Carnegie Mellon University
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Critical Technologies for a Post COVID-19 World: **Building short- and long-term recovery strategies**

Executive Summary

As the United States continues to reopen in the attempt to limit the depth and duration of the COVID-19 economic crisis, technology — particularly artificial intelligence (AI) — will play a critical role. In the short term, AI and smarter data-driven tools can vastly improve contact tracing initiatives and support more targeted testing strategies. New technologies can also facilitate more effective personal protective equipment (PPE) distribution and critical supply chain management. However, limiting policies that advance technology to short-term reopening strategies would be a missed opportunity for shoring up the U.S. economy in the long term. Instead, local, state, and federal governments must consider how critical technologies can provide ongoing support for workers and the economy.

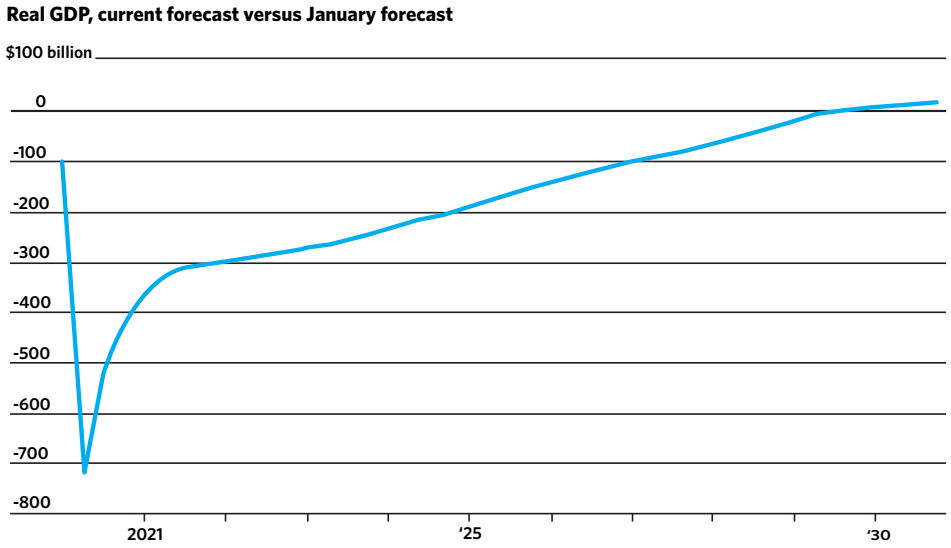
The pandemic forced an abrupt shift to the implementation of remote work technologies that will likely translate into fundamentally new workflow dynamics for countless firms and workers. In order to fully adapt to this "new normal," the country needs to formulate a comprehensive strategy for technology-driven training. At the same time, the crippling delay in obtaining life-saving PPE has laid bare extraordinary weaknesses in the United States' manufacturing supply chains that demand long-term investments in new infrastructure, technologies, and processes.

This white paper follows a virtual congressional briefing held on June 12, 2020. During the coming year, Carnegie Mellon University will engage with policymakers, industry, and academic colleagues to consider the role of technology in a post COVID-19 world, as well as investigate the short- and long-term policies needed. Through a series of convenings, white papers, and local and national partnerships, we aim to highlight how AI and other critical technologies can play a role in the United States' long-term economic recovery. This first paper considers:

- Short term technologies for monitoring, managing, and accelerating the safe reopening of the economy;
- The role of AI in the moderate- and long-term transition to remote and new forms of work;
- Critical supply chain constraints and what can be done to ensure supply chains are efficient, flexible, and resilient.

Introduction

It is now devastatingly clear that the economic consequences of COVID-19 will not be short lived. Recent estimates by the Congressional Budget Office (CBO) suggest the recovery will not be "V-shaped" — a deep but temporary trough followed by a rapid return — but more like the Nike "Swoosh," a deep trough with a much slower return to economic stability. The CBO predicts that it may take up to a decade for GDP to return to pre-COVID-19 levels.[1] Even when economy-wide growth figures return, significant portions of the economy will remain forever altered.

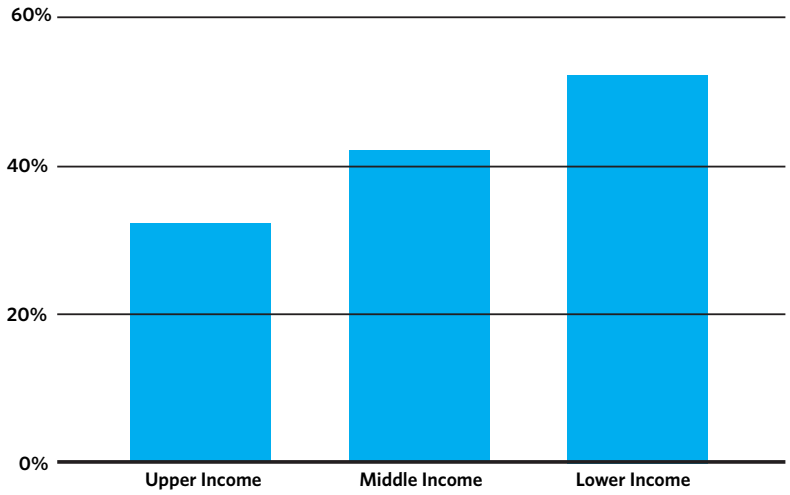


Source: Congressional Budget Office

The Great Recession offers telling lessons: while it took 10 years for the country's overall jobs numbers to return to pre-2008 levels, businesses and jobs never returned in many sectors. The country lost over 65,000 manufacturing establishments and currently employs a million fewer workers in the manufacturing industry than a decade ago.[2] The economies of the industrial Midwest and Rustbelt have been forever altered and, in some cases, decimated. While the question of whether technological change and automation or globalization were primarily responsible for the decline in manufacturing jobs continues to be a subject of debate, it is undeniable that the Great Recession, and the lack of policy preparedness, accelerated these underlying forces. Economy-wide, CMU economist Shu Wee finds that it takes 20 years for the generation entering the labor market during a recession to reach wage parity.[3] Without bolder policy initiatives, the country may see similar long-term closures in particular sectors like the retail industry and among other brick-and-mortar businesses. A recent Harvard study finds that at least 100,000 small businesses — predominately in the restaurant sector — will not return once the economy is reopened.[4]

The COVID-19 economic crisis may also have further long-run consequences because the fallout has disproportionately impacted low-income workers. For example, Pew finds over half of all low-income workers report income lost due to the pandemic, compared to under one-third of high-income households.[5]

Percentage of households with lost work or pay due to COVID-19



Source: Pew Research Center, April 2020.

Of course, the fact that this downturn is exacerbated by a public health crisis makes this situation unique. A full 20 percent of the workforce is in sectors that have been closed.[6] Safely getting those individuals back to work is clearly a top priority, but it should be considered a first step of many necessary to returning the economy to full employment. Moderate- and long term workforce and growth strategies are now more important than ever to 'bend the curve' of the current recession and avoid similar consequences to those that resulted from the last Great Recession.

The Role of Science and Technology Policy

Addressing the COVID-19 economic crisis will require all the tools in policymakers' toolkit. However, the role of technology policy is usually neglected – or relegated to a second-tier priority — during economic recoveries. While broadband buildout is often part of larger 'shovel ready' infrastructure conversations, science and technology (S&T) policy more broadly is generally left out of the conversation. This is unfortunate for any recession, as novel uses of technology can both speed the recovery and position the economy for long-term productivity growth. But neglecting the role of technology in the COVID-19 recovery in particular would be detrimental for a number of reasons. First, the economic shock of COVID-19 is not like prior recessions, and there is so much about the economy that traditional data sources and techniques simply cannot tell us. Second, the pandemic requires unique and complicated trade-offs between economic reopening and public health that could be supported by machine learning and operational research techniques. Third, the economy-wide 'flip' to remote work will have profound implications for the use of technology in the workplace going forward.

Stronger data governance and public-private partnerships coupled with deployment of AI can go a long way to support the reopening phase; but once policy makers have a better sense of the economic damage done by the pandemic, the country will need a new class of training and workforce support structures that neither rely on traditional brick-and-mortar classrooms and curricula or existing online training methods that have proven largely ineffective at retraining workers left behind in prior recessions. Doing so will likely demand new AI-driven cognitive tutors coupled with better in-person training as well as machine learning applications that can help workers find new career pathways. This is particularly true in light of the fact that in the aftermath of the crisis, some industries and jobs will see a significant decline — as did manufacturing during the last economic downturn — while others will rapidly expand.

Sound science and technology policy bolsters the long-term capacity of an economy to innovate and compete. As technology strategies are adopted and deployed to address the COVID-19 crisis, we should not treat these as

isolated interventions for an acute moment. Instead, we must consider these to be the first steps in a sequence of necessary new policies and programs to improve the long-term competitiveness of the U.S. economy. It may be counterintuitive to advocate for long-term thinking amidst a global pandemic and likely the worst economic downturn since the Great Depression, but that is exactly what is needed in times like these. Decisions made today around safely reopening the economy should lay the foundation for renewed investment into long-term growth strategies.

Short-Term Policy: Informing Reopening Decisions and Protecting Public Health

During the coming months, as workers return to their jobs and businesses reopen, the country will be in a precarious position. On the one hand, moving quickly may reduce the long-term economic costs of closing the economy; while on the other hand, a more gradual reopening could limit the risk of a second wave of COVID-19 that would cost lives and potentially cause an economic depression if stay-at-home orders need to be reinstated. Although a wide consensus among public health experts suggests extensive COVID-19 testing is a key element of this safe reopening, the country's testing capacity has fallen far short of these experts' recommendations. Therefore, we will need smart, targeted testing strategies to ensure the most vulnerable and those at greatest risk of spreading the disease are identified and prioritized for testing.

Currently, there is no comprehensive strategy to decide who should receive testing on a national level. Instead, states, municipalities, and private companies have deployed a variety of methods, many of which are devoid of data-driven decision-making tools. The country needs an intelligent testing platform to target the deployment of scarce tests and PPE.

Artificial intelligence and operational research techniques have proven effective at efficiently and equitably allocating scarce resources in the past, ranging from prioritizing inspections to reduce lead poisoning in children to targeted mental health outreach to help break the cycle of the incarceration of vulnerable populations.[7] The COVID-19 testing strategies employed by both public and private organizations should be developed with a focus on the benefits to society and the ability to limit the spread of the disease. Machine learning can help policymakers better understand where and to whom limited tests can most effectively be deployed.

Building an intelligent testing platform will also require novel data governance and organizational design to bring together public and private data sources. For example, there currently seems to be little coordination on COVID-19 testing among federal, state, local, and private actors. Collaboration among these entities is imperative not only to share and disseminate best practices and guidance, but also to centralize data generated by testing for viral infection (importantly, both positive and negative results) that can provide timely and valuable insights for continuing to respond to the pandemic, such as identifying locations for pop-up or mobile testing sites, informing public outreach for encouragement (e.g., to get tested, wear masks, etc.) or education, and even coordinating PPE distribution.

While federal leadership is important to develop standards, best practices, and models of data governance, many improved data-driven tools can be deployed in a flexible and decentralized manner. Contact tracing represents one such opportunity. Despite the fact that our economic recovery depends critically on contact tracing to identify workers and others who should self-isolate despite being non-symptomatic, the country has not yet formed a plan to tap into the vast array of available datasets to achieve high-accuracy contact tracing.

Efforts such as the Apple-Google phone app that tracks which phones are within Bluetooth distance of one another are a great start, but they are just the tip of the iceberg compared to what we could accomplish by taking advantage of additional data sources to improve contact tracing.[8] For example, millions of credit card transactions at retail outlets are already recorded, allowing us to determine which two people were next to each other in line at Starbucks, and airline passenger records allow us to determine who sat next to whom and for how long. The COVID-19 pandemic has created a narrow window of opportunity to develop new data sharing and governance strategies and policies across the public and private sector to save lives. To support such efforts, the

federal government could expand the scope and breadth of initiatives like the U.S. Digital Service to go beyond supporting the use of technology in the federal government, to coordinating public-private data governance.

Another way to improve contact tracing would be to turn every subway car, coffee shop, and waiting room into a contact tracing hub at the cost of a few hundred dollars each. By simply installing a dedicated cell phone to run the Apple-Google app, these hubs would be able to capture who visited a given location and when.

Of course, to achieve any of these ideas, addressing privacy concerns is critical. The Apple-Google app is a good example of how some in the private sector are successfully navigating these issues. Also, public perception of the tradeoff between privacy and health has been altered by the brutal realities of the pandemic. Both policymakers and the public have difficulty considering "black swan" events — that is, low probability but extraordinarily consequential incidents — when evaluating the tradeoffs between public wellbeing and personal privacy, and therefore may have undervalued the societal benefits of shared data.[9] COVID-19 is clearly such an event. This crisis creates a moment to engage in a more fruitful, comprehensive conversation around the use of private data for public good while preserving individual privacy.

Now is the time to redefine data sharing practices that both preserve privacy and leverage ever-advancing capabilities in machine learning to harness individual information to achieve socially beneficial outcomes. The public sector must lead in defining the rules of the road and ensuring that constituents are confident that information they provide will serve the public good. That will require both thoughtful attention to processes and practices, as well as clearly communicating these standards to the public.

Moderate- and Long-Term Policy: Workforce Restructuring and Training

The pandemic has shown how quickly certain jobs and skills can become essential while others become obsolete. But COVID-19 is a specific example of a broader theme: workforce demands are changing rapidly, and with it, so too are the skills required by workers. To be clear, the point is not that a set of skills required in the past are being replaced by a new suite of workforce competencies (though that of course is true), but that to be successful, *the rate at which a worker must acquire new skills is accelerating.*

Federal agencies tasked with supporting workers must have the tools at their disposal to treat workforce development as an ever-evolving exercise in innovation. For example, the U.S. Department of Labor currently has no R&D budget. For too long federal technology innovation has remained the province of energy, defense, and health. It is past time to invest in new technologies, practices, and research that can drive improvements in education and workforce training. Similarly, as technology and labor market trends accelerate demand for new skills it will be essential to bring organizations that support and represent workers more squarely into the innovation process. For example, the AFL-CIO's Commission on the Future of Work and Unions lays out a blueprint for how unions can help workers pro-actively prepare for technological change, instead of simply responding to workplace innovation.[10]

These dynamics are playing out in real-time. For example, in a matter of weeks, the UK healthcare system went from less than one percent of appointments occurring via video, with the vast majority in person, to 100 percent of doctors assessing patients by phone, with only seven percent of those followed by an in-person consultation.[11] One view is that the abrupt shift to remote work demanded by the global pandemic was swift, but will ultimately be short-lived. Another view is that COVID-19 radically produced, or at least accelerated, a long-term trend toward remote work. As McKinsey describes it, the pandemic has almost overnight created "a blueprint for the long term."[12]

Advances in AI technologies such as robotics, computer vision, conversational assistants, and machine learning are bound to have a significant impact on future jobs. While it is impossible to know the rate at which these technologies would have been adopted by firms under more normal circumstances, it is undeniable that the rapid shift to remote work will accelerate this process. For example, as remote work and video conferencing

become more prevalent, so will the opportunity for computers providing more observability of the workflow to computer-automated assistants and accelerating the deployment of natural language processing and machine learning.

Remote work also creates opportunities for changes in the relationship between occupations and tasks. Advances in AI are already creating enormous pressure for employers to decouple the tasks within a given job that can be automated with those that cannot.[13] The move to more long-standing virtual work arrangements is likely to widen those fault lines. While we have seen the effects of skill-biased technological change (the notion that the adoption of new technology tends to benefit workers with particular skills) on growing inequality, the pandemic has introduced a new occupational differentiator that will reward workers with certain skills while making others increasingly obsolete.

Yet the same technologies that help close the productivity gap between virtual and face-to-face work also create opportunities for new workforce training strategies for those left behind. Advances in computer vision can identify specifically when a student begins to fall behind, while AI tutors can provide tailored assistance to help the student catch up.[14] At the same time, we will need significant advancements in educational videos and digital content to ultimately increase student engagement, retention, and learning.

COVID-19 is the largest natural experiment in remote education that the world has ever seen. In a matter of weeks, the lion's share of the nation's higher educational institutions shifted to 100 percent remote education. The lessons learned during this massive experiment can be translated into superior, long-standing virtual training pedagogy. While online learning obviously isn't new, Massive Open Online Course (MOOCs) have been marred by high attrition and low completion rates and mixed job market signaling, compared to their in-class counterparts, for decades. New federal investments that carefully identify — and more importantly, scale — the virtual training practices that worked during the pandemic may finally produce policies to help workers quickly and inexpensively acquire the necessary skills to stay ahead of global and technological forces.

Of course, for any advances in AI for remote learning to benefit a broad cross-section of the country, all students and workers must have access to high-speed internet. Currently almost one-third of households don't have broadband at home. Internet connectivity is an obvious necessity for participating in the modern economy, just as access to roads, electricity, and railroads were a necessity at the turn of the last century. From a technical perspective, the connectivity issue is different for urban and rural communities, but ultimately the implications for the future of work are similar. Without addressing the digital divide, the push towards remote work and education accelerated by COVID-19 will only exacerbate existing inequality.

Moderate- and Long-Term Policy: Supply Chain Resiliency and Critical Technologies

The COVID-19 crisis has laid bare significant, long-standing weaknesses in U.S. supply chains. More than 40 percent of active pharmacological ingredients and 50 percent of global PPE supplies are made in China.[15] Today, 90 percent of the chemical ingredients for generics to care for people in the U.S. that are hospitalized with serious coronavirus infections come from China, including sedatives, antibiotics, anti-inflammatories, and medications to raise blood pressure.[16] Efforts by U.S. manufacturers expect to only meet 50 million of the 300 million masks per month needed domestically as part of the pandemic response. Identifying and responding to these global supply chain constraints and ramping up U.S. domestic manufacturing is no simple task. Companies converting production lines to meet the demand for COVID-related medical products face material as well as skill shortages, both domestically and internationally.

Given the United States' reliance on China for critical PPE, it makes sense that much of the policy debate around improving U.S. supply chains has focused on the fact that China has become the world's factory. For example, 200 of the Fortune 500 companies have operations in Wuhan, the Chinese city where the outbreak began.[17] For many policy makers, the question becomes: what manufacturing capacity needs to return to the United States to avoid future shortfalls in essential products?

While targeted reshoring of critical technologies and competencies is warranted, reshoring low-value manufacturing capacity from China is not a tenable long-run strategy given increased competition from low-cost countries. Nor is attempting to predict and domestically produce anything and everything that might be affected by future global trade shocks. A better approach is to expand the innovative capacity of domestic production to improve flexible production and provide data-driven insights into global supply chain dynamics before existing inventories are exhausted. Today, advances in AI, the Internet of Things, robotics and other technologies have greatly expanded the ability to identify future supply chain threats and quickly shift production decisions.

For decades, the primary focus of supply chain optimization has been to improve efficiency, by minimizing costs, increasing asset utilization and reducing inventories.[18] These strategies have come at the cost of innovation in production flexibility and supply chain visibility technologies. While in many sectors, the pandemic has highlighted the need for new private sector investments in supply chain innovation, there is also an important role for policymakers in supply chain reform.

First, policymakers should approach supply chain problems in the same way the country would consider poor infrastructure that hamstrings the movement of goods — as a national problem to be addressed by national public policy. Second, many small- and medium-sized suppliers often service multiple industries. Thus, while the economy as a whole would benefit from improving the innovative capacity of these firms, no single industry has sufficient incentives to do so. Improving the productivity and resilience of lower tier suppliers through innovation and investments in technology represents a positive externality to the national economy that requires federal action. Third, research from the Organization for Economic Co-operation and Development (OECD) finds that in advanced economies, the gap between firms on the 'technological frontiers' — those investing in R&D, technology and cutting-edge skills — and the average firm is growing.[19] In other words, the country does not simply have an innovation problem, but a diffusion problem. Expanding technical capacity to a broader share of U.S. firms would greatly improve the nation's ability to identify and adjust to future global shocks, not to mention improve productivity, enhance the United States' economic competitiveness, and ultimately create more and better jobs.

Investments that improve the flexibility and resilience of supply chains also create important opportunities for workforce development. Retrofitting U.S. manufacturing, wholesale, and other industries to improve flexibility and increase the adoption of new technology will require complementary investments in new worker training and reskilling. Such a two-pronged national strategy could kick off a new era of U.S. manufacturing that not only provides greater resiliency to future global shocks, but creates new and better jobs and buoys the long-term competitiveness of the manufacturing sector in response to our international rivals.

Conclusion

As states begin to reopen their economies, it is understandable to hope that we are in the beginning phases of a return to normalcy. In many cases, things will return to the way they were pre-pandemic. Many stores will reopen (though many will not), stay-at-home orders will be rescinded, and consumer and business confidence will slowly grow. However, as no one yet knows what the ultimate cost of COVID-19 will be to the United States or global economy, it is just as impossible to predict what work and social disruptions will remain as a 'new normal.' What is clear is that COVID-19 has exposed numerous underlying weaknesses inherent to the U.S. economy that, due to the pandemic, have only become a greater liability to shared prosperity. While most agree that AI and other technologies can improve the safety, efficiency and equity of reopening in ways that more than justify the cost, investing in the recovery alone would be short-sighted. As policymakers rally the necessary resources to get the United States back on track, they should ensure that new policies in response to the pandemic also consider the longer term future of the U.S. economy.

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Endnotes

1 Paul Hannon and Saabira Chaudhuri, "Why the Economic Recovery Will Be More of a "Swoosh" Than V-Shaped," *The Wall Street Journal*, May 11, 2020.

2 The Bureau of Labor Statistics, 2020.

3 Shu Lin Wee, "Delayed Learning and Human Capital Accumulation: The Cost of Entering the Job Market During a Recession," March 2016.

4 Alexander Bartik et. al., "How are Small Businesses Adjusting to COVID-19 Early Evidence from a Survey," *NBER, Working Paper 26989*, April, 2020.

5 Kim Parker, Juliana Horowitz and Anna Brown, "About half of Lower-income Americans Report Household Job or Wage Loss Due to COVID-19," (Pew Research Center, Washington, 2020).

6 "How many workers are employed in sectors directly affected by COVID-19 shutdowns, where do they work, and how much do they earn?," *Monthly Labor Review*, Bureau of Labor Statistics, April 2020.

7 For more information on these examples, see: Rayid Ghani, "Equitable Algorithms: Examining Ways to Reduce AI Bias in Financial Services," Testimony before the Committee on Financial Services, U.S. House of Representatives, February 12, 2020.

8 "Apple and Google partner on COVID-19 contact tracing technology," Newsroom, April 10, 2020.

9 Nassim Taleb, *The Black Swan: The Impact of the Highly Improbable*, (Random House, New York, 2010).

10 "AFL-CIO Commission on the Future of Work and Unions," (AFL-CIO, Washington, September 2019).

11 Sapana Agrawal, et. al., "To emerge stronger from the COVID-19 crisis, companies should start reskilling their workforces now," McKinsey, May 7, 2020.

12 Ibid.

13 Erik Brynjolfsson, Tom Mitchell, and Daniel Rock, "What Can Machines Learn and What Does It Mean for Occupations and the Economy?," *AEA Papers and Proceeding*, 2018.

14 For examples of these new AI-driven educational applications see: CMU's LearnLab.

15 World Input-Output Database 2019, Gibson and Singh 2018, Woodcock 2019, Sutter et al., 2020.

16 Gibson 2020.

17 "COVID-19: Managing supply chain risk and disruption," Deloitte, April 2020.

18 Ibid.

19 Muge Adalet McGowan, et. al., "The Future of Productivity," Organization of Economic Co-operation and Development, 2015.