



TECHNOLOGY AT WORK v7.0

The Third Phase of Globalization

Citi GPS: Global Perspectives & Solutions

October 2023



Citi is one of the world's largest financial institutions, operating in all major established and emerging markets. Across these world markets, our employees conduct an ongoing multi-disciplinary conversation - accessing information, analyzing data, developing insights, and formulating advice. As our premier thought leadership product, Citi GPS is designed to help our readers navigate the global economy's most demanding challenges and to anticipate future themes and trends in a fast-changing and interconnected world. Citi GPS accesses the best elements of our global conversation and harvests the thought leadership of a wide range of senior professionals across our firm. This is not a research report and does not constitute advice on investments or a solicitations to buy or sell any financial instruments.

For more information on Citi GPS, please visit our website at www.citi.com/citigps.

Primary Authors**Carl Benedikt Frey**

Carl is the Dieter Schwarz Associate Professor of AI & Work at the Oxford Internet Institute and a Fellow of Mansfield College, University of Oxford. He is also Director of the Future of Work Programme and Oxford Martin Citi Fellow at the Oxford Martin School. In 2016, Frey co-authored “The Future of Employment: How Susceptible Are Jobs to Computerization.” His academic work has featured in over 100 media outlets, including The Economist, New York Times, Time Magazine, The New Yorker, Le Monde, and Frankfurter Allgemeine Zeitung. In addition, he has frequently appeared international broadcast media such as CNN, BBC, PBS News Hour, Al Jazeera, and Sky News. His most recent book, The Technology Trap: Capital, Labor, and Power in the Age of Automation, was selected a Financial Times Best Books of the Year in 2019, when it also won Princeton University’s prestigious Richard A. Lester Prize.

carl.frey@oxfordmartin.ox.ac.uk

**Robert Garlick**

Rob Garlick is a Managing Director and is the Head of Innovation, Technology, and the Future of Work at Citi Global Insights. With 30 years of Investment Banking experience, Rob was previously: Head of Citi Research EMEA, Global Product Head at Citi Research, ran Citi's U.S. Equity Sales desk in the UK servicing some of the world's leading asset managers and hedge funds, a top Media Global Specialist salesperson, and a U.S. equity Fund Manager at Singer & Friedlander.

+44-20-7986-3547 | robert.j.garlick@citi.com

**Helen H Krause**

Helen is a Managing Director and Head of Data Science Insights at Citi Global Data Insights. Previous to Citi, Helen was an Executive Director in Alternative Investment at Morgan Stanley and a Senior Portfolio Manager at BlackRock. She has an MSc in Economics and Finance from University of Warwick and an MSc in Mathematical Trading and Finance from Cass Business School.

+44-20-7986-8653 | helen.krause@citi.com

**Brian Yeung**

Brian is a Vice President and a founding Data Scientist at Citi Global Data Insights. Brian’s work focuses on developing data science-driven investment insights by leveraging alternative data, and he has led various projects including employment and workforce dynamics, supply chain resilience, and consumer credit card spend analysis. He holds an MSc in Data Science from University College London and a BSc in Mathematics from Imperial College London.

+44-20-7986-8692 | brian.yeung@citi.com

TECHNOLOGY AT WORK v7.0

The Third Phase of Globalization

Kathleen Boyle, CFA
Managing Editor, Citi GPS

Trying to predict future trends and identify new technologies that will truly be disruptive can be both challenging and rewarding. It can also be incredibly humbling. Getting the trend right is only half the battle. The “you don’t know what you don’t know” is where things can get a little upside down.

Our very first [Technology at Work](#) Citi GPS report was based on a seminal report from Carl Benedikt Frey and Michael Osborne that predicted 47% of U.S. jobs were susceptible to automation over the coming decades. The rationale was that non-routine manual tasks were increasingly able to be automated, and for the first time, low-skill and low-income jobs were at risk of automation. Lower automation risk was attributed to jobs that were intensive in social and creative skills. We did also note that a growing share of office and administration support jobs would soon be subject to automation as advances in big data continued.

We still think automation will continue to affect U.S. jobs and may impact even more sectors as recent developments in artificial intelligence take shape. But here is where our predictions missed something and “we didn’t know what we didn’t know”: The COVID-19 pandemic brought with it a rush of new technology that enabled workers to work from home while offices were closed. And while these advances were crucial to workers maintaining productivity from remote locations, it led to a realization: If a job could be done remotely, it could be done anywhere.

Corporates in industries like technology, which were historically clustered in large cities, can now move out of high-priced city centers to lower-cost secondary hubs. Initially, this should lead to a decline in economic disparities between regions. As skilled professionals follow their companies to lower-cost areas, service jobs are created in their new locations, and unskilled workers who have been battling the high cost of urban housing can follow.

But this shift may be short-lived. If a job can be done in a lower-cost region of the country, it can also be sent offshore. Similar to what happened in manufacturing decades ago, instead of moving a job to a secondary hub, corporates may decide to take advantage of the global wage arbitrage in professional jobs and move jobs outside the country.

What can be done to avoid the loss of jobs? Policymakers in advanced economies should focus on supporting science and education. Remote technology boosts collaboration at a distance, which is leading to increased innovation and breakthrough science. This, in turn, can lead to new job creation.

As we absorb this new information, we will keep trying to predict the future and identify the next disruptive innovation. As we keep learning from experience, hopefully we will get hit with fewer “don’t knows.”

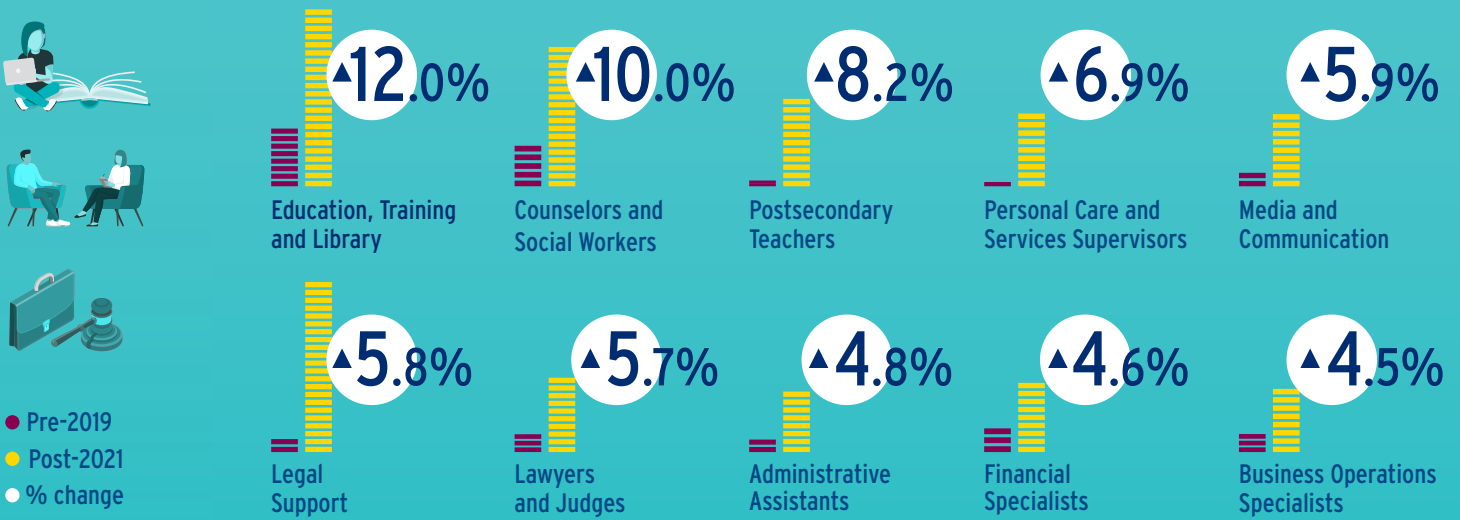
Remote Work Productivity and Collaboration Rising

CHARTING THE RISE OF REMOTE WORK GLOBALLY

To analyze the remote work revolution, we collected data on global job postings from LinkUp for 70 of the world's largest cities, spanning six continents, since the onset of the pandemic. The increase in remote work is broad-based across a range of professions. There was a robust relationship between the increase in remote work and cities with a lower cost of living.

TOP 10 OCCUPATIONS BY REMOTE WORK SHARE 2021

Source: LinkUp



THE GLOBAL WAGE ARBITRAGE

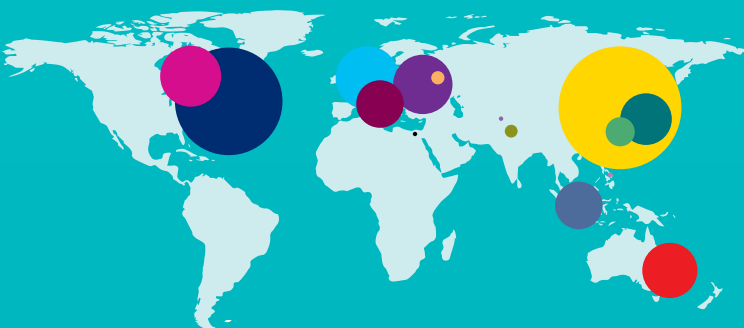
Over the course of the 20th century, manufacturing jobs gradually diffused from developed to emerging markets where labor was cheaper. A similar process is now playing out in technology and services. Going forward, competition for talent around the world will likely intensify with a global wage arbitrage developing for skilled workers as remote work increasingly becomes an option. If a job can be done remotely, it could also be done offshore.



AVERAGE ANNUAL SALARY FOR GOOGLE ENGINEERS ACROSS CITIES (US\$, '000s)

● NEW YORK CITY	\$128.3	● SHANGHAI	\$35.3
● TORONTO	\$86.4	● TOKYO	\$30.8
● FRANKFURT	\$58.8	● MOSCOW	\$12.2
● SYDNEY	\$53.7	● NEW DELHI	\$8.0
● LONDON	\$50.8	● CAIRO	\$7.7
● PARIS	\$48.9	● MANILA	\$6.0
● SINGAPORE	\$39.7	● LAHORE AND RAWALPINDI	\$3.1
● HONG KONG	\$38.3		

Source: LinkUp



TECHNOLOGY AND REMOTE COLLABORATION

As the proliferation of the internet drove an increase in remote collaboration scientists became more focused on incremental improvements rather than the kind of breakthrough technologies that open up new avenues for progress. However, new collaboration technology introduced in the 2010s created a turning point where remote teams became more likely to produce breakthrough discoveries relative to their onsite counterparts. The promise of remote collaboration is that connecting different local knowledge networks increases the innovating potential of the “collective brain.”

THE 2010s SAW REMOTE TEAMS BECOME MORE LIKELY TO MAKE BREAKTHROUGH DISCOVERIES

Source: Frey and Presidente (2022)



IMPLICATIONS OF REMOTE WORK

Job creation since the computer revolution of the 1980s has been highly concentrated to a few superstar cities. The result has been a marked increase in regional inequality. However, a surge in collaborative technology during the pandemic is facilitating remote work as jobs shift to secondary hubs and locations where housing and labor is cheaper. The implications of this new geography of work include:



Reduction in regional inequality within countries



Intensification of competition for talent around the world



Increase in total welfare for the average worker via lower cost-of-living and less commuting



Cost savings for employers on office space and travel expenses



Revival of disruptive science and faster productivity growth

Contents

Introduction	7
The New Geography of Work	10
When Jobs Disappear	11
Silicon Valley: The Next Detroit?	12
How Jobs Diffuse	14
The Cost-of-Living Crisis	15
Escaping the City	17
The Housing Dilemma	21
Leveling Up?	23
Charting the Rise of Remote Globally	26
The Global Arbitrage	27
The Collective Brain	29
Implications for the Third Phase of Globalization	32
Implications for Geography and Globalization	32
Implications for Medium-Term Inflation Performance	34
Implications for Management	36
Implications for Productivity and Innovation	36

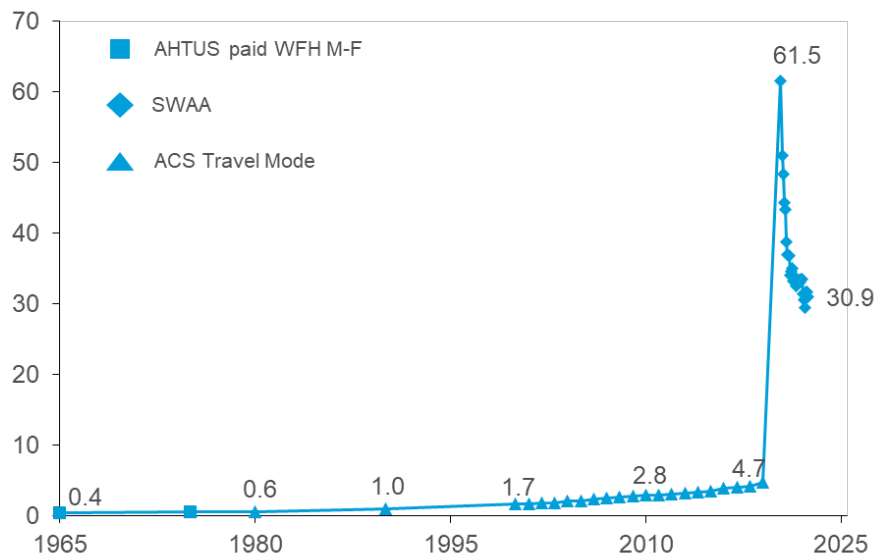
Introduction

Skeptics of the remote work revolution tend to point to the 1990s. The Web had just arrived, email had just arrived, and pundits and academics widely predicted the end of the office and the death of cities. These predictions culminated in the New York Times columnist Thomas Friedman’s widely cited book, published in 2005, proclaiming that The World Is Flat. Finally, people could save their commutes to work and move to places where housing was cheaper, eliminating regional inequalities in the process, or so it was widely believed.

However, until 2020, both offices and cities remained remarkably resilient. In fact, urbanization continued and even accelerated in many parts of the world. And in similar spirit, companies like Google spent enormous amounts on making the workplace more attractive before telling its employees to stay remote until the summer of 2021, leaving its new Googleplex standing empty.

It took a pandemic for remote work to take off. As we documented in Technology at Work 5.0, between 2000 and 2018, the share of people working from home in the European Union hovered below 6 percent, with no clear upward trajectory in most countries. Then, suddenly, in the summer of 2020, the percentage of full days worked from home in the U.S. reached 60 percent. By 2023, as the pandemic subsided, this figure came down to around 30 percent, where it has stabilized, yet the shift from the pre-COVID era is still dramatic (Figure 1).¹

Figure 1. Percentage of Full Days Worked from Home in the U.S. over Time



Copyright 2022 by Jose Maria Barrero, Nicholas Bloom, and Steven J. Davis. The data in this .csv file are made available under the CC-BY 4.0 license <https://creativecommons.org/licenses/by/4.0>. 1965-1975 uses data from American Heritage Time Use Study (AHTUS). 1980-2019 uses data from American Community Survey (ACS). May 2020-present uses data from U.S. Survey of Working Arrangements and Attitudes (SWAA).
Source: Barrero, Bloom, and Davis (2021)

¹ Jose Maria Barrero, Nicholas Bloom, and Steven J. Davis, “Why Working from Home Will Stick,” National Bureau of Economic Research (NBER), Working Paper No. 28731, April 2021.

Meanwhile, in the U.K., data published by the Office for National Statistics (ONS) reveal a similar trend: The share of the working population planning to work mostly from home rose 12 percentage points between April 2021 and February 2022, while 38% of working adults reported having worked from home at some point over the past seven days in May 2022. For comparison, before the COVID-19 pandemic, only one in eight adults reported working from home in previous week.² Other data, exploring the share of job postings that offer hybrid or remote work, reveal a similar picture: In the UK, this percentage increased from below 4 percent in 2020 to around 18 percent in 2023. The U.S., Australia, New Zealand, and Canada saw similar trajectories.³

As we all know, the consequences of the COVID-19 pandemic have been far-reaching. The “Great Resignation,” the “Zoom Revolution,” supply chain disruptions, and rampant inflation are just some of its legacies. People have been quitting their jobs at record rates, they are moving out of cities in search of new opportunities, and they are changing their buying habits. Given the unevenness of economic growth and job creation in recent years — with tech hubs flourishing, while rustbelt regions have fallen further behind — some of this change is certainly welcome. After decades of rising regional inequalities, a correction is finally underway. As we shall see, rural areas and low-cost cities have been closing the gap in new job creation, while tech jobs are moving out from expensive innovation hubs.

The potential for remote work means that cash-strapped families are now able to escape the metropolis, where the cost-of-living crises has become particularly severe. But this trend might be short-lived. For one thing, if a job can be done remotely, it can also be offshored, meaning that regional convergence in advanced economies might be short-lived. To what extent this will happen, remains an open empirical question.

To shed some light on these issues, this report takes a data-driven approach to assess recent and ongoing trends in the geography of work around the world. Specifically, to explore the pace and shape of recent employment trends, our analysis tracks job postings data from across some of the largest metropolitan areas globally, before and after the COVID-19 pandemic. Doing so, we document a marked upsurge of job postings mentioning opportunities for remote work in general, and in particular, in places where the cost-of-living is relatively high.

While this should serve to alleviate some of the housing pressures in the most expensive cities, companies may gradually claw back some of those benefits to employees by introducing living-cost adjustments to people’s salaries, thereby reducing the incomes of those moving further away from the office where housing is cheaper. And over time, companies might even move jobs abroad to take advantage of vast pools of cheap labor in the developing world. Examining wage differentials across countries, we note that the opportunities for wage arbitrage are huge going forward. The good news is that developing countries — whose growth prospects have been hampered by “premature deindustrialization” — might find that professional services are becoming the new escalator to prosperity, reducing global inequalities between countries in the process.

² UK Office of National Statistics, “Is Hybrid Working Here to Stay?,” May 23, 2022.

³ Stephen Hansen et al., *Remote Work Across Jobs, Companies, and Space*, National Bureau of Economic Research Working Paper 31007, March 2023.

As we will see, while the first wave of globalization was unleashed by transportation technologies like steamships and railroads in the 19th century, allowing the West to export its products to the rest of the world, a second phase of globalization began in the 1990s, as firms began to offshore manufacturing jobs to East Asia *en masse*.⁴ We are now entering a third phase of globalization based on trade in services, as remote work technologies are becoming increasingly good substitutes for face-to-face interaction.

To be sure, not all jobs can be done remotely. And even if they can, it does not follow that they should be. For example, geolocation data on Apple and Google workers shows that they are most likely to encounter each other around the workplace. And a back-of-the-envelope calculation suggests that if one quarter of office workers in the Bay Area worked from home, face-to-face meetings would fall by 17%, reducing knowledge flows in the region.⁵

A remaining drawback with the virtual world is that it does not facilitate sporadic encounters. However, as this report will demonstrate, recent improvements in remote work technology have made it much easier even for scientists and innovators to collaborate at distance. Drawing upon a novel dataset of over 10 million scientific collaborations between 1961 and 2020, we show that we are also learning to do remote work in innovation and scientific discovery. Against this backdrop, we argue that a revival of breakthrough science seems likely and could reverse the productivity stagnation of recent decades.

⁴ Richard Baldwin, *The Great Convergence: Information Technology and the New Globalization* (Harvard University Press, 2016).

⁵ David Atkin, M. Keith Chen, and Anton Popov, "The Returns to Face-to-Face interactions: Knowledge Spillovers in Silicon Valley," NBER, Working Paper No. 30147, June 2022.

The New Geography of Work

Much like in the 1990s, economists are now debating how the rise of remote work will change the geography of jobs and shape the fates of cities. On one end of the spectrum, Paul Krugman thinks that “the best bet is that life and work in, say, 2023 will look a lot like life and work in 2019, but a bit less so. We may commute to the office less than we used to; there may well be a glut of urban office space. But most of us won’t be able to stay very far from the madding crowd.”⁶

Others see more sweeping changes ahead. According to Richard Baldwin, the remote work revolution might prompt another wave of offshoring as companies take advantage of services becoming more tradable and the fact that countries like India have large pools of cheap, skilled, and English-speaking workers.⁷

A question that emerges is this: if many professional service jobs end up offshore, or indeed in the hinterland, where labor and housing is cheaper, what happens to the billions of dollars of investment that has gone into building skyscrapers and urban infrastructure, like electricity grids, transit, and sewage systems? And what happens to the enormous sums that have been spent on new corporate campuses? Indeed, in recent years, companies like Amazon, Apple, Facebook, and Google have all hired leading architects to design office and outdoor spaces to tear down the “walls that often separate work, socializing, wellness, and creativity.”⁸ When the 175-acre Cupertino campus, known as Apple Park, opened in 2017, for example, it had cost \$5 billion and had 12,000 people working there.⁹

The rise of remote will have consequences well beyond technology companies and professional services, however. When people do not come into the office, other complementary services take a hit as well. For example, Pret A Manger was forced to close 30 stores and cut 1,000 jobs in the U.K. during the pandemic, as fewer commutes to work meant fewer customers.¹⁰ And when jobs disappear, the demand for residential housing is reduced as well. As shown in Figure 2, there has been a marked increase in remote work across U.S. a wide range of geographies. The figure shows the percentage of people reporting having worked from home during the previous week. In some cities, like Washington DC, Fremont City, California, and Bethesda, Maryland, almost 50% of the population reported having worked from home in 2021 — an astonishing figure compared to pre-pandemic.

⁶ Paul Krugman, “The Pandemic and the Future City,” *New York Times*, March 15, 2021.

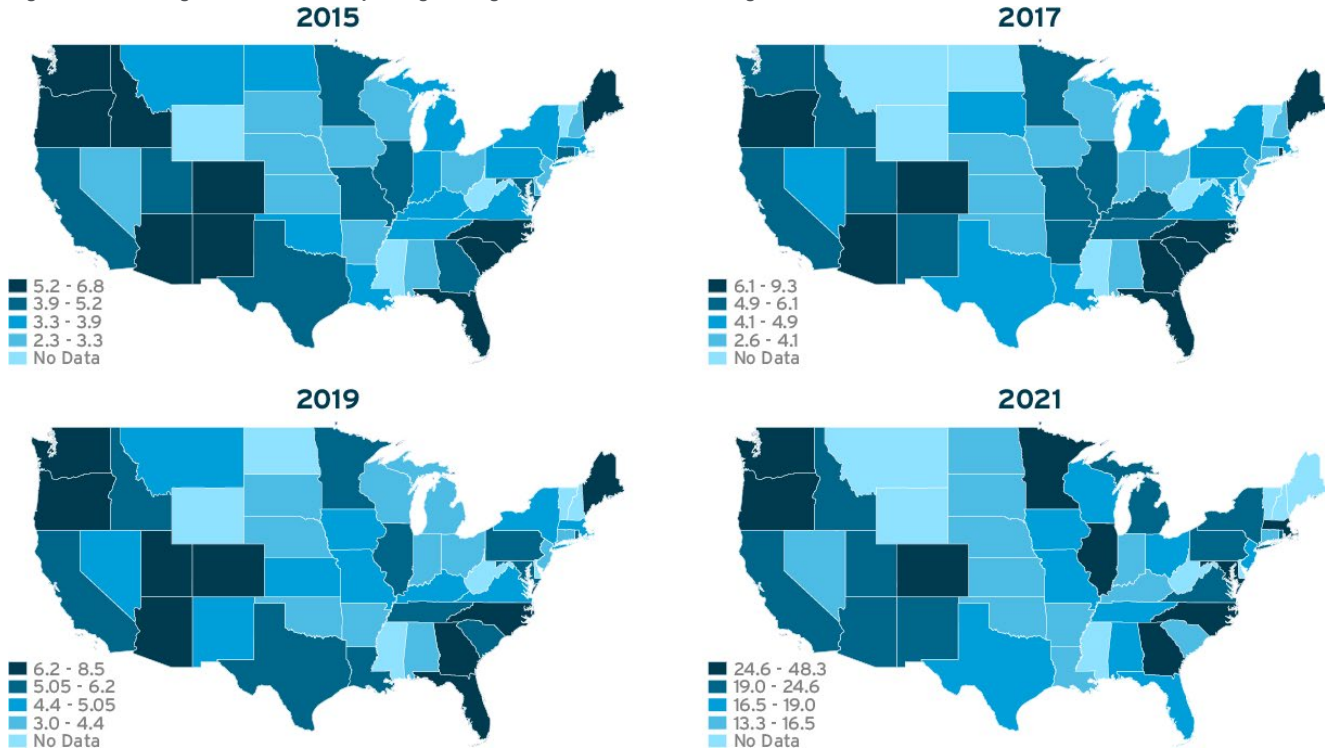
⁷ Richard Baldwin, *The Globotics Upheaval: Globalization, Robotics, and the Future of Work* (London, Oxford University Press, 2019).

⁸ Matthew E. Kahn, *Going Remote: How the Flexible Work Economy Can Improve Our Lives and Our Cities* (University of California Press, 2022) pp. 2-3.

⁹ Anita Balakrishnan, “Apple’s New Headquarters Will Reflect Steve Jobs’s Desire to Replicate the Outdoors,” *CNBC*, May 17, 2017.

¹⁰ Rebecca Smithers, “Pret a Manger to Close 30 Stores and Could Cut More than 1,000 Jobs,” *The Guardian*, July 6, 2020.

Figure 2. Percentage of Americans Reporting Having Worked from Home During the Previous Week



Source: U.S. Census Bureau, American Community Survey (2015-2021)

When Jobs Disappear

History tells us that when jobs dry up, entire cities can fall into disrepair. In America, Cleveland and Pittsburgh are smaller today than they were in the 1930s, as is Liverpool in England. How the wrenching of industries can leave a lasting mark on communities in the modern world is captured by the film *The Full Monty* (1997), which follows the down-and-out steelworkers in Sheffield looking to escape unemployment who turn to a male revue show in desperation. But what makes good comedy is in real life a terrible thing to watch. When the economists Eric Gould, Bruce Weinberg, and David Mustard studied the relationship between vanishing jobs and criminal offenses, they found the former to have caused large increases in property crime.¹¹ In addition, there is evidence that import competition from China has disrupted the job prospects of young men, made them less marriageable, and increased their likelihood of experiencing an early death.¹²

¹¹ E. D. Gould, B. A. Weinberg, and D. B. Mustard, 2002, "Crime Rates and Local Labor Market Opportunities in the United States: 1979–1997," *Review of Economics and Statistics*, Vol. 84, No. 1, February 2002.

¹² David H. Autor, David Dorn, and Gordon Hanson, "When Work Disappears: Manufacturing Decline and the Falling Marriage Market Value of Young Men," *American Economic Review: Insights*, Vol. 1, No. 2, September 2019.

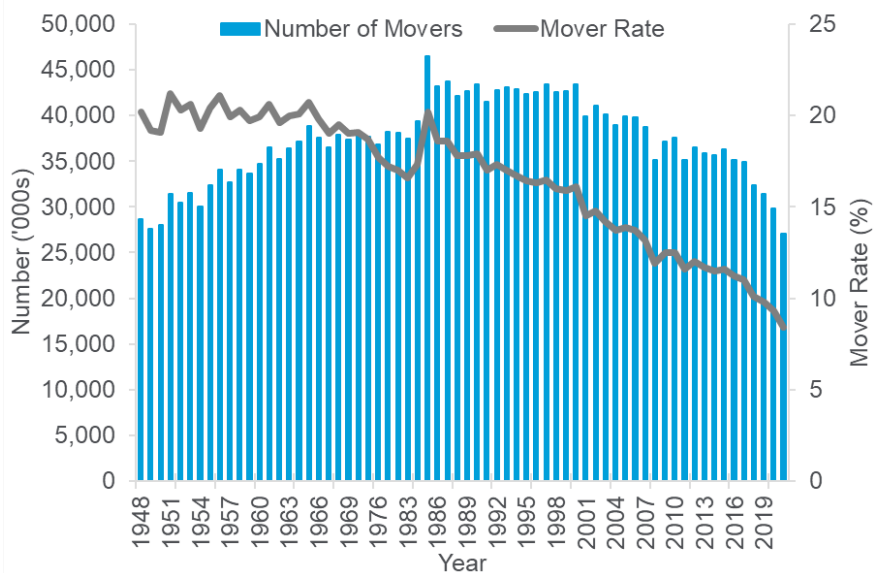
Consider Pennsylvania which saw many plants close or downsize during the recession of the early 1980s. Even six years after people lost their jobs, their income losses were still more than 40 percent.¹³ But layoffs did not just affect workers' earnings. Again, the ones who saw their jobs disappear experienced up to a 100 percent increase in short-term mortality rates after being laid off.¹⁴

The consequence of faltering employment prospects is often a vicious cycle. As jobs are lost, crime increases and local tax bases fall, prompting cities to raise taxes and cut spending on police, schools, and health care. Hence, unemployment and crime become solidified, public infrastructure deteriorates, and new companies stay away, leading even more people to leave.

Silicon Valley: The Next Detroit?

Is what happened to manufacturing and mining cities in the past now also happening to technology hubs? Writing in the 1970s, the futurist Alvin Toffler suggested that the world was at the cusp of a third wave. The first "wave" had been launched with the agricultural revolution some 10,000 years ago and was followed by a second wave which took off with the Industrial Revolution. But the third wave, he argued, would be even more transformational. It would bring about "the death of industrialism" and establish a new information age. This, in turn, would create a "new race of nomads" and turn the world into one "global village."¹⁵

Figure 3. U.S. Geographic Mobility Over Time



Source: Citi GPS, U.S. Census Bureau, Current Population Survey, Annual Social and Economic Supplement 1948-2021, <https://www.census.gov/library/visualizations/time-series/demo/historic.html>

¹³ Louise S. Jacobson, Robert J. LaLonde, and Daniel G. Sullivan, 1993, "Earnings Losses of Displaced Workers," *American Economic Review*, Vol. 83, No. 4, September 1993.

¹⁴ Daniel Sullivan and Till Von Wachter, "Job Displacement and Mortality: An Analysis Using Administrative Data," *Quarterly Journal of Economics*, Vol. 124, No. 3, August 2009.

¹⁵ Alvin Toffler, *Future Shock* (London, Bantam Books, 1970).

Computerization did certainly radically change the way we live and work. But so far, several of Toffler's predictions have not held up well against the evidence. For one thing, there are still few digital nomads. In fact, geographic mobility in the United States today is lower than it ever has been since the end of World War II (Figure 3). In a bracing new book, Ian Goldin and Thomas Lee Devlin estimate that in 1980, 1 in every 35 U.S. citizens moved across state borders each year. By 2020, that figure had halved to 1 in every 70.¹⁶ In addition, precisely the information-intensive industries that Toffler wrote about are the ones that are highly clustered. Work between the Carl Frey of the Oxford Martin School and Thor Berger, for example, shows that new jobs created by the computer revolution are highly concentrated in skilled cities. Before 1980, when many new jobs were still in manufacturing, cities with large pools of skilled workers did not add new jobs disproportionately. But as many new jobs in information and communication technology (ICT) emerged — like those of computer programmers, software engineers, and database administrators — the comparative advantage in new job creation firmly shifted toward cities like San Francisco, Boston, and New York.¹⁷ And in a follow-up study, a similar pattern emerged for new industries, like online auctions, web design, and video and audio streaming.¹⁸

Thus, in short, the industries that many believed would flatten the world have made it more uneven. Between 1970 and 2010, the U.S. population in cities expanded by almost 100 million, while rural America grew by less than 6 million. In the U.K., which saw less rapid population growth, the total population in rural areas even declined. Meanwhile, cities like London and New York experienced another renaissance. Wall Street boomed in the 1980s as information technology transformed financial services. Not to mention Silicon Valley, whose success AnnaLee Saxenian famously attributed to its dense social networks, which she noted encouraged entrepreneurship and experimentation.¹⁹ Importantly, these local social networks were not replaced but amplified by the virtual world. As Edward Glaeser and David Cutler write:²⁰

“

As problems became more complex, there were more nuances to lose in translation. Email, Twitter, and Facebook may save some meetings with existing friends, but they may also lead to having more friends, many of whom will want to meet in person... In the language of economics, electronic interactions don't just substitute for face-to-face meetings, they also complement those meetings. And being in a city makes in-person meetings easier. There was plenty of evidence—even in 1980—that new media forms often complemented interacting face-to-face. Phone calls were more common between people who lived nearby and who were more likely to see one another. Today, Facebook friendships are more common among people who live close by.

– EDWARD GLAESER AND DAVID CUTLER — AUTHORS OF SURVIVAL OF THE CITY

”

¹⁶ Ian Goldin and Tom Lee-Devlin, *Age of the City: Why Our Future Will be Won or Lost Together*, (Bloomsbury, 2023).

¹⁷ Thor Berger and Carl Benedikt Frey, 2016, “Did the Computer Revolution Shift the Fortunes of U.S. Cities? Technology Shocks and the Geography of New Jobs,” *Regional Science and Urban Economics*, Vol. 57, March 2016.

¹⁸ Thor Berger and Carl Benedikt Frey, “Industrial Renewal in the 21st Century: Evidence from US Cities,” *Regional Studies*, Vol. 51, No. 3, August 2015.

¹⁹ AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128, With a New Preface by the Author*, (Harvard University Press, 1996).

²⁰ Edward Glaeser and David Cutler, *Survival of the City: Living and Thriving in an Age of Isolation*, (John Murray Press. Kindle Edition, 2021).

This helps explain why clustering is still so common across many technology fields. For example, when Stanford University's Nicholas Bloom and collaborators studied the proliferation of 20 new technologies during the 2000s, they found evidence of "winner-take-more" dynamics, where the majority of related job gains were highly clustered in a few places close to the site of the original innovation.²¹ To borrow their words: "the distribution of pioneer locations across technologies is remarkably skewed — i.e., a few super-clusters are the birthplace of a surprising number of the disruptive technologies in our data. Collectively, locations in California alone host a remarkable 40.2% of our technology-pioneer location pairs. Another super-cluster along the Northeast Corridor from Washington to Boston accounts for an additional 21.2%. More broadly, the geographic distribution of patenting related to our 29 disruptive technologies is even more skewed than that of patenting in general."²²

How Jobs Diffuse

However, Bloom and coauthors also found that in later development stages, when the technologies become more mature and standardized, jobs associated with them diffused more widely. It took some 20 years for low-skilled jobs that use or produce new technologies to become fully dispersed geographically. But it took almost 40 years for high-skilled job postings to fully disperse from pioneer locations. And if pioneers can invent new technologies at a faster pace than old ones diffuse, the tendency will be towards greater concentration.²³

A recent study by the Brookings Institution shows that the tendency was towards greater clustering before the pandemic struck. True, a handful of less-established "rising stars" grew briskly between 2015 and 2019, including Atlanta, Dallas, Denver, Miami, Orlando, San Diego, Kansas City, St. Louis, and Salt Lake City. These cities all increased their share of national tech employment, adding jobs at a rate of 3% per year or more. And yet, the leading technology centers increased their share of nationwide tech employment in this period. In 2015, America's eight superstar tech clusters — that is, San Francisco, San Jose, Austin, Boston, Seattle, Los Angeles, New York, and Washington, D.C. — accounted for 1.2 million tech jobs or 36.8% of the nation's tech employment share. And by 2019, they were home to 1.5 million tech jobs or 38.2% of America's tech employment.²⁴

Hence, while nothing might last forever, there is ample evidence that disruptive technologies, which tend to emerge in urban areas, are also first commercialized there, giving pioneer regions a persistent advantage. In similar fashion, emerging technologies like the metaverse, quantum computing, augmented reality (AR)/virtual reality (VR), Web3, and artificial intelligence might well lead to even greater concentration in the established hubs. For example, an analysis of the geography of AI jobs from the Citi GPS report [Skills That Pay](#) found that almost one-third of AI professionals in the U.S. are located in California.

²¹ Nicholas Bloom et al., "The Diffusion of Disruptive Technologies," NBER, Working Paper No. 28999, July 2021.

²² Ahmed Tahoun et al., "How Disruptive Technologies Diffuse," *VoxEU*. August 10, 2021. Also see the relevant discussion on regional clusters in the Citi GPS report *Disruptive Innovations IV: Ten More Things to Stop and Think About*, July 2016.

²³ Gilles Duranton and Diego Puga, "Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products." *American Economic Review*, Vol. 91, No. 5, December 2021.

²⁴ Mark Muro and Yang You, "[Superstars, Rising Stars, and the Rest: Pandemic Trends and Shifts in the Geography of Tech](#)," Brookings Institution, March 8, 2022.

But things might also go the other way. In the end, the reason that economic activity tends to cluster comes down to the cost of moving goods, ideas, and people. Transportation technology has already reduced the cost of moving goods around dramatically over the centuries. And following the ICT revolution of the 1990s, the cost of transmitting ideas across the globe has been reduced to almost zero.

What long remained the key bottleneck to remote was the cost of moving people. But the world has seen significant improvements in remote work technology since Toffler was writing in the 1970s, or even since the early 2000s, when people like British economist Frances Cairncross predicted the death of cities. While some technologies — like Skype and Dropbox — began to spread that decade, it is only after 2010 that many key remote work technologies emerged, including Trello/Office 365 (2011), Zoom/Google Drive (2012), Slack (2013), Overleaf (2014), and Microsoft Teams (2017). And innovation in this space accelerated during the pandemic, which saw a doubling in the share of patents related to remote work technologies.²⁵ Taken together, it is possible that these advances will increasingly substitute for face-to-face interactions.²⁶

The Cost-of-Living Crisis

Add to this the cost-of-living crises, which has recently been exacerbated by supply chain disruptions and Russia's invasion of Ukraine. While it used to be the case that all workers benefited from higher productivity in cities, this is no longer true (Figure 4) and could easily spark an exodus from the metropolis. In a recent study, Philip Hoxie, Daniel Shoag, and Stan Veuger show that “non-college workers now effectively face a housing-inclusive urban wage penalty, while workers with college education continue to face a significant urban wage premium.”²⁷

This pairs with work showing that wage inequality within larger cities has grown very rapidly since the 1980s, in large part because routine jobs have been automated or sent elsewhere in response to rising production costs in dense places. This has put downward pressure on the wages of the unskilled, while allowing people in skilled professional services to export their services to an ever-larger global market.²⁸

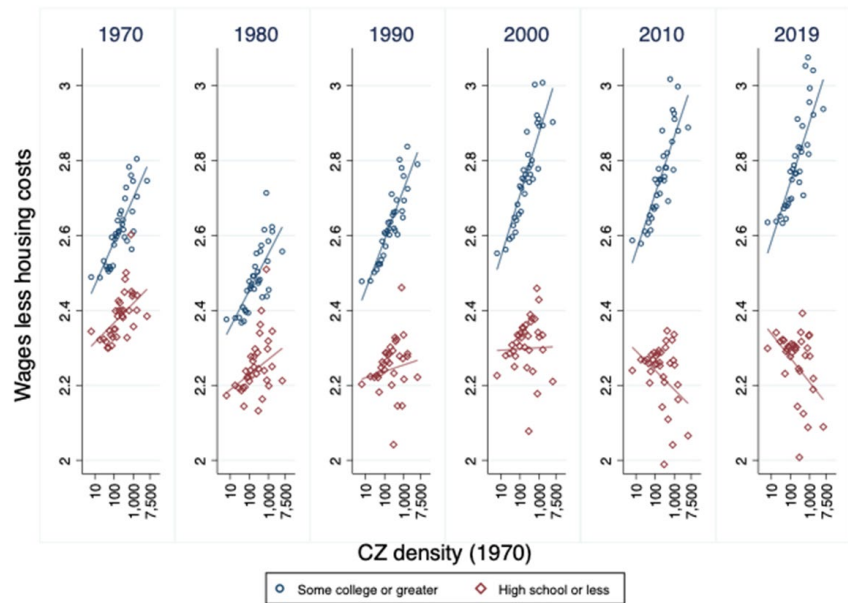
²⁵ Nicholas Bloom, Steven J. Davis, and Yulia Zhestkova, “COVID-19 Shifted Patent Applications Toward Technologies that Support Working from Home,” AEA Papers and Proceedings Vol. 111, May 2021.

²⁶ Richard Baldwin, *The Globotics Upheaval: Globalization, Robotics, and the Future of Work* (London, Oxford University Press, 2019).

²⁷ Philip G. Hoxie, Stan Veuger, and Daniel Shoag, “Moving to Density: Half a Century of Housing Costs and Wage Premia from Queens to King Salmon,” AEI Economic Policy Working Paper Series, No. 2019-24, April 11, 2022.

²⁸ Christoph Hedtrich, Roberto Pinheiro, Jan Eeckhout, “[Inequality Is an Urban Affair, and It's Due to New Tech](#),” VoxEU, October 16, 2021.

Figure 4. Increasingly, Workers Do Not Benefit from Higher Productivity in Cities



Source: Hoxie, P., Shoag, D., & Veuger, S. (2019). Moving to density: half a century of housing costs and wage premia from queens to King Salmon (No. 2019-24). Working Paper.

So why do the unskilled stay in cities? One explanation is that cities are more enjoyable places to live. The old German phrase, “city air makes you free” (*Stadtluft macht frei*), captures the essence of it: In medieval times, cities were free from serfdom, making them places of opportunity and excitement for the many. And even if the job opportunities are being diminished and rents are rising, the fun-factor remains. Television shows like *Seinfeld* and *Friends* justly celebrated the pleasures of hanging out in coffee shops and restaurants, which still appears to appeal to young people. And so, many citizens might be willing to pay a premium to live in cities, even if the pay does not make up for the extra cost of housing.

Another explanation, however, is that their jobs are tied to those of people paying for their services. If banks cluster in places like Wall Street and Canary Wharf, people working at the local restaurant need to live close by as well. But even though the job of a waiter cannot be done at distance, the rise of remote work has the potential to change the geography of in-person service jobs. Indeed, if the jobs of bankers and lawyers relocate, so will the people providing in-person services. For example, during the pandemic, the remote work habits of the educated rippled through the economy. As they were no longer buying lunches from restaurants or coffees from cafes around the office, service jobs dried up, to the detriment of low-income families.

Data from keycard swipes in office buildings shows that as late as September 2023, just under 50% of workers were back at their office seat across 10 of the largest metro areas, with significantly lower shares in some tech hubs like San Francisco (44%) and San Jose (41%).²⁹ But if jobs move to cities or rural areas where housing is cheap, this could — while causing some disruption in the short-run — ease the financial pressure on low-income households over the medium term.

²⁹ Kastle, “[Kastle Back to Work Barometer](#),” October 5, 2023.

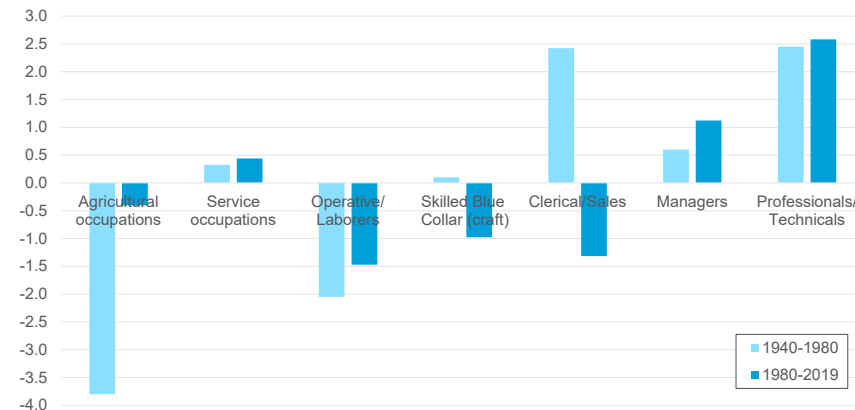
Escaping the City

Technology jobs moving out of city centers could reduce the cost of housing in those cities. As noted, if those jobs move to the hinterland, so would the jobs of people providing face-to-face services, which would reduce their cost of living. This would be a significant shift: Estimates suggest that one tech job in a given city supports around five local service jobs.³⁰

However, if more jobs are offshored rather than relocated to the hinterland, the incomes of people in face-to-face jobs would instead be adversely affected, if the demand for their services is reduced.

From the 1980s onwards, many routine clerical jobs have been automated away or shipped abroad (Figure 5).³¹ But this process has happened even faster in the metropolis where wages are higher and real estate is more expensive. Between 1990 and 2015, the most expensive cities in America saw a 4.5% drop in the share of routine clerical jobs compared to the cheapest locations.³²

Figure 5. Many U.S. Clerical Jobs Have Been Automated or Shipped Away Since 1980 (ppts)



Note: Updated and amended to include the years 2011 to 2019.

Source: David Autor, "Why Are There Still So Many Jobs? The History and Future of Workplace Automation," *Journal of Economic Perspectives*, Vol. 29, No. 3, 2015, Citi GPS

³⁰ Enrico Moretti, "Local Multipliers," *American Economic Review*, Vol. 100, No. 2, 2010; Enrico Moretti, *The New Geography of Jobs*, (Houghton Mifflin Harcourt, 2012).

³¹ Martin Goos and Alan Manning, "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain," *The Review of Economics and Statistics*, Vol. 89, No. 1, February 2017; Guido Matias Cortes, Nir Jaimovich, and Henry E. Siu, "Disappearing Routine Jobs: Who, How, and Why?," *Journal of Monetary Economics*, Vol. 91, November 2017; David H. Autor and David Dorn, "The Growth of Low-Skill Service Jobs and the Polarization of the U.S. Labor Market," *American Economic Review*, Vol. 103, No. 5, August 2013.

³² Jan Eeckhout, Christoph Hedtrich, and Roberto Pinheiro (2021), "IT and Urban Polarization", CEPR Discussion Paper No. 16540, September 22, 2021.

What is different this time around is that we are even seeing an exodus of non-routine technology jobs from leading innovation clusters. A yearly survey by Initialized Capital — a San Francisco-based venture fund — found that just before the pandemic, the Bay Area remained the leading choice for entrepreneurs: 42% of the founders of its invested companies would still have started their companies around San Francisco, while only 6% would have started using a remote or distributed model. In 2021, however, the tables had turned: 42% of founders said they would have preferred to launch their business with a remote or distributed work model, if they had started today, while only 28% would have stuck with the Bay Area.³³

Even some of the largest venture capitalists are moving out. Andreessen Horowitz, for example, announced in July 2022 that it is moving its headquarters from Silicon Valley to the cloud. However, while the company's new operating model will primarily be virtual, new offices are being created in Miami Beach, New York, and Santa Monica.³⁴

Meanwhile, Google and Apple have announced satellite and engineering offices in North Carolina, while companies like Tesla, Hewlett Packard, Palantir, and Oracle, have moved their headquarters from California to cities like Austin, Denver, and Houston. And Intel's announcement of two semiconductor plants in the Columbus, Ohio has brought much excitement about a new "Silicon Heartland."³⁵

True, technology companies have taken different approaches to the remote work revolution.³⁶ Apple's CEO Tim Cook thinks collaboration is best done in person and worries that a distanced and isolated workforce will have a negative effect on creativity and innovation. And in an email in June 2022, Elon Musk told his employees to spend at least 40 hours per week in the office.

However, at Apple, the return to three days at the office has faced some fierce opposition from employees with a group calling itself *AppleTogether*, warning that there should be no "uniform mandate from senior leadership," and an internal Slack channel advocating for remote has ballooned to 10,000 members.³⁷ Meanwhile, Google and Amazon staff have also been told to return to the office three days per week.

Meta and Dropbox, on the other hand, continue to encourage virtual work. And Airbnb has embarked on a fully remote model. As the company's co-founder and CEO, Brian Chesky, put it to his employees in a recent email:³⁸

³³ Kim-Mai Cutler, "[Post-Pandemic Silicon Valley Isn't A Place](#)," Initialized, Jan 21, 2021.

³⁴ Sarah Donaldson, "Andreessen Horowitz Moves Its Headquarters to the Cloud," *The Wall Street Journal*, July 22, 2022

³⁵ Mark Muro. and Yang You, "[Superstars, Rising Stars, and the Rest: Pandemic Trends and Shifts in the Geography of Tech](#)," Brookings Institution, March 8, 2022.

³⁶ Indeed, even within the same industry, there are large differences in companies' reliance on remote work, see Stephen Hansen et al., *Remote Work Across Jobs, Companies, and Space*, National Bureau of Economic Research Working Paper 31007, March 2023.

³⁷ Dave Lee, "Apple's Return-to-Office Order Sparks Anxiety Among Tech Workers" *Financial Times*, August 22, 2022.

³⁸ Airbnb, "[Airbnb's Design for Employees to Live and Work Anywhere](#)," April 28, 2022.



Two decades ago, Silicon Valley startups popularized the idea of open floor plans and on-site perks, which were soon adopted by companies all around the world. Similarly, today's start-ups have embraced remote work and flexibility, and I think this will become the predominant way that we all work 10 years from now. This is where the world is going... We've designed a way for you to live and work anywhere — while collaborating in a highly coordinated way, and experiencing the in-person connection that makes Airbnb special... This means you can move from San Francisco to Nashville, or from Paris to Lyon. You'll have the flexibility to do what's best for your life — whether that's staying put, moving closer to family, or living in a place you've always dreamed of.

– BRIAN CHESKY, CO-FOUNDER AND CEO OF AIRBNB



The push for remote, in other words, has been strong, with companies trying to roll back virtual working facing considerable resistance. And in an exceedingly tight labor market, rival tech companies stand ready to attract any disgruntled workers. Data from ZipRecruiter, for example, suggests that the percentage of fully remote job openings in tech has increased from 12% in 2019 to 39% in early 2022.³⁹

As noted, in the years leading up to the pandemic, established innovation hubs dominated the growth of the tech sector. Between 2015 to 2019, the two Bay Area metro areas — San Francisco and San Jose — even increased their share of technology jobs, generating almost 20% of the nation's entire new tech employment, while the eight largest hubs saw employment in the technology industry grow by 4.9% annually. However, this figure fell sharply to 2.9% in 2020. In San Jose, for example, growth slowed from 5.3% to just 1.9% as COVID-19 began to spread. In fact, analysis by the Brookings Institution shows that a significant number of other cities saw their share of technology jobs expand as remote work became more common:⁴⁰



A number of smaller quality-of-life meccas and college towns also seemed to add tech jobs sharply during the initial year of the crisis. Among the former group, high-amenity and vacation towns such as Santa Barbara, Calif.; Barnstable, Mass.; Gulfport-Biloxi, Miss.; Pensacola, Fla.; and Salisbury, Md. all saw their tech employment surge by 6% or more. These locations offered proximity to larger technology centers in addition to an attractive quality of life for footloose firms or workers. Likewise, attractive and convenient college towns such as Boulder, Colo.; Lincoln, Neb.; Tallahassee, Fla.; Charlottesville, Va.; and Ithaca, N.Y. all grew their tech jobs by more than 3% during the first year of the pandemic. Smaller-town job surges like these likely reflected the rise of “Zoom towns”: communities bolstered (at least for now) by the remote tech work of new residents whose work relies on digital tools.

– THE BROOKINGS INSTITUTION



In addition, the share of tech-related job postings declined in San Francisco, San Jose, Boston, New York, and Washington, DC, while rising considerably in Austin, Los Angeles, and Seattle. The bottom line is that technology jobs are spreading out following COVID-19 pandemic. But the persistence of leading technology hubs is also striking. Despite the recent rise of remote work having sparked some levelling, the geography of tech has remained highly skewed towards superstar cities.

³⁹ Dave Lee, “Apple’s Return-to-Office Order Sparks Anxiety Among Tech Workers” *Financial Times*, August 22, 2022.

⁴⁰ Mark Muro. and Yang You, “[Superstars, Rising Stars, and the Rest: Pandemic Trends and Shifts in the Geography of Tech](#),” Brookings Institution, March 8, 2022.

Beyond technology industries, however, a broader shift is seemingly underway. When Lightcast (previously Burning Glass Technologies) analyzed job postings across the United States, they found that while urban areas experienced faster growth in job postings between 2017 to 2019, this trend reversed thereafter. Between 2019 and 2021, nine out of the ten places experiencing the fastest job postings growth were rural.⁴¹ Meanwhile, counties like Santa Clara, Manhattan, and San Francisco, all saw job postings drop by more than 30%.⁴²

Other studies using census data on changes in city populations concur. Cities registering negative population growth between 2020 and 2021 included San Francisco (-6.3%), New York (-3.5%), Washington, D.C. (-2.9%), and Boston (-2.9%).⁴³ True, between 2021 and 2022, cities with over a million experienced a partial rebound, but in some of the biggest cities, like New York, San Francisco, Boston, and Los Angeles, the population decline continued, even if in less dramatic fashion. And among the cities that rebounded, most did still not register the growth levels they achieved earlier in the 2010s, or even in 2019, despite significant tailwinds stemming from the reopening of the economy to both domestic and international migration.⁴⁴

The most pronounced shifts have most certainly already happened but given the high share of jobs that can be done remotely, and the cost of living in prime locations, this trend could well continue for some time. As we showed in the Citi GPS report [Technology at Work v5.0](#), 52% of American jobs can be done remotely, though there are some striking differences across sectors (Figure 6).

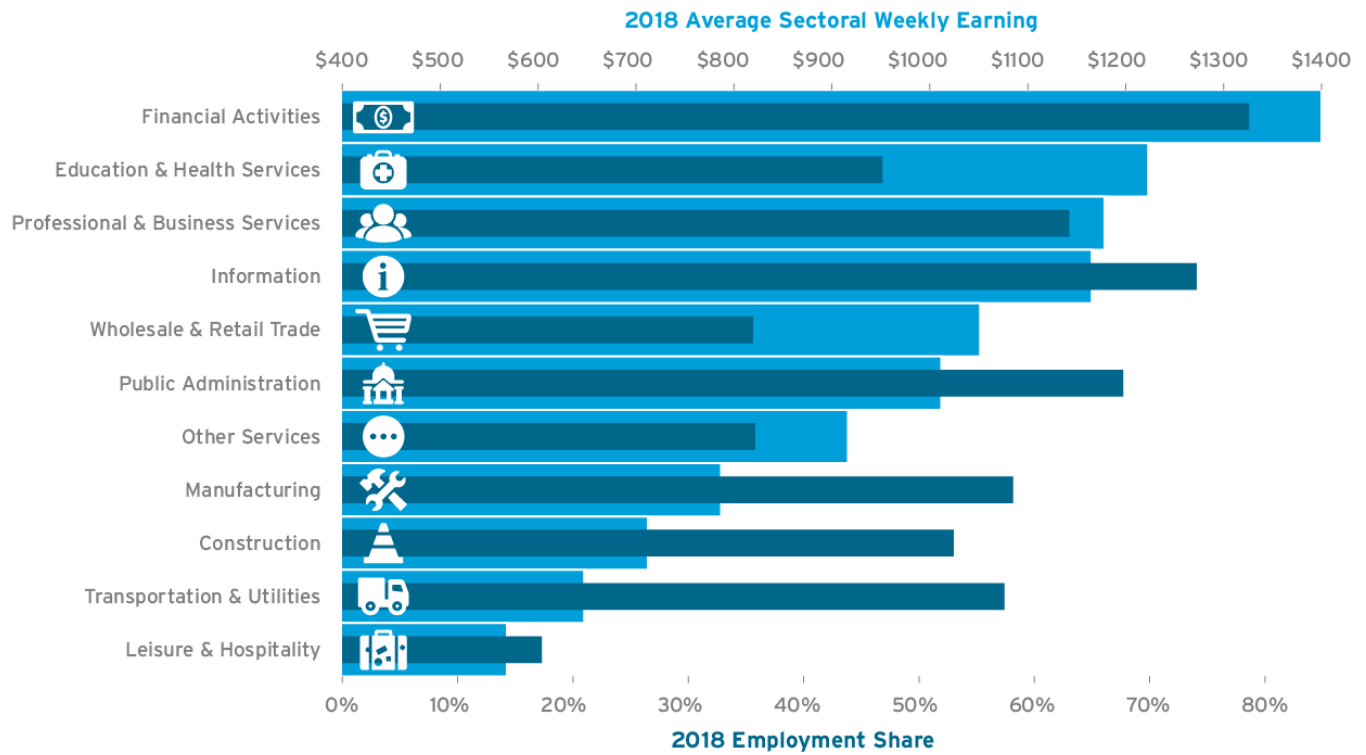
⁴¹ Defined as counties with 40% of their population living outside areas with 2,500 people or more.

⁴² Julia Nietschke et al., "Rural's Rise: Shifting Trends in Rural and Urban Job Postings," Emsi Burning Glass, 2022.

⁴³ William H. Frey, (2022), "[Big Cities Saw Historic Population Losses While Suburban Growth Declined During the Pandemic](#)," Brookings Institution, July 11, 2022..

⁴⁴ William H. Frey, "Big Cities Are Showing Signs of Recovery After Historic Population Losses," Brookings Institution, June 22, 2023.

Figure 6. Remote Work Frontier vs. Average Weekly Earnings of U.S. Employment Sectors



Source: Citi GPS: Technology at Work v5.0, Citi GPS

The Housing Dilemma

One reason to think that technology sectors, but also other industries, might continue to spread out more in the future is that fewer people want to live in cities post-pandemic. According to a recent Pew Research survey, the share of U.S. adults expressing a preference for living in a city is down from about one-in-four in 2018 to one-in-five at the end of 2021. Instead, more people are now longing for suburban life: while the share with a preference for rural areas remained unchanged, the percentage wanting to live in suburbs increased from 42% to 46%.

Meanwhile, about 43% of urban dwellers — up from 37% in 2018 — say they would like to move, compared with 35% of people in the suburbs, and 25% in rural areas. And while younger people are more likely to prefer cities, people prefer suburbs to cities — or indeed rural areas — across most age groups; though among adults aged between 50 and 64, almost as many prefer rural communities.⁴⁵

At the same time, however, what people are looking for in a community has barely changed since the pandemic. The only statistically significant change is that a higher share of the population indicates easy access to recreational and outdoor activities as a high priority, but the magnitude of the change is very small. What is more noteworthy is that about half of U.S. adults say the availability of affordable housing is a major problem — up 10 percentage points since 2018.

⁴⁵ Kim Parker et al., “[Americans Are Less Likely Than Before COVID-19 To Want To Live in Cities, More Likely To Prefer Suburbs](#),” Pew Research Center, December 16, 2021.

This is especially true of urban residents of which fully 63% complain about the lack of affordable housing. In rural areas, in contrast, people are more likely to cite high-speed internet as a key concern. On the other hand, rural areas saw a remarkable drop in the share of citizens pointing to the availability of jobs as a major problem.⁴⁶

Taken together, this suggests a shift is underway, prompted by the rising cost of living in cities and improvements in digital technology, making remote work increasingly feasible. Indeed, the pandemic has already shifted housing demand to areas that are better suited for remote work. Before the spread of COVID-19, attractive amenities and cheap housing were key factors shaping the local distribution of occupations and their propensity for remote work, and those places also saw significantly higher house price growth over the course of the pandemic: Studies suggest that an additional percentage point of remote work in 2020 increased house price growth by 1.47 percentage points nationwide between December 2019 and November 2021.

Clearly, house prices will grow faster in places where remote work migrants move in while slowing in cities losing migrants. But remote work does not just mean that people move. It also increases the overall demand for housing as individuals and families want more space. Working from home requires an office at home. And economists at the U.S. Federal Reserve have noted that fewer adults are now living with roommates, while more seem to prefer living alone.⁴⁷

Overall, recent estimates suggest that in the U.S., migration only accounts for around one-third of the remote work effect on house price growth. Controlling for migration, remote work accounts for at least one-half of the astonishing 24% increase in house prices from December 2019 to November 2021.⁴⁸

To be sure, the housing boom will not last forever, provided that supply responds to increased demand. The recent surge in interest rates has certainly hit house prices, though at the price of more expensive mortgages for ordinary people. But more fundamentally, the housing market has only had a few years to adjust to the pandemic so far. For example, empty offices might be converted into residential real estate, which would eventually take some pressure off the housing market.⁴⁹ And more housing will be built in cities that are attractive for remote work. But such adjustments could take some time, and if the current trend towards remote work continues, it could feed into inflation through rising housing costs in the coming years.

⁴⁶ Ibid.

⁴⁷ Daniel García and Andrew Paciorek. "[The Remarkable Recent Rebound in Household Formation and the Prospects for Future Housing Demand](#)," FEDS Notes, May 6, 2022.

⁴⁸ Christopher T. Stanton and Pratyush Tiwari, "Housing Consumption and the Cost of Remote Work," NBER, Working Paper No. 28483, February 2021.

⁴⁹ It is estimated that the rise of remote work has prompted a 45% decline in office values in New York City in 2020 and 39% in the longer run with the latter amounting to a \$413 billion of value destruction. See Arpit Gupta, Vrinda Mittal, and Stijn Van Nieuwerburgh, "Work From Home and the Office Real Estate Apocalypse," NBER Working Paper No. 30526, November 26, 2022.

At the same time, the rise of remote might also put downward pressure on wage inflation. As the economist Oliver Blanchard has argued, there is real concern that “catch-up” in real wages will make it even harder to bring inflation down to acceptable levels without a recession. Put simply, if workers are feeling squeezed in terms of purchasing power, they will bargain for higher wages, and given currently tight labor markets, employers will seek to accommodate their demands. This, in turn, would increase production costs and feed into higher price inflation, creating a vicious cycle.⁵⁰

But as compensation adjusts to share the amenity-value people get from remote work with employers, wage-growth pressures will moderate, counteracting concerns over a wage-price spiral. Estimates by Jose Maria Barrero and collaborators suggest that over two years the cumulative moderating effect is 2 percentage points over two years, prompting a drop in labor’s share of national income by 1.1 percentage points. This would offset more than half the catch-up effect that Blanchard worries about.⁵¹

In addition, the rise of remote might also put downward pressure on inflation in services if jobs move to low-income destinations — a topic we turn to next.⁵²

Leveling Up?

As we are writing this report, we have just experienced what has been called the “Great Resignation.” So far, quits have been concentrated to low-paying industries, like retail and hospitality.⁵³ And there is survey evidence to suggest that low pay, the lack of opportunities for advancement, and the feeling of being disrespected are among the main reasons for the upsurge in quits among the unskilled.⁵⁴ However, another perhaps underappreciated reason is that remote work has made it easier to interview for a new job. Indeed, people no longer have to travel for interviews and come up with justifications for their current employer, reducing the cost of searching and matching in the labor market (Figure 7).⁵⁵

⁵⁰ Olivier Blanchard, “[Why I Worry about Inflation, Interest Rates, and Unemployment](#),” Peterson Institute for International Economics, March 22, 2022.

⁵¹ Jose Maria Barrero et al., “The Shift to Remote Work Lessens Wage-Growth Pressures,” NBER, Working Paper No. 30197. July 2022.

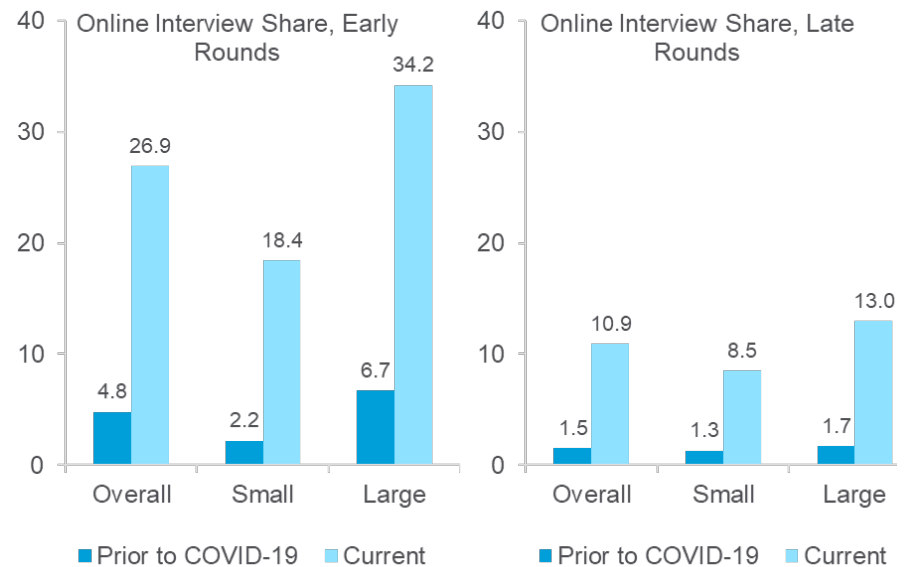
⁵² See also Richard Baldwin and Rikard Forslid, “Globotics and Development: When Manufacturing Is Jobless and Services are Tradable,” NBER, Working Paper No. 26731, February 2020.

⁵³ Elise Gould, “[A Strong Finish to 2021, but Omicron’s Impact Looms](#),” Economic Policy Institute, January 6, 2022.

⁵⁴ Kim Parker and Juliana Menasce Horowitz, “[Majority of Workers Who Quit a Job in 2021 Cite Low Pay, No Opportunities for Advancement, Feeling Disrespected](#),” Pew Research Center, March 9, 2022.

⁵⁵ Jose Maria Barrero, Nicholas Bloom, and Steven J. Davis, “Why Working from Home Will Stick,” NBER, Working Paper NO. 28731, April 2021.

Figure 7. Online Interview Shares, Pre- and Post-Covid



Note: N=572 (113 pre-COVID-19). Results are weighted by firm size.

Source: Survey of Business Uncertainty conducted by the Federal Reserve Bank of Atlanta, Chicago and Stanford University. <https://www.atlantafed.org/research/surveys/business-uncertainty>

The relative ease with which people can interview for new jobs is also happening at a time when there is unprecedented opportunity for wage arbitrage across locations. While remote wages are more equalized across space than wages for local jobs, striking disparities remain.⁵⁶ In Silicon Valley, the average salary for a software developer is \$167,420.⁵⁷ In Austin, Texas, in contrast, it is \$112,520.⁵⁸ Or consider Santa Fe, New Mexico, where the average software developer earns \$100,780.⁵⁹ Hence, working in Silicon Valley, while living in Santa Fe, where housing is cheaper, would surely be a good deal for many workers.⁶⁰

Conversely, being able to hire talent remotely, in cities like in Santa Fe, promises access to cheaper talent for companies around the county. This also means that employers might eventually adjust pay and benefits accordingly. As the economist Austan Goolsbee has noted, historically companies have usually found ways of clawing back gains from workers.⁶¹

⁵⁶ Agostina Brinatti, Alberto Cavallo, Javier Cravino, and Andres Drenik, "The International Price of Remote Work," NBER, Working Paper No. 29437, November 2022.

⁵⁷ U.S. Bureau of Labor Statistics, "[May 2021 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates, San Jose-Sunnyvale-Santa Clara, CA,](#)"

⁵⁸ U.S. Bureau of Labor Statistics, "[May 2021 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates, Austin-Round Rock, TX,](#)"

⁵⁹ U.S. Bureau of Labor Statistics, "[May 2021 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates, Santa Fe, NM,](#)"

⁶⁰ Indeed, we are likely to see more quits also among high-income workers going forward as people take advantage of the opportunities for wage arbitrage.

⁶¹ Austan Goolsbee, "The Battles to Come Over the Benefits of Working from Home," *The New York Times*, July 20, 2021.

In June 2021, for example, Google announced it would adjust pay according to the cost of living, reducing the salaries of those working remotely or moving farther away from the office.⁶² The Verge reports that Microsoft employees wanting to remain remote also will see changes in compensation based on an internal geopay scale.

However, companies might be able to reduce costs even further. Indeed, jobs that can be done remotely can also be offshored to low-income countries, allowing firms to cut both wage bills and real estate costs in the process.

⁶² Danielle Kaye, "Pay Cut: Google Employees Who Work from Home Could Lose Money," *Reuters*, August 10, 2021.

Charting the Rise of Remote Globally

To analyze the remote work revolution globally, we collected data on job postings from LinkUp for 70 of the largest cities around the world, spanning six continents, since the onset of the pandemic. Figure 8 shows the top 20 occupations in terms of their remote work share in 2021, and their respective changes since 2019. We note that the increase in remote work is large and broad-based across a wide variety of jobs, including those of lawyers, teachers, financial specialists, media workers, record clerks, secretaries, sales managers, as well as computer occupations.

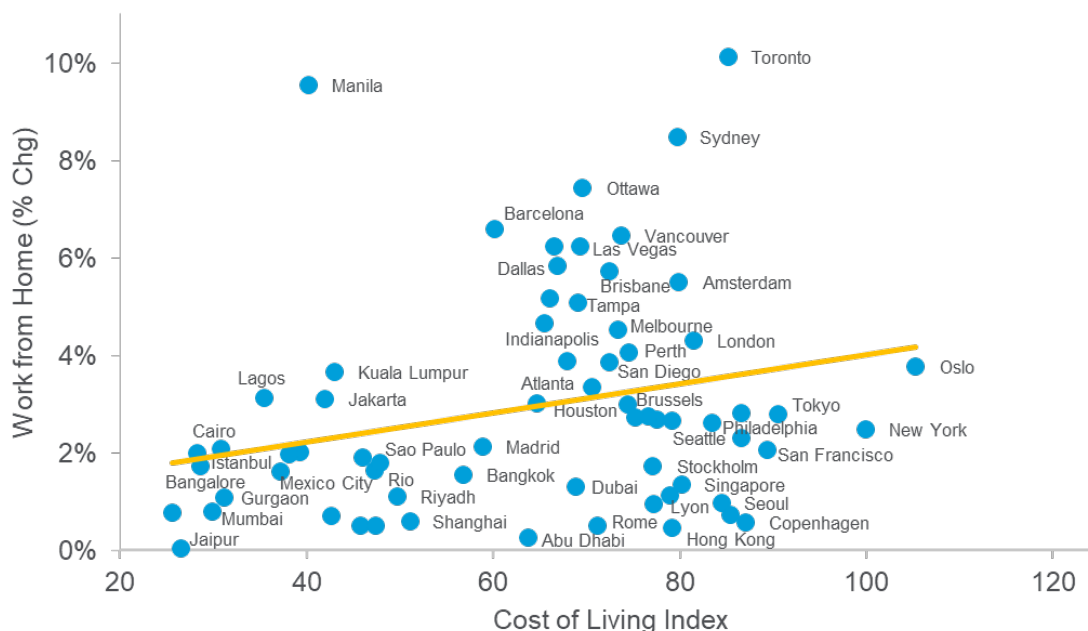
Figure 8. Top 20 Occupations by Remote Work Share, 2021

Occupation	Pre-2019	Post-2021	% Change
Other Education, Training, and Library Occupations	5.8%	17.9%	12.0%
Counselors, Social Workers, Other Community & Social Service Specialists	4.1%	14.8%	10.7%
Postsecondary Teachers	0.6%	8.8%	8.3%
Lawyers, Judges, and Related Workers	1.8%	7.5%	5.7%
Other Teachers and Instructors	10.0%	7.5%	-2.5%
Supervisors of Personal Care and Service Workers	0.4%	7.4%	6.9%
Media and Communication Workers	1.4%	7.3%	5.9%
Legal Support Workers	1.3%	7.2%	5.9%
Financial Specialists	2.4%	7.0%	4.6%
Business Operations Specialists	1.8%	6.4%	4.6%
Other Management Occupations	2.4%	6.3%	3.9%
Mathematical Science Occupations	1.9%	6.2%	4.3%
Secretaries and Administrative Assistants	1.3%	6.1%	4.8%
Advertising, Marketing, Promotions, Public Relations, and Sales Managers	2.0%	6.0%	4.1%
Sales Representatives, Services	1.4%	5.4%	4.0%
Other Sales and Related Workers	1.6%	5.2%	3.6%
Financial Clerks	0.7%	5.1%	4.4%
Computer Occupations	1.3%	4.9%	3.7%
Information and Record Clerks	0.8%	4.9%	4.1%
Media and Communication Equipment Workers	0.6%	4.9%	4.3%

Source: LinkUp, Citi GPS

Figure 9 plots the increase in the share of job postings mentioning the possibility for remote work between 2019 and 2021 against a cost-of-living index across some of the largest cities around the world. It shows that the COVID-19 pandemic sparked an extraordinary rise in remote work in most places. And as expected, we note a robust relationship between the increase in remote work and the cost of living, though there is a wide variation, pointing also to other significant factors behind the geographic variation we observe.

Figure 9. Working from Home (% Change) vs. Cost-of-Living Index (City-Level)



Source: Citi GPS, LinkUp

The rise of remote is clearly a global phenomenon. With the exception of Delhi, Abu Dhabi, Osaka, Hong Kong, and Jaipur, where remote worked increased by less by 1% — or even declined very slightly in the case of Delhi — all cities in our sample saw significant increases in the percentage of remote job postings. We also note a particularly sharp rise in the percentage of remote job postings in Toronto, followed by Manilla, Sydney, Ottawa, and Barcelona.

While the remote work revolution is happening all around the world, it seems particularly pronounced in Canada and Australia, possibly due to their combination of good broadband infrastructure, low population density, and vast distances, making working from home more feasible and compelling. We also note that remote work shares are generally somewhat lower in the United States relative to Europe, which speaks to anecdotal evidence suggesting that American companies have been more insistent on employees returning to the office. The uptake of remote work practices also seems to have been slower in high-income cities in East Asia, including Hong Kong, Osaka, Seoul, Shenzhen, and Shanghai, possibly for cultural reasons.

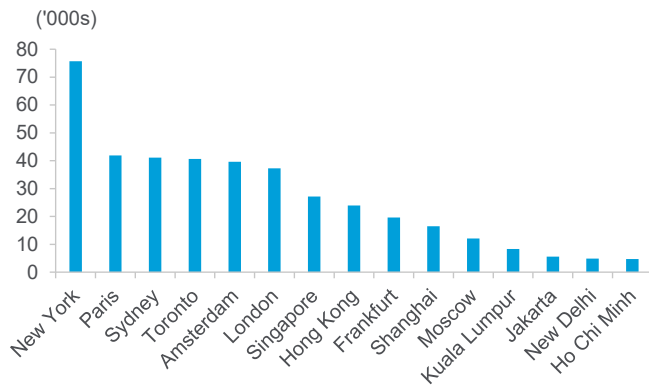
The Global Arbitrage

Meanwhile, as expected, the increase in remote work in the developing world has been relatively muted — Manilla, Kuala Lumpur, Lagos, Jakarta, and Buenos Aires being noteworthy exceptions. And yet, it is developing countries that might end up as the prime beneficiaries of the rise of remote. The simple reason is that the opportunities for wage arbitrage across borders are immense going forward. Hence, start-ups like Deel now specialize in helping companies to take advantage of such opportunities, providing a platform for executives looking to hire employees and independent contractors located in another country.

Consider Figure 10, which plots the average wages of accountants across the Big Four companies — PwC, KPMG, EY, and Deloitte — as well as the wages of software engineers at Google across geographies. We note that while a software engineer in New York City earns \$128,301 on average per year, she earns \$6,001 in Manila. Similarly, an accountant in New York City makes \$75,709 annually, but only \$3,010 in Cairo.

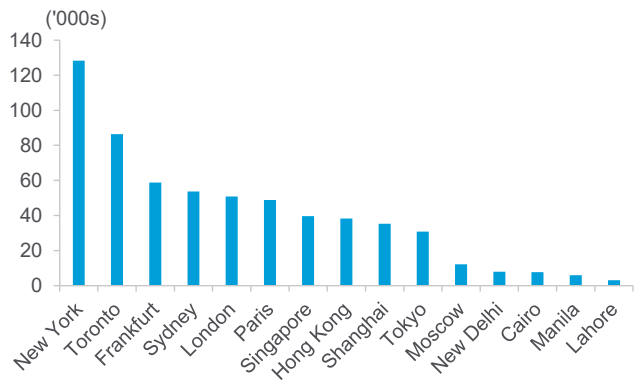
Such striking wage disparities, combined with new opportunities for remote work, suggests that we are still not in equilibrium. Studies analyzing the equalizing effect of remote work on wages around the world unsurprisingly show that wages in jobs that can be done remotely are more compressed than location-specific ones. But even on web-based job platforms, striking wage gaps remain across locations that cannot be explained by differences in workers’ characteristics, occupations, or the employers’ locations.⁶³

Figure 10. Average Annual Salary for Big 4 Auditors (0-1 Year Experience) Across Cities (US\$)



Source: Glassdoor

Figure 11. Average Annual Salary for Google Software Engineers (0-1 Year Experience) Across Different Cities (US\$)



Source: Glassdoor

⁶³ Agostina Brinatti, Alberto Cavallo, Cravino, J., & Drenik, A. (2021). “The International Price of Remote Work,” NBER, Working Paper No. 29437, Revised November 2022.

The Collective Brain

Perhaps the greatest source of hope for convergence in job creation around the world, however, is that remote collaboration for the first time offers the potential of boosting innovation and productivity, while reducing regional inequalities at the same time. Indeed, at the time of writing, there is widespread concern over the striking decline in productivity in recent decades. To take just one example, it now takes 18 times the number of researchers to achieve Moore's law than in the early 1970s.⁶⁴

One reason is that we are making fewer breakthrough discoveries. For instance, while the discovery of mRNA created an entirely new field and made the most effective vaccines against COVID-19 possible, having more and more researchers working to improve vaccine efficiency, from say 95% to 99%, naturally runs into diminishing returns. And we have been doing too little of the former (e.g., breakthrough discoveries) while obsessing too much over the latter (e.g., incremental improvements).

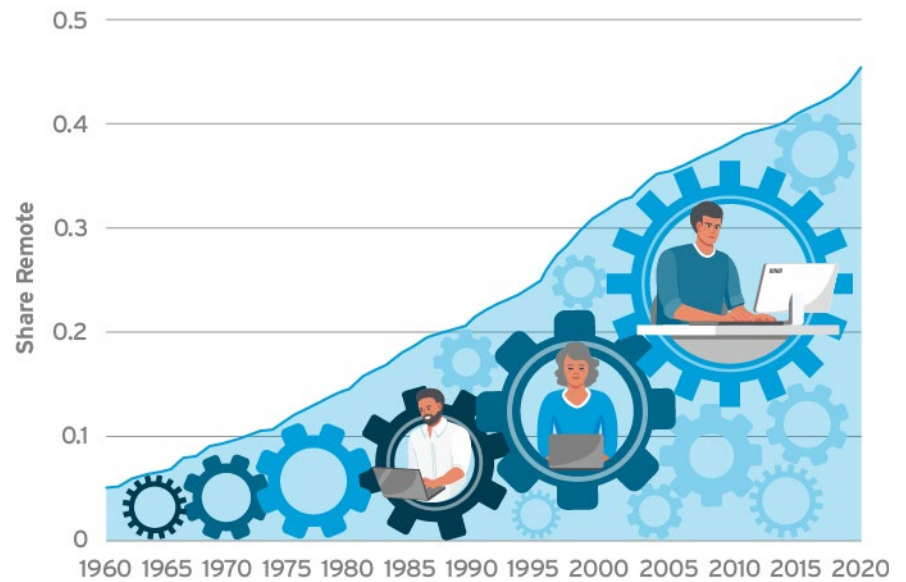
Indeed, analyzing the publications of over 10 million research teams over the past half century, we found that scientists have become more focused on incremental improvements rather than the kind of breakthrough technologies that open up new avenues for progress. There are of course many possible explanations for this, including the "burden of knowledge."⁶⁵ Scientists simply need to know more today in order to push the frontiers of research. But another factor is the rise of remote collaboration (Figure 12). As our research shows, when teams split geographically, they are less likely to produce disruptive discoveries, suggesting that face-to-face has remained critical for radical innovation.⁶⁶

⁶⁴ Moore's Law suggests that computational progress will become significantly faster, smaller, and more efficient over time. Nicholas Bloom, Charles I. Jones, John Van Reenen, and Michael Webb, "Are Ideas Getting Harder to Find?," *American Economic Review*, Vol. 110, No. 4, April 2020.

⁶⁵ Benjamin F. Jones, "The Burden of Knowledge and the "Death of the Renaissance Man": Is Innovation Getting Harder?" *The Review of Economic Studies*, Vol.76, No.1, April 2005.

⁶⁶ Carl Benedikt Frey and Giorgio Presidente, "Disrupting Science," The Oxford Martin Working Paper Series on Technological and Economic Change, Working Paper No. 2022-4, April 26, 2022.

Figure 12. The Rise of Remote Collaboration



Source: Frey & Presidente (2022), Citi GPS

The case of BITNET illustrates this point vividly. The co-operative computer network was introduced in 1981 by Ira Fuchs at the City University of New York (CUNY) and Greydon Freeman at Yale University to facilitate electronic communication between researchers working at different universities. And it soon spread beyond American borders to Canada, Europe, South America, Israel, India, and parts of Africa.

Scholars have shown that the proliferation of BITNET delivered a boost to innovation as it reduced the cost of communication and increased access to relevant information. In addition to e-mail communication and text file transmission, it also contained mailing lists on several thousand topics. However, the discoveries that BITNET spawned were generally not very disruptive. Consequently, when the Web finally arrived scholars started to leave the platform, which was soon abandoned as a project. There was no videoconferencing technology at the time, nor did the cloud exist. And this made BITNET a poor substitute for in-person meetings.⁶⁷

With the proliferation of the Web, remote collaboration soon became a reality outside academia. But videoconferencing technology was still lagging. A 2005 survey of employees at Hewlett Packard found that a mere 3% of respondents regularly used videoconferencing.⁶⁸ Even in the technology sector, adoption rates were very low.

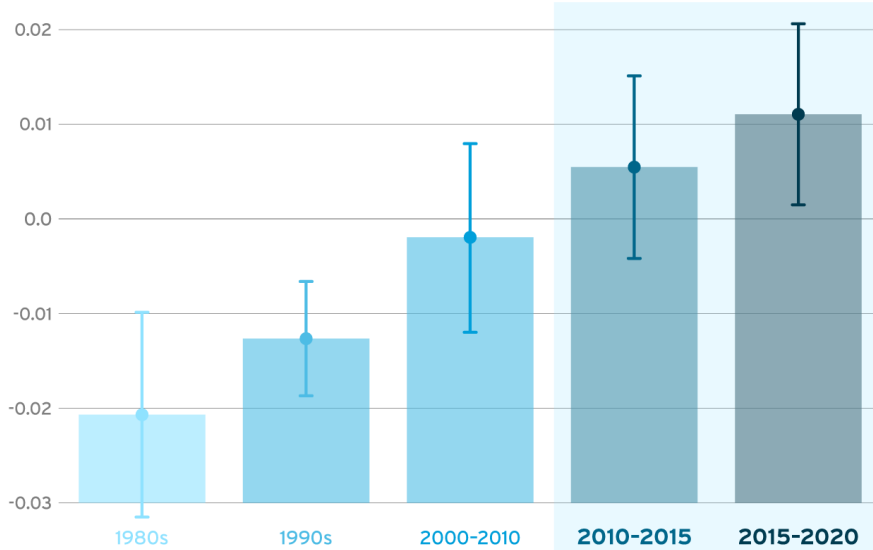
Our findings show that a turning point came in the 2010s when Zoom, Google Drive, Slack, and Microsoft Teams arrived. In this period, we find remote teams became more likely to produce breakthrough discoveries relative to their onsite counterparts (Figure 13). At first, this might seem puzzling, because even the latest remote work technologies are not as good as face-to-face.

⁶⁷ Kathrin Wernsdorf, Markus Nagler, and Martin Watzinger, "ICT, Collaboration, and Innovation: Evidence from BITNET," *Journal of Public Economics*, Vol. 211, July 2022.

⁶⁸ Sandra Hirsh, Abigail Sellen, and Nancy Brokopp, "[Why HP People Do and Don't Use Video Conferencing Systems](#)," HP Laboratories Palo Alto, February 4, 2005.

However, they are sufficiently good for scientists and innovators to leverage the fact that complementary skills and talent are often scattered around the world. And this has seemingly offset some of the drawbacks of collaboration at distance. Suddenly, a team at the University of Padua could benefit from a team member moving to Stanford, where her learning also helped her team in Italy.

Figure 13. 2010s Saw Remote Teams Become More Likely to Make Breakthrough Discoveries



Note: Units on Y-axis are coefficients.
 Source: Frey and Presidente (2022), Citi GPS

Thus, corporates and academic institutions will not benefit from collaboration if it means people working in complete isolation. The promise of remote collaboration is that by connecting different local knowledge networks, whether Munich and Tel Aviv, or Cambridge and Shanghai, it increases the innovating potential of what Henrich and Muthukrishna have called our “collective brain.”⁶⁹ Rather than having all of its talent clustered in the Bay Area, a corporate might be better off having its employees dispersed across different knowledge hubs. In our view, this makes President Joe Biden’s pledge to “ensure that science and technology hubs flourish in every part of the country” easier to achieve in practice.⁷⁰

⁶⁹ Michael Muthukrishna and Joseph Henrich, “Innovation in the Collective Brain,” *Philosophical Transactions of the Royal Society London B: Biological Sciences*, Vol. 371, No. 1690, March 19, 2016.

⁷⁰ Press Release, “[President-elect Biden Announces Key Members of his White House Science Team](#),” January 15, 2021.

Implications for the Third Phase of Globalization

Implications for Geography and Globalization

The concentration of innovation activity remains striking: Six tech clusters — San Francisco, Boston, Seattle, San Diego, Denver, and Austin — and the five largest cities account for more than 50% of U.S. patenting, with San Francisco alone accounting for almost 20%. And in software, the six tech hubs account for a striking 45% of patenting.⁷¹

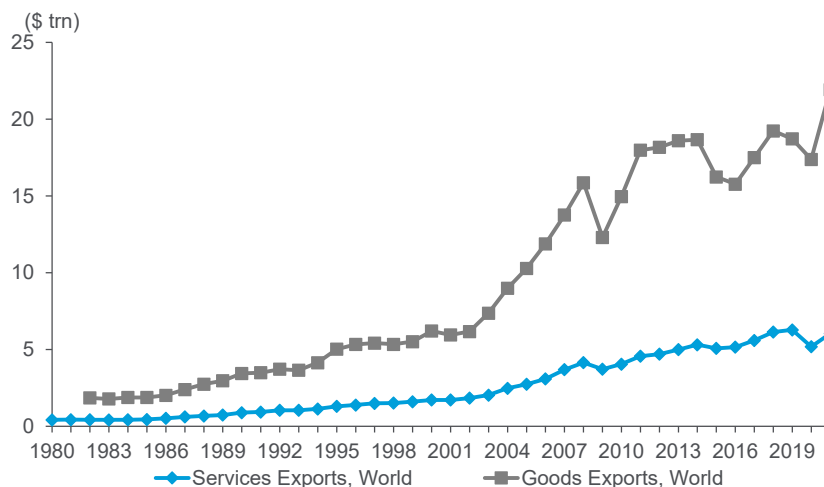
However, as we have shown in this report, a shift is already underway. Tech jobs are diffusing to secondary hubs where housing and labor is cheaper. This trend is certainly welcome. While the postwar decades saw manufacturing jobs spread from one city to another, since the computer revolution of the 1980s new job creation has been highly concentrated to a few superstar cities. The result has been a marked increase in regional inequality.

The key question, of course, is how long it will last. If a job can be done remotely, it could also be done offshore. Hence, rather than moving jobs to secondary domestic cities, corporates might increasingly move remote jobs abroad. As we have shown, the potential cost-savings from wage arbitrage across borders remain enormous. And as companies begin to exploit such opportunities, it will reduce inequality across countries while increasing it within the developed world.

For developing countries, which are facing significant headwinds as a result of premature deindustrialization, this would certainly help their growth prospects. As automation in manufacturing has permanently reduced their capacity to shift workers from fields to factories, the offshoring of services opens up new employment prospects. Indeed, as shown in Figure 14, the share of service trade in globalization is already rising.

⁷¹ B. Chattergoon and W.R. Kerr, "Winner Takes All? Tech Clusters, Population Centers, and the Spatial Transformation of U.S. Invention," *Research Policy*, Vol. 51, No. 2, March 2022.

Figure 14. The Share of Service Trade Worldwide Is Rising



Source: Citi GPS, IMF Balance of Payments Statistics Yearbook

Over the course of the 20th century, manufacturing jobs gradually diffused from cities, like Detroit and Manchester, to the hinterland — to foreign lands where labor is cheaper. A similar process is now playing out in technology and services. But it will not happen overnight. One reason that remote workers’ wages in low-income countries are lower is that they are less productive.⁷² It will take additional investment in education, learning-on the job, and spending on digital infrastructure to facilitate remote work to prompt another wave of offshoring.

Going forward, the competition for talent around the world will only intensify. For one thing, former industrial powerhouses, which have fallen behind in the age of computers, will look to capitalize on the remote world of work and attract talent. In the U.K., for example, many in the industrial heartland hope to attract London talent as part of their agenda for their Levelling Up policy, which aims to reduce the imbalances between areas and social groups.

To keep jobs onshore, policymakers in advanced economies will want to focus their efforts on boosting science and education. Indeed, even if the cost of production is higher in Leeds than in Bangalore, local learning and spillovers mean that higher productivity could offset the higher production costs if the right investments are made. Increasing the productivity of workers locally will be critical for Levelling Up to succeed.

Even so, workers in Leeds will face growing competition from places like India, which has both cheap and highly-skilled labor. According to data collected by UNESCO, 31.7% of graduates in India choose STEM compared to 26.3% in Britain. In total, India produced 2.6 million STEM degrees in 2020, relative to just short of 200,000 in the U.K., leaving India with huge pools of skilled workers for the world to tap into. In our view, the third wave of globalization will center on India rather than China.

⁷² The evidence on the productivity of remote workers in emerging economies is mixed. For example, Atkin, Schoar, and Shinde find that remote workers are less productive based on a randomized control trial in the city of Chennai, India (David Atkin, Antoinette Schoar, and Shinde, S. (2022), “Worker Sorting, Work Discipline, and Development,” Technical Report, MIT Sloan Working Paper, 2020.)

That said, the extent of future offshoring might depend on factors beyond economics. As we are writing, the Biden administration has introduced sweeping export controls, aiming to cut China off from certain semiconductor chips made anywhere in the world with U.S. equipment. We might see similar efforts in AI and software going forward. However, we also note that restrictions on trade in software and services will be much harder to implement.

Implications for Medium-Term Inflation Performance

With inflation recently hitting a 40-year high, policymakers, employers, and employees are all looking at ways to mitigate rising prices. Remote and hybrid work could be part of the solution, leading to a cost adjustment, impacting where inflation lands in the next three to five years, and becoming a deflationary force beyond this.

Studies have shown hybrid work can increase total welfare for the average worker by 7% via less commuting time and larger, or cheaper, houses outside of cities.⁷³ During periods of rising travel and food costs, one of the attractions to employees is money saved on commuting and sundries. With additional non-financial benefits such as time savings from commuting and grooming, more comfortable surroundings, and greater autonomy and flexibility, surveys have shown that employees are willing to be paid less for work from home (WFH) options. One recent study by Aksoy et al. estimates an average willingness to give up 5% of pay, with work from home more highly valued by those with longer commutes, by women, by people with children under 14, and by those with more education.⁷⁴ Looking at amenity-value in a different way, respondents in a Society of Human Resources survey said they would need a 20% pay rise to stay in a full-time office position with a 30-minute commute, or a 10% rise for a hybrid job.⁷⁵ While there could be an argument that if employees who work from home are more productive they should get paid more, the direction of travel currently looks like work from home benefits could be shared between employee and employer. It is possible in time that more days out of the office could lead to higher cost savings for companies. To help quantify the impacts on inflation a July 2022 National Bureau of Economic Research study calculated cumulative wage-growth moderation of 2% over 2 years.⁷⁶

It may be in employee's best interest to share these benefits as the longer-term alternative could be problematic. If a job can be done from home, it is possible that job, or parts of it, could be done from anywhere (WFA). Part of WFA will include an increase in digital nomads, with over 45 countries offering work visas and some offering very attractive tax incentives for workers to locate in their countries. The bigger trend however will be the incentive for employers to seek talent in lower-cost locations.

⁷³ Matt Delventhal and Andrii Parkhomenko, "Spatial Implications of Telecommuting," Available at SSRN 3746555, December 9, 2020.

⁷⁴ Cevat Giray Aksoy et al., "Working from Home Around the World," NBER, Working Paper No. 30446, September 2022.

⁷⁵ Matt Gonzales, "Nearly Half of Workers are 'Definitely Looking' to Work Remotely," SHRM, June 13, 2022.

⁷⁶ Jose Maria Barrero, Nicholas Bloom, and Stephen J. Davis, "Why Working from Home Will Stick," NBER, Working Paper No. 28731, April 2021.

As discussed in [Technology at Work 6.0](#), we estimate 18% of U.S. work could be offshored and a large labor cost arbitrage opportunity may be too significant to turn down, especially as many office jobs in expensive cities are high cost.⁷⁷ Just as we have seen in the outsourcing of manufacturing over the last 50 years, lower-value tasks may move first and over time higher value activities follow. Like manufacturing before it, the trend towards offshoring of services is likely to provide a significant counterpoint to wage inflation in developed economies for several decades to come.

There may be good reasons why governments, employers and employees prefer to first see wage arbitrage opportunities taking place within countries rather than amongst countries but given the level of regional wage disparities in many countries, this will also be disinflationary for wages. Whether jobs move out of high-cost locations to cheaper locations within countries or abroad, there will be a knock-on implication for the price of ancillary services, such as food, hospitality, and retail in high-cost cities.

Employers are also likely to consider other cost savings offered by digital labor. An obvious place to start is with lower travel and expense budgets, as two-way video services offer almost free connectivity instead of physical travel's costs in time, airfares, carbon, hotels, and related expenses. While in-person meetings will remain important, it is possible we never revisit pre-pandemic norms.

It is also clear that less high-cost office space will be required if jobs move abroad. There is more debate on the role of offices for hybrid work structures, with the simple narrative that the number of desks required drops, but the amount of collaborative space increases. Given ongoing hybrid experimentation and long lead times for office rent renewals, often with 10-year lease periods, the exact configuration of offices is still a work in progress for most. According to Citi's Europe Real Estate research team, office desk costs can be between 20%-50% of staff costs and two days per week of working from home would take 26 years of full employment to refill space in London, all other things being equal.⁷⁷ So, with 40% less days in the office in a 3/2 hybrid structure, or 60% with 2/3 structure, and increasing new forms of sharing or flexible space, the temptation to find efficiencies could be meaningful. Timelines and degree will vary — one recent study on U.S. office occupancy is titled "Working From Home and the Office Real Estate Apocalypse" — the direction of travel for office costs looks disinflationary for developed market corporates.⁷⁸

Reduced wage or office costs can provide a level adjustment in costs for firms and countries in the medium term. However, if productivity improvements from work from home are shared between workers and firms, unit labor costs would fall. Thus, as long as wage increases are smaller than gains in productivity, hybrid and remote work could also be a powerful longer-term disinflationary force.

⁷⁷ Citi GPS, [Technology at Work v6.0. The Coming of the Post-Production Society](#), June 2021.

⁷⁸ Arpit Gupta, Vrinda Mittal, and Stijn Van Nieuwerburgh, "Work from Home and the Office Real Estate Apocalypse," NBER, Working Paper No. 30526, November 26, 2022.

Implications for Management

The proliferation of remote work has also created new opportunities and challenges for management. With a reduced physical presence of staff in office settings, managers find their oversight abilities diminished.

In principle, companies can respond to this challenge in two ways: by either using technology to better monitor workers at distance, or by trying to better align incentives through a greater use of performance-linked pay. The former approach, of course, has clear drawbacks as it potentially intrudes on the privacy of individuals. Not to mention the fact that greater monitoring is likely to reduce the wellbeing for workers.

It is, therefore, perhaps not surprising that many companies have resorted to performance-linked pay. Using dictionary methods and an exhaustive dataset which encompasses nearly all online job advertisements across the United States from 2018 to 2022, we find that remote work job advertisements are much more likely to include offerings of performance-based remuneration when juxtaposed with onsite positions.⁷⁹

Yet this comes with a different set of implications, particularly as it threatens to undermine the vital role companies play as insurance providers. Indeed, because companies have easier access to financial markets, they can spread out risk better than individuals, including their employees. Companies, in other words, can shield their employees from dramatic changes in earnings, even if it means paying them a bit less to offset this cost. But by using performance-based pay, they pass on some of the risks to their workers. This, in turn, could have consequential effects on employees' access to credit as well as their decision to work.

Implications for Productivity and Innovation

As we have noted, there are reasons to be optimistic about future productivity and broadly shared prosperity. As we are writing this report, the debate on the future of economic growth is ongoing. One influential theory, championed by Erik Brynjolfsson and collaborators, is that productivity growth tends to follow a J-curve as complementary investments and organizational changes are required to realize the benefits of new technologies, making a productivity resurgence likely, as happened with electricity and steam power.⁸⁰

⁷⁹ Carl Benedikt Frey, Giorgio Presidente, and Pia Andres (2023), "Remote Control," Oxford Martin School, 2023.

⁸⁰ Eric Brynjolfsson, Daniel Rock, and Chad Syverson, "The Productivity J-Curve: How Intangibles Complement General Purpose Technologies," *American Economic Journal: Macroeconomics* Vol. 13, No. 1, January 2021.

Consider James Watt's steam engine. When John Smeaton examined it early on, he declared that "neither the tools nor the workmen existed that could manufacture so complex a machine with sufficient precision."⁸¹ This required complementary skills to perfect the technology, which first happened when the combined genius of Matthew Boulton and James Watt made it a commercial success. In fact, it took eight decades for the Watt engine to deliver its main boost to productivity after it was invented.⁸²

Oxford University's Paul David noted something similar regarding electrification: It took roughly four decades after the construction of Thomas Edison's first power station in 1882 until electricity appeared in the productivity statistics as it required a complete reorganization of the factory.⁸³ And David went on to predict a similar trajectory for computerization and was right on target: In a number of studies, economists have shown that investments in computers boosted productivity mainly when complementary organizational changes were made.⁸⁴

We agree with this assessment. Our findings similarly show that harnessing the benefits of the information and communications technology (ICT) revolution for remote collaboration also required complementary investments in technologies that support remote work. As recent studies show that the pandemic has sparked a striking acceleration in patenting related to remote work technologies, there are good reasons to believe that this will also spark a revival of disruptive science and faster productivity growth.⁸⁵ Thus, even if we are agnostic about the much debated impact of remote on productivity at work, which would be at best a one-off boost anyway, there are good reasons to believe that the spillovers it creates in science and innovation could deliver a more lasting productivity contribution.

Finally, every time a physical interaction becomes digital, new metadata is produced. This data is the lifeblood of business analytics and artificial intelligence. Citi's Mapping Innovation report has shown that 14% of all venture capital investment in 2022 went into AI, and the release of ChatGPT in November 2022 will certainly have driven this figure upwards. At the same time, Large Language Models (LLMs) have already been trained on the bulk of the internet, whose size is unlikely to increase by order of magnitude in the coming years, and this could hinder further progress. As more interactions become digital, however, new data sources are becoming available to help alleviate this challenge.

⁸¹ Cited in Carl Benedikt Frey, *The Technology Trap*, (Princeton University Press, Kindle Edition, 2019).

⁸² Nicholas Crafts, "Steam as a General Purpose Technology: A Growth Accounting Perspective," *Economic Journal*, Vol. 114, No. 495, April 2004.

⁸³ Paul A. David, "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox," *American Economic Review*, Vol. 80, No. 2, May 1990.

⁸⁴ See, for example, Timothy F. Bresnahan, Eric Brynjolfsson, and Lorin M. Hitt, "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence," *Quarterly Journal of Economics*, Vol. 117, No. 1, February 2002; Eric Brynjolfsson, Lorin M. Hitt, and Shinkyu Yang, "Intangible Assets: Computers and Organizational Capital," *Brookings Papers on Economic Activity*, No. 1, 2002; Eric Brynjolfsson and Lorin M. Hitt, "Beyond Computation: Information Technology, Organizational Transformation, and Business Performance," *Journal of Economic Perspectives*, Vol. 14, No. 4, October 2000.

⁸⁵ Paul A. David, "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox," *American Economic Review*, Vol. 80, No. 2, May 1990; Nicholas Bloom, Stephen J. Davis and Yulia Zhestkova (2021), "COVID-19 Shifted Patent Applications Toward Technologies that Support Working from Home," *AEA Papers and Proceedings*, Vol. 111, May 2021.

As our premier thought leadership product, **Citi Global Perspectives & Solutions (Citi GPS)** is designed to help readers navigate the most demanding challenges and greatest opportunities of the 21st century. We access the best elements of our global conversation with senior Citi professionals, academics, and corporate leaders to anticipate themes and trends in today's fast-changing and interconnected world.



All Citi GPS reports are available on our website www.citi.com/citigps



[Africa](#)

A New Growth Model
October 2023



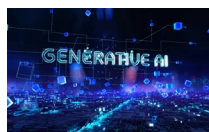
[Skills That Pay](#)

The Returns from Specific Skills
October 2023



[Future of Cross-Border Payments](#)

Who Will Be Moving \$250 Trillion in Next Five Years?
September 2023



[Unleashing AI](#)

The AI Arms Race
September 2023



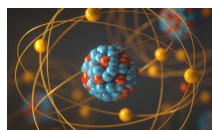
[Hydrogen](#)

A Reality Check on the Hydrogen Craze
August 2023



[Quantum Computing](#)

Moving Quickly From Theory to Reality
July 2023



[Future of Nuclear Energy in a Low-Carbon Environment](#)

Fission and Fusion Advanced Reactors to Prevail
July 2023



[Voluntary Carbon Market](#)

A Critical Piece of the Net Zero Puzzle
July 2023



[Economic and Social Mobility](#)

The Role of Business in Improving Outcomes
June 2023



[Sustainable Ocean Economy](#)

Charting a Prosperous Blue Future: Risk to Resilience
June 2023



[Asia as a Time Machine to the Future](#)

Seven Areas Where Asia Gives Insights Into the Future
May 2023



[Money, Tokens, and Games](#)

Blockchain's Next Billion Users and Trillions in Value
March 2023



[The Cyber Problem](#)

Causes and Consequences of the Rise in Cyber Skill Demand
March 2023



[The Creator Economy](#)

Getting Creative and Growing
March 2023



[Generative AI](#)

ChatGPT and Search
February 2023



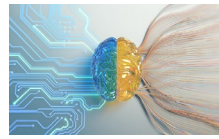
[Supply Chain Finance](#)

Uncertainty in Global Supply Chains Is Going to Stay
January 2023



[State of Global Electric Vehicle Adoption](#)

A Trip Around the World
January 2023



[Disruptive Innovations IX](#)

Ten More Things to Stop and Think About
December 2022



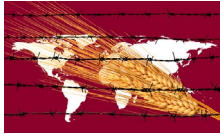
[Antimicrobial Resistance](#)

The Silent Pandemic
December 2022



[Climate Finance](#)

Mobilizing the Public and Private Sector to Ensure a Just Energy Transition
November 2022



[Food Security](#)

Tackling the Current Crisis and Building Future Resilience
November 2022



[Energy Transition: Vol 1](#)

Mixed Momentum on the Path to Net Zero
November 2022



[Energy Transition: Vol 2](#)

Building Bridges to Renew Momentum
November 2022



[China's Inward Tilt](#)

The Pursuit of Economic Self-Reliance
October 2022



[Philanthropy v2.0](#)

Reinventing Giving in Challenging Times
October 2022



[Food and Climate Change](#)

Sustainable Foods Systems for a Net-Zero Future
July 2022



[Home of the Future 2](#)

PropTech – Towards a Frictionless Housing Market?
June 2022



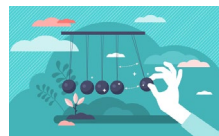
[Global Supply Chains](#)

The Complexities Multiply
June 2022



[Space](#)

The Dawn of a New Age
May 2022



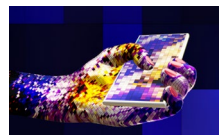
[Investing for Outcomes](#)

Why Impact Is Relevant Beyond Impact Investing
April 2022



[Metaverse and Money](#)

Decrypting the Future
March 2022



[Global Art Market Disruptions](#)

Pushing Boundaries
March 2022



[Women Entrepreneurs](#)

Catalyzing Growth, Innovation, and Equity
March 2022



[Eliminating Poverty](#)

The Importance of a Multidimensional Approach
February 2022



[Global Supply Chains](#)

The Complicated Road Back to "Normal"
December 2021



[Philanthropy and the Global Economy](#)

Opportunities in a World of Transition
November 2021

If you are visually impaired and would like to speak to a Citi representative regarding the details of the graphics in this document, please call USA 1-888-800-5008 (TTY: 711), from outside the US +1-210-677-3788

IMPORTANT DISCLOSURES

This communication has been prepared by Citigroup Global Markets Inc. and is distributed by or through its locally authorised affiliates (collectively, the "Firm") [E6GYB6412478]. This communication is not intended to constitute "research" as that term is defined by applicable regulations. Unless otherwise indicated, any reference to a research report or research recommendation is not intended to represent the whole report and is not in itself considered a recommendation or research report. The views expressed by each author herein are his/ her personal views and do not necessarily reflect the views of his/ her employer or any affiliated entity or the other authors, may differ from the views of other personnel at such entities, and may change without notice.

You should assume the following: The Firm may be the issuer of, or may trade as principal in, the financial instruments referred to in this communication or other related financial instruments. The author of this communication may have discussed the information contained herein with others within the Firm and the author and such other Firm personnel may have already acted on the basis of this information (including by trading for the Firm's proprietary accounts or communicating the information contained herein to other customers of the Firm). The Firm performs or seeks to perform investment banking and other services for the issuer of any such financial instruments. The Firm, the Firm's personnel (including those with whom the author may have consulted in the preparation of this communication), and other customers of the Firm may be long or short the financial instruments referred to herein, may have acquired such positions at prices and market conditions that are no longer available, and may have interests different or adverse to your interests.

This communication is provided for information and discussion purposes only. It does not constitute an offer or solicitation to purchase or sell any financial instruments. The information contained in this communication is based on generally available information and, although obtained from sources believed by the Firm to be reliable, its accuracy and completeness is not guaranteed. Certain personnel or business areas of the Firm may have access to or have acquired material non-public information that may have an impact (positive or negative) on the information contained herein, but that is not available to or known by the author of this communication.

The Firm shall have no liability to the user or to third parties, for the quality, accuracy, timeliness, continued availability or completeness of the data nor for any special, direct, indirect, incidental or consequential loss or damage which may be sustained because of the use of the information in this communication or otherwise arising in connection with this communication, provided that this exclusion of liability shall not exclude or limit any liability under any law or regulation applicable to the Firm that may not be excluded or restricted.

The provision of information is not based on your individual circumstances and should not be relied upon as an assessment of suitability for you of a particular product or transaction. Even if we possess information as to your objectives in relation to any transaction, series of transactions or trading strategy, this will not be deemed sufficient for any assessment of suitability for you of any transaction, series of transactions or trading strategy.

The Firm is not acting as your advisor, fiduciary or agent and is not managing your account. The information herein does not constitute investment advice and the Firm makes no recommendation as to the suitability of any of the products or transactions mentioned. Any trading or investment decisions you take are in reliance on your own analysis and judgment and/or that of your advisors and not in reliance on us. Therefore, prior to entering into any transaction, you should determine, without reliance on the Firm, the economic risks or merits, as well as the legal, tax and accounting characteristics and consequences of the transaction and that you are able to assume these risks.

Financial instruments denominated in a foreign currency are subject to exchange rate fluctuations, which may have an adverse effect on the price or value of an investment in such products. Investments in financial instruments carry significant risk, including the possible loss of the principal amount invested. Investors should obtain advice from their own tax, financial, legal and other advisors, and only make investment decisions on the basis of the investor's own objectives, experience and resources.

This communication is not intended to forecast or predict future events. Past performance is not a guarantee or indication of future results. Any prices provided herein (other than those that are identified as being historical) are indicative only and do not represent firm quotes as to either price or size. You should contact your local representative directly if you are interested in buying or selling any financial instrument, or pursuing any trading strategy, mentioned herein. No liability is accepted by the Firm for any loss (whether direct, indirect or consequential) that may arise from any use of the information contained herein or derived herefrom.

Although the Firm is affiliated with Citibank, N.A. (together with its subsidiaries and branches worldwide, "Citibank"), you should be aware that none of the other financial instruments mentioned in this communication (unless expressly stated otherwise) are (i) insured by the Federal Deposit Insurance Corporation or any other governmental authority, or (ii) deposits or other obligations of, or guaranteed by, Citibank or any other insured depository institution. This communication contains data compilations, writings and information that are proprietary to the Firm and protected under copyright and other intellectual property laws, and may not be redistributed or otherwise transmitted by you to any other person for any purpose.

IRS Circular 230 Disclosure: Citi and its employees are not in the business of providing, and do not provide, tax or legal advice to any taxpayer outside of Citi. Any statements in this Communication to tax matters were not intended or written to be used, and cannot be used or relied upon, by any taxpayer for the purpose of avoiding tax penalties. Any such taxpayer should seek advice based on the taxpayer's particular circumstances from an independent tax advisor.

© 2023 Citigroup Global Markets Inc. Member SIPC. All rights reserved. Citi and Citi and Arc Design are trademarks and service marks of Citigroup Inc. or its affiliates and are used and registered throughout the world.

NOW / NEXT

Key Insights regarding the future of Technology and Work



LABOR MARKET

Since the 1980s, many U.S. clerical jobs have been either automated away or shipped overseas. / **What is different this time is that we are seeing an exodus of even non-routine technology jobs from leading innovation clusters.**



INNOVATION

The pandemic has seen a striking acceleration in patenting related to remote work technologies. / **We see reasons to believe this will spark a revival of disruptive science and faster productivity growth.**



HUMAN CAPITAL

In the postwar decades, manufacturing jobs spread from one city to another but since the computer revolution of the 1980s, new job creation has been highly concentrated to a few superstar cities. / **Remote and hybrid work had led to a shift where technology jobs are diffusing to secondary hubs where housing and labor is cheaper.**



