THE WORK OF THE FUTURE

BUILDING BETTER JOBS IN AN AGE OF INTELLIGENT MACHINES

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FOREWORD

Robert M. Solow*

I am writing this in the last week of January 2021. Sixty years ago, almost to the day, my family arrived in Washington, DC, and I started a year's work on the staff of President Kennedy's Council of Economic Advisors. The US economy had not yet emerged from the "typical postwar recession" of 1960. The unemployment rate, as I remember it, was a hair under 7 percent.

But another, more difficult problem had arisen. Each of the last three typical postwar recessions had taken place at higher unemployment rates than the ones before. Some economists and many in Congress and the financial press were suggesting that this higher unemployment rate was not the usual sort. It reflected not a lack of demand for goods and services but the fact that the unemployed workers were unqualified for employment: they were in the wrong place or had the wrong skills or no skills at all, or inadequate education. The usual fiscal and monetary policy maneuvers would do no good at all.

There is a tendency, whenever there is unexpectedly high or persistent unemployment, for simple monocausal explanations to circulate. Blaming the unemployment rate on the characteristics of the unemployed is

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one such. There is a certain immediate plausibility to such an explanation. The unemployed do tend to be less qualified than the employed. But whatever the true source of the unemployment, the normal process of turnover and selection will eventually focus the unemployment on the least qualified. This certainly does not mean that training the untrained will increase employment.

Here is a simple analogy: think of a high school basketball game played in a gym with a fixed number of seats bolted to the floor. Tickets are free, and more spectators arrive than there are seats. The seats will go on the average to the quick and aggressive. For the slow and passive there is standing room. Now suppose you train the standees to be faster and more aggressive. At next week's game more of them will get seats. But the total number of seats does not change at all. Getting employed in a modern industrial economy is a lot more complicated than getting a seat at a basketball game, but you see the point.

This was an important matter when the Council of Economic Advisors tried to calculate appropriate fiscal and monetary policy. My first assignment from Walter Heller, the council chairman, was to evaluate this theory of rising "structural" unemployment. This being Washington and not MIT, I think I had three weeks. My conclusion was that there was certainly an element of structural unemployment but there was no evidence that it was increasing.

Of course, blaming the characteristics of the unemployed is not the only simplistic way to account for unexpectedly high and persistent unemployment. Dramatic changes in technology are another and equally common theory. I first heard the word "automation" during that 1961 debate. We are already beginning to hear that the robots are coming, the robots are coming (and some day they will actually come).

The current situation is different. Leaving the COVID-19 pandemic aside, there has been no long-run rise in the unemployment rate, at least not yet. What we have instead is something more complex.

For generations, the real wage rate in the US had grown at more or less the same rate as output per hour of work. This meant that their ratio, the share of output paid out in wages and salaries, had no trend. There were short-run variations but not much else. That seems to have changed

in late 1960s or early 1970s. The real wage trend began to fall short of the productivity trend. It was not that the productivity trend accelerated; that might suggest something technological going on. The difference was that real wages fell behind. That involves a lot of economics, especially when it is set beside David Autor's famous finding that the economy was providing lots of low-wage and high-wage jobs but was losing the middle-skilled employment that had been part of the American Dream. The dramatic increase in inequality of income and wealth fits in here, too.

Now there were many candidate causes, and they were not mutually exclusive. Those middle-skilled jobs may have been lost to workers in poor, low-wage countries. Workers were clearly losing bargaining power, as evidenced by the virtual disappearance of labor unions from the private sector. Employers hardened their attitudes. The general market power of large firms in concentrated industries was probably increasing, maybe by a lot. The problem was not to pick a cause but to reckon how much weight to attach to each of a list of causes, and that is a very hard thing to do. It follows, of course, that fitting remedies to the disease, if it is a disease, is equally complicated.

By the way, I do not want to leave the impression that education and training are minor factors in all this. Certainly maintaining a skilled and adaptable labor force makes a necessary contribution to productivity. Second, easy access to education can function as an equalizing factor, although it is pretty clear that it does not perform this function very well in the US. Finally, the system of education and training maintains a common culture and a common understanding of citizenship. The point I was making just now was only that more training or even better training does not necessarily lead to higher employment.

During the first seventy years or so of the twentieth century, American capitalism pretty regularly delivered about three-fourths of the national income in the form of wages and salaries. That is the trendless number I mentioned earlier. During the past forty years or so that number began to diminish, and it had reached something like two-thirds when the pandemic arrived. That is still much the larger part of national income. At that scale, any major change in the labor market is bound to have consequences for the rest of the economy, consequences that will then

reflect back on the labor market. Disturbances arriving from outside the labor market will directly influence outcomes in the labor market. That is why, instead of being a dreary recycling of the work skills needed for oncoming technologies, this book turned into a wide-ranging survey of the economy as it now appears. No doubt we will need another such report someday, perhaps when the robots arrive. In the meanwhile, read on and learn what the grown-ups are thinking.

1

INTRODUCTION

A decade ago, powerful mobile phones were still a novelty, driverless cars were never seen on public roadways, computers did not listen to conversations or respond to spoken questions. The possibility of robots taking jobs seemed far off, save for an assembly line or two. But as the emerging capabilities of robotics and artificial intelligence (AI) began capturing headlines and the popular imagination, researchers and commentators began warning that jobs long thought to be immune to automation—those demanding expertise, judgment, creativity, and seasoned experience—might soon be better accomplished by machines. Citizens of industrialized countries took notice, reacting with mounting trepidation.

In this context, in the spring of 2018 MIT president L. Rafael Reif commissioned the MIT Task Force on the Work of the Future. He tasked the group with understanding the relationships between emerging technologies and work, to help shape public discourse around realistic expectations of technology, and to explore strategies that might enable a future of shared prosperity. The Task Force was co-chaired by this book's authors, Professors David Autor and David Mindell and Executive Director Dr. Elisabeth Reynolds. Its members included more than twenty faculty members drawn from twelve departments at MIT and more than

twenty graduate students. The Task Force commissioned and conducted numerous research studies, many of them published as working papers and research briefs, on which we draw heavily for this book (a complete list of Task Force publications is presented at the end of the book).

In the three years that the Task Force delved into the future of work, autonomous vehicles, robotics, and AI advanced remarkably. But the world was not turned on its head by automation, nor was the labor market. Despite massive private investment, technology deadlines have been pushed back, part of the normal evolution of breathless promises as concepts are tested in pilot trials, integrated into business plans, and actualized in early deployments. These are the diligent, if prosaic, steps toward making real technologies work in real settings to meet the demands of hard-nosed customers and managers.

Our research did not confirm the dystopian vision of robots ushering workers off factory floors or AI rendering superfluous human expertise and judgment. But it did uncover something equally pernicious: amid a technological ecosystem delivering rising productivity and an economy generating plenty of jobs (at least until the COVID-19 crisis), we found a labor market in which the fruits are so unequally distributed, so skewed toward the top, that the majority of workers have tasted only a tiny morsel of a vast harvest.

For most US workers, the trajectory of productivity growth diverged from the trajectory of wage growth four decades ago. This decoupling had baleful economic and social consequences: low-paid, insecure jobs held by non-college-educated workers; low participation rates in the labor force; weak upward mobility across generations; and festering racial earnings and employment disparities that have not substantially improved in decades. While new technologies have contributed to these poor results, these outcomes were not an inevitable consequence of technological change, or of globalization, or of market forces. Similar pressures from digitalization and globalization affected most industrialized countries, yet their labor markets fared better.

Yet we know that history and economics show no intrinsic conflict among technological change, full employment, and rising earnings. The dynamic interplay among task automation, innovation, and new work creation, while always disruptive, is a primary wellspring of rising

productivity. Innovation improves the quantity, quality, and variety of work that a worker can accomplish in a given time. This rising productivity, in turn, enables improving living standards and the flourishing of human endeavors. Indeed, in what should be a virtuous cycle, rising productivity provides society with the resources to invest in those whose livelihoods are disrupted by the changing structure of work.

When innovation fails to drive opportunity, however, it generates a fear of the future: the suspicion that technological progress will make the country wealthier while threatening numerous livelihoods. This fear exacts a high price: political and regional divisions, distrust of institutions, and mistrust of innovation itself. This anxiety has been laid bare in US politics as a growing gulf between the "haves" and the "have-nots" has driven a deepening national schism over how society should respond to the needs of those at the bottom of the economic ladder.

The central challenge ahead—indeed, the work of the future—is to advance labor market opportunity to meet, complement, and shape technological innovation. This drive will require innovating in our labor market institutions by modernizing the laws, policies, norms, organizations, and enterprises that set the "rules of the game."

The labor market impacts of technologies like AI and robotics are taking years to unfold. But we have no time to spare in preparing for them. If those technologies are deployed in the labor institutions of today, which were designed for the last century, we will see similar effects to recent decades: downward pressure on wages and benefits and an increasingly bifurcated labor market.

This book suggests a better alternative: building a future of work that harvests the dividends of rapidly advancing automation and ever more powerful computers to deliver opportunity and economic security for workers. To do that, we must foster institutional innovations that complement technological change.

We are living in a period of significant disruption, but not of the kind envisioned in 2018, when the Task Force was launched. The final phases of researching and writing this book occurred during the 2020 months of COVID-19, when citizens of many countries were in a state of pandemic lockdown. Our technologies have been instrumental in enabling us to adapt to these new circumstances via telepresence, online services,

remote schooling, and telemedicine. These tools for performing work remotely don't look anything like robots, but they too are forms of automation, displacing vulnerable workers from low-paying service jobs in such industries as food service, cleaning, and hospitality. We face a labor market crisis stemming from the COVID-19 pandemic. Millions are unemployed. But technological advances did not cause this crisis.

Long before this disruption, our research on the work of the future made it clear how many in our country are failing to thrive in a labor market that generates plenty of jobs but little economic security. The effects of the pandemic have made it even more viscerally and publicly clear: despite their official designation as "essential," most low-paid workers cannot effectively do their jobs through computing platforms since they must be physically present to earn their livings.

Some forecast that robots will soon take over those roles, though few have to date. Others see the indispensable role of human flexibility since it is human, not machine, adaptability that has allowed us to reorganize work on the fly during the pandemic. Still others see COVID-19 as an automation-forcing event—a catalytic force that will pull technologies from the future into the present as we learn to deploy machines in jobs that humans cannot safely perform. However it plays out, the effects of COVID-19 on technology and work will last long beyond the pandemic, although those effects may look quite unlike what anyone envisioned in 2018.

Other forces have also roiled the 2018 visions of the future, including the rupture between the world's two largest economies and a surge of political turmoil and economic populism that culminated in a violent attack on the US Capitol in the wake of the 2020 election of President Joe Biden. These pressures are reshaping alliances, breaking apart and reorganizing global business relationships, and spurring new forms of cyberwarfare, including disinformation, industrial-scale espionage, and electronic compromising of critical infrastructure. The US and China had friction before, but nothing like the fracture that is now occurring. What began as a trade war has morphed into a technology war. China's whole-of-government approach to tackling major industrial and technological goals poses a competitive challenge for Western economies, which typically take a decentralized, often business-led approach. It remains to be

seen whether China's focus on government-driven domination of data accumulation yields technological advances beyond creating powerful tools for monitoring and controlling its own population.

The clash with China is rippling through the economy and threatens to hinder innovation, which increasingly emerges from countries around the world, often by researchers who are collaborating across borders and time zones. How can we make sure that technological advances, whenever they come, yield prosperity that is widely shared? How can the US and its workers continue to play a leading role in inventing and shaping the technologies and reaping the benefits?

To address these questions, this book is divided into two parts. In part I, we look at the evolution of work and the status of key technologies that are poised to shape its future. Part II suggests how to shape policy, technology, and labor institutions toward shared prosperity.

We start with an essential observation: No compelling historical or contemporary evidence suggests that technological advances are driving us toward a jobless future. On the contrary, we anticipate that in the next two decades, industrialized countries will have more job openings than workers to fill them, and that robotics and automation will play an increasingly crucial role in closing these gaps. Nevertheless, the implications of robotics and automation for workers will not be benign. These technologies, in concert with economic incentives, policy choices, and institutional forces, will alter the set of jobs available and the skills they demand.

This process is both challenging and indispensable. Inventing new ways of accomplishing existing work, new business models, and entirely new industries drives rising productivity and new jobs. Such innovations bring new occupations to life, generate demands for new forms of expertise, and create opportunities for rewarding work. Most of today's jobs hadn't even been invented in 1940. The US needs not less but more technological innovation to meet humanity's most pressing problems, including climate change, disease, poverty, malnutrition, and inadequate education. Mastering these challenges through investment and innovation will create opportunity and improve well-being.

A second key observation is that the momentous impacts of technological change are unfolding gradually.

Spectacular advances in computing and communications, robotics and AI are reshaping industries as diverse as insurance, retail, health care, manufacturing, logistics, and transportation. But we observe substantial time lags, often on the scale of decades, from the birth of an invention to its broad commercialization, assimilation into business processes, widespread adoption, and impacts on the workforce. We find examples of this incremental pace of change in the adoption of novel industrial robots in small and medium-sized firms, and in the still imminent large-scale deployments of autonomous vehicles. Indeed, the most profound labor market effects of new technology that we found were due less to robotics and AI than to the continuing diffusion of decades-old (though much improved) technologies of the internet, mobile and cloud computing, and mobile phones.

This time scale of technological change provides the opportunity to craft policies, develop skills, and foment investments to constructively shape the trajectory of change toward the greatest social and economic benefit.

Part II of this book looks at what will be required to reshape and refocus the institutions and policies of the US to create the shared prosperity that is possible if we are willing to make the necessary changes.

We begin by looking at how workers are trained to make their way in a fast-changing economy. Enabling workers to remain productive in a continuously evolving workplace requires empowering them with excellent skills programs at all stages of life—in primary and secondary schools, in vocational and college programs, and in ongoing adult training programs. The distinctive US system for worker training has shortcomings, but it also has unique virtues. For example, it offers numerous points of entry for workers who may want to reshape their career paths or need to find new work after a layoff. We argue that the US must invest in existing educational and training institutions and innovate to create new training models to make ongoing skills development accessible, engaging, and cost-effective.

But even well-trained and motivated workers need and deserve a sense of basic security. Rising labor productivity has not translated into broad increases in incomes because labor market institutions and policies have fallen into disrepair.

Peer nations from Sweden to Germany to Canada have faced the same economic, technological, and global forces as the US, and have enjoyed equally strong economic growth, but have delivered better results for their workers. What sets the US apart are US-specific institutional changes and policy choices that failed to blunt, and in some cases magnified, the consequences of these pressures on the US labor market.

The US has allowed traditional channels of worker voice to atrophy without fostering new institutions or buttressing existing ones. It has permitted the federal minimum wage to recede to near irrelevance, lowering the floor under the labor market for low-paid workers. It has embraced a policy-driven expansion of free trade with the developing world, Mexico and China in particular, that has raised aggregate national income, and yet it has failed to redress the employment losses and retraining needs of workers displaced by these expansions.

No evidence suggests that this strategy of embracing growth while ignoring the plight of rank-and-file workers has paid off for the United States. US leadership in growth and innovation is long-standing: It led the world throughout the twentieth century, and led even more definitively in the several decades immediately after World War II. Conversely, the labor market maladies documented here are recent. Nothing suggests that these failures inevitably follow from innovation or constitute costs worth paying to gain the other economic benefits that they ostensibly deliver. We can do better.

In the absence of deliberate policy, good jobs are undersupplied by markets and yet have broad social and political benefits, especially in a democracy. Work is a crucial human good. "Not simply a source of income," Task Force Research Advisory Board member Josh Cohen writes in an MIT Work of the Future research brief, "work is a way that we can learn, exercise our powers of perception, imagination, and judgment, collaborate socially, and make constructive social contributions."[1] Even when work is solely a means of acquiring an income, it should offer a sense of purpose and not require submission to demeaning or arbitrary authority, unhealthy or unsafe conditions, or physical or mental degradation.

Recognizing the centrality of good jobs to human welfare and the centrality of innovation to the creation of good jobs leads us to ask how

we can leverage investments in innovation to drive job creation, speed growth, and meet rising competitive challenges.

Investments in innovation grow the economic pie, which is crucial to meeting challenges posed by a globalized and fiercely technologically competitive world economy. Throughout our studies, we found technologies that were direct results of US federal investment in research and development over the past century and longer: the internet, advanced semiconductors, AI, robotics, and autonomous vehicles, to name but a few. These new goods and services generate new industries and occupations that demand new skills and offer new earnings opportunities. The US has a stellar record of supporting innovations that inventors, entrepreneurs, and creative capital deploy to support and create new businesses.

Adopting new technology creates winners and losers and will continue to do so. The involvement of all stakeholders—including workers, businesses, investors, educational and nonprofit organizations, and government—can minimize the harms and maximize the benefits to individuals and communities and help ensure that the labor market of the future offers benefits, opportunity, and a measure of economic security to all.

NOTES

1. Josh Cohen, "Good Jobs," MIT Work of the Future Research Brief, RB11-2020.

CHAPTER 2

1. Institutional factors are also essential in determining what technologies are invented, how they are applied, and how they are distributed. See Angus Deaton, *The Great Escape: Health, Wealth, and the Origins of Inequality* (Princeton, NJ: Princeton University Press, 2013).

2. As Moses Finley remarked in a 1973 discussion of the "peculiar institution" of slavery, "In the context of universal history, free labor, wage labor, is the peculiar institution." Moses I. Finley, *The Ancient Economy* (Berkeley: University of California Press, 1973).

3. By more productive, we mean performing the same work at lower total cost. At present, it is infeasible for humans to be more productive than computers in performing standard mathematical calculations, though this was not the case a century ago. Computers are now more productive at this task not only because they are faster but also because they are cheaper than workers at any reasonable wage. The concern is that this will become true in an expanding fraction of all work tasks.

4. The US employment to population ratio has fallen by several percentage points since the year 2000. A substantial driver of this trend is the aging of the US population, which has increased the fraction of adults who are approaching or in retirement. Of course, citizens in high-income countries work fewer annual hours, take more vacations, and retire earlier (relative to age at death) than a century ago—implying that they choose to spend part of their rising incomes on increased leisure. See Stephanie Aaronson, Tomaz Cajner, Bruce Fallick, Felix Galbis-Reig, Christopher L. Smith, and William Wascher, "Labor Force Participation: Recent Developments

and Future Prospects," *Brookings Papers on Economic Activity* 45, no. 2 (2014): 197–275; and David H. Autor, "Why Are There Still So Many Jobs? The History and Future of Workplace Automation," *Journal of Economic Perspectives* 29, no. 3 (2015): 3–30.

5. Though aggregate employment can certainly fall in the short and intermediate term, with substantial adverse consequences for workers. See, for example, Daron Acemoglu and Pascual Restrepo, "Robots and Jobs: Evidence from U.S. Labor Markets," *Journal of Political Economy* 128, no. 6 (2019): 2188–2244.

6. For theoretical analysis and empirical evidence of these ideas, see Daron Acemoglu and Pascual Restrepo, "The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment," *American Economic Review* 108, no. 6 (2018): 1488–1542; Daron Acemoglu and Pascual Restrepo, "Automation and New Tasks: How Technology Displaces and Reinstates Labor," *Journal of Economic Perspectives* 33, no. 2 (2019): 3–30; and David Autor, Anna Salomons, and Bryan Seegmiller, "New Frontiers: The Origins and Content of New Work, 1940–2018," mimeo, MIT Department of Economics, 2020.

7. To construct this figure, Autor, Salomons, and Seegmiller, in "New Frontiers," use historical data to catalog the introduction of new jobs into the US Census Bureau's occupational coding manuals in each decade between 1940 and 2018.

8. See Daniel P. Gross and Bhaven N. Sampat, "Inventing the Endless Frontier: The Effects of the World War II Research Effort on Post-War Innovation," NBER Working Paper 27375 (Cambridge, MA: National Bureau of Economic Research, 2020); Daniel P. Gross and Bhaven N. Sampat, "Organizing Crisis Innovation: Lessons from World War II," NBER Working Paper 27909 (Cambridge, MA: National Bureau of Economic Research, 2020).

9. See Autor, Salomons, and Seegmiller, "New Frontiers."

10. See Christine Walley, "Robots as Symbol and Social Reality," MIT Work of the Future Research Brief, October 2020.

11. Approximately 60 percent of national income is paid in wages and benefits: Federal Reserve Bank of St. Louis, Economic Research, https://fred.stlouisfed.org/series/LABSHPUSA156NRUG.

12. OAPEC sharply curtailed ("embargoed") oil output in October 1973, ostensibly to punish countries that supported Israel during the 1973 Yom Kippur War. See Daniel Yergin, *The Prize: The Epic Quest for Oil, Money & Power* (New York: Free Press, 2008).

13. The research brief by Task Force member Erik Brynjolfsson along with Seth Benzell and Daniel Rock documents that despite the seeming ubiquity of powerful new technologies with enormous industrial potential, the rate of US productivity growth in recent years has been disappointingly low. US productivity growth averaged 2.8 percent annually between 1995 and 2005, but it has been less than half as rapid since that time. While some have argued that the productivity slowdown is an artifact of measurement, Chad Syverson presents a variety of evidence that mismeasurement is not plausibly large enough to be the main culprit; see Chad Syverson.

"Challenges to Mismeasurement Explanations for the US Productivity Slowdown," *Journal of Economic Perspectives* 31, no. 2 (2017): 165–86. Complementing this conclusion, Brynjolfsson, Benzell, and Rock find that mismeasurement was probably worse *before* the productivity slowdown, meaning mismeasurement only deepens the puzzle; see Erik Brynjolfsson, Seth Benzell, and Daniel Rock, "Understanding and Addressing the Modern Productivity Paradox," MIT Work of the Future Research Brief 13-2020, November 10, 2020.

14. For discussion, see the four articles in "Symposium: The Slowdown in Productivity Growth," *Journal of Economic Perspectives* 4, no. 2 (Fall 1988): 3–97.

15. Reported changes in "real" wage levels should be viewed as approximate; it is not possible to capture all changes in living standards across decades using a single cost of living index. Indeed, the true purchasing power of the median worker has likely risen faster than these numbers suggest, which also means that productivity likely rose faster than depicted here and that real wages stagnated by less. But these caveats do not alter the key points made by figures 2.4 and 2.5: median earnings stagnated relative to productivity growth over the last four decades; earnings of women rose faster than earnings of men; and earnings of whites rose faster than those of Blacks or Hispanics.

16. Edward P. Lazear, "Productivity and Wages: Common Factors and Idiosyncrasies across Countries and Industries," NBER Working Paper 26428 (Cambridge, MA: National Bureau of Economic Research, 2019).

17. See table 2.1 of OECD, "Decoupling of Wages from Productivity: What Implications for Public Policies?," in *OECD Economic Outlook*, vol. 2018, no. 2. The OECD report studies data for the years 1995 through 2013.

18. Wages do not merely reflect productivity, they also determine how productively workers are used. When minimum wages are higher, for example, employers must find ways to make low-paid workers more productive to justify their higher cost. Our argument is not that most wage differentials reflect institutional factors rather than productivity differentials. Rather, we view productivity and wage differentials as a joint outcome of skills investments, technology investments, and institutions. Moreover, skill and technology choices are themselves shaped by institutions and vice versa. For discussion, see Brynjolfsson, Benzell, and Rock, "Understanding and Addressing the Modern Productivity Paradox," and Acemoglu and Restrepo, "The Race between Man and Machine."

19. Florian Hoffmann, David S. Lee, and Thomas Lemieux, "Growing Income Inequality in the United States and Other Advanced Economies," *Journal of Economic Perspectives* 34, no. 4 (2020): 52–78.

20. Marcus Stanley, "College Education and the Midcentury GI Bills," *Quarterly Journal of Economics* 118, no. 2 (2003): 671–708.

21. David Autor, Claudia Goldin, and Lawrence F. Katz, "Extending the Race between Education and Technology," *AEA Papers and Proceedings* 110 (2020): 347–351.

22. In 1979, 60 percent of US males at the median of the wage distribution possessed a high school or lower education, whereas only 20 percent had a bachelor's degree or above. By 2018, fully 35 percent of males at the median of the earnings distribution had attained a four-year college degree—a 75 percent increase—and only one-third had high school or less education. The gain among the median working women was even larger: the four-year degree attainment rate tripled from 13 percent to 45 percent, while the fraction with high school or below dropped from 68 percent to 22 percent. Statistics refer to workers at the forty-fifth to fifty-fifth percentile of the gender-specific hourly wage distribution in the respective year. They are from table 5 of Sarah A. Donovan and David H. Bradley, "Real Wage Trends, 1979 to 2018" (Washington, DC: Congressional Research Service, 2019), 35.

23. See Facundo Alvaredo, Lucas Chancel, Thomas Piketty, Emmanuel Saez, and Gabriel Zucman, eds., *World Inequality Report 2018* (Cambridge, MA: Belknap Press of Harvard University Press, 2018).

24. Brynjolfsson, Benzell, and Rock, "Understanding and Addressing the Modern Productivity Paradox"; Thomas Piketty, Emmanuel Saez, and Stefanie Stantcheva, "Optimal Taxation of Top Labor Incomes: A Tale of Three Elasticities," *American Economic Journal: Economic Policy* 6, no. 1 (2014): 230–271; Josh Bivens and Lawrence Mishel, "The Pay of Corporate Executives and Financial Professionals as Evidence of Rents in Top 1 Percent Incomes," *Journal of Economic Perspectives* 27, no. 3 (2013): 57–78.

25. See Alvaredo et al., *World Inequality Report 2018*. Anglophone countries include Australia, Canada, Ireland, the UK, and the US. Western European countries include France, Germany, Italy, and Spain. Northern European countries include Denmark, Finland, the Netherlands, Norway, and Sweden. The top 1 percent share does not exceed 15 percent in any of these countries and is generally much lower (below 10 percent in Northern Europe). In no other country did it rise by nine percentage points, though the UK comes close to that level.

26. "American Inequality Reflects Gross Incomes as Much as Taxes," *Economist*, April 13, 2019.

27. To be clear, this decline is not due solely to digitalization, as international trade added substantially to the displacement of middle-skilled production and operative jobs during the 2000s. See David H. Autor, David Dorn, and Gordon H. Hanson, "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade," *Annual Review of Economics* 8, no. 1 (2016): 205–240.

28. See our discussion of autonomous vehicles in chapter 3 and John Leonard, David Mindell, and Erik Stayton, "Autonomous Vehicles, Mobility, and Employment Policy: The Roads Ahead," MIT Work of the Future Research Brief, July 22, 2020, https://workofthefuture.mit.edu/research-post/autonomous-vehicles-mobility-and-employment-policy-the-roads-ahead.

29. US Bureau of Labor Statistics, Employment Projections, table 1.4: Occupations with the Most Job Growth, 2019 and Projected 2029, https://www.bls.gov/emp/tables/occupations-most-job-growth.htm.

30. The next four occupations on this list are also illustrative: office clerk; executive secretary and executive assistant; inspector, tester, sorter, sampler, and weigher; and bookkeeping, accounting, and auditing clerks.

31. While these projections should be understood as educated guesses, the Bureau of Labor Statistics has a good track record of projecting employment trends at the level of broad occupations. See Andrew Alpert and Jill Auyer, "Evaluating the BLS 1988–2000 Employment Projections," *Monthly Labor Review* (October 2003): 13–37.

32. Because of the nation's aging population, employment in health care occupations is predicted to grow by 18 percent from 2016 to 2026—more than seven times more rapidly than overall employment—and to add 2.4 million jobs. Mercedes Delgado and Karen G. Mills, "The Supply Chain Economy: A New Industry Categorization for Understanding Innovation in Services," *Research Policy* 49, no. 8 (October 2020).

33. Ari Bronsoler, Joseph Doyle, and John Van Reenen, "The Impact of New Technology on the Healthcare Workforce: A White Paper," MIT Work of the Future Research Brief, October 2020.

34. "Measuring and Assessing Job Quality: The OECD Job Quality Framework," In *OECD Social, Employment and Migration Working Papers*, vol. 174, December 18, 2015.

35. For purposes of this comparison, the OECD defines low-skilled workers as those with less than a high school diploma. Performing the same comparison for medium-skilled workers, which the OECD defines as having completed secondary education (i.e., high school), the US ranks tenth among twenty-one countries, where countries eleven through fourteen are the UK, Japan, Finland, and Canada, and countries six through nine are Korea, the Czech Republic, Portugal, and Ireland (https://stats.oecd.org/Index.aspx?QueryId=82334).

36. Jérôme Gautié and John Schmitt, *Low Wage Work in Wealthy Countries* (New York: Russell Sage Foundation, 2009), https://www.russellsage.org/publications/low-wage-work-wealthy-world.

37. Nicholas Kristof, "McDonald's Workers in Denmark Pity Us," *New York Times*, May 8, 2020.

38. In light of the COVID-19 pandemic now sweeping the globe, it bears note that every Dane also has health care and paid sick leave, though these benefits are publicly provided rather than employer-provided, as is typical in the United States.

39. In 2015, only one in six white non-college-educated adults lived in the densest quartile of urban CZs [commuter zones] versus one in four non-college-educated Hispanics and nearly one in three (29 percent) non-college-educated Blacks. In short, many minority workers are situated in the declining urban middle of the US labor market. On a more positive note, Black and Hispanic college graduates are also overrepresented in the densest quartile of urban labor markets. These shares are 34 percent of Hispanic college-degreed workers and 35 percent of Black college-degreed workers versus 26 percent of white college-degreed workers.

40. More encouragingly, among most subgroups of college graduates, polarization was reflected in a rise in employment in both high- and low-paying occupations. An exception to this generalization is the experience of Black male college graduates, however. Their employment share in medium-paying occupations fell by seven percentage points and their share in low-paying occupations rose by almost five percentage points. Thus, despite high levels of educational attainment, they exhibited downward occupational mobility in urban relative to nonurban labor markets. This stark finding is consistent with that of Ellora Derenoncourt , who shows that upward mobility deteriorated among urban Black residents following the Great Migration, and with that of Chetty and co-workers, who document the exceptionally poor labor market outcomes of Black men raised in poor urban US neighborhoods. See Ellora Derenoncourt, "Can You Move to Opportunity? Evidence from the Great Migration," Princeton University Working Paper, December 2019; and Raj Chetty, Nathaniel Hendren, Maggie R. Jones, and Sonya R. Porter. "Race and Economic Opportunity in the United States: An Intergenerational Perspective," *Quarterly Journal of Economics* 135, no. 2 (2020): 711–783.

41. We note that figure 2.9 reports changes in urban relative to nonurban wages by demographic group. The steep decline in the non-college-degreed wage premium could reflect a fall in urban wages among non-college-degreed workers, a rise in nonurban wages among non-college-degreed workers, or a combination of the two.

42. Loukas Karabarbounis and Brent Neiman, "The Global Decline of the Labor Share," *Quarterly Journal of Economics* 129, no. 1 (2014): 61–103.

43. For discussion, see Charles I. Jones and Paul M. Romer, "The New Kaldor Facts: Ideas, Institutions, Population, and Human Capital," *American Economic Journal: Macroeconomics* 2, no. 1 (January 2010): 224–245.

44. This argument is made most forcefully in Thomas Philippon, *The Great Reversal: How America Gave Up on Free Markets* (Cambridge, MA: Belknap Press of Harvard University Press, 2019).

45. For evidence on the relationship between rising market power and the declining labor share, see Jan De Loecker, Jan Eeckhout, and Gabriel Unger, "The Rise of Market Power and the Macroeconomic Implications," *Quarterly Journal of Economics* 135, no. 2 (January 23, 2020): 561–644.

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47. See Michael W. L. Elsby, Bart Hobijn, and Ayşegül Şahin, "The Decline of the U.S. Labor Share," *Brookings Papers on Economic Activity* 2013, no. 2 (2013): 1–63.; David Autor and Anna Salomons, "Is Automation Labor Share-Displacing? Productivity Growth, Employment, and the Labor Share," *Brookings Papers on Economic Activity* 2018, no. 1 (2018): 1–87; and Acemogluand Restrepo, "Robots and Jobs."

48. Daron Acemoglu, Claire LeLarge, and Pascual Restrepo, "Competing with Robots: Firm-Level Evidence from France," NBER Working Paper 26738 (Cambridge, MA: National Bureau of Economic Research, February 2020).

49. This finding is reported in two recent papers: David Autor, David Dorn, Lawrence F. Katz, Christina Patterson, and John Van Reenen, "The Fall of the Labor Share and the Rise of Superstar Firms," *Quarterly Journal of Economics* 135, no. 2 (May 1, 2020): 645–709; and Matthias Kehrig and Nicolas Vincent, "The Micro-Level Anatomy of the Labor Share Decline," NBER Working Paper 25275 (Cambridge, MA: National Bureau of Economic Research, rev. October 2020).

50. Abhijit V Banerjee and Esther Duflo, "Inequality and Growth: What Can the Data Say?," *Journal of Economic Growth* 8, no. 3 (2003): 267–299.

51. Raj Chetty, David Grusky, Maximilian Hell, Nathaniel Hendren, Robert Manduca, and Jimmy Narang, "The Fading American Dream: Trends in Absolute Income Mobility Since 1940," *Science* 356, no. 6336 (2017): 398–406.

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53. Lawrence F. Katz and Alan B. Krueger, "Documenting Decline in U.S. Economic Mobility," *Science* 356, no. 6336 (2017): 382–383, https://doi.org/10.1126/science.aan3264.

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55. Brynjolfsson, Benzell, and Rock, "Understanding and Addressing the Modern Productivity Paradox."

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CHAPTER 3

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CHAPTER 4

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8. As explained in Jepsen, Troske, and Coomes, "The Labor-Market Returns," "Community colleges are diverse institutions that offer several opportunities for individuals to gain human capital. Community colleges offer a variety of each of the three types of awards: degrees, diplomas, and certificates. Certificates are primarily awarded in technical programs and typically require one or two semesters of course work. Examples include medical records coding specialist, IT network administrator, automotive mechanic, and electrician. Diplomas typically require more than a year of study and are also most common in technical fields, such as surgery technology, accounting, and practical nursing. Associate's degrees require the most number of credits, 60–76, depending on the field of study. The curricula for associate's degree programs have much in common with those of the first 2 years of a 4-year college, including liberal arts and general education courses as well as those geared to specific vocations, such as registered nursing. Associate's degree credits generally are transferrable to a 4-year college toward a bachelor's degree."

9. Stevens, Kurlaender, and Grosz, "Career Technical Education and Labor Market Outcomes."

10. This next section draws heavily from Lawrence F. Katz, Jonathan Roth, Richard Hendra, and Kelsey Schaberg, "Why Do Sectoral Employment Programs Work? Lessons from WorkAdvance," NBER Working Paper 28248 (Cambridge, MA: National Bureau of Economic Research, December 2020).

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12. See Paul Osterman, "Skill Training for Adults," MIT Work of the Future Research Brief, 2020

13. See Thomas J. Kane and Cecilia E. Rouse, "Labor-Market Returns to Two- and Four-Year College: Is a Credit a Credit and Do Degrees Matter?," *American Economic Review* 85, no. 3 (1995): 600–614; and Christopher Jepsen, Kenneth Troske, and Paul Coomes. "The Labor-Market Returns to Community College Degrees, Diplomas, and Certificates," *Journal of Labor Economics* 32, no. 1 (January 1, 2014): 95–121.

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17. Osterman, "Skill Training for Adults."

18. Katz, Roth, Hendra, and Schaberg, "Why Do Sectoral Employment Programs Work?"

19. See Marianne Bertrand, Magne Mogstad, and Jack Mountjoy, "Improving Educational Pathways to Social Mobility: Evidence from Norway's 'Reform 94'" (*Journal of Labor Economics*, forthcoming), for a discussion about high school vocational education: it has a controversial history in the United States, largely because of a perceived trade-off between teaching readily deployable occupational skills versus shunting mostly disadvantaged students away from the educational and career flexibility afforded by general academic courses.

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21. Robert Lerman, "Scaling Apprenticeships to Increase Human Capital," in *Expanding Economic Opportunity for More Americans*, ed. Melissa Kearney and Amy Ganz (Washington, DC: Aspen Institute, February, 2019), 56–75.

22. Kathleen Thelen and Christian Lyhne Ibsen, "Growing Apart: Efficiency and Equality in the German and Danish VET Systems," MIT Work of the Future Research Brief, October 2020.

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35. Alistair Fitzpayne and Ethan Pollack, "Lifelong Learning and Training Accounts: Helping Workers Adapt and Succeed in a Changing Economy" (New York: Aspen Institute Future of Work Initiative, May 2018), 1–12.

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CHAPTER 5

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4. Chris O'Leary and Stephen A. Wandner, "An Illustrated Case for Unemployment Insurance Reform," Upjohn Institute Working Paper 19-317, 2020.

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12. See US Bureau of Statistics, "Home Health and Personal Care Aides" and "Nursing Assistants and Orderlies" in *Occupational Outlook Handbook*, https://www.bls.gov/ooh/healthcare/home-health-aides-and-personal-care-aides.htm and https://www.bls.gov/ooh/healthcare/nursing-assistants.htm.

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CHAPTER 6

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