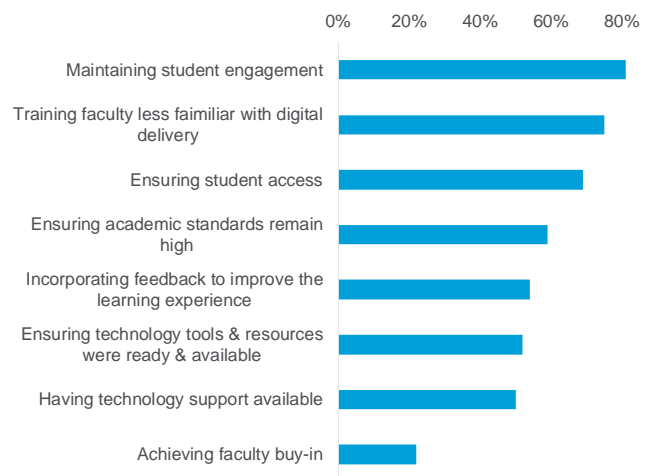
Figure 28. Percent of U.S. Higher Education Using Full Online Delivery of Education During COVID-19



Source: Philonedtech, Listedtech, bryanalexander.org, Ithaka S+R, Entangled Solutions

Most universities have shifted to online settings and student engagement is their biggest challenge

Figure 29. Key Challenges Associated With Moving to an Online Setting for Higher Education



Source: Inside Higher Ed; Survey of c.170 US University administrators

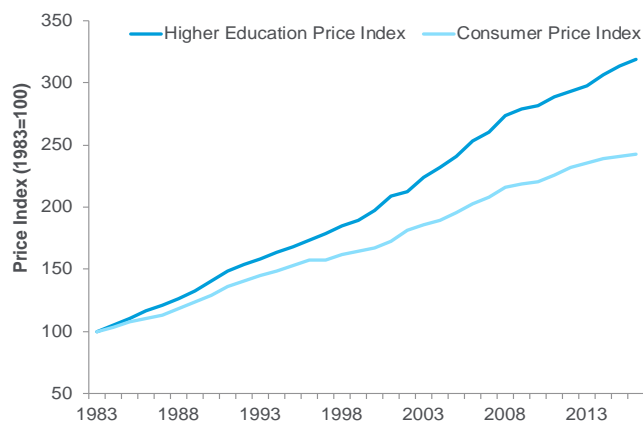
A representative sample of 1,000 U.S. universities suggests all institutions have transferred their operations to an exclusively online setting (Figure 28). Many K-12 schools are also engaging with students online in some capacity for some duration. However, most of these university online engagements are stop gap measures designed to tide over the pandemic for a few months.

If classes need to be conducted online for the fall semester and beyond, a decision universities will have to take in early summer, simple virtual online lectures are unlikely to suffice and could lead to demands for tuition discounts or even complete waivers. Student engagement is the biggest challenge educational institutions, particularly universities, are facing in an online setting (Figure 29).

We expect strong enquiries for online tools such as OPM, LMS, digital courseware, and self-learning online aids

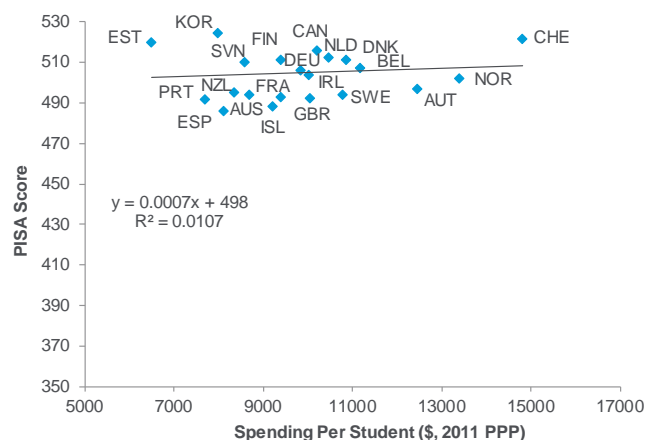
In the near term, as institutions plan for the fall semester, we expect strong enquiries for online tools such as online program management (OPM), digital courseware, self-learning online aids (math and language learning), and learning management systems (LMS). Even before the pandemic, edtech has been suggested as a panacea for the education industry's legacy issues around stagnant productivity (universities) and outcomes (both universities and K-12). However a combination of budgetary constraints and general inertia (lack of training, time etc.) has resulted in limited take up of edtech.

Figure 30. The Core Aspects of Higher Education Have Not Innovated, Resulting in Limited Productivity and Above-Average Cost Inflation



Source: Commonfund Higher Education Price Index (2016)Citi Research

Figure 31. K-12 Outcomes Have Stagnated in the Highest Spending Countries



Source: OECD Education at a Glance (2016), OECD PISA Scores, Results in Focus (2016), World Bank (2016),Citi Research

A Hybrid Model

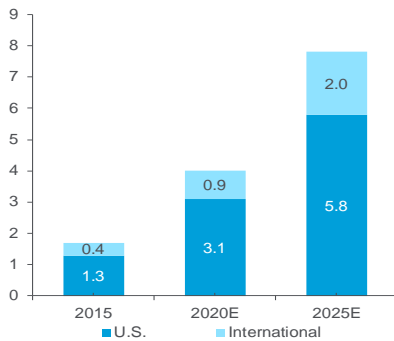
We suspect time attitudes toward edtech might be different then pre-COVID-19

While budgetary issues are, if anything, more acute now, we suspect this time attitudes towards edtech might be different. For example, building out technological resilience and redundancy will be seen as critical now. In the current circumstances, given the amount of time administrators and faculty have been forced to invest in thinking about integrating online learning into their pedagogy, there might be a greater appetite for adopting edtech resources in order to deliver a more engaging and personalized learning experience.

Early indications for the fall 2020 semester suggest a hybrid model of online and in-person instruction is being adopted

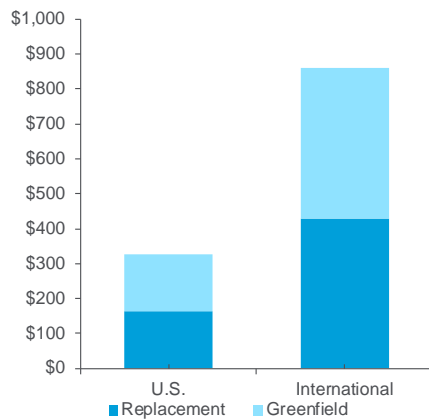
Early indications for the fall 2020 semester suggest a hybrid model. Purdue University for example will reopen its campus, but class sizes will be reduced through the use of online instruction and virtualization of laboratories. California State University is planning a virtual fall 2020 with limited exceptions for in-class teaching. We believe some of this hybridization will continue in the post-COVID-19 world in the form of flipped classrooms (assigned reading and listen/view online lectures at home, concept engagement in the classroom), virtual labs and field trips using immersive tech, greater engagement through gamification, or greater personalization through adaptive digital courseware.

Figure 32. OPM Market Size & Opportunity (2015-2025E, Revenue, \$bn)



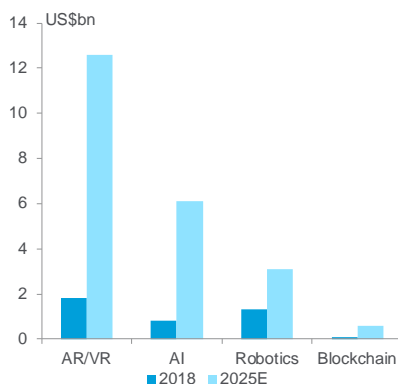
Source: HolonIQ

Figure 33. Over Half of Worldwide K-12 LMS Market is Greenfield Amounting to \$600mn



Source: Citi Research

Figure 34. Market for Four (Currently Peripheral) Advanced Education Technologies Could Reach \$20Bn+ by 2025



Source: HolonIQ

■ **Online Program Management (OPM):** Simmons University announced plans to convert its undergraduate program into an online learning experience — entailing the redesign of about 300 undergraduate courses for the fall semester. This is a sign of things to come as universities will increasingly think of OPM's as more than just a source of additional revenue. A survey in our November 2019 Citi GPS report [Education: Power to the People](#) found some respondents in developed markets expressed dissatisfaction with the perceived value of tertiary education. The high cost of education was often cited as the primary reason for their dissatisfaction. We see an opportunity for university services to make access to education more cost effective through the use of OPMs, MOOCs (massive open online courses), short courses, and bootcamps. These online services might also be relevant for international students in emerging markets where a once-in-a-lifetime demand surge is unlikely to be met by local tertiary supply (about 50 million incremental enrollments are expected in the next 15 years).

■ **Learning Management Systems (LMS) and Devices in K-12:** In the U.S., K-12 schools are lagging universities in terms of technology adoption due to budget constraints and, to a degree, stakeholder resistance. We suspect the greenfield opportunity for even something as basic as an LMS to be around 50%. Several surveys also indicate a key impediment to the proliferation of online learning is the lack of devices in the classroom and at the student's home. This has raised a debate around equitable access to online learning under current circumstances.

■ **Digital Courseware:** A hybrid of print and digital tools is gaining greater acceptance in higher education. It integrates an e-textbook with digital supplements, i.e. assessment tools. This model has worked particularly well with quantitative STEM (Science, Technology, Engineering & Math) courses where practice-based learning and problem solving is important. Some publishers also offer an integrated digital product, for example combining content, assessment, and feedback in a fully digital and mobile model that replaces the traditional textbook. Here the content and user experience can be reimagined based on learning design and it is suited to a broader range of courses, including soft science or non-quantitative subjects. These blended models can also be integrated with adaptive learning systems.

■ **Next-Gen Tech:** While the current adoption rates of immersive technology are low in the education industry, the use cases, including virtual labs and field trips, are promising. HolonIQ estimates the use of technologies such as augmented & virtual reality (AR/VR), artificial intelligence (AI), robotics, and blockchain in education will be significantly more widespread by the middle of the next decade. Spend on these technologies for educational purposes is estimated to rise to over \$22 billion by 2025 from \$4 billion in 2018.

■ **Gamification:** Gamification is the application of video game rules, mechanics, and conventions to a non-gaming situation. The idea is to shift the learning process away from the use of books and lectures and towards experiential and inquiry-based learning. Techniques such as experience points (instead of grades), badges for completion of assignments, and tournaments drive motivation and engagement levels — both critical in a remote learning set up.

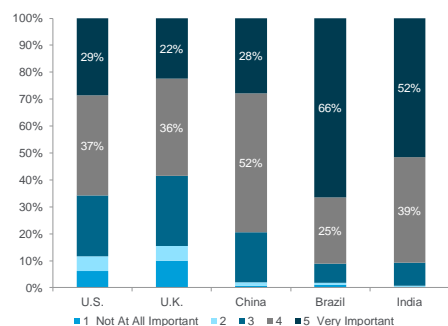
Lifelong Learning – Already Shifting Towards Digital

The half-life of learned skills is estimated to have fallen to five years making lifelong learning a necessity

Learning of course is not restricted to K-12 and tertiary. The “half-life of knowledge” — an expression used to describe the time it takes for half the knowledge in a particular domain to be superseded — is declining rapidly. Broadly, Deloitte now estimates the half-life of a learned skill at just five years. According to some estimates, software engineers need to redevelop skills every 12–18 months.

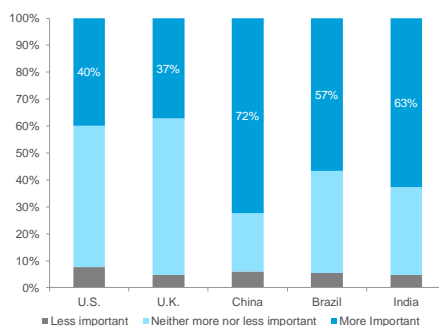
As part of a broader survey on education trends, we reached out to a representative sample of 500 people each in the U.S., U.K., China, Brazil, and India. The responses to our questions on lifelong learning and on-the-job training are below. Our high level take away is that (1) superior on-the-job training opportunities can actually act as a source of positive differentiation for employers; (2) many people believe vocational training is now superior to academic qualifications; and (3) there is plenty of appetite for upskilling opportunities.

Figure 35. How important to you is on the job training and professional development when considering employers?



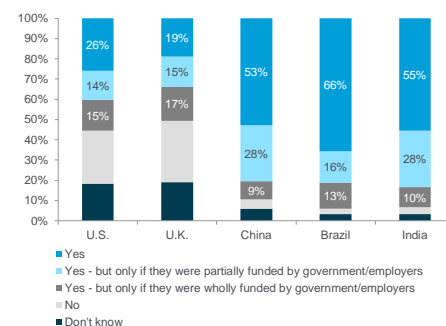
Source: Citi Research Survey

Figure 36. Do you think vocational training is becoming more or less important relative to academic qualifications?



Source: Citi Research Survey

Figure 37. If the opportunity arose, would you participate in further professional training/learning & development (e.g. the latest coding language)?

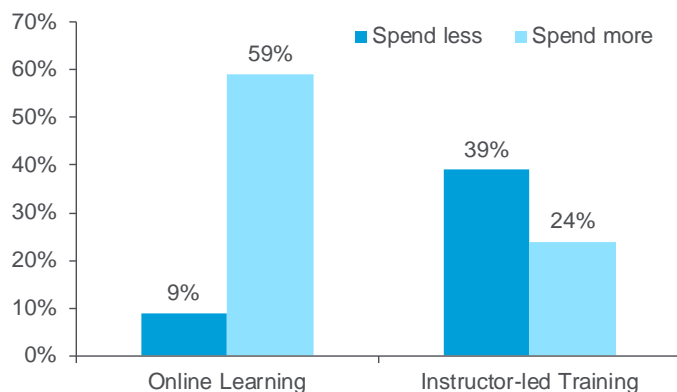


Source: Citi Research Survey

We expect an acceleration of existing trends in corporate learning

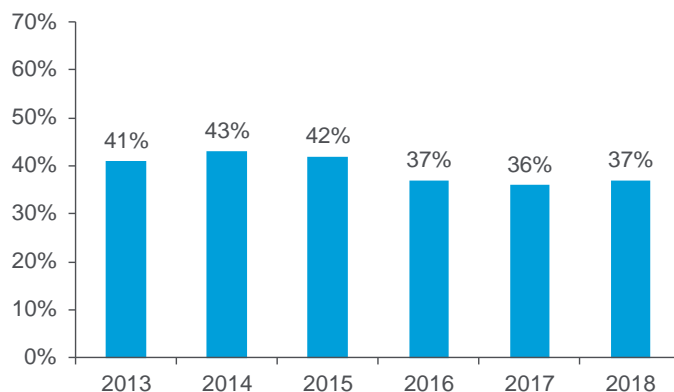
Within corporate learning, we expect an acceleration of existing trends. i.e., a shift in investment for instructor-led classroom training to online tools.

Figure 38. Budgets Shifting Towards Digital Learning



Source: 2019 LinkedIn Learning Report

Figure 39. U.S.: Steady Decline in Instructor-Led Classroom Training



Source: Training Industry Report (2013-18)

Corporates are adopting LMSs resembling consumer websites and are increasingly tying up with MOOC and bootcamps

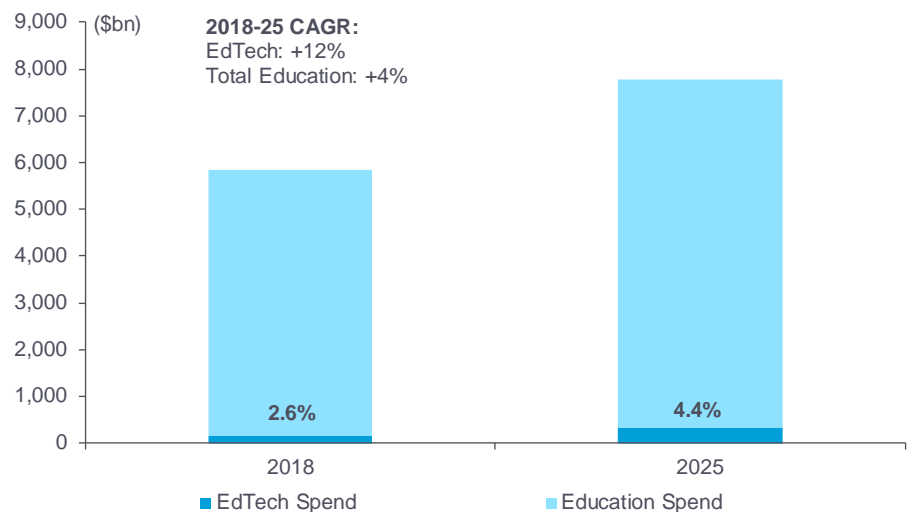
As careers become less linear and the knowledge body in an existing field becomes outdated faster, employers need to curate the learning experience. Their learning management systems should resemble a consumer website providing content and access to experts, as well as personalized recommendations to help people find precisely what they need. Increasingly, corporates are tying up with MOOCs, coding bootcamps (22,500 corporate training graduates at about 1,000 corporates in the U.S. in 2019), and other technology-oriented training solution providers for content and measurement of proficiency/mastery. Learning management system modules are no longer an afterthought within a bigger Human Capital Management (HCM) suite and offer personalized, mobile, and social learning capabilities with an interface created with the user in mind (rather than admin) thus driving engagement.

Our View: 'Necessity is the Mother of Adoption'

Edtech currently represents about 2.6% of global education spend

Although an absolutely huge market in financial terms — worth about \$6 trillion annually (making it almost 2x bigger than the global auto industry), the global education market has been fairly slow to adopt new technologies at least relative to other industries. One famous statistic that speaks to this point is the penetration of edtech, which only represents about 2.6% of this global spend.

Figure 40. Worldwide Spend on Education and Edtech



Source: HolonIQ

The cost of technology solutions has been a key factor in slow adoption...as has inertia

As noted previously, a big part of the reason for this is cost. The fact is that technology solutions may be effective but they don't necessarily come cheap when viewed holistically. For example, a digital textbook may itself not be expensive but the device/reader it is consumed on and the WiFi network you need to have to access the book can be. The COVID-19 crisis and the risk of future outbreaks will likely push school administrations to have a rethink about student /device ratios and once devices are in the hands of more students, edtech is likely to be a more integral part of the pedagogy.

Another key factor slowing adoption is inertia. For whatever reason — whether it be habit or political views — sometimes technological advances are simply not welcomed and therefore not adopted. Two examples are below:

- **‘Virtual’ or online schools:** For a variety of reasons, only around 20 of the 50 states in the U.S. have seen the launch of virtual schools. One reason for this is opposition from some industry stakeholders, typically in relation to involvement of private capital in what is seen as a public service. In this context, the longer-term impact of COVID-19-related disruption may not be a reevaluation of what is possible — virtual schools have been around for and have worked for a long term — but rather a reevaluation of what is acceptable.
- **Digital textbooks:** More often than not in a higher education setting, the only reason physical textbooks continue to be used is because the faculty member in charge of a particular course still wants to use that format rather than an online/digital equivalent. Again the technology is there, but the problem lies in resistance to adoption. This may well be reassessed in the light of COVID-19 related disruption.

These two examples play into how we think COVID-19-related disruption will impact the education landscape longer term. We don’t necessarily envisage any significantly new or different trends arising out of the current crisis, just faster rates of adoption as historical sources of inertia, especially those based on habit or political acceptability, are brushed aside.

We see COVID-19 as pushing ‘necessity’ as the ‘mother of adoption’ for edtech

It is often said that ‘necessity is the mother of invention’ but in education the innovation has already happened. Rather we think in the case of education, COVID-19-related ‘necessity’ will end up being the ‘mother of adoption’.

A Question to Cameron Hedrick, Chief Learning Office at Citi

If more employees work from home in the future, what opportunities, challenges and solutions do you see for Learning and Development?

1. **Learning technology:** While we’ve invested in distance learning technologies, we need to rethink the durability and effectiveness of said technologies in a world where distance work and learning is even more pervasive. Examples include: high bandwidth video with breakout room functionality/chat /whiteboard access; adaptive learning development platforms; peer-to-peer video content; and asynchronous/cohort based platforms such as Nomadic.
2. **Collaboration tools and practices:** I think we’ll see increased use of collaboration tools — both synchronous and asynchronous. The fatigue associated with long duration video events will drive greater adoption of efficient, ‘off meeting’ collaboration. For example, collaboration tools such as Slack, Yammer and MS Collaborate can be used to prepare for meetings, rendering the actual video time for discussion and debate versus the conveyance of information. I also view learning experience platforms such as Degreed and Edcast as essential collaboration tools given they enable communities of practice to ‘spring up’ around specific areas of interest.
3. **Meeting management:** Better meeting constructs, a more thoughtful approach to attendee composition, and meeting pre-work will become the norm.
4. **Inclusion will be a greater challenge:** Soliciting and truly hearing and acting on diverse opinions can be difficult in proximate environments — you have to really work at it from a distance.

Chapter 7: Telecom Services

Georgios Ierodiaconou
Europe Telecoms Analyst

COVID-19 has raised the importance of basic connectivity with reliability more important than maximum speed or potential

Networks by and large have performed well in the developed world

Consumers are more aware of reliability in connectivity and are more willing to upgrade

Businesses & government are looking for ways to move more of their applications and services online

The most profound change could be in the way products, devices and applications are delivered — COVID-19 may accelerate uptake

Telecom networks are the key enablers for a number of services and applications that are being discussed in this report. The old model of pure connectivity whether voice, data, or — in recent years — more and faster data is reaching its twilight.

But before we move to that, it is worth noting that COVID-19 has raised the importance of basic or adequate connectivity itself. Working from home (WFH) hasn't just been a 'killer application' but in many ways the fundamental pillar for many businesses and economies. Reliability is more important than maximum speed or potential, so networks access differences (e.g., fiber-to-the-home (FtH) is typically better than fiber-to-the-curb (FtC)) are less relevant. Instead bottlenecks in terms of transmission/core tend to be more critical. Upgrading these parts of the network is not as costly as changing the access itself (which requires investment dedicated to each line).

In the developed world, by and large networks have performed well throughout the COVID-19 crisis. As the traffic peaks tend typically to be in the early hours of the evening, WFH does not contribute that much additional traffic during those hours. Lockdowns meant more demand at peak hours also but traffic management measures has been able to deal with it by reducing the quality of video streaming.

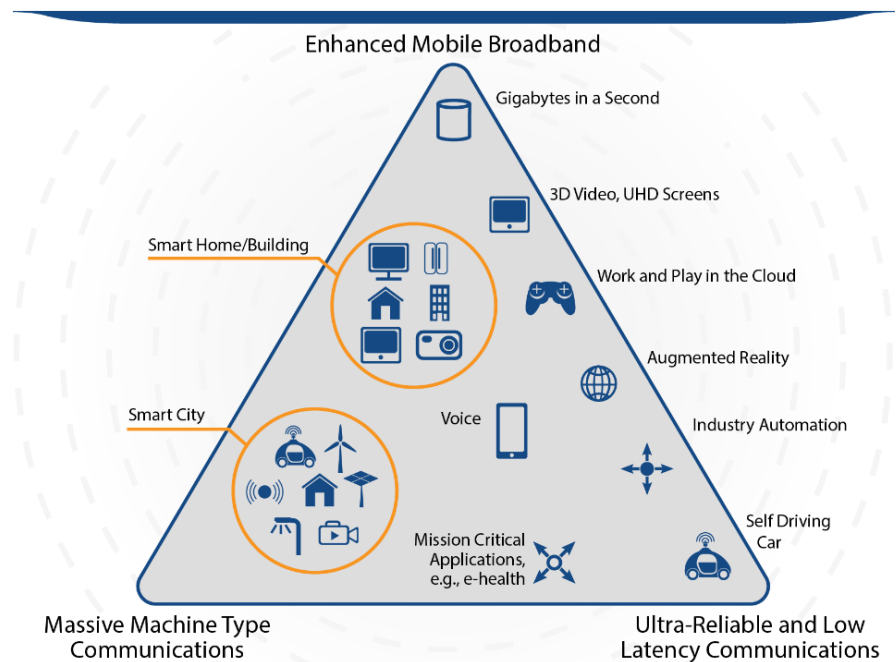
Telecom companies could see other forms of demand stemming from the lockdown. In the consumer segment, customers are more aware of the importance of connectivity and may be willing to look at upgrading earlier than they would otherwise. We are seeing a resurgence in demand for fixed broadband, which could prove important particularly in countries with high penetration of mobile-only households (typically single households which don't spend much time on home entertainment). In developed markets, consumers are already consistently upgrading their connection via a combination of needs and promotions being pushed by telecom operators to entice them. We see an acceleration in that trend but we do not expect it to be significant in most cases.

Businesses are now looking at ways to transform their systems to more agile, cloud-based solutions, which should drive demand earlier than what would have been the case pre-COVID-19. Similarly governments need to move more of their applications and services online. Some are contemplating how remote learning could be enhanced to be better prepared for when it is required again in the next crisis and maybe even have a role during normal times.

Looking beyond the initial changes, perhaps the most profound transformation could come in changing the way all products, devices, and applications are delivered. The future model is more about the ability of networks (especially in mobile) to support a plethora of different applications with dramatically different requirements. We are on the eve of the big Internet-of-things (IoT) cycle where devices, rather than individuals, will be connected to the Internet with applications and services available to support each of them.

The uptake of such applications may be brought forward in some cases by many years as a result of changing patterns from COVID-19 and the measures taken to contain it.

Figure 41. Use Cases Take Advantage of Technologies Advanced Capabilities



Source: Citi Research

In the next section, we list some of the shifts we anticipate and the implications for network development. We also discuss a couple of these applications in more detail. The focus is more on the specific attributes and applications networks will need to acquire to deal with crises in the future, both in terms of supporting health services and in managing/analyzing information.

Finally, we discuss why networks are becoming mission critical, what that implies not just in terms of performance but also security, and how these factors can affect the regulatory environment.

The Evolution is Accelerating

Private networks are the support pillars of an increasingly mobile workforce

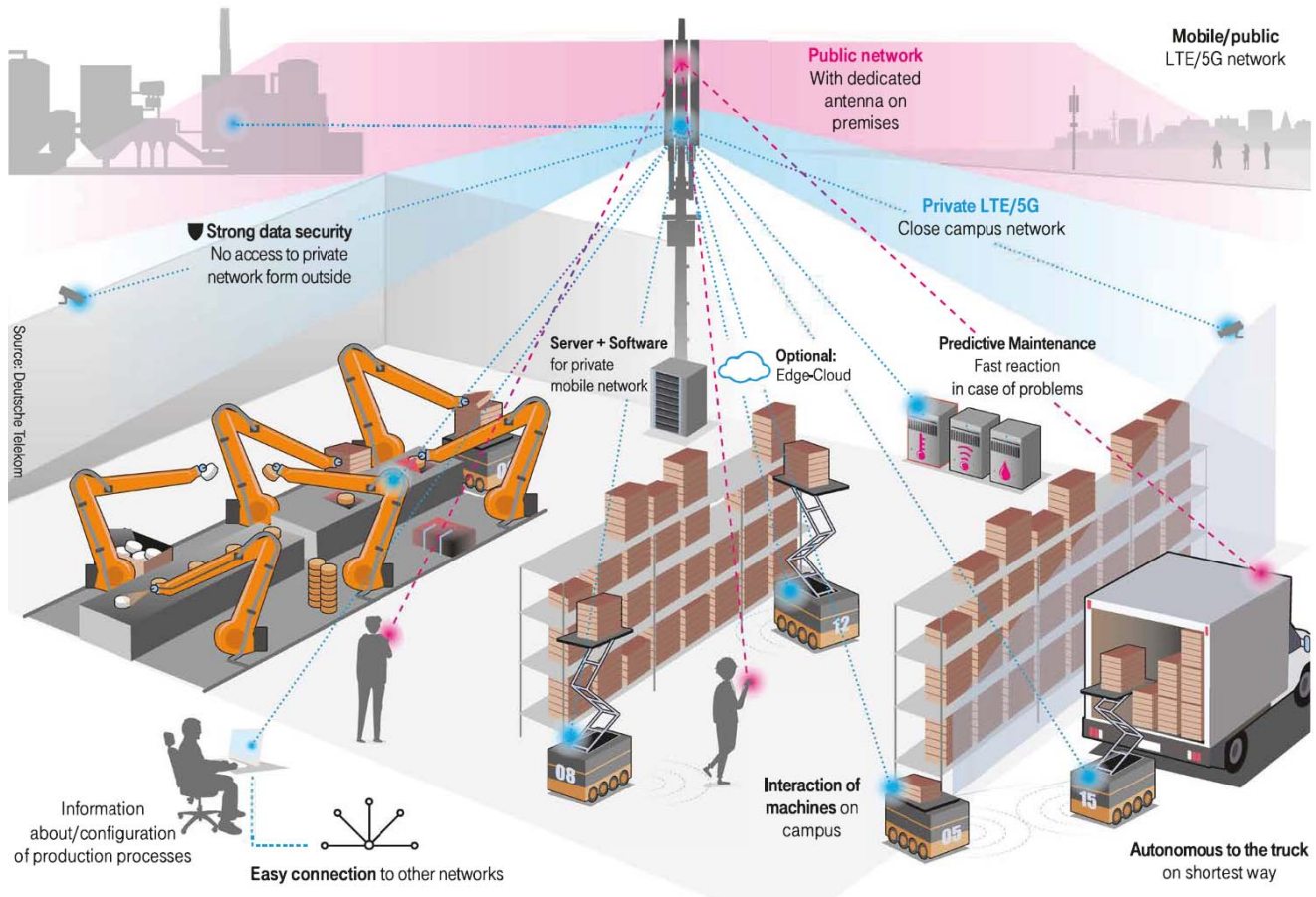
Private networks are the support pillars of an increasingly mobile workforce and allow employees to work securely. If more people opt to either work from home full time or to work more often than before, there will be a growing need for employers to support such patterns. But we do not expect it to stop there. Full cloud solutions and entire IT transformations are the natural evolution and indeed already in some countries (e.g., Switzerland) these services are already available. Over time significant efficiencies are driven from the agility/scalability of such virtual solutions compared to the 'old fashioned' outsourcing of IT services.

On the business-to-business (B2B) side, private networks for IoT purposes are likely to take off. Network-as-a service is needed for telecom operators to be able to offer their IoT customers (industrial companies with their products/devices connected to the internet) a secure and flexible way of managing and running their applications; fixing/updating their products; receiving data and processing information etc.

Campus network are the future of industrial production as factories get 'virtualized'

Campus networks are expected to be the future of industrial production as factories also get 'virtualized', abandoning the model of having specific appliances to one where software is more prevalent. The vision is for factories to be able to switch production from one product (e.g., car model) to another without having to change the hardware components (e.g., robots, machines). The ability to switch production could be critical in times of emergencies in quickly focusing production on scarce products.

Figure 42. In an Automated Enterprise Set-up, Data Is Processed Locally on the Cloud, thus, Significantly Reducing Latency Due to Short Transmission Distances



Source: T-Mobile, Citi Research

Uptake for streaming services at home and VR/AR could be driven low-latency connectivity

In terms of home entertainment, there is obviously significant 'raw' demand for streaming services. But we anticipate virtual and augmented reality (VR/AR) could become more mainstream in terms of gaming, the way we view live events (sports, concerts etc.), even series/films. The main hurdle for the uptake of these services is that the equipment needed is still too bulky and in most cases expensive. But this will likely change as low-latency connectivity would allow for most (if not all) of the processing and applications to be on the edge/distributed cloud.

Two takeaways from the pandemic are the need to deliver health services remotely and to analyze information more efficiently

But there are two specific areas worth considering

When the dust finally settles, it is likely that authorities around the world try to make better use of the technology that is available to be able to deliver health services and to be able to analyze information more efficiently.

- **E-health:** It is possible for individuals, private, or public health services to provide remote monitoring of the most vulnerable individuals, not just during periods like a pandemic but also on an ongoing basis for more comprehensive, affordable monitoring. Leaving the lessons from COVID-19 aside for a moment, it is likely that as the population continues to age, specialized homes/facilities will not be able to accommodate everyone in need; nor will everyone want to be in a specialized care facility. The solution could be devices that feed an individual's health data back to a center, which can monitor and intervene where necessary. Monitoring ensures better prevention in general. But especially during a crisis — like the one caused by COVID-19, — e-health can ensure more cases are being monitored and in the future perhaps encourage more regular and extensive testing. More people may also be checked without putting other people at risk (not just doctors that do the monitoring but also infections caused by patients having to travel to health centers).
- **Big Data and Monitoring:** Whether it's the data collected from e-health devices themselves or information about potential patients (e.g., people who have traveled or who have been in proximity with individuals who have contracted a virus), networks can gather very accurate information not just about the whereabouts of individuals but also the patterns of spread of a virus. Both gathering and analyzing data efficiently are crucial to making the right decisions and forming plans of action (macro) as well as implementing plans on the ground (micro). Artificial intelligence (AI) has been progressing for years — initially being used to help us sort preferences and predict when we want to rent a movie but now moving to much more advanced services such as our smartphones and other devices becoming better at predicting our behavior, our preferences and our needs. In many ways we may just be at the start of what AI can offer.

Even today, there are examples of how AI can be used. The city of Hangzhou in China was one of the first to use big data for the prevention and control of COVID-19. Information was used to establish which businesses should be prioritized as the city 'reopened'. Every individual was provided with a code which determined the freedom of their movement. Green to move freely, yellow for 7-day self-quarantine and red codes for 14 day self-quarantine; with the codes changing color accordingly. Individuals were also asked to monitor and report their temperatures and update their daily profiles (again linked to e-health). AI is and will be capable to do a lot more than that in the future.

Strategic Importance

Performance and security/privacy are the two main parameters that matter for networks

As individuals, businesses, and health authorities rely more on networks to 'function', networks are increasingly becoming the key infrastructure to support development. With networks, there are two main parameters that matter: performance (capabilities) and security/privacy.

Starting with performance. Networks are evolving in two main ways — they need better connectivity and agility.

- Improving connectivity requires significant investment to roll out more efficient technologies (e.g., FttH in fixed, 5G in mobile). FttH is costly as it typically requires a lot of civil engineering work. Costs involved with 5G networks range from the acquisition of spectrum, to the installation of new equipment and the rollout of new sites to densify networks and utilize the higher frequency bands.
- Agility comes from upgrading the core of the network in order to deliver on the increasing number of applications required and to update/upgrade and introduce new services in a seamless manner.

Not all regions are the same in terms of network capability – developed Asia is way ahead of the U.S. and Europe

For years, regulation especially in Europe, has been more focused on ensuring enough competition to maintain the lowest possible prices. Other parts of the world chose different routes. As a result, the global landscape has significant variations in terms of network capabilities with developed Asia way ahead of the U.S. (although the U.S. has cable and is quickly behind in 5G) and Europe which is way behind. This network disadvantage could prove more costly as other industries move to IoT. Japan and Korea should be better placed to capture and adopt these new services earlier, as well as in developing future products (drones for example) given their networks will be years ahead in the ability to support these functionalities

Standards for security of the network itself and security of the information that passes on the network are currently being debated

The other variable is security. There is a debate around whether individuals (especially in Western democracies) should be accepting of giving away their personal information to authorities (even during times of crisis) and how that information can be potentially exploited or manipulated. Even if that hurdle is cleared, there is still a remaining question about network security. A big global debate ahead of the launch of 5G networks globally is about whether it is appropriate for Chinese vendors to be involved in the rollout of these networks. The U.S, Australia, Canada, and New Zealand have opted for a full ban, citing security concerns. The other member of the Five Eyes alliance, the U.K., opted for a partial ban (a full ban on the core network but a limited ban in the radio access network (RAN)). Europe has set a framework for each member state to decide on their own but telecom operators in Europe are already proactively leaving Chinese vendors out of their core networks. As more and more sensitive information passes through the network and as more advanced ways of processing information become available, the importance of security will only increase. Whether that means politicians will impose further restrictions on operators or whether they shift their attention to vendors and other players remains to be seen.

Chapter 8: Collaboration and Productivity Technology Tools

Walter H Pritchard, CFA

U.S. Software Analyst

The drivers of cloud/mobile, software-as-a-service (SaaS), and machine learning have caused a renaissance in the productivity/collaboration software market after stagnation around “Office” suites up to five years ago. While software tools have always complemented in-person interactions, the high productivity demands of the modern team of information workers have driven differentiation based on adoption of software. Work from home is also likely to change how organizations prioritize workplace technology. While a focused set of technologies have seen greater adoption as a result of immediate COVID-19-related business priorities (remote access and certain security items), we expect teams that have been dispersed (instead of being in the same office) will look to augment their collaborative capabilities.

The Nature of Work and Jobs Are Changing

We are in the midst of a ‘fourth industrial revolution’ driven by technology

Nowadays, it is generally well emphasized that humankind is in the midst of the ‘fourth industrial revolution’ whose implications are very real. Technology is at the heart of this trend, with the rapid pace of change arguably defining the world we all live in. Along with rapid technological advances, information is now plentiful and the challenge has turned to sorting through and interpreting this information instead of sourcing it.

Software is automating human labor similar to the way machinery did in prior industrial revolutions

These broader trends have made their way into the mainstream work environment and are impacting day-to-day duties, as well as influencing the criteria for career success amongst information workers. Ultimately, software is automating human labor at all levels, just like machinery did in prior industrial revolutions. It has been well discussed that artificial intelligence and machine learning may outright replace humans in many fields such as truck or taxicab operation. It is instead more likely that a much broader set of job roles will see an ‘assistance’ relationship between humans and technology coalesce. We expect this to be mainstream in the years to come and adoption of such technology at an organizational level is likely to be a positive differentiator.

The entrance of Gen Z into the workforce is driving this evolution

Some of what is also driving this evolution is generational. “Gen Z” — the cohort born between 1995 and 2010 just as the first smartphones were released — are starting to enter the workforce. Information workers are garnering a premium and ‘digital skills’ are becoming a pre-requisite. With search technologies and an increasing body of knowledge being freely available, needed jobs skills are now more and more cognitive and duties are non-routine. Along with generational differences, there is an increasing culture of ‘working from anywhere’ and an expectation that technology can bridge the physical divide.

This Isn’t ‘Your Father’s’ Office Suite

Productivity software applications aren’t new but the market has stagnated

Productivity applications have been broadly deployed amongst information workers for years and are not new. There have also been a number of more specialized offerings, targeting specific and usually particularly high-value productivity workers such as developers and other technical professionals (creative pros, architects, etc.). However, about a decade ago, the market significantly stagnated. At the time, industry watchers would joke it was more about moving around functions on the screen (the infamous Office 2007 “ribbon”) as well as about the ever incremental, but not transformational releases of Adobe’s Creative Suite.

Innovation and use adoption has been driven recently by SaaS adoption, mobility, and cloud compute/synchronization

The utility and breadth of usage of productivity tools has been advanced by SaaS, mobility/cloud, and machine learning

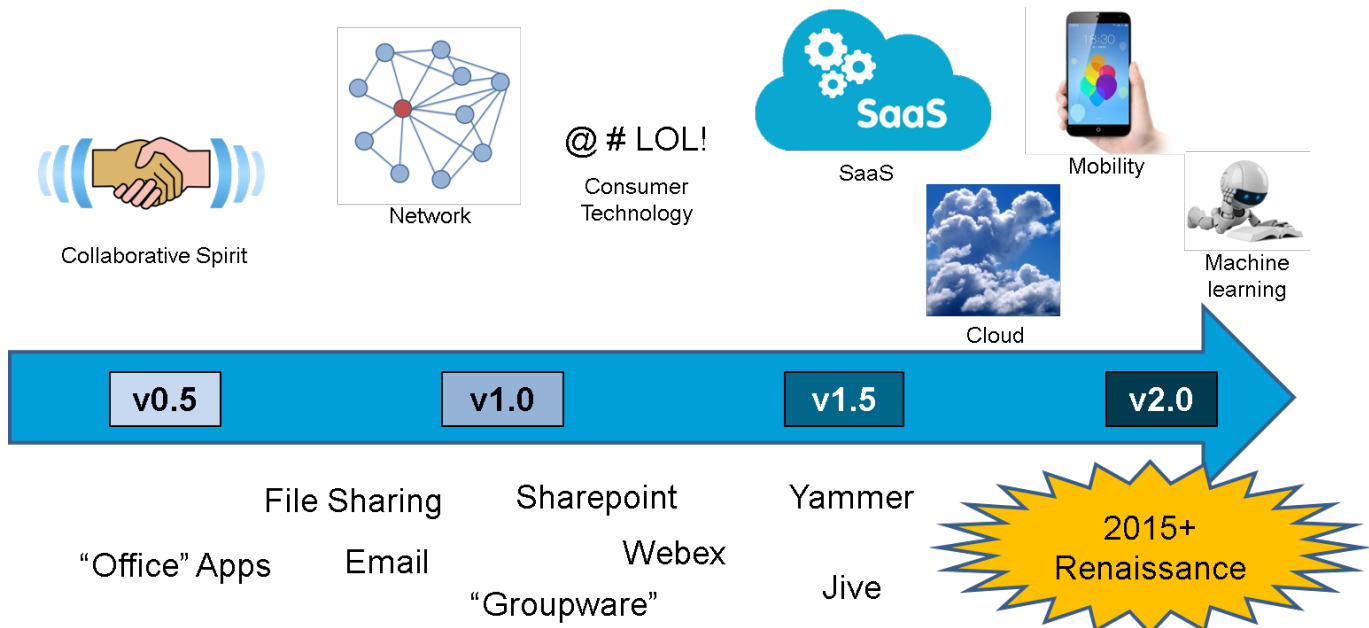
The compute power in the cloud is creating value by saving users time thereby increasing productivity

Over time, there have been a few catalysts to drive innovation and therefore use adoption in this market. Networking was the catalyst for the adoption of 'v1' of productivity, which included file servers, email, shared calendars, and then "groupware" collaboration offerings like Sharepoint. More recently, SaaS adoption, mobility, and cloud compute/synchronization has been a catalyst for the adoption of 'v2.0' (Figure 43). After the post-2008 recession and market stagnation for several years, there has been new era of innovation in the market.

The combined and accelerating forces of SaaS, mobility/cloud, and machine learning have helped to significantly advance the state of the art utility and breadth of usage of v2.0 productivity tools. SaaS and even 'try to buy'/freemium models on-premises (on-prem) have enabled adoption with little to no IT involvement, as well as consumption of upgrades as they are made available. Mobility has put the worker productivity 'in a pocket' and allowed new mobile communication scenarios. Cloud has gone hand in hand with mobile, syncing data between devices, user workspaces and also with other applications through easy-to-use application programming interfaces (APIs).

Lastly, the tremendous compute power in the cloud has enabled operations on data that were previously not possible. The escalation of compute is pointing machine learning technology towards data stored in these systems to help automate much of what users have had to do and also surface insights that would otherwise take valuable user time. For many, many years, saving users' time (i.e., increasing productivity) has been the key to creating value. As a result, AI/ML may drive a whole new wave of value, independent of the cloud/mobile benefits we've already seen.

Figure 43. Evolution of Productivity Tools and the Forces Driving



Source: Citi Research

Software Eating (non-) Productivity

Along with the above-mentioned technology drivers, the adoption of productivity applications has consumed processes that were previously done in 'analog'.

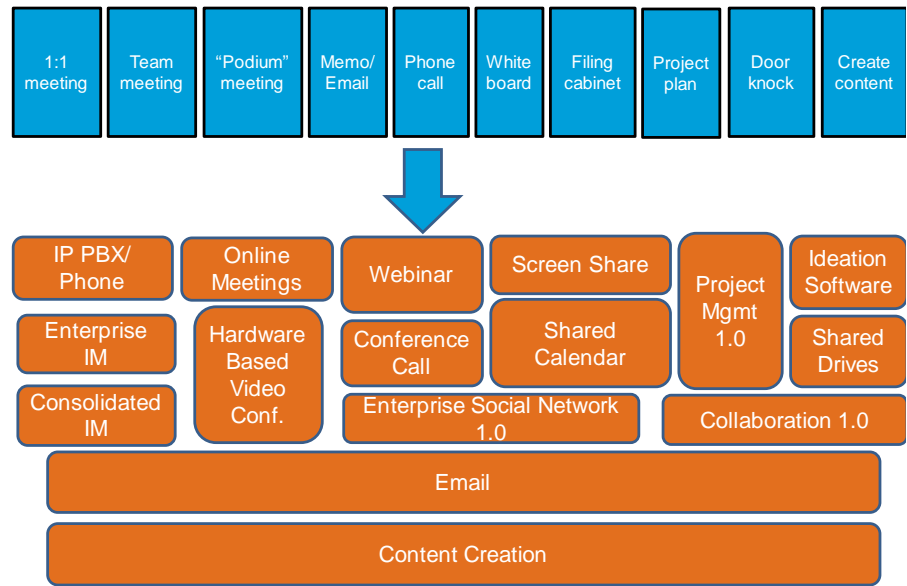
- In-person meetings → Online meetings, shared spaces, real-time chat, automated transcription
- Project white boards → Collaborative work management and workstream collaboration
- File servers, document versioning → Online storage
- Manually re-coloring an illustration → AI-driven color optimization in digital illustration
- Using email and spreadsheets to track a business process → Building no-code application to automate the business process.
- Manually collecting data sources, manipulating the data and completing analysis → End-user analytics software

In the analog world, there are a number of interactions and tools used in the collaborative process and the 'v1.0' tools market was structured very similarly. Just like in the analog world, there is some overlap between various types of interactions and tools. For example, a phone call can be a substitute for a 1:1 in-person meeting or an impromptu 'door knock'. Plans for a new initiative can be stored in a written project plan or written out on a white board.

We Are in the 'Mid-Morning' of the 'Post-Office' Era

As this 'v1.0' era of tools matured, there was a stagnation of innovation and a natural 'grouping' of capabilities, where capabilities continued to be layered on top of the Office. As we got to the end of the on-prem Office era (~2012), most customers had access to the full capability of the Office suite, even if they didn't use its full capability. We'd argue by 2012, information workers were 'over-using' the Office suite, employing spreadsheets/Excel for tracking projects, spreadsheet/Excel 'collaboration' to roll up forecasts, word processing/Word to take notes, build meeting agendas, and create requirements documents to share with colleagues (via email).

Figure 44. Analog Productivity/Collaboration Instantiated in v1.0 Software



Source: Citi Research

v2.0 tools are being driven by SaaS, cloud, mobile & machine learning and make it easier to adopt a point product vs. a multi-product ‘suite’

We are still in the early adoption of v2.0 tools but COVID-19 has accelerated the trend and a rapid work from home transition will likely be a further catalyst

Adoption of productivity/collaboration software will be permanently impacted by the extended time works the information worker population is working from home

With the v2.0 drivers we have identified (SaaS, cloud, mobile, ML), we see a further proliferation of tools, including a host of new offerings, which were natively architected on a modern technology stack. This has happened very much in parallel with the proliferation of business applications that have arisen in the SaaS generation. Along with SaaS proliferation, it has been easier to adopt a point product, versus a multi-product “suite” in most of these markets. This adoption pattern has happened in common across business applications as well as in productivity as each solves a discrete pain point.

Lastly, there has been a very liberal fundraising environment for technology companies and software specifically. This has given rise to an unprecedented level of new company formation, although recent events may have halted this trend. Significant investment for a number of years and low barriers to entry in some of these markets has driven a proliferation of point-products and a very fragmented landscape of tools. We believe we are still early in the adoption of v2.0 tools but we note the recent COVID-19 pandemic has accelerated this, and the rapid work from home transition that has occurred will likely be a catalyst for consideration of v2.0 products.

COVID-19 Likely Accelerates Consideration of Next-Gen Productivity/Collaboration Adoption

We expect the 2020 COVID-19 pandemic to have an impact on how organizations look at the utility of productivity/collaboration software. In many ways, the technology ranges from “must have” to “high utility” for employees that are in disparate locations. We expect adoption will be permanently impacted by the extended time that large portions of the worldwide information worker population are working from home. In addition, we expect the balance of in-office vs. at-home workforce will drive long-term adoption. As best put by Citrix CEO David Henshall, “We expect the long-term state of the world, in terms of worker location will be somewhere between where we were and where we are now. Either way, the acceptability or tolerance of more complexity of worker location, work hours and device will be a likely result.”

The percentage of U.S. workers who say they have worked from home during the crisis has doubled since mid-March

Pre-COVID-19, the U.S. worker population working from home half the time or more was in the range of 3-4%, while a much larger percentage (~43%) did some remote work (both based on American Community Service data). A recent Gallup poll suggested the percentage of workers doing some remote work has doubled since mid-March in the U.S. and this is likely with a greater percentage of their day remote. While the state of working from home may not persist at these levels, the same Gallup poll suggested that near 60% of the workers who were working from home would like to continue remote work as much as possible. A change to work from home on a more permanent basis will likely impact the usage of productivity/collaborative tools, which help make a work from home situation more productive in a team environment.

Our Views of Six Sub-Segments within Two Broader Markets

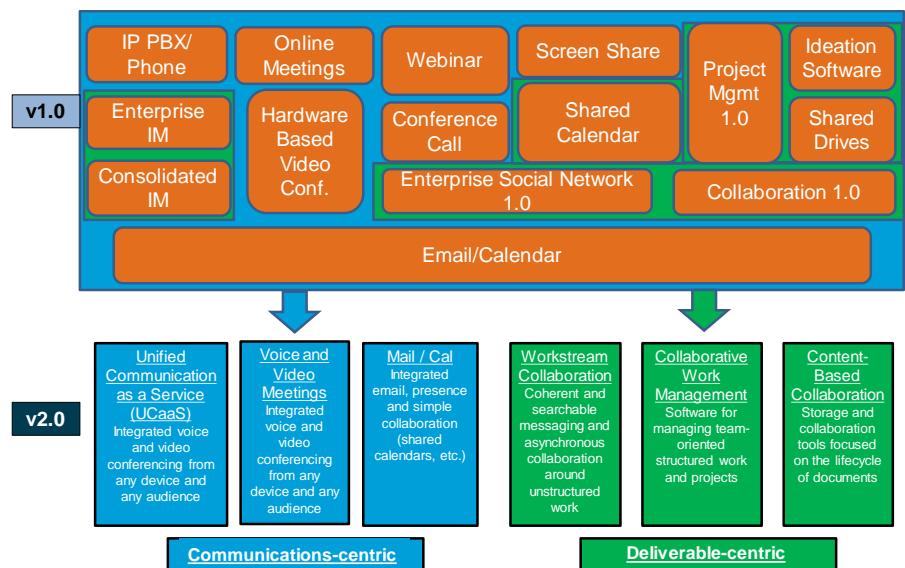
The 'v1.0' generation of productivity/collaboration centered on content creation applications

The 'v1.0' generation of productivity and collaboration was dominated by content creation and most notably the Office suite. We view this as having already evolved, with content creation (and the core Office apps of Word, Excel, PowerPoint and even Creative Cloud core apps) as largely unchanged. We propose there are new markets emerging that are similar in terms of being at the center of the core job function for certain information workers, for example in software development and in data analysis. These core 'content creation' applications, as well as email, have mostly been integrated with, as opposed to being disrupted/competed with by the rest of the productivity/collaboration landscape.

'v2.0' applications are more centered on communication and work deliverables

We see an additional six areas of productivity/collaboration (outside of core content creation) moving quickly in a 'v2.0' view of the world, segmented into two broader markets, or 'swim lanes' — one around communication and the other around work deliverables. We are in the early stages of seeing convergence within each of these two areas and even outside of these sub-markets.

Figure 45. v2 Productivity and Collaboration Evolution



Source: Citi Research

Communications-centric: Towards Seamless, Multi-Mode Communication

In the communications-centric swim lane, multiple-modes of communication including voice, video, and text messaging are used, depending on the type of interaction, level of engagement, and location/device. Here, communication is the product, although ultimately, the communication is part of a larger business objective. These business objectives are wide ranging and involve one-to-one (1:1) communication, one-to-many (1:many) or what we call one-to-:"adhoc" (1:adhoc), meaning anywhere in between and capturing the dynamic nature of who is involved in communication.

In theory, we see a fairly low bar to add lightweight voice & video (V&V) capability into other applications. However, we also see the user as unforgiving of a bad experience. Given the technical challenges of delivering a 4K video stream over variable network connectivity, we see V&V communications as presenting one of the harder technical problems to solve in the productivity / collaboration space.

Over time we expect these video platforms to be on the forefront of tech-enablement of meetings with voice, video, and content capturing

We see the convergence of the three major use cases of 1:1 (video call, which might start out as a phone call), 1:relevant (workgroup meeting via video, which had been focused around screen sharing) and 1:many (such as the webinar or "all hands meeting") as likely provided by one solution, where the capability around video is prioritized. Over time, we expect these video platforms to be on the forefront of greater tech-enablement of meetings generally with capabilities that include real-time transcription, meeting translation, digital white-boarding, captive/process/distilling of meeting notes and action items. We believe it will take the full capability of voice and video (who is talking for example), as well content capture (output from screen sharing) to add this value and evolve into technology that can enable a business meeting to be tech-enabled and re-imagined. One example of real-time transcription, which enables someone to join a meeting already in progress by reviewing the notes and also concentrate on the interactions in the meeting, knowing that a complete record of the meeting will be able to be referenced later.

Email is likely to be sustained as the primary mode of communication in "old world" companies

Email is likely to be sustained as the primary mode of communication in "old world" companies that are slower to embrace change and have information workers that use computers less intensively. We've seen studies suggesting the average full-time worker in the U.S. spends nearly three hours a day on email and has to process ~120 received messages. With the inefficiencies well understood, we expect time spent on email will decline, although it will be substituted for other modes of interaction. We believe this also goes for simple chat-like enterprise instant messaging (IM). At the same time, email is ubiquitous and there doesn't appear to be a rationale to "unplug" it.

Faster-moving companies will likely see email maintained as a mechanism for alerts and updates in other productivity tools

In faster-moving companies, where more productive/efficient communication is paramount, we see email maintaining its "lowest common denominator" status as a mechanism for alerts and updates in other productivity tools. Here, while it's important for email to integrate with other tools, we don't see the email incumbents as well positioned to sell their other communication capabilities, as they are generally lagging. We also expect email to remain the primary means for communication with external parties, where it is extraordinarily difficult to pose another standard across a diverse set of relationships (customers, partners, suppliers, etc.).

Deliverable-centric: Driving Efficiency and Productivity in the Digital Workspace

The deliverable-centric swim lane focuses on technologies that collect and organize group communications, track individual/group progress, and organize content

A second market is deliverable-centric, where a persistent virtual workspace is facilitated with various technologies that collect and organize group communications, track individual/group progress, and organize content. While communication is involved in the second area, the focus is more around the work process, workers and teams working together, and the ultimate deliverable. When we described the communications space above, we noted that inherently, communication is transactional. We draw distinction here with deliverable-centric collaboration, in that the nature of its use is persistent. We expect in a post-COVID-19 world, with teams needing to accommodate more geographic separation, asynchronous work, and flexible schedules, this broad category of productivity/collaboration will see incremental adoption.

The first market that evolved within what we call the “digital workspace” is the content-based collaboration space. These offerings started out as “access-from-anywhere” online storage. The initial utility of these products is very high, with the ability to store files from any application on any device to one place and then share these files with others. Several years ago, a simple global file system that worked across devices was also very hard to do. We are now at a point where all players have the table-stakes features.

We’ve gradually seen unique, general purpose features being added that enable support of new workflows in these content-based solutions, including

- Digital signatures for scenarios where there is an approval or agreement involved;
- Optical character recognition (OCR), which enable ingestion of “less-structured” documents;
- Embedded real-time co-authoring and commenting; and
- Portfolio display for creative professionals.

In the medium-term, it is possible that if a horizontal solution can have enough value propositions, it can become a sort of “virtual file service” that sits on top of other storage, even the embedded variety.

Collaborative work management is the newest area on productivity/collaboration

The youngest area within the deliverable-centric productivity/collaboration arena is around collaborative work management (CWM). These products are an evolution of the project management tools of yesterday, although they go well beyond the prior target of trained project managers, bringing capabilities to a broader set of users. We see the SaaS/mobile/cloud drivers take their utility to a new level and that is why we see a ‘renaissance’ in that market. Much like we saw business intelligence tools “for IT” ten years ago and they are being democratized by the forces of SaaS/mobile/cloud, we see this happening in project management. The tools of ten years ago serviced the centralized project management office (PMO) and now they are being pushed out to all information workers.

These tools enable work, especially the non-routine variety, to be managed and tracked from one place for the benefit of individual contributors, teams, departments, and ultimately the entire organization. Project deliverables/deadlines and their interdependencies can all be tracked, updated, and reported with all relevant users informed. Right now, these tools are being adopted workgroup by workgroup, in-line with the trend of “departmental SaaS”, but even at a slower pace

than we see in other markets. There are few customers that have gone company-wide with one tool.

In Figure 46 below, we have highlighted what we see as the key areas of technical differentiation in the six areas of productivity/collaboration we have outlined, plus the content creation tools. In this area, we see the CWM offerings as less technically challenging to build.

Figure 46. Citi Comparison of Technology Differences Between Various Productivity/Collaboration Sub-Segments

Attribute		Foundational Technology	Hardware Integration	Partner App Integration	Volume of Features	Security/User Admin	UI / UX	
Details		Challenging computer science problems to solve, requiring strong core team of experts	Relationships with the right partners and core team of hardware engineers, many times custom engineering	Ability to forge relationships with partners and produce volume and richness of API-based integrations	Requires time and maturity of product	Hiring of engineers with enterprise experience as well as ability to integrate into adjacent areas	Core group of engineers focused on this area	
Standalone Rating	UCaaS	2	3	1	1	1	1	Average: 1.6
	V&V	3	3	2	2	2	2	2.4
	Messaging	1	1	1	1	1	1	1.0
	Workstream	1	1	3	2	2	3	1.8
	CWM	1	1	2	2	2	3	1.7
	Content-Based	3	1	2	1	3	2	2.0
	Content Creation	1	1	1	3	1	2	1.6
Scarcity / Challenge in Replicating		3X	2X	1X	3X	2X	1X	
Overall Rating	UCaaS	6	6	1	3	2	1	Average: 3.2
	V&V	9	6	2	6	4	2	4.8
	Messaging	3	2	1	3	2	1	2.0
	Workstream	3	2	3	6	4	3	3.5
	CWM	3	2	2	6	4	3	3.3
	Content-Based	9	2	2	3	6	2	4.0
	Content Creation	3	2	1	9	2	2	3.2

Source: Citi Research

The value of these products increases significantly as more users are connected

The value of these products increases significantly the more users are connected. When project management evolves into all work being tracked and that work being tied into high-level company goals, there is significantly more value than that from driving efficiency in information worker and team productivity. For example, if an executive can see what everyone in their organization is working on and how that aligns to their goals and company-wide goals, they are in a better position to manage their organization. We saw this happen in the Human Resources space a number of years ago, where simple performance management and succession planning capabilities took on much more strategic value when they were deployed company wide and tied into broader company strategy.

We see annual per-user spend on productivity/collaboration users ranging from \$0 - >\$1,600 per year, based on a varied level of consumption. The potential addressable market is significant and is growing rapidly as working from home becomes both more possible and acceptable for companies and employees.

Figure 47. User Propensity to Spend on Productivity / Collaboration Tools

User Tier/ Cohort	Sample Career	Users: “OECD High” (MM)	Typical Tools Outfitting	Annual Spend/ User (\$)	“OECD High” TAM (\$BB)	Productivity/ Collaboration Consumption
0 / Minimal Computer	Cashier Food Prep Cargo Handler Janitor/Custodian Truck Driver	193	None	\$0	\$0	Very low price points
1 / Info Consumers	Retail Sales Customer Svc Rep Childcare Worker Home Health Aide	70	Email Corp apps	\$120	\$8	Basic suite
2 / Lightweight Creators	Teacher Office Clerk / Asst. Nurse Retail Super/ Manager	129	Office 365 E3	\$300	\$38	Suite if “good enough”
3 / Collaborators	Operations Mgr Bookkeeper Accountant	46	Office 365 E5	\$420	\$19	Suite if “good enough”
4 / Collaboration Hosts	Business Analyst Lawyer Exec. Asst Construction. Mgr	19	Office 365 E5 2-3 BoB apps	\$1,020	\$19	Suite augmentation/ BoB
5 / Power Users	Software Developer IT Manager Civil Engineer Mech. Engineer	18	Office 365 E5 2-3 BoB apps Domain tools	\$1,860	\$33	Best of breed

Source: Citi Research

Cybersecurity

Security is at odds with the openness and flexibility inherent in remote work so a re-focus on cybersecurity is likely

Beyond productivity considerations for information workers, the broader remote work topic is likely to cause a re-focusing on cybersecurity. Broadly, we see the COVID-19 pandemic accelerating remote work, something that was already underway, driven by forces that we have already discussed. As is typically the case, security is at odds with the sort of openness and flexibility that is inherent in remote work, as compared to traditional “in-office” environment. Today’s cybersecurity architectures, especially within larger organizations, were originally designed in an environment where the overwhelming majority of information workers were physically located in a company facility. Remote work was very much the exception and many times “bespoke” sort of security measures were applied to accommodate remote work.

The risks associated with remote working are numerous

At a high level, one may observe that the fundamental tenants around cybersecurity are unchanged no matter where an employee is working. Employees will continue to access business systems and interact with proprietary company data. However, the risks introduced from remote work are numerous. We don’t here present an exhaustive list, but rather a few illustrative examples.

- Home and other non-work Internet connections generally lack the filtering most companies have “behind the firewall”. Many remote users use “split tunneling” and otherwise mix native browser access with corporate application access, increasing their vulnerability to attacks. There has been a reported uptick in phishing attacks (links coming through in corporate email) already with COVID-19, exploiting this.

- Similarly, home WiFi may lack the enforcement of appropriate encryption and access control, allowing other devices on the same network as corporate devices at home, as well as communications that can be intercepted.
- Employees at home can many times download data to non-corporate devices. Employers then lose control of this data. Also, related to lack of control of non-work Internet connections, this data can many times be saved locally or on unsanctioned file storage/sharing systems.
- Home computers that are accessing corporate systems may not be properly patched. Also, it is harder to enforce patching even of corporate laptops on home networks, as they are intermittently connected and may not be online with updates are “pushed”.
- Lastly, it is more challenging to control physical access to systems in a home environment, especially with family members, roommates and others sharing spaces outside of the office.

We expect that cybersecurity architecture will evolve at an accelerated pace

We expect that cybersecurity architecture will evolve at an accelerated pace, in parallel to this cultural change of remote work within many organizations. We conceptualized this as a shift from “inside-in” to “outside-in” and “outside-out” will likely have a profound impact. This maps the shift we see in security being provided as a service and being able to extend the reach of corporate security policy out to the edges of the Internet. Additionally, with more and more data outside the corporate firewall, in systems such as SaaS applications and hyperscale infrastructure, this approach is being pushed by more than just remote access.

We see specific focus on defensive measures such as cloud-based Internet filtering/policy management and VPN services, broader deployment of strong authentication, closer monitoring of end-points (corporate laptops and even home computers) to detect security issues earlier, more sophisticated monitoring and control of corporate data (using cloud-access security broker and data loss prevention technology) and even auditing and assessment of employee remote access physical environment with traditional means or through the camera on the device.

Interview with Mark Loehr, CEO of Open Exchange

Does 2020's pandemic mark a turning point for video conferencing technology?

The pandemic and global WFH marks an inflection point in video adoption which will be looked at years from now as before and after. Whereas online businesses took 10+ years to achieve 40% market share, video usage jumped from 5% to 100% in a matter of weeks. But most notable has been the reaction of participants. Buy side clients are saying they are finding meetings more valuable as they have the right people in the right meetings at the right time. Sell side firms are finding that their conference attendance has gone up by over 20% as ease of participation has increased. For OpenExchange we saw a fairly consistent 40% compound annual growth rate (CAGR) from 2016-2019, with Citi being the leader by growing client interactions from 4,000 to 25,000 during that period. We are seeing 3000% growth in 2020. Current thinking is that new normal will lead to a 35/65 split of virtual/physical starting in 2021.

How has the technology improved over the last 5-10 years?

The two biggest changes are Zoom and livestreaming. Zoom's ease of use revolutionized usage for corporates and buy side firms with firms like OpenExchange providing interoperability to major banks such as Citi to allow for much greater video usage into previously approved platforms. Security is critical of course and Zoom's recent issues temporarily allowed competitors such as Webex and Teams to gain some traction. Having said that, the release of Zoom 5.0 with 256 AES encryption and better use of waiting rooms has allayed most such concerns and Zoom's upward trajectory has renewed.

Livestreaming differs from webcasting in that it points participants to a destination such as a bank portal, distinct microsite or community destination. It allows content to reach a much wider audience in a YouTube for Finance video library that is secure and searchable. Watch for this phenomenon to increase dramatically in 2H20

What types of mass virtual meetings have you facilitated during this pandemic?

OpenExchange handled the first ever 100% virtual conference in HK/China in February and since then have handled 40 virtual conferences for 9 out the top 10 global banks. This included Citi's flagship Communications Conference in March in which the highlight was the CEO of BT doing his first virtual meeting with investors while quarantined with the virus. Virtual conferences started off with 1x1 and small group meetings, but have grown to include webinars, simultaneous livestreamed plenary sessions and creation of unique conference microsites to enhance user experience. Upcoming conferences will include Citi's TMT conference in September which is expected to have over 5,000 meetings in just two days

Ex 2020's need for isolation, what lasting advantages will virtual meetings bring to the business community?

As OpenExchange has supported 10,000 virtual meetings with senior management teams around the world in the last three months we have been able to speak with CEO's and leadership teams about their views on this subject. It has been a rolling wave of awareness, processing and decision making on their part. But as we write this note, the comments made from one CEO today resonated with what we are hearing across the board. Back to work may never be fully back to work. They are going to start with the leadership team and then move to certain groups in safer areas and then move to a Red/Blue workforce until a vaccine or other solution is available. They also remarked on how efficient work had become and how much cost savings had been achieved.

The net result is that companies coming out of this disruption will need to control costs and they just realized one area where they can save 30-40% and possibly increase productivity. But will their clients accept that? As mentioned earlier, clients are also finding video meetings to be extremely efficient. I spoke with one portfolio manager who said today that he was able to save several hundred thousands of dollars from his travel and conference budget in just three months that he could allocate to other research services.

The final point I would make is the question of audio versus video. The results are in. While there was a brief dip towards audio in the first weeks of WFH, once professionals established their workplace setup at home, we are seeing over 80% of connections using video. What the kids are doing ... is what the grownups are doing. The adoption curve is a super-sized S-curve that will be noted for decades to come.

Chapter 9: Impact of Telework on Real Estate

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We note the number one topic dominating conversations on U.S. office space is how big of an impact working from home or other alternate/flexible arrangements will have in a post-COVID-19 world and the impact this could have on fundamentals in both the near and longer term.

Similarly in Europe the discussion and debate that office space is potentially 'dead' has accelerated with new vigor from the realization that more work from home is at least logistically possible. Systems have been stress-tested during the largely globally enforced work from home lockdowns and have seemingly not melted down.

In more recent weeks the strength of the work from home argument has moderated and ultimately the outcome will be different for each individual job as employers and employees maximize the benefits of more agile working. It should be remembered this is not a new debate. Flexible working has been increasing for decades. The key new piece on information added by the virus is that logistically, systems have been able to cope with almost whole cities working from home. Combined with the forced accelerated resolution of other work from home challenges (e.g., changing communication lines), office markets face a likely acceleration of flexible working for many more than previously thought. In the section that follows, we discuss some of the potential implications for office property and the cities they occupy.

As of the beginning of June, European office workers are beginning to return to the office. As competitive pressures resume, each existing job faces new flexible work arrangements based on the optimal enhancement to (not maintenance of) revenue and costs, with the human factors ultimately featuring in one or both. However a key unknown for real estate is can new industries be created without office space? Human ideas, grown by human collaboration into reality, have to date formed for a large part within cities and indeed created cities while work from home was in fact enabled.

Job Numbers Have Swelled in European Cities at the Same Time as Technology Enablement Accelerated

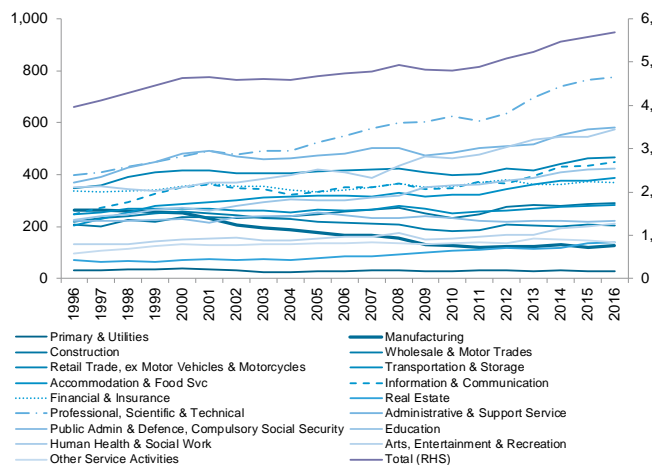
Despite an increase in technology and technology sector employment, European cities have thrived

During a period of significant technology enablement, agile working European cities have thrived. London has a deep pool of data, which show job numbers have grown through a tech boom and where work from home was enabled per Figure 48. The dotted lines represent industries which make up a larger component of the central London office market. Some of the highest areas of job growth are within the technology sector, which is largely producing the agility of work technology and often is the driver of modern office design and a more flexible working enablement. The virus could have acted as a catalyst for a permanent and significant transfer of value created in the office to value created in the home. However, cities are flexible environments, adaptable over time to create an economic ecosystem that in the past has accommodated increasingly higher-value activities at the demise of lower value uses. Figure 48 shows the insignificance and continued decline of manufacturing jobs on London. It also shows the flattening of job growth in mature traditional sectors like banking and finance — a growth area in the 80's and 90's in particular. The growth of tech jobs overtook banking and finance headcount in London in around 2013. This data shows how cities evolve significantly over time often driven by big bang events.

Buildings in cities often change in use over time as city demand evolves

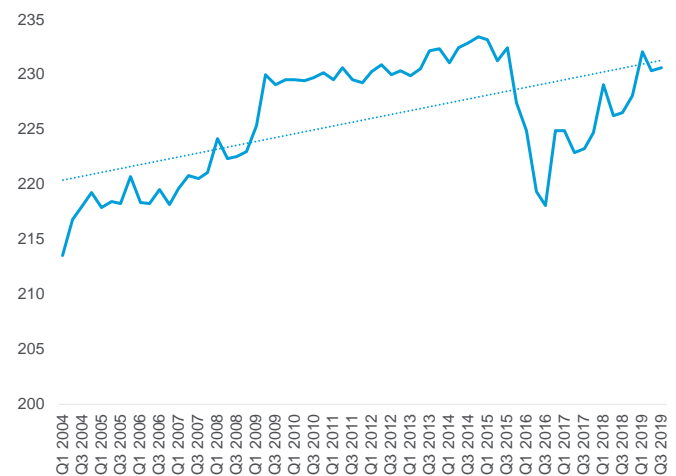
This evolution has led to a continued growth in London office space, seen in Figure 49, even against the conversion of significant office space to residential around the mid-2010's after a housing price boom. This drove a decline in some central business distance (CBD) office space, which was converted to residential, and lower value office space shifted to the periphery of the city. As employment growth continued, office rents grew and as the residential market cooled again office became more profitable to develop, driving growth in office supply in the city. Buildings in cities often change use over time as city demand evolves. While work from home may reduce office demand, it could accelerate residential and other flexible uses, and indeed create new uses that do not exist today.

Figure 48. London's Job Growth Led by Agile Working Enablers ('000s)



Source: GLA, Citi Research

Figure 49. London Office Space Growth (m-sq. ft.)



Source: Knight Frank, Citi Research

Increased work from home should be seen as an evolution of existing trends

This growth occurred while flexible working, including work from home, had been growing. For example, a 2017 Greater London Authority (GLA) office policy review noted that London office space demand could reduce by more than 10% as more agile working enabled working from home. Office of National Statistics (ONS) data showed that 20% of those employed in business services in London worked mainly at, or from home and the jobs that home workers carried out tended to be concentrated in higher-skilled roles. In 2014, homeworkers were 4.2 million in the U.K. (up from 2.9m in 1998) a trend London shared. As a proportion, home workers were 13.9% nationally of which 5% worked within the grounds of their home and 8.9% used their home as a base. Roughly, 10% of London's workforce worked from home and a further 10% had no fixed place of work, highlighting that increased work from home should be seen as an evolution of existing trends once social distancing measures are completely removed.

In the U.S., a recent survey by Gensler showed that 30% of employees wanted some type of flexible work arrangement (3-5 days remote) while 70% preferred to work the majority of their time in office.

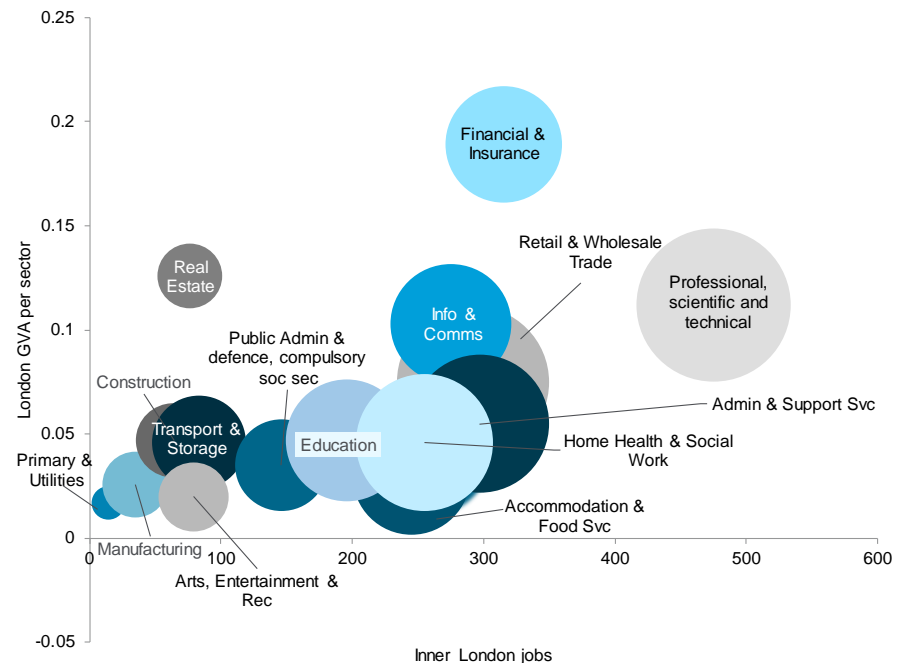
Cities Have Higher GDP Density

Densification of cities is key to their longevity and appeal to business

Densification brings a wealth of capacity in many forms. Gross value added (GVA) in London is spread over many subsectors, which change in importance over time per Figure 50. While some subsectors are in decline, more are growing headcount and new jobs that didn't exist before are being created. While this has historically been clustered physically, the market should be open to the possibility this could be done virtually. Can the new industries and business titans of tomorrow be created virtually? We believe this is key question that has not been proven. The threat to London presented by Brexit caused the most recent examination and test of the clustering benefits of cities. It is likely that physical factors contribute to the creation of the jobs. For example circularity of the density of jobs, wealth, and spend drives the best restaurants, museums, art galleries, theaters, and bars that aid in the cross pollination of ideas and sectors that create the job growth that attract the talent pool of employees, that attract the strongest employers.

Density appears to feed off itself and indeed creates the circular ecosystems of jobs, higher pay, and job security offered by cities as re-employment opportunities are higher where the density of jobs is the highest. Figure 51 compares the GDP of London and New York to global countries highlighting the challenge the virtual world must overcome if it is to dismantle cities. Cities offer the commercial potential of whole counties and there are physical enablers of this many of which cannot transfer online. Competitive pressures will ultimately dictate the work from home or office mix.

Figure 50. The GVA of Cities Are Diverse. Some Jobs Will Disappear but New Jobs Not in Existence Today Will be Created.



Source: GLA

Figure 51. GDP of Cities like London and New York are Bigger than Most Countries

Rating	Economy	US\$ mn	Rating	Economy	US\$ mn
1	United States	17,419,000	17	Netherlands	879,319
2	China	10,354,832		London (Brookings)	835,866
3	Japan	4,601,461	18	Turkey	798,429
4	Germany	3,868,291	19	Saudi Arabia	746,249
5	United Kingdom	2,988,893		Paris (Bookings)	715,080
6	France	2,829,192	20	Switzerland	701,037
7	Brazil	2,346,076		London (BBC)	657,557
8	Italy	2,141,161	21	Sweden	571,090
9	India	2,048,517	22	Nigeria	568,508
10	Russian Federation	1,860,598	23	Poland	544,967
11	Canada	1,785,387	24	Argentina	537,660
12	Australia	1,454,675	25	Belgium	531,547
13	Korea, Rep.	1,410,383	26	Norway	499,817
	New York (Brookings)	1,403,463	27	Austria	436,888
14	Spain	1,381,342	28	Iran, Islamic Rep.	425,326
15	Mexico	1,294,690	29	Thailand	404,824
16	Indonesia	888,538	30	United Arab Emirates	399,451

Source: Citi Research

The removal of outdated jobs in a city is needed in order to create capacity for new job growth

Indeed cities need to be re-vitalized and reinvent themselves so the removal of outdated jobs is needed to create vacancy for new job growth. With vacancy rates across many cities in the very low single digits, freeing up space is needed to keep the cities the pinnacle of most endeavors.

Office Design Evolution Could Accelerate Blurring Home and Office and Increasing Employee-to-Desk Ratios

Office are not set up for social distancing

Offices are certainly not designed for social distancing, nor is the profitability of services like food & beverage supporting offices. Office configuration and density (including elevator capacity and inter-office mobility) are key transition issues unless social distancing becomes permanent, which could in theory drive higher floor space demand reversing higher densification trends if combined with competitive pressure to occupy office space. Pre-virus office density had been increasing. In our models for European office space, we estimate the average employee uses 150-175sq.ft of office space (including communal spaces). While office efficiency, particularly for new builds can be well below 100sq.ft per employee, we find that in practice such high efficiency utilization is not generally achieved or desired. Hot-desking can mean some businesses run significantly more people than desks. Other businesses run higher levels of space per employee than our estimates and many take additional capacity to accommodate expected growth.

Flexible working could see employees create the working environment that maximizes their individual performance

Office rent costs have been reported at around 10% to 15% of the salary costs of the employees in them, so this is a meaningful cost to be balanced between employees and shareholders. BYOD (bring your own device) could extend to BYOO (bring your own office) as flexible working could see employees create the working environment that maximizes their individual performance. The process of accelerating more flexible working could identify opposed objectives with companies needing to weigh the cost/benefit of real estate cost savings versus productivity, culture development, and efficiency that a physical office provides. Employees are most focused on the social aspects of in-office attendance (meetings, collaboration, socialization, community) and less on productivity. Some employers who have announced a post-COVID-19 work from home flexibility are adjusting wages depending on geography. Furthermore, the cost of back up business continuity offices for disaster recovery may be increasingly called into question as possibly replaced by work from home in a disaster situation.

Office design has also been evolving for many years to include better internal food & beverage and coffee facilities, break out areas, and more flexible working layouts including hot-desking. Numerous employers for particular jobs go even further and are deskless, utilizing embedded technology in the deskless office as workers are increasingly working via tablet or laptop.

New take up of flexible office space averages 10% of take up

Flexible office space is already a significant portion of London office space. Although flexible office space is less than 10% of total office space, new take up of flexible office space averages 10% of take up and in some cities in Europe can be as high as 25% of new take up. Indeed the flexible office market has been transformed over that last 5-10 years and most traditional office landlords in Europe have flexible offering products in addition to the many flexible office specialists. Some offerings are aimed at start-ups and others at existing businesses seeking flexible office space for a variety of reasons such as office project work or as their staff work more flexibly in terms of task and location. Traditional office occupiers continue to re-design and optimize their space. Offices in many cases have been increasingly taking on the characteristics of hotels.

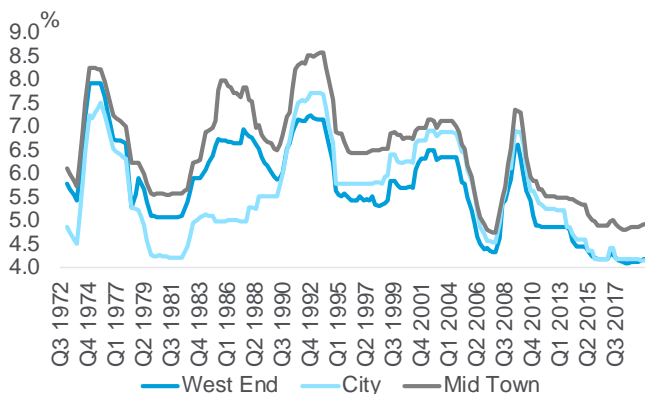
In the U.S., in terms of location, satellite offices are being opened already around New York City. Companies may look to open satellite offices near employees' homes to avoid commutes and public transportation. While this satisfies the immediate need for space caused by social distancing it is likely shorter term in nature and will either lead more heavily toward larger offices or at home work arrangements.

The Value of Cities is Volatile and Transferable to the Highest Value Use

Given the volatility of office rents and valuation, the negative demand shock from a virus-driven recession is likely to cause a short-term painful rent and value decline

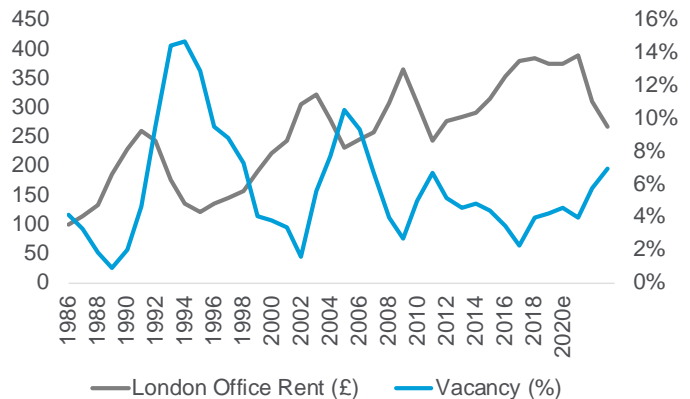
The immediate impact from the virus on office markets is most likely to be caused by the economic damage to businesses ability to pay rent and a GDP recession. Optimizing work from office/home is likely to evolve later. Office rents and valuation yields are volatile per Figure 53 and Figure 52. The negative demand shock from a virus-driven recession is likely to cause a short-term, painful rent and value decline as office markets are and remain very cyclical.

Figure 52. Valuation Yield Volatility Is High and Driven by Employment Growth (Office Demand) vs. Supply



Source: CBRE data

Figure 53. If the Virus Causes Unemployment and Vacancy Rates to Rise, Office Rents Will Collapse, Collapsing Values (£ psf, %)

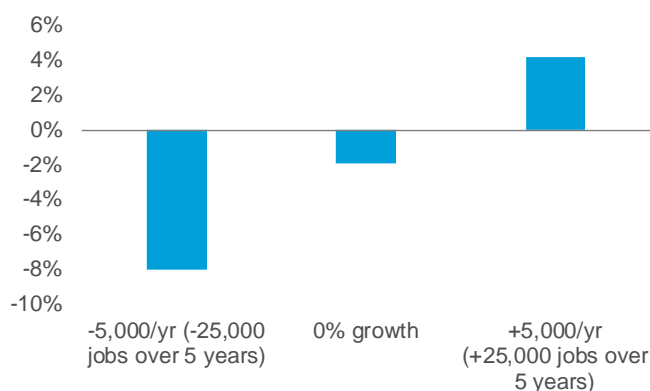


Source: Knight Frank, CBRE, Citi Research

Office rents are driven by demand from (1) new employment and (2) the space requirement per employee. The supply pool of office space is driven by (1) new development supply adding to space and (2) the obsolescence of existing space shrinking the total size of an office market by about 2-3% per year.

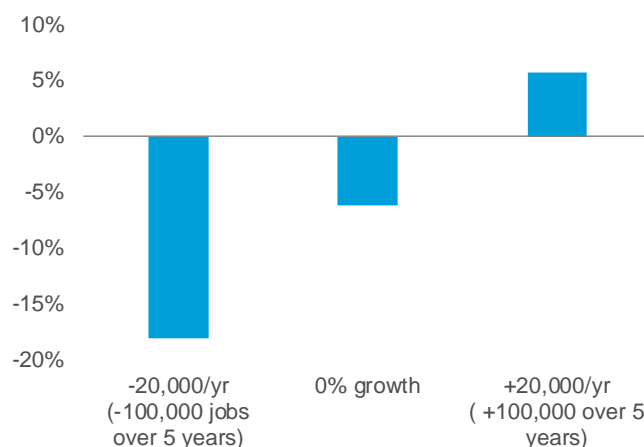
Combining office demand and supply drivers allows us to estimate a city's vacancy rate, which has an inverse correlation to rents (see Figure 53 above). Looking specifically at Paris and London in the current environment as both have known development supply, the charts below plot the average annual rent growth at different employment levels.

Figure 54. Paris Office Rent Growth Estimates at Various Job Growth Levels Annually



Source: Citi Research

Figure 55. London Office Rent Growth Estimates at Various Job Growth Levels Annually



Source: Citi Research

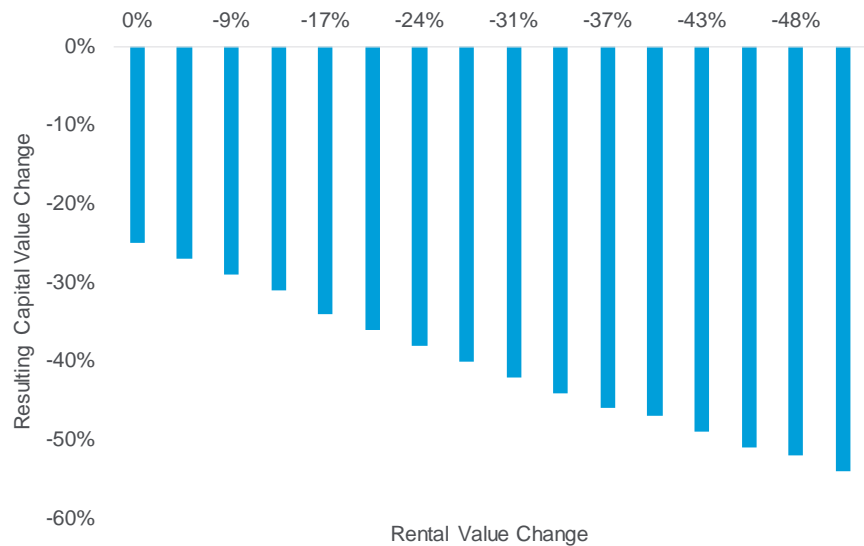
For London & Paris, if office space requirements fall by 40%, it will take 26 years of strong employment demand to refill vacated space

But the value on the property could transfer from office to residential or other flexible-work real estate arrangements

The estimates above are based on 175sq.ft per head of employment. If that requirement is 40% lower assuming space can be condensed in lock step from two days a week working at home, it would take 26 years of strong employment demand to refill vacated space, all other factors being equal. With real estate rents a derivative of the value produced on the property, this is shifting the gross value added (GVA) of an office to residential or other uses. There will be some transfer of usage but it is unlikely to be one-for-one. One square foot of office space rendered not required because of work from home is unlikely to create one square foot of residential or other use demand, i.e., flexible office space, hotels, or coffee shops. It is likely to be some percentage of the decline in usage, resulting in a lower net space requirement with supply exceeding demand for some time. The negative office job growth above is likely to translate into significant valuation decline for office assets until demand returns to exceeding supply.

If we assume the GVA of an employee is the same at home as in the office and rent is a derivative of the value produced on that land, then value could transfer from offices to residential or other flexible work real estate beneficiaries. The costs associated with owning an office property requires at least 3% per year rental growth to earn a 6% internal rate of return (IRR). Figure 56 shows that zero percent rental growth drives negative valuation for office properties from current valuations. Construction of new offices would fall, refurbishment could increase, and higher-value uses like residential could take over office space.

Figure 56. Capital Value Decline of the Office Market at Various Rent Decline Intervals



Source: Citi Research

Can the next generation of employers be created without office property?

There are a number of risks and benefits to allowing employees to work in a more flexible environment

As the virus has proven it is possible to work from home — we expect an acceleration of agile flexible working trends...

...however, we expect the benefits of cities to continue to drive new job growth, office evolution, and continued space demand

A key question is can the next generation of employers be created without office property, or with very little office space? Or do businesses have to grow and mature through office space, then transfer existing measurable jobs to work from home?

A number of work from home risks and opportunities have been identified by our U.S. REIT team. Benefits to allowing employees to work in a more flexible environment include (1) hiring from an expanded talent pool; (2) allowing for more work-life balance; (3) minimizing time and costs lost commuting; and (4) higher flexibility. Risks identified included: (1) hiring, training and ramping up new employees; (2) establishing and maintaining company culture; (3) collaboration and idea generation; (4) potentially renegotiated pay structures; (5) fear of missing out; (6) increased distractions; (7) blurred lines between work and home, which could lead to burn out; (8) infrastructure challenges; and (9) security/regulation.

Our current base case is that the key new piece of information this work from home enforcement has brought is that logistically it is possible to work from home en masse. We therefore believe the new normal, after an extended transition period back to office life, will likely see a continuation, if not acceleration, of agile, flexible working trends, where working from home was already a feature having benefits for both employer and employee in many cases. We expect the benefits of cities to continue to drive new job growth, office evolution, and continued space demand across the real estate sub sectors the make a city. However for office property specifically, work from home could become a significant office rental and value deflator with office value lost transferred to other sub sectors. It is unlikely to cause the death of cities, but a continual evolution of cities who have changed through many other big historical events.

Work from home also has implications for other ancillary services, for example contract catering inside offices.

Contract caterers are companies hired to provide catering services (cafeteria, coffee shop etc.) on a regular basis within an office building.

We see the threat of home-based working days in a range of 10-20%, equivalent to perhaps 4-8% of revenues for a typical contract caterer

We think caterers are well-placed to adapt to changes in the office environment

Increased focus on safety and hygiene could mean corporates with self-operated cafeterias may consider outsourcing

Impacts on the Contract Catering Industry

The contract catering industry is also exposed to the structural threats to office working. That said it is important to scale the issue. For the major caterers, around 40% of their revenue is collected from Business & Industry (B&I) clients with the balance predominantly from Education, Healthcare, and Sports & Leisure clients for whom working from home is less relevant. Even within the B&I segment not, all clients will be able to allow staff to work from home (e.g., manufacturing plants). Carl Frey's analysis at the beginning of this report suggests around 52% of jobs in the U.S. can plausibly be done from home but a recent study by the National Bureau of Economic Research (NBER) suggests the figure is lower, at 37%. Data from the U.S. suggests around 15% of workers regularly worked from home prior to the crisis and this has increased to about 50% post the COVID-19 lockdowns.

This suggests the incremental long-term threat to attendance on B&I client sites is in the 22-37% range, assuming all those able to do so permanently work from home. Carl's analysis of the benefits humans derive from getting together to collaborate and innovate makes it seem implausible that all these workers will permanently shift out of their offices. We think a more credible outcome is that the recent crisis emboldens firms and individuals to be more flexible, acknowledging that working from home may be productive 2-3 days per week but important collaboration and client/customer facing work will require office attendance on the other days. As a result we think this scales the threat down further to a range of perhaps 10-20% lost office based days — equivalent to perhaps 4-8% of revenues for a typical contract caterer.

Despite the risk to group revenues we think caterers are well placed to adapt. The vast majority of costs for a contract caterer (70-80%) are variable food and labor costs and we expect styles of service and headcount levels will adapt to the potentially lower volume environments. We also expect organizations to enhance onsite food & beverage and coffee offers to encourage collaboration between individuals on the days they do come into the office. Indeed some professional services firms are already pursuing exactly this approach to their onsite offers. Similarly, those attending the office may well choose to make the most of office time on the days they are present to arrange coffee/lunch catch ups, reckoning that working from home days are better for running chores during lunchtime.

We also see potential opportunities from increased outsourcing. The COVID-19 crisis has increased the focus all of us put on hygiene and safety — never has it been more important to conform to appropriate standards. We expect this crisis will encourage those organizations providing self-operated cafeterias to reconsider this approach. We think this could potentially drive a new wave of outsourcing to specialist providers who are well-versed in delivering food service in the safest and most compliant way.

Impacts on the Housing Market

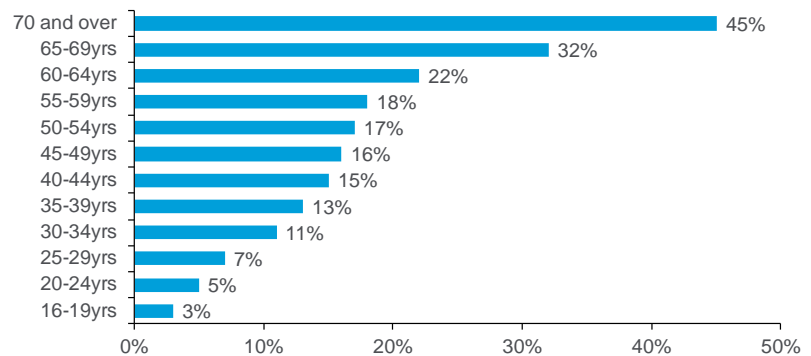
The move towards remote working as a result of the current COVID-19 pandemic has had a further knock-on effect on our appreciation for work-life balance, need for access to green spaces, and increased consciousness towards our environmental footprint especially air pollution. We believe the possibility of working from home becoming some part of mainstream work-life is also likely to influence design and specification changes for new homes as well as location preferences among homebuyers.

The new found willingness to include some form of flexible working pattern is likely to influence home buying decisions

Anecdotally, several factors influence a potential home buying decision including mortgage affordability, commute time, need for space, and location of schools. Although employers are unlikely to move towards full-time remote working post the pandemic, their willingness to include some form of flexible working pattern is likely to influence home buying decisions. This may reduce the emphasis of proximity to work while prioritizing the need for greener spaces such as gardens and woodlands. This could have a significant impact on the supply/demand dynamics in the housing market across some global cities.

While there are variances between regions and cities, we look at the U.K. and London for the potential implications of increased telework. Examining the remote working trends pre-COVID19, around 14% of the U.K.'s employed workforce mainly worked from home in 2019 and the current crisis has seen this rise to about 50%. However, the preference for remote working is likely to be skewed to older age groups and changes to their location preference has a direct impact on affordability.

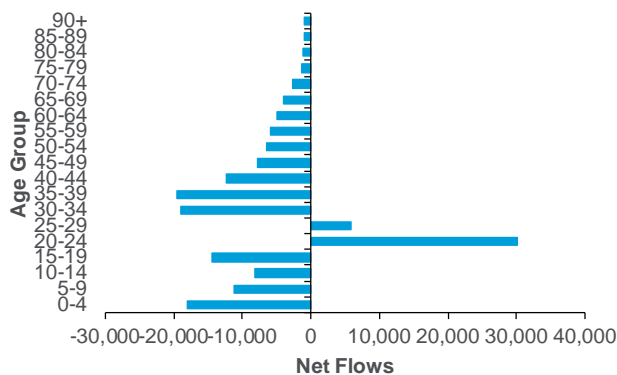
Figure 57. U.K.: Percentage of Workforce Working from Home by Age Group, 2019



Source: ONS

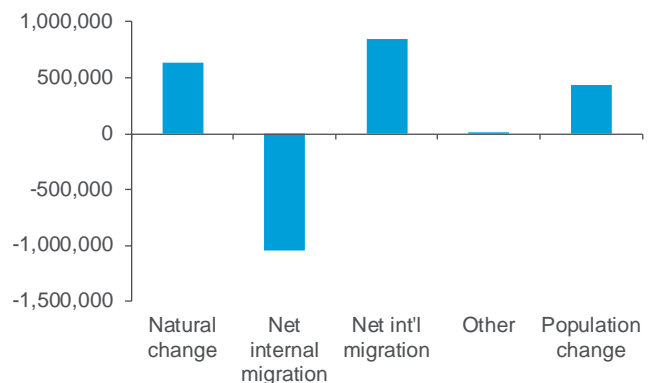
Before the pandemic, there was already an underlying net trend with the 30+ age group moving out of London driven mainly by affordability and space constraints. We believe flexible work structures further accelerates this trend. Current population projections for London outline about 5% population growth over 2018-28 broadly in line with England but a sharper internal emigration implies we may well be past peak London house prices.

Figure 58. London: Net Internal Migration by Age, 2018



Source: ONS

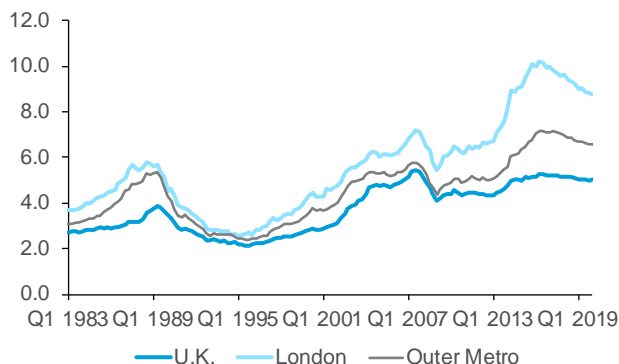
Figure 59. London: Components of Population Change (mid-2018-mid-2020E)



Source: ONS

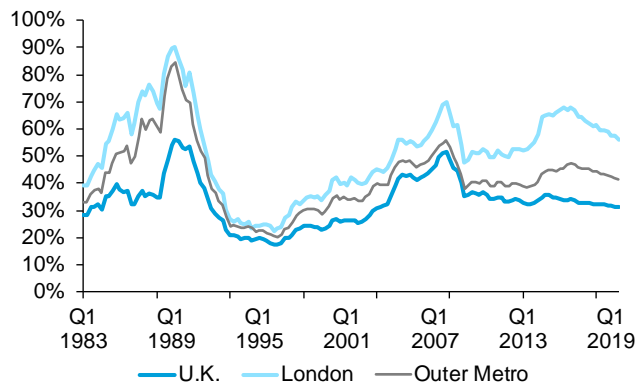
Affordability constraints continue to be a key challenge for the London market, which has resulted in a trend of softer house prices over the last five years.

Figure 60. FTB House Price-to-Income Multiple – London vs. U.K.



Note: FTB = First-time Buyer
Source: Nationwide

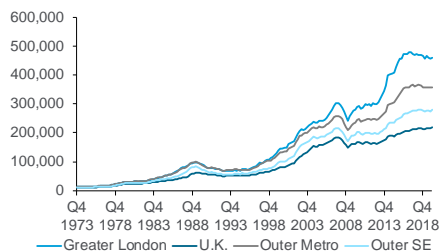
Figure 61. FTB Mortgage Cost-to-Income Ratio – London vs. U.K.



Note: FTB = First-time Buyer
Source: Nationwide

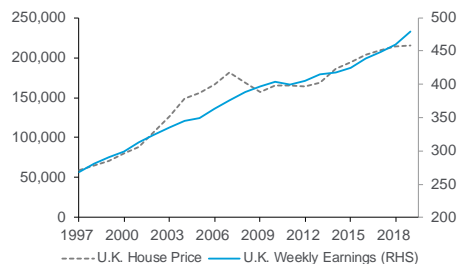
Long term, average incomes remain the biggest driver of house prices in any region and the differences in job opportunities and income levels between London and the rest of the country explain the trend in house prices over the last twenty years.

Figure 62. House Price: U.K. vs London (£)



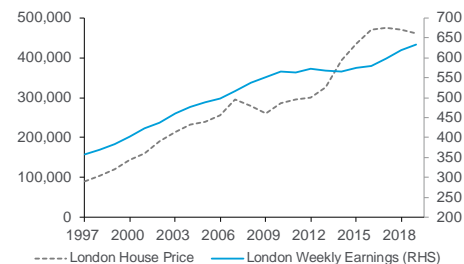
Source: Citi Research

Figure 63. U.K.: House Price vs. Earnings (£)



Source: Citi Research

Figure 64. London: House Price vs. Earnings (£)



Source: Citi Research

As places of work becomes less important and more flexible, longer commutes will likely become more acceptable leading to changing attitudes about where home buyers choose to live. Currently the average standard price in Greater London is generally 1.3x the price of houses in the Outer Metropolitan region and are 1.7x the price in the Outer Southeast region. As attitudes change, there is an increasing likelihood of normalization in house prices between cities and regions in proximity.

Chapter 10: Impact of Telework on Corporate Travel

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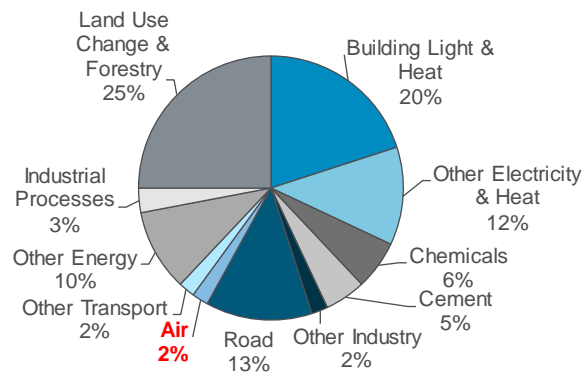
As we all start to muse the new world in which we find ourselves post-COVID-19, we expect changes in travel patterns to have structural consequences on numerous industries including airlines, airports, hotels, and car hire.

Airlines

Across airlines, we see impacts in carbon emissions and corporate travel.

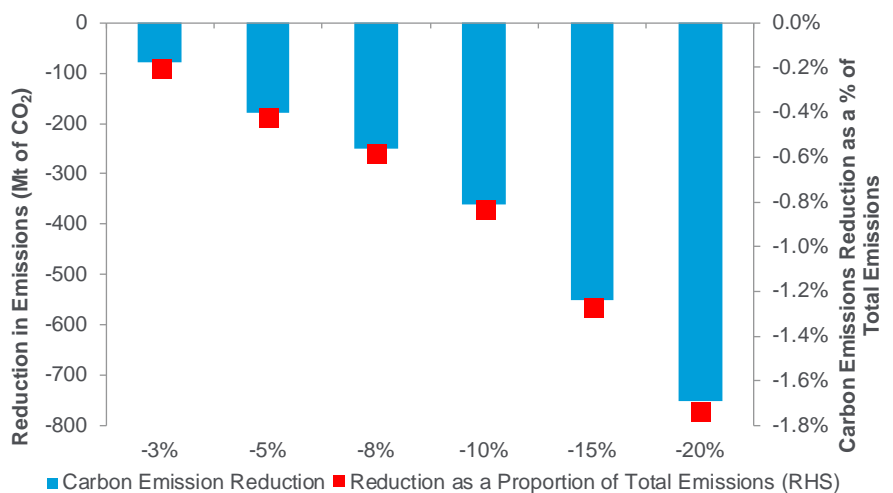
■ **Carbon Emissions:** In 2019, the theme of flight shaming infiltrated into corporate and public consciousness and began to dominate the aviation press. However with aviation only making up 2% of global emissions, it is hard to see any immediate deterioration in passenger volumes having a material impact on total global carbon emissions in the short term.

Figure 65. Global CO₂ Emissions



Source: IPCC, WRI

Figure 66. Carbon Emission Reduction Under Different Scenarios

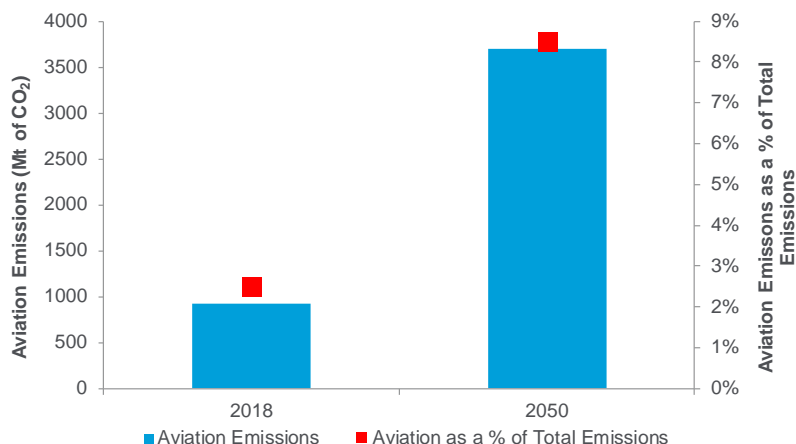


Source: IEA, IATA, Citi Research

As airlines are expected to make up an increasing amount of global carbon emissions in the long term, any substantial change in passenger consumptions will have a bigger effect

Longer-term however, there is likely to be more of a profound impact from a secular change in passenger volumes, with the International Energy Agency (IEA) estimating (prior to the crisis) that global emissions were to jump to 43 gigaton (Gt) by 2050. In other words airlines (on their prior trajectory) would have made up 9% of global carbon emissions, rather than just 2% today....and thus any substantial change in passenger (both leisure & corporate) consumption will likely have a more material long-term impact on global emissions as a percent of the (future) whole.

Figure 67. Aviation Emission to Jump from 2% to 9% by 2050 Without Additional Measures



Source: IEA, ICAO

- **Corporate travel:** Switching focus to corporate travel, we see the impacts as far reaching both short- and long-term, given (1) the varying quarantining and border rules of different countries for the foreseeable future (creating, if anything, significant litigation risks for corporates) and (2) the proliferation of virtual meeting facilities, creating a secular shift.

1. In the Short Term, Quarantining Will Have an Impact

Every 1% impact on corporate travel volumes, has a 10% impact on airline profits

Based on our analysis, we find that a 1% impact on corporate travel volumes globally has a 10% impact on airline profits. For perspective, the global airlines industry generated an average of around \$30 billion in revenue over the past two years. Realistically, this number is just an estimate as our analysis assumes all other variables are held constant, i.e., it assumes constant fuel prices and no offsetting costs therefore it doesn't take into account lower fuels and that the airline industry has averages about 40% fixed costs.

Figure 68. Airlines' Revenue Impact Under Different Scenarios of Permanent Traffic Impact Post COVID-19 (US\$bn)

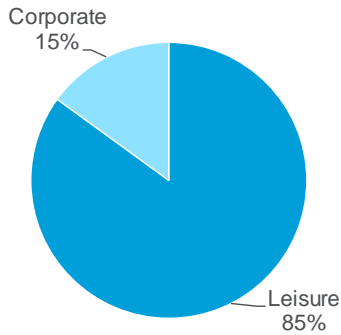
Traffic Impact	-1.0%	-2.5%	-5.0%	-7.5%	-10.0%	-15.0%	-20.0%
Corporate Revenue Impact	-3	-8	-17	-25	-34	-50	-67
Leisure Revenue Impact	-5	-13	-25	-38	-50	-75	-101
Total Impact	-8	-21	-42	-63	-84	-126	-168

Source: IATA, Citi Research

Despite making up 15% of passenger volume, corporate travel accounts for 40% of global airline revenue

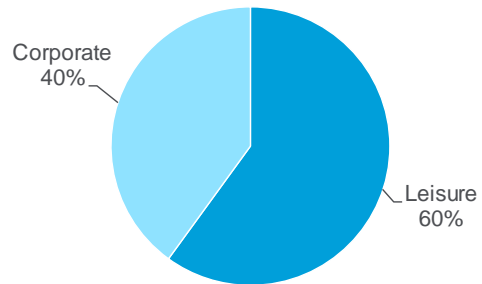
The scale of this headline impact should not come as a surprise given the outsized reliance the industry puts on revenue from corporate travel revenue. Despite only making up 15% of passenger volume, corporate travel accounts for 40% of global airline revenue.

Figure 69. Airlines Passenger Volume Breakdown



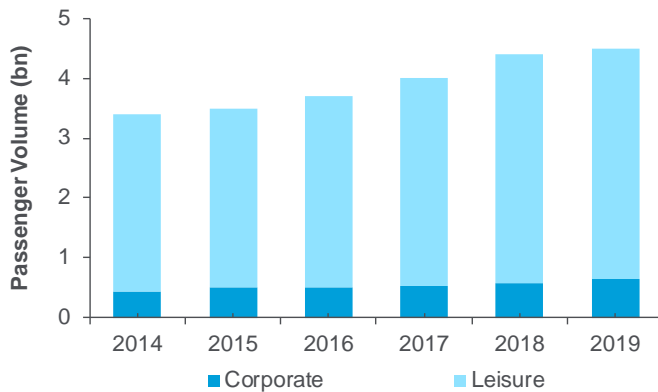
Source: IATA, Citi Research

Figure 70. Airlines Revenue Breakdown



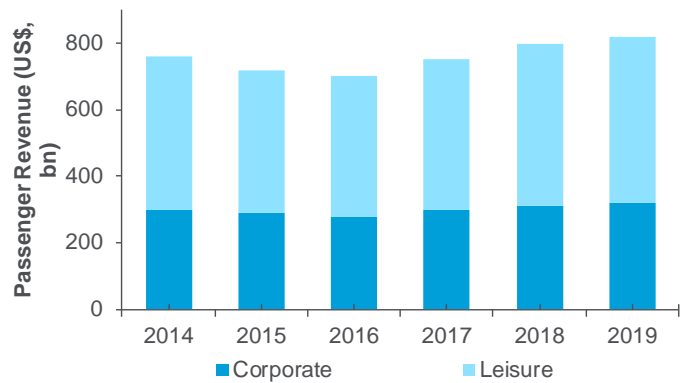
Source: IATA, Citi Research

Figure 71. Airlines Passenger Volume Breakdown (In billions)



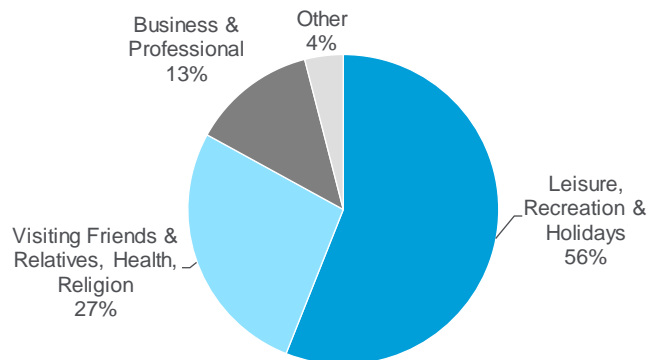
Source: IATA, Citi Research

Figure 72. Airlines Revenue Breakdown (In US\$ bn)



Source: IATA, Citi Research

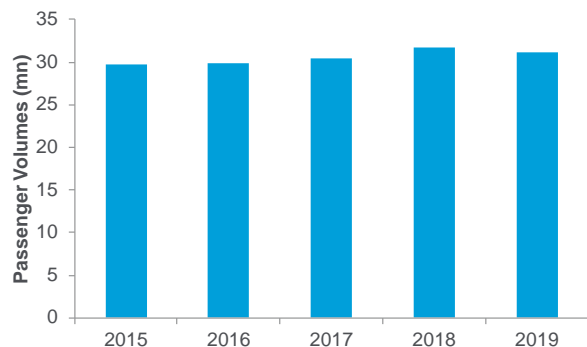
Figure 73. International Inbound Tourism By Purpose of Visit 2018



Source: GBTA, Statista

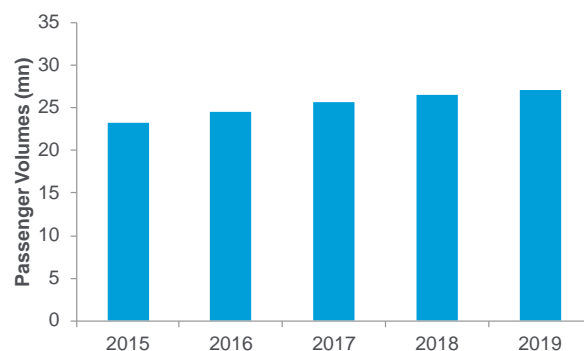
Another way to visualize the outsized benefit of corporate travel to overall travel is to look at the corporate passenger volume for the top ten global cities as shown in Figure 74 through Figure 83 below.

Figure 74. New York Corporate Passenger Volume (mn)



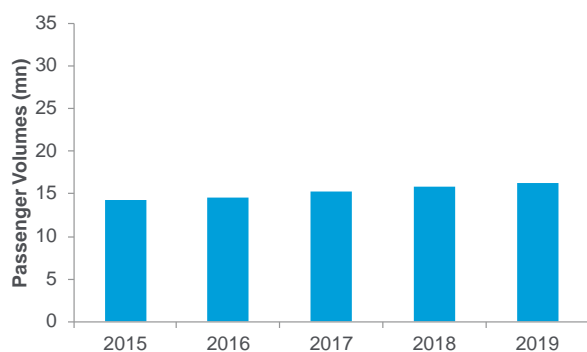
Source: Company Reports

Figure 75. London Corporate Passenger Volume (mn)



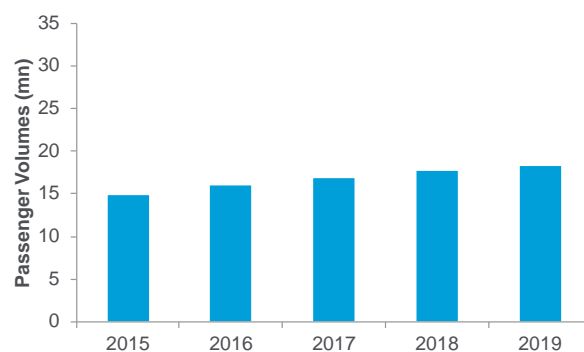
Source: Company Reports

Figure 76. Paris Corporate Passenger Volume (mn)



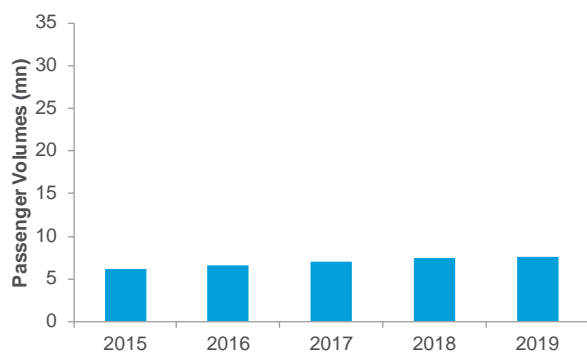
Source: Company Reports

Figure 77. Shanghai Corporate Passenger Volume (mn)



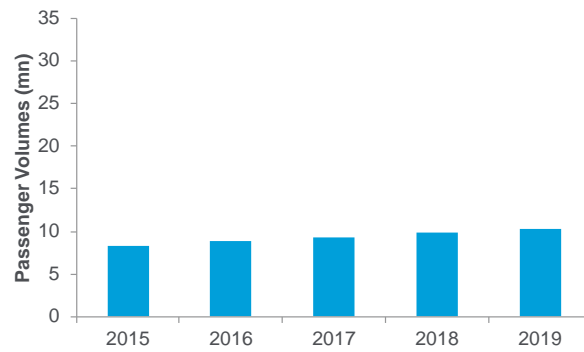
Source: Company Reports

Figure 78. Toronto Corporate Passenger Volume (mn)



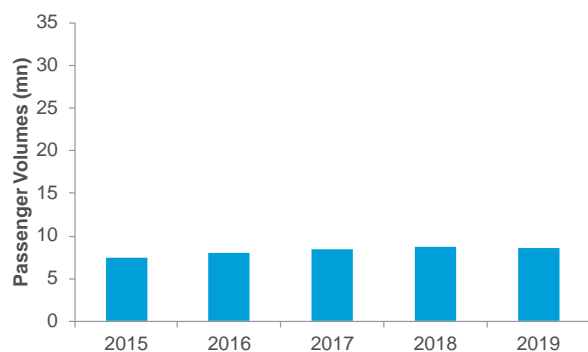
Source: Company Reports

Figure 79. Singapore Corporate Passenger Volume (mn)



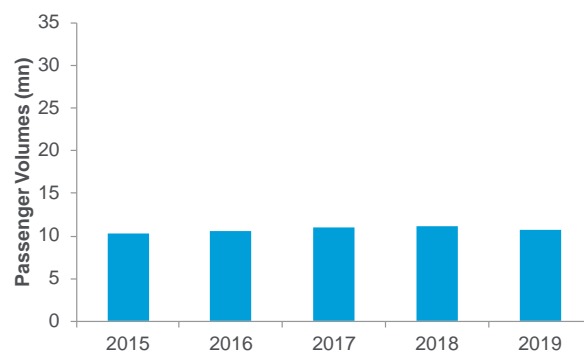
Source: Company Reports

Figure 80. San Francisco Corporate Passenger Volume (mn)



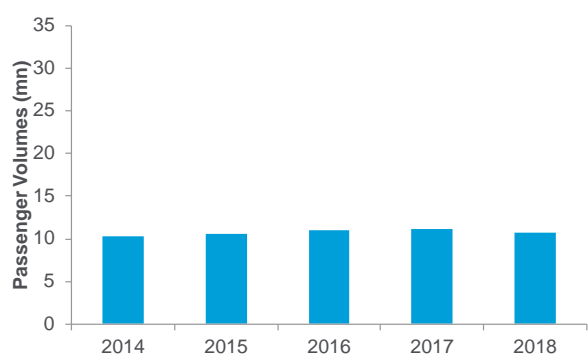
Source: Company Reports

Figure 81. Hong Kong Corporate Passenger Volume (mn)



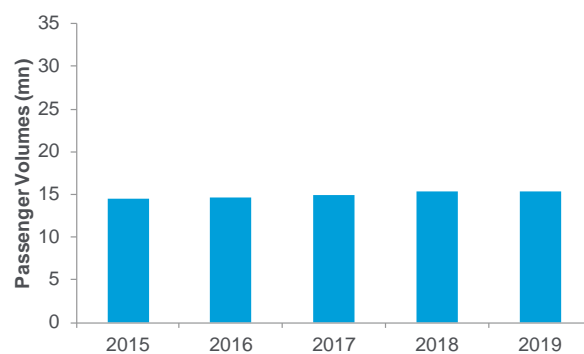
Source: Company Reports

Figure 82. Tokyo Corporate Passenger Volume (mn)



Source: Company Reports

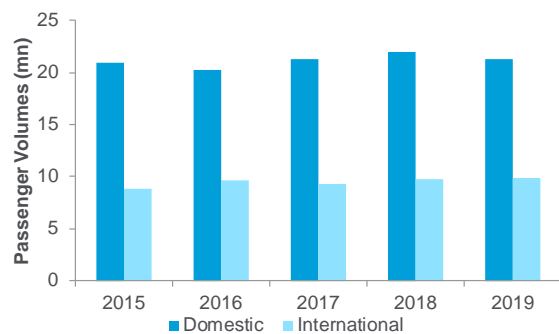
Figure 83. Chicago Corporate Passenger Volume (mn)



Source: Company Reports

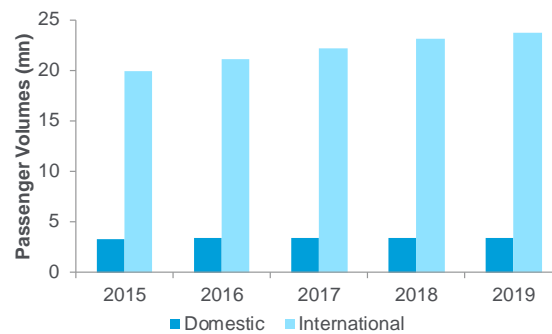
Importantly, in addition to high corporate passenger volumes, these same cities have high international traveler volumes (over domestic). Given the combination of corporate and international volume, these cities have higher risk of being impacted by quarantining in the short-term.

Figure 84. New York Corporate Passenger Volume (mn)



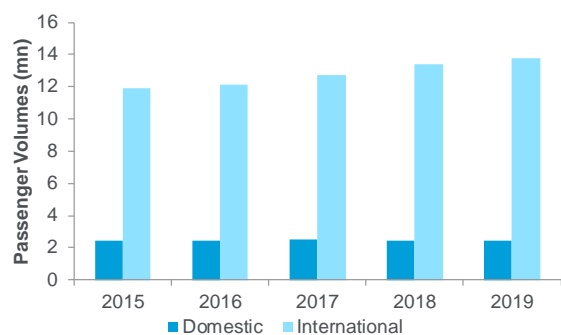
Source: Company Reports

Figure 85. London Corporate Passenger Volume (mn)



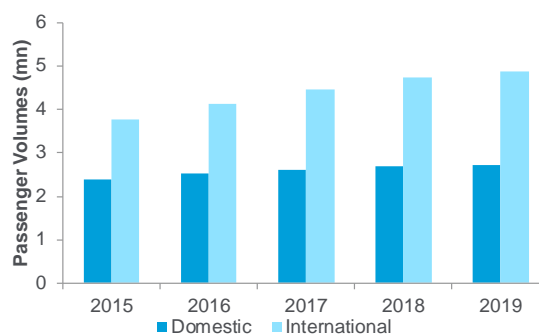
Source: Company Reports

Figure 86. Paris Corporate Passenger Volume (mn)



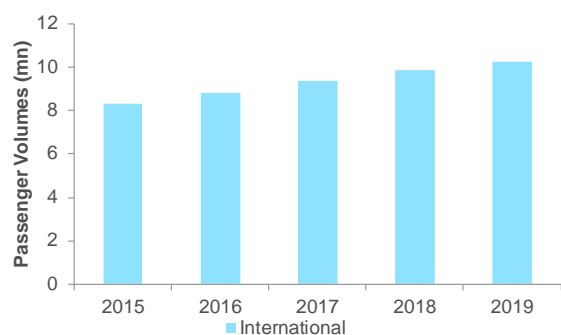
Source: Company Reports

Figure 87. Toronto Corporate Passenger Volume (mn)



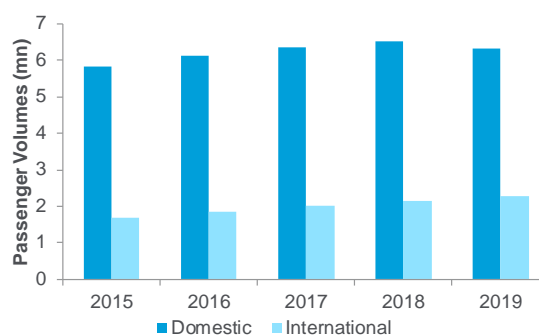
Source: Company Reports

Figure 88. Singapore Corporate Passenger Volume (mn)



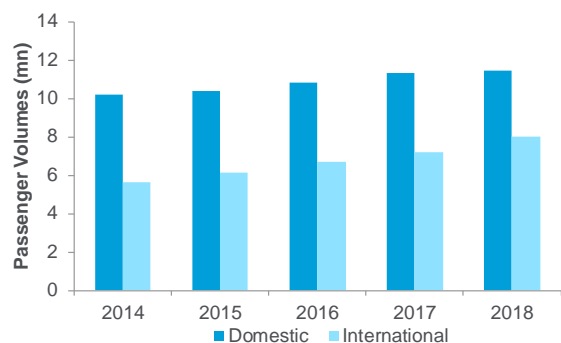
Source: Company Reports

Figure 89. San Francisco Corporate Passenger Volume (mn)



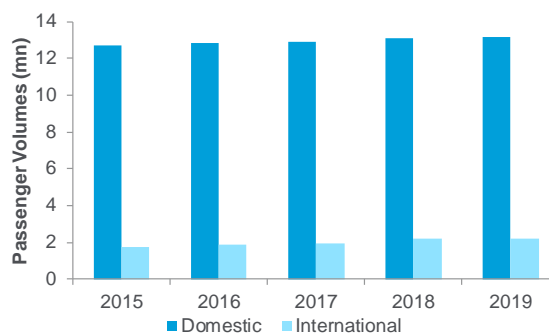
Source: Company Reports

Figure 90. Tokyo Corporate Passenger Volume (mn)



Source: Company Reports

Figure 91. Chicago Corporate Passenger Volume (mn)



Source: Company Reports

2. Long Term Look for a Secular Shift from the Proliferation of Virtual Meetings

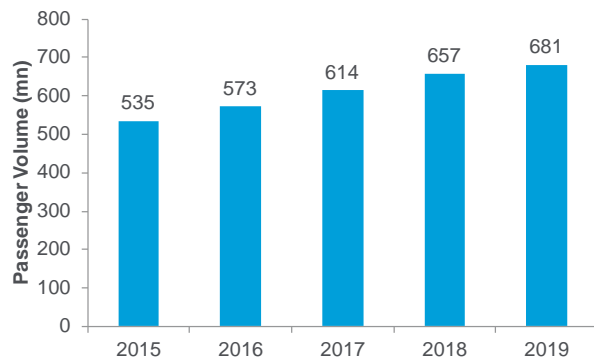
The uptake of virtual meetings has been significant since the beginning of the pandemic crisis as businesses scrambled to find new ways to maintain their business functions including both internal and clients meetings. Anecdotal evidence on the uptake of virtual conferences/ meetings can be seen in recent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

"Zoom surpasses 300 million daily meeting participants." Source: [Reuters](#)

*"Cloud-based applications have also had a major increase in traffic. On March 18th, four million meetings took place over Cisco Webex, more than 2X what we typically handle on a high traffic day. **At peak hours, we saw 24x the normal Webex volume.** And we anticipate these numbers will continue to grow as people adjust and settle into a temporary virtual-first world."* Source: [Cisco](#)

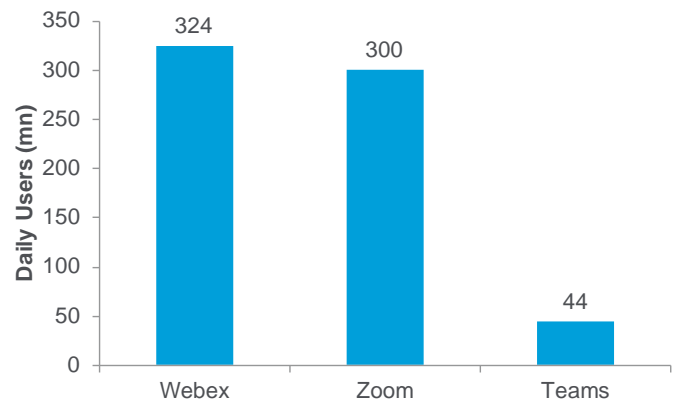
"Webex grew 2.5 times in Americas, four times in Europe and 3.5 times in Asia Pacific. Our growth is sourced from enterprise expansion, education and telehealth." Source: [Reuters](#)

Figure 92. Global Annual Corporate Passenger Volume (mn)



Source: IATA, Citi Research estimates

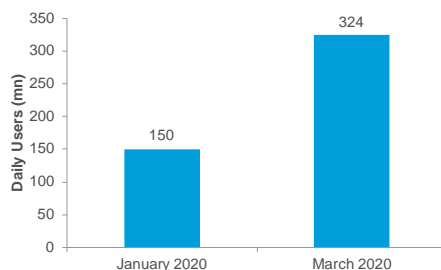
Figure 93. Daily Users in March 2020



Note: Zoom reports Daily Meeting Participants. Webex has over 300mn users but does not report Daily Active Users or Daily Meeting Participants. Teams reports Daily Meeting Participants. Daily meeting participants can be counted multiple times: if you have five Zoom meetings in a day then you're counted five times. A Daily Active User is counted once per day, and is commonly used by companies to measure service usage

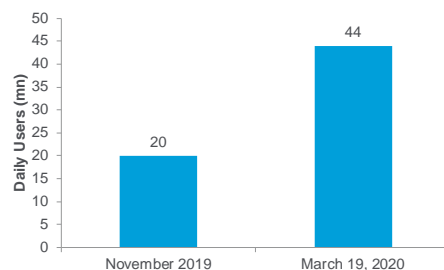
Source: Company Reports

Figure 94. Webex: Daily Users in March 2020 (mn)



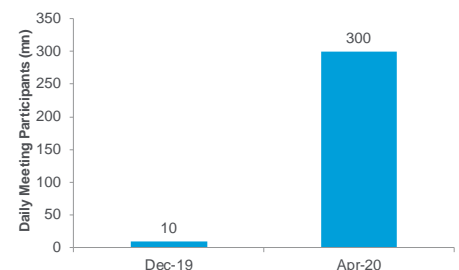
Source: Company Reports

Figure 95. Teams: Daily Users (mn)



Source: Company Reports

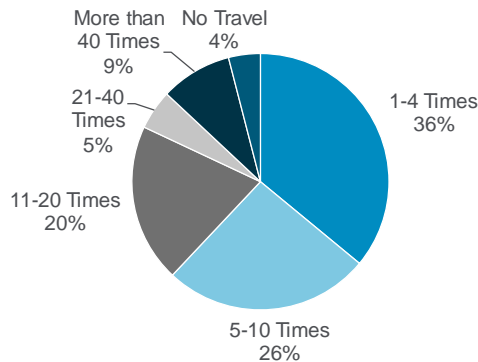
Figure 96. Zoom: Daily Meeting Participants in April 2020 (mn)



Source: Company Reports

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.

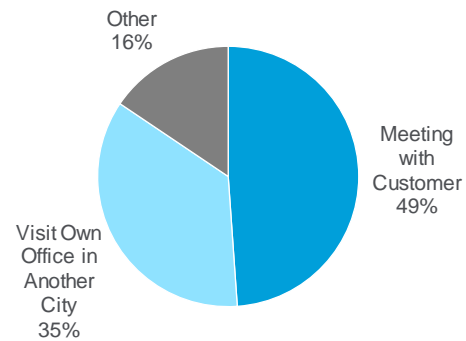
Figure 97. Annual Frequency of European Corporate Traveler Business Trips



Source: GBTA, Statista, Aeolus

Cutting the number of trips for heavy travelers sees corporate travel being secularly impaired by 25% vs. 2019

Figure 98. Purpose of Travel for European Corporate Travelers



Source: GBTA, Statista, 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 new 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.

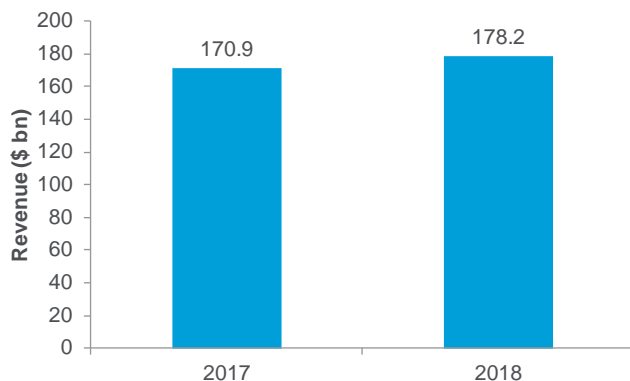
In fact, we could see a scenario where the majority of long-haul airlines undergo a gradual nationalization process. This is on par with what is currently enjoyed in the Middle East; where destinations and jobs in the airline industry are largely controlled by the respective governments.

Airports

Corporate represent 40% of airport revenues globally — a 25% drop in corporate travel will affect revenues by 10%

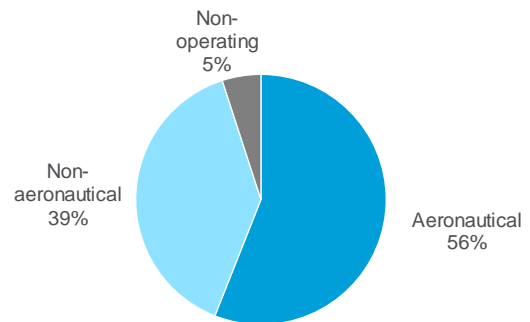
Airports will also see an impact from changes in corporate travel. For global airports, corporates represent 40% of revenues globally, and thus a 25% drop in corporate travel will affect revenues by 10%. And specifically, every 1% impact on corporate travel volumes, will have a 1% impact on global airport profits. This relatively smaller number is largely as a result of airport margins being substantially higher (i.e., lower operational gearing) and corporate travelers not spending as much on retail as their leisure counterparts.

Figure 99. Global Airport Revenues (US\$ bn)



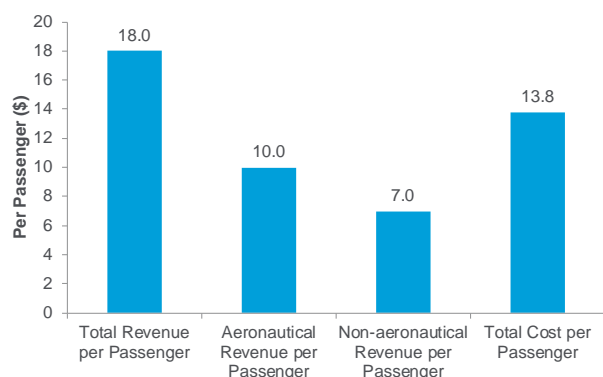
Source: ACI

Figure 100. Global Airport Revenue Breakdown



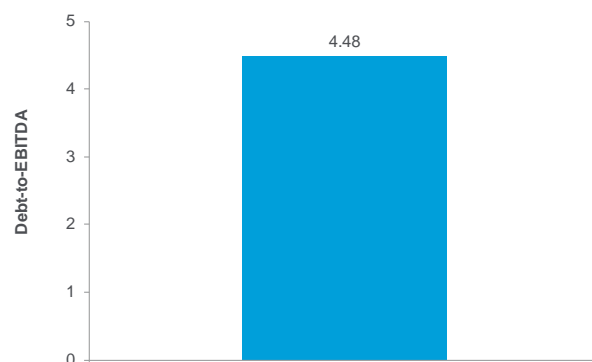
Source: ACI

Figure 101. Airport Revenue and Cost per Passenger



Source: ACI

Figure 102. Global Airport Debt-to-EBITDA



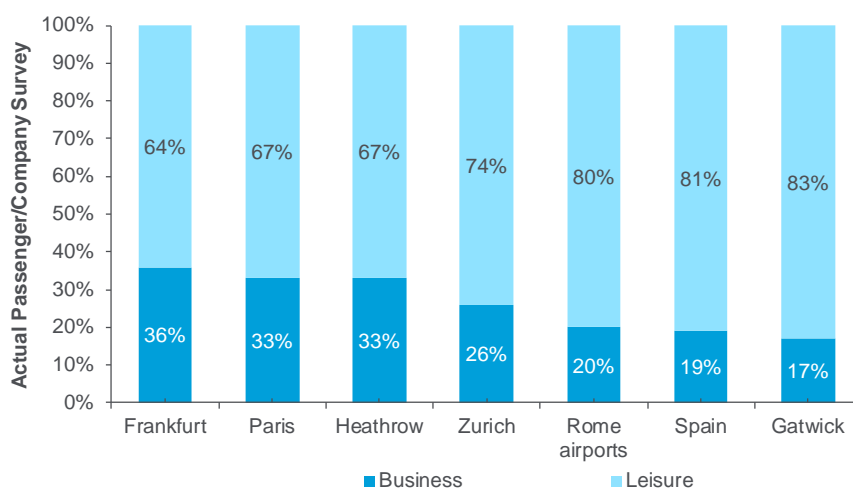
Source: ACI

Figure 103. Airports' Aeronautical Revenue Impact Under Different Scenarios of Permanent Traffic Impact Post-COVID-19 (In billions, \$)

Traffic Impact	-1.0%	-2.5%	-5.0%	-7.5%	-10.0%	-15.0%	-20.0%
Corporate Aeronautical Revenue Impact	-0.4	-1.0	-2.0	-3.0	-4.0	-6.0	-8.0
Leisure Aeronautical Revenue Impact	-0.6	-1.5	-3.0	-4.5	-6.0	-9.0	-12.0
Total Aeronautical Revenue Impact	-1	-2	-5	-7	-10	-15	-20

Source: ACI, Citi Research

Figure 104. Business vs. Leisure Traffic Volume Splits Across European Airports



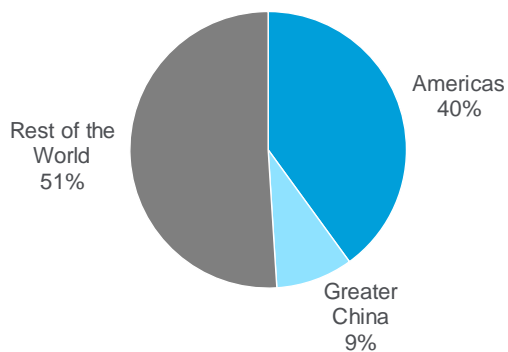
Source: Company Data, Dilo Mi, Citi Research

Hotels

A 25% drop in corporate travel will affect hotel revenues by about 18%

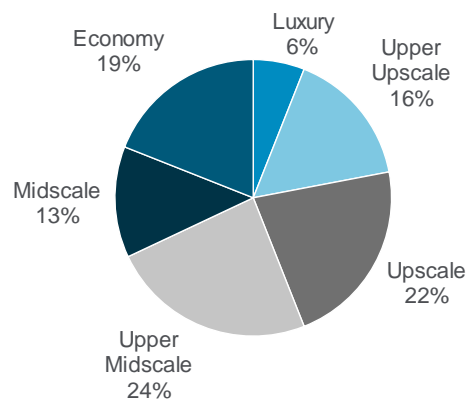
Hotels will also see an impact from changes in corporate travel. For hotels, corporates make up 70% of revenue, and thus a 25% drop in corporate travel will affect revenues by about 18%. Moreover, every 1% impact on corporate travel volumes, will have about a 10% impact on global hotel profits. The \$535 billion hotel industry remains fragmented, with 54% of rooms affiliated with a global or regional chain. This suggests conversions of independent hotels can still provide a growth opportunity for global hotel brand franchisors if industry growth remains lackluster in the coming years, given the potential headwind from corporate travel. We also expect any longer-term impact on corporate travel to impair hotel valuations, which would limit future supply growth. Currently we believe sellers of hotel assets would need to take 30%-40% valuation discounts (vs. 2019) in order to transact, and while we would expect this to improve as hotel trading normalizes, some of the discount will remain if corporate revenues do not return to pre-COVID-19 levels.

Figure 105. Proportion of Room Revenues



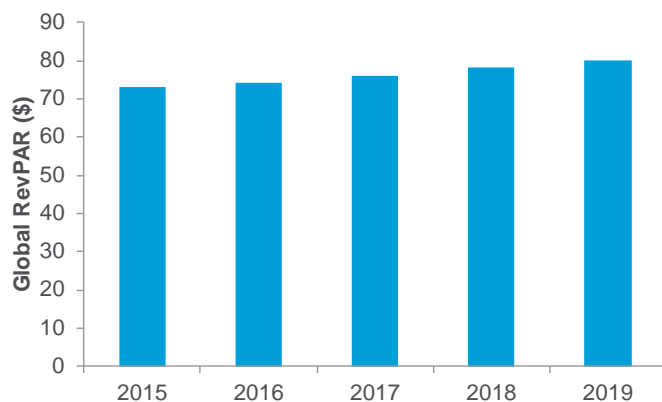
Source: STR

Figure 106. Proportion of Rooms by Category



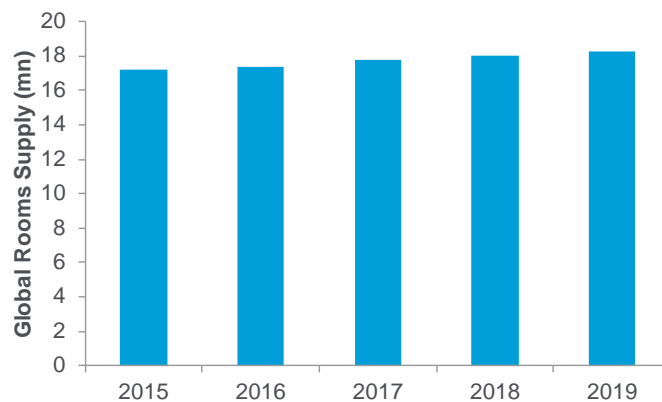
Source: STR

Figure 107. Global Industry Revenue per Available Room (US\$)



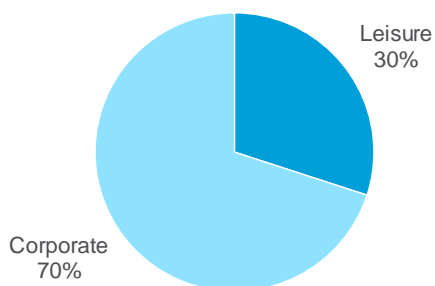
Source: STR

Figure 108. Global Rooms Supply (mn)



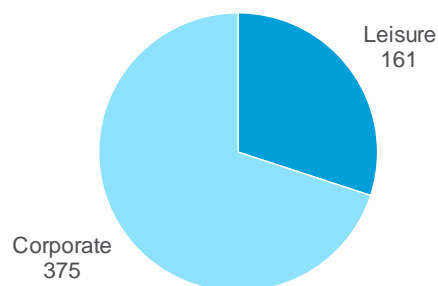
Source: STR

Figure 109. Room Revenue Breakdown Category



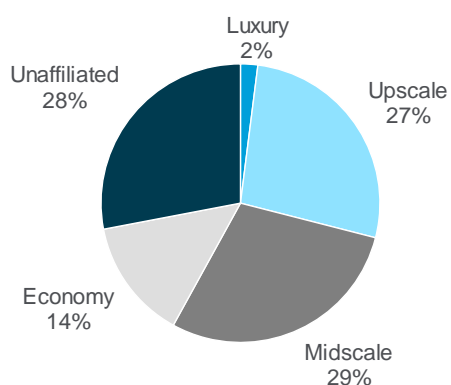
Source: Citi Research

Figure 110. Room Revenue Breakdown by Category (US\$, bn)



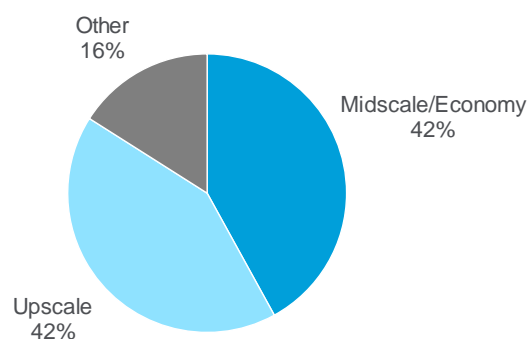
Source: Citi Research

Figure 111. U.S. Rooms by Chain Scale (March 2020)



Source: STR

Figure 112. Europe Rooms by Chain Scale (March 2020)



Source: STR, Citi Research

Figure 113. Hotel Industry Revenue Impact Under Different Scenarios of Permanent Traffic Impact Post-COVID-19 (US\$ bn)

Traffic Impact	-1.0%	-2.5%	-5.0%	-7.5%	-10.0%	-15.0%	-20.0%
Corporate Revenue Impact	-4	-9	-19	-28	-37	-56	-75
Leisure Revenue Impact	-2	-4	-8	-12	-16	-24	-32
Total Impact	-5	-13	-27	-40	-54	-80	-107

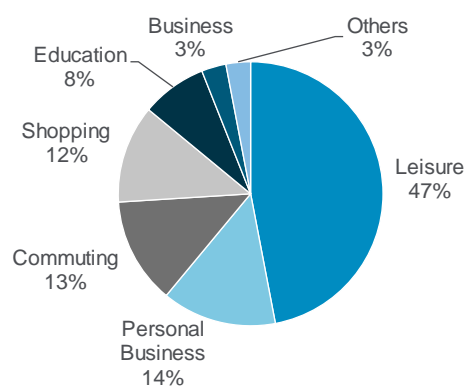
Source: STR, Citi Research

Car Hire

Business revenue makes up less than 5% of the total market for private care hire and taxis

Finally we address the private car hire and taxi market where we see the least impact of the four industries addressed, from any changes in corporate travel. This is as a result of care hire for business purposes making up less than 5% of the total market.

Figure 114. Purpose Share of Taxi or Private Hire Vehicle Trips, 2019



Source: UK.gov

Chapter 11: Impact of Telework on Climate Change

Elizabeth Curmi, PhD

Citi Global Insights

A silver lining of the pandemic is the lockdown has undoubtedly had a positive effect on air quality in many areas

We are living in unprecedented times. At one stage during the crisis, nearly one-third of the global population was on lockdown or under some form of restriction. Many businesses either shut their workplace or asked the majority of their employees to work from home. In some countries, the government has only allowed their citizens to leave their house if they have been classified as an essential worker, to buy groceries, or to exercise. Industrial activity shut down, and many flights were cancelled “Stay home” was becoming the new motto and a popular hashtag on Twitter and Instagram. Traffic was brought to a standstill with many bustling cities such as London, New York, Milan, Paris, and others becoming completely silent.

However, if there is something positive we can take out of this terrible crisis, it is an improvement in the environment in many places, in particular a reduction in air pollution and a decrease in greenhouse gas emissions.

The World Health Organization estimates approximately 4.2 million people globally die each year from ailments related to ambient air pollution, and more than 80% of people living in urban centers are exposed to air quality levels that exceed safe limits.⁸⁰ A silver lining of the pandemic is the lockdown has undoubtedly had a positive effect on air quality in many areas. A study done by Stanford University Professor Marshal Burke estimated the two month reduction in pollution in the city of Wuhan due to lockdown saved approximately 4,000 children under the age of five and 73,000 adults over 70 years old.⁸¹ In the U.S., NASA estimated nitrogen dioxide levels in March 2020 were approximately 30% lower on average across the region of the I-95 corridor from Washington D.C to Boston than compared to the March mean of 2015-2019.⁸² Some cities in the U.K. have also seen a 60% drop in nitrogen dioxide levels versus the same period last year.⁸³

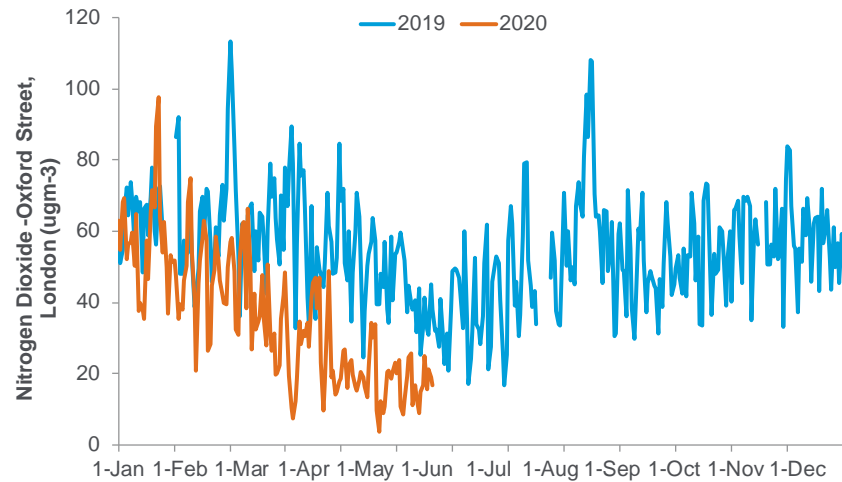
⁸⁰ https://www.who.int/health-topics/air-pollution#tab=tab_1

⁸¹ <https://www.forbes.com/sites/jeffmcmahon/2020/03/16/coronavirus-lockdown-may-have-saved-77000-lives-in-china-just-from-pollution-reduction/#2fe1ef0134fe>

⁸² <https://www.nasa.gov/feature/goddard/2020/drop-in-air-pollution-over-northeast>

⁸³ World Economic Forum (2020), Here's how lockdowns have improved air quality around the world

Figure 115. Nitrogen Dioxide Levels in Oxford Street, London



Source: www.Londonair.org.uk

The lockdowns during the pandemic have led to a sharp reduction in energy and hence in carbon emissions

And it's not only air pollution that has been affected. COVID-19 has also led to a sharp reduction in energy use and hence in carbon emissions. The IEA estimates countries in full lockdown are experiencing on average a 25% decrease in energy demand per week, while the energy demand in countries in partial lockdown has fallen 18% per week. They also estimate electricity demand has decreased by at least 20% in many lockdown countries as the increase in residential energy use is far outweighed by the reductions in commercial and industrial electricity use. Overall under the IEA COVID-19 scenario, global CO₂ emissions in 2020 are expected to decrease by 8% (approximately 2.6 gigatonnes) to levels last seen 10 years ago.

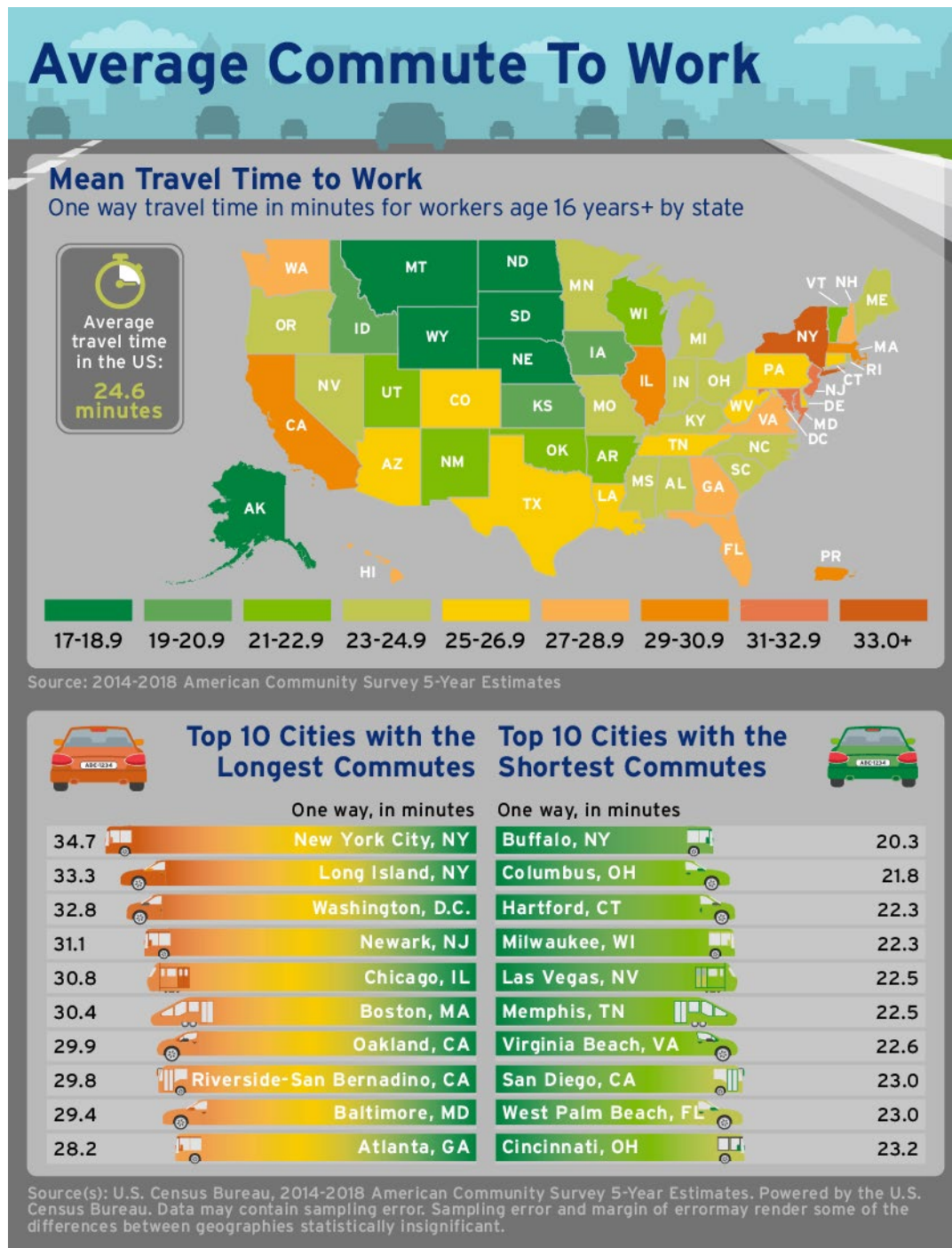
The question is can we continue on this trajectory?

So the big question is whether we can continue on this trajectory — whether when we return to normal whatever normal might be, we can continue living in cities with better air quality and in a world with less CO₂ emissions. While it is difficult to model air pollution due to the localized nature of the problem, we analyze the impact a continuation of remote working could have on CO₂ emissions in the U.S.

Remote Working in the U.S.

Pre-COVID-19, 77% of the U.S. workforce drove themselves to work, while 6% used a car pool system. Figure 116 below shows the work commuting times (each way) in a number of U.S. states. Looking at cities, the longest commute on average according to their research was 34.7 minutes in New York City. The time taken to commute is based on a number of different factors including distance and traffic. However, on average the total distance that U.S. workers travel by car to work is 15 miles each way.

Figure 116. Average Commute in Different U.S. States and Cities



Source: <https://www.visualcapitalist.com/wp-content/uploads/2018/04/average-commute-time-by-state.html>

Many workers would consider extending remote working to at least a few days a week post the lockdowns

Carl Frey's analysis at the beginning of the report indicates approximately 52% of U.S. workers have the opportunity to work from home due to the nature of their profession. Of these 52%, 3.6% currently already work from home. COVID-19 has led to many U.S. workers being confined to working at home due to lockdown restrictions imposed by different states. However many workers have stated that after the pandemic they would consider extending remote working at least for a few days a week.

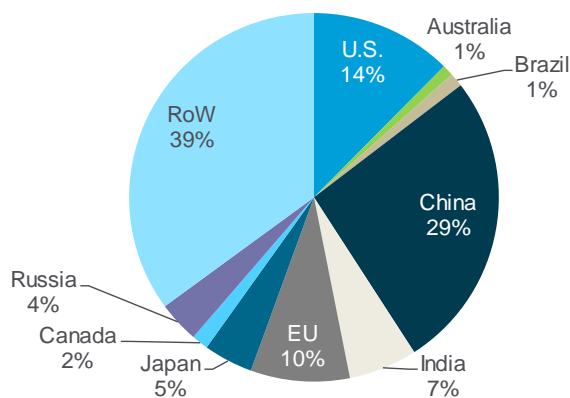
In fact a survey by Gallop has found that three in five U.S. workers who have been doing their jobs from home during the COVID-19 pandemic would prefer to continue to work remotely as much as possible, once restrictions have lifted.⁸⁴ Technology has allowed many workers to work remotely from home in comfort, with communications platforms allowing people to have virtual meetings with their team and clients, with just a click of the button.

So if people are able to work remotely from the comfort of their home, could it be that after the crisis is over this becomes the new normal? And if this is the case, what impact could this have on CO₂ emissions in the U.S.? To answer this question we use the integrated energy and emissions framework developed for the September 2019 Citi GPS report [Energy Darwinism 3](#) to analyze these impacts. However, before we look at the results, it is first important to understand what the current CO₂ emissions are in the U.S.

CO₂ Emissions in the U.S.

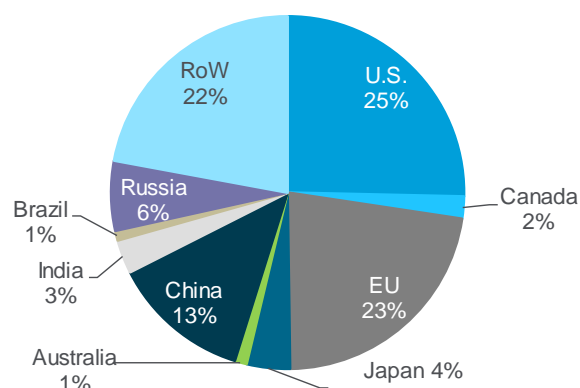
Currently the U.S. is the second largest emitter of annual CO₂ emissions and is responsible for 25% of cumulative CO₂ emissions as shown in Figure 117 and Figure 118 below.

Figure 117. Share of Annual Global CO₂ Emissions in 2017



Source: Citi Global Insights

Figure 118. Share of Global Cumulative CO₂ Emissions



Source: Citi Global Insights

Power & heat generation and transportation make up 30% each of the total annual energy-related CO₂ emissions in the U.S.

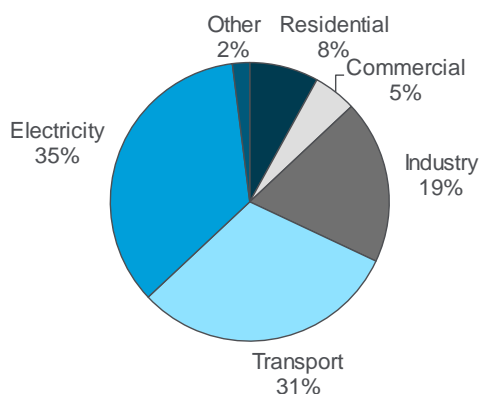
Passenger cars and light vehicles are responsible for 50% of transport-related CO₂ emissions (or 17% of total)

Power & heat generation and transport are currently the two largest emitters of energy-related CO₂ emissions with over 30% each of the total annual energy-related CO₂ emissions. This is followed by the industrial sector which contributes approximately 19% of current CO₂ emissions. If we zoom into transport-related CO₂ emissions we see that passenger cars and light vehicles are responsible for over 50% of transport-related CO₂ emissions and 17% of total energy-related CO₂ emissions.⁸⁵ Similar to other countries, the U.S. has legislation in place to increase the efficiency of passenger vehicles and light trucks. The Corporate Average Fuel Economy system (CAFE) was set up in 1975 with the main aim to improve fuel efficiency in passenger cars and light trucks. It is rather a complex system but basically what requires car manufacturers to meet efficiency improvements which increase every year through 2025.

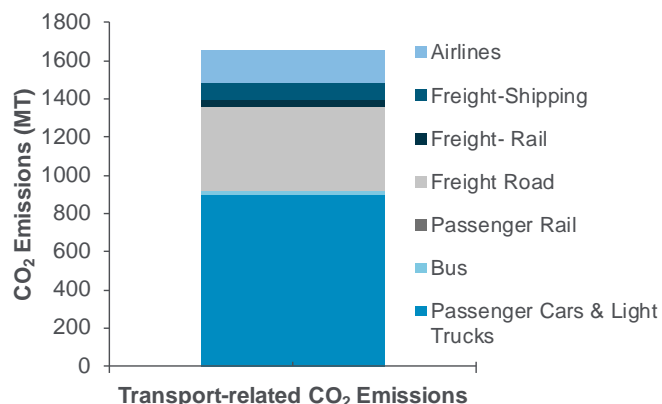
⁸⁴ Brenan M (2020), U.S workers discovering affinity for remote work, Gallup, April 3rd 2020

⁸⁵ Data for 2018

In March this year a new piece of legislation called the Safer Affordable Fuel Efficient Vehicle Rule (SAFE) was issued and will come into force in June. This legislation provides for a 1.5% annual increase in fuel efficiency as opposed to the original of 5% under the CAFE system. However 20 U.S. States are expected to challenge these regulations. The challenge is led by California whose waiver to set its own greenhouse gas emissions standards was revoked last year. It is also not quite clear whether auto manufacturers would support the new rule, as it is an election year in the U.S. and there is a chance that things regulation changes if there is a change in administration. Given this uncertainty, for the purpose of this modelling exercise we have used the CAFE fuel efficiency standards. .

Figure 119. U.S. Current CO₂ Emissions by Sector, 2018

Source: Citi Global Insights, Energy Darwinism 3

Figure 120. Transport-related CO₂ Emissions by Sector

Source: Citi Global Insights, Energy Darwinism 3

Could working from home be an easy way to reduce CO₂ emissions from transportation?

In our *Energy Darwinism 3* Citi GPS report we analyzed the effect that electric vehicles (EVs) could have on CO₂ emissions. As we show in the report, EVs do have an impact on transport CO₂ emissions, however it takes time to see this effect — this is due to legacy fleets, as many people keep the same vehicle for an average of 11.5 years. Could the answer be to drive less? Could working from home be an easy win for the reduction of CO₂ emissions?

To test this, we use our integrated energy and emissions framework to analyze the effect that remote working could have on U.S. emissions. We look at three particular scenarios:

- Scenario 1 assumes 52% of the U.S. workforce continue to work at home 1 day a week.
- Scenario 2 assumes 52% of the U.S. workforce work at home 3 days a week.
- Scenario 3 assumes 52% of the U.S. workforce work at home 5 days a week.

All three scenarios assume a person travels on average 30 miles a day (15 miles each way) to their workplace and they use gasoline cars to commute. We run each scenario for 10 years from 2020 to 2030 to see the effect remote working could have on both annual and cumulative CO₂ emissions over this period. The model is entirely modular and we can change our assumptions easily.

Results

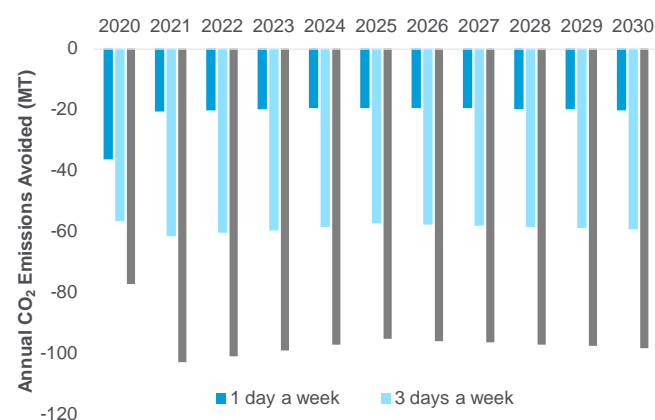
Working from home one day per week could cut annual CO₂ emissions by an average of 20MT, or a 2.5% decrease

20 MT is equivalent to 4.3 million passenger cars not being driven in one year

The results show that working from home reduces annual CO₂ emissions per year by an average of 20, 59 and 98 million tonnes (MT) of CO₂ for scenario 1, 2 and 3, respectively. This works out to be on average an annual decrease of 2.5%, 7%, and 12% per year in the total CO₂ emissions from passenger cars and light trucks based on our 'business as usual' scenario (reference scenario) identified in our *Energy Darwinism 3* report. To put the results into some form of context, if 52% of the U.S. workforce work at home for one day per week, there are saving 20 million tonnes of CO₂ which is equivalent to 4.3 million passenger cars NOT driven in one year. If they work at home five days a week, they would avoid nearly 100 tonnes of CO₂ emissions per year, which is equivalent to Belgium's total CO₂ emissions.⁸⁶

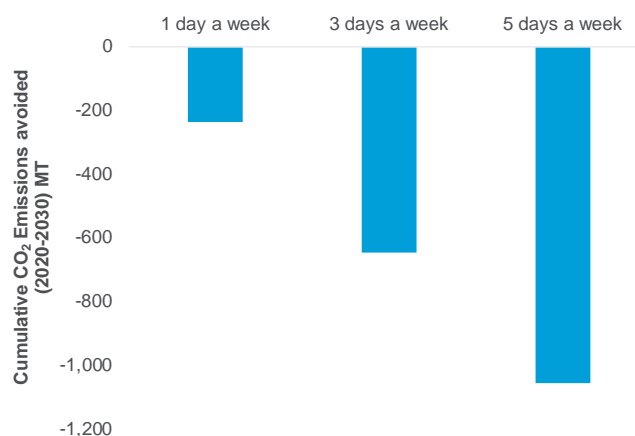
Cumulatively over the period of 10 years, a total of 230, 645, and 1,050 million tonnes of CO₂ emissions could be avoided across the scenarios, respectively, as people commute less to work. Even better, these reductions are achievable just by changing people's behavior and require absolutely zero investment.

Figure 121. CO₂ Avoidance per Year Due to Remote Working



Source: Citi Global Insights

Figure 122. Cumulative CO₂ Avoidance Due to Remote Working



Source: Citi Global Insights

With the lockdowns, aviation emissions fell by almost one-third, equivalent to taking approximately 6 million cars off the road

With people getting used to working remotely throughout the pandemic and holding business meetings from the comfort of their sofa, could they also realize they don't need to travel around the world for business purposes anymore? Could the future also lead to less business travel and therefore less CO₂ emissions from aviation? Aviation is responsible for 2% of global CO₂ emissions, however pre-COVID-19 this was expected to increase dramatically over the coming years. The pandemic has caused aviation CO₂ emissions to decrease sharply with some estimating a 38% decrease in 2020 overall. Just in March, aviation emissions fell by almost one-third which is equivalent of taking approximately 6 million cars off the road.⁸⁷

⁸⁶ <https://ww3.arb.ca.gov/cc/factsheets/1mmtconversion.pdf>

⁸⁷ FT (2020), Aircraft emissions fall sharply as pandemic grounds flights, April 11, 2020

Both commercial and residential electricity demand would decrease as less people worked in office, more than offsetting the increase in residential energy demand

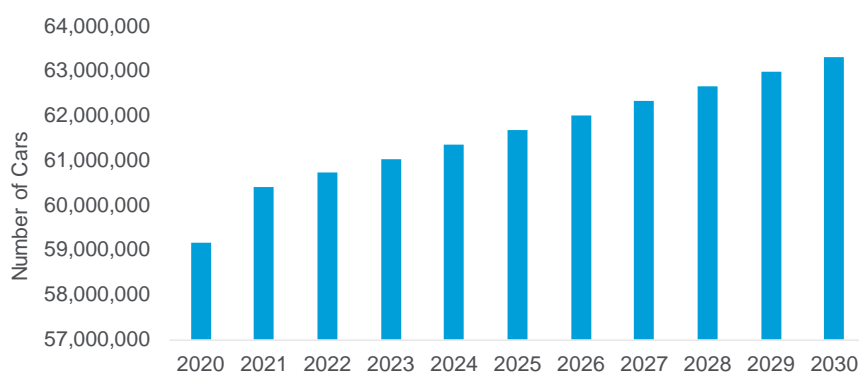
It is not only transport CO₂ emissions which can be reduced. With less people working in the office, demand for electricity and heat from commercial outlets could fall and ultimately outweigh the increase in residential energy demand from the increase in remote working. On average in the U.S. (it differs between different states), overall residential electricity demand increased by 3%-7% in April, however this was outweighed by decreases in commercial demand of 5%-15%, and a 5%-25% decline for industrial energy demand. In fact the EIA estimates power sales to the commercial sector as a whole in 2020 to drop by 4.7% as many businesses close. These closures include not only businesses which could switch their workforces remote, but other businesses affected by the lockdowns including restaurants, shops, schools, etc. Surprisingly, electricity sales to residential are also expected to decline by about 0.8% in 2020, as a result of a reduction in heating and air conditioning use due to milder winter and summer weather which is offset by an increased household consumption as many people stay at home.

Air Quality

Reducing the number of workers during commuting times will increase air quality

Undoubtedly a reduction in the number of people commuting to work would also reduce air pollution in many places. According to our estimates, we could see a reduction of over 60 million cars on the road per day during commuting times if 52% of U.S. workers worked from home — at least if they worked remotely on the same day. Figure 123 below shows the estimated number of cars that could be left off the road during commuting time. Most of the traffic congestion happens during commuting times, and traffic congestion increases both vehicle emissions and degrades ambient air quality — reducing this would save lives. The Global Burden of Disease reports that air pollution in the U.S. in 2016 was responsible for more than 100,000 fatalities and some of these deaths are attributed to pollution from cars.

Figure 123. Estimated Number of Cars that Could be Off the Road During Commuting Time as People Work from Home



Note: Estimates of cars are based on the number of U.S. people in the workforce, unemployment rates and estimated number of people that use their car to commute to work. We have estimated that unemployment rate in the U.S. in 2020 was higher than the other projected years — estimated at 5.9%. However there is some uncertainty in this- as we are not entirely sure whether the economy in the U.S. will rebound in the second half in 2020 or whether unemployment rates would increase drastically.

Source: Citi Global Insights

Reducing CO₂ emissions by working from home more requires zero investment, only a change in peoples' current behavior

Conclusion

Working from home undoubtedly reduces CO₂ emissions and air pollution. The good news is it will require zero investment to get that result and instead only requires people to change their current behavior. Technology is enabling remote working and we can have virtual meetings with our colleagues and clients from the comfort of our home. Overall, there also have been reports that remote workers are generally more satisfied with their work-life balance and improvement of their personal relationships.⁸⁸ According to a 2016 self-reporting survey, about 91% American remote workers feel they are more productive than when they work in an office. While many believe that one can struggle concentrating at home, the study shows that workplace is rife with opportunities for interruption, sometimes even generating additional stress. Besides, working from home saves workers from wasting their time spent in endless traffic jams. This study has only quantified the amount of CO₂ avoided from not driving into work; however further reductions could also be achieved if business air travel was also reduced.

Working from home is not an option for every job, but there is clear evidence that it can have major advantages in the right applications and with the right workers. And as we show in this report it also can have a positive impact on the environment.

⁸⁸ Gajendran et al. (2014)

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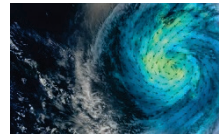
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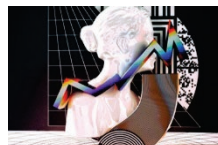
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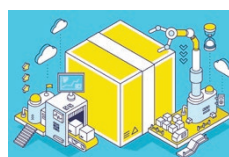
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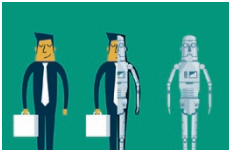
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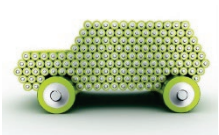
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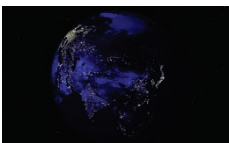
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Key Insights regarding the future of Remote Working



LABOR MARKET

Throughout the 20th century, home and work were two distinct places as a majority of labor required either being close to work or connectivity in an office. / **Digital technologies are driving a host of tools designed to enable remote working.** Post-COVID-19 we expect corporates to be increasingly flexible with work schedules and encourage more 'work from home' days.



URBANIZATION

Urban history is full of examples of industries clustering to reduce transportation costs, which created jobs, and a flow of workers into the city. / **Even with remote working, cities will remain valuable as knowledge centers and will continue to play an important role in facilitating the exchange of ideas and driving innovation.**



SOCIAL CONSTRUCTS

Business has traditionally relied on face-to-face relationships and networking, spawning the business travel industry as companies grew. / **Technology has evolved to the point that virtual communication can substitute for face-to-face interactions.** From telehealth to business meetings, more human interaction will take place on a screen in the future.



