Can We Predict the Jobs & Skills Needed for the AI Era?

By Adam Thierer

New technological capabilities will give society new business models, new professions, and new roles—but likely many that experts are not likely able to currently envision or plan for today.

Executive Summary

In an effort to better plan for the economy of the future, many academics and policymakers regularly attempt to forecast the jobs and worker skills that will be needed going forward. Driving these efforts are fears about how technological automation might disrupt workers, skills, professions, firms and entire industrial sectors. The continued growth of artificial intelligence, robotics, and other computational technologies exacerbate these anxieties.

Yet, the limits of both our collective knowledge and our individual imaginations constrain well-intentioned efforts to plan for the workforce of the future. Past attempts to assist workers or industries have often failed for various reasons. However, dystopian predictions about mass technological unemployment persist, as do retraining or reskilling programs that typically fail to produce much of value for workers or society. As public efforts to assist or train workers move from general to more specific, the potential for policy missteps grows greater. While transitional support mechanisms can help alleviate some of the pain associated with fast-moving technological disruption, the most important thing policymakers can do is clear away barriers to economic dynamism and new opportunities for workers.

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Introduction: The Endless Automation Panic

It is the sort of panicky headline that is all too common these days: "Automation's Really Here; Jobs Go Scarce—POINT OF NO RETURN FOR EVERYBODY."[1] In this case, however, the headline appeared six decades ago on a 1963 cover of *LIFE* magazine (Figure 1). Two years prior, *Time* magazine published a 1961 report on "The Automation Jobless," which noted that job experts of the time were worried that "automation may prevent the economy from creating enough new jobs" and that "the hard core of permanently unemployed will continue to rise."[2]

Fears about how machines might displace our jobs, skills, and livelihoods (aka, "technological unemployment") are timeless.[3] By its very nature, technological change always disrupts the economic and social status quo, which is why innovation has created many opponents throughout history.[4]

The expanding "computational revolution" of modern times is intensifying those concerns.[5] Artificial intelligence, robotics, and other automated systems are giving rise to various anxieties—some old, some new. That AI and robotics will upend some jobs, skills and industries is a given. But which ones, and in what measure are questions that remain unanswered. The result of these questions has been continuous crystal ball-gazing exercises by academics and policymakers who look to predict the jobs or skills that will be needed as technological systems grow ever more advanced.

There has been a flood of articles, books and hearings related to these concerns in recent years. It is understandable that many experts engage in prophesying about the jobs and worker needs of the future. After all, it is better that people think about how to plan sensibly for the future instead of trying to stop it altogether. On the other hand, the limits of our knowledge regarding the future will often foil many of our best-laid plans. For instance, many agree on the need for "upskilling" the American workforce and preparing workers for the future, but there is far less agreement on how to accomplish that. Beyond some obvious broad-based educational strategies and labor market reforms, we should understand that a degree of learning-by-doing will become the most common individual and organizational response to our uncertain technological future. Clearing away barriers to economic dynamism and worker mobility will make that transition easier and should be the nation's top policy priority.

We Often Lack a Vocabulary to Describe Future Jobs

From past efforts to forecast the jobs or skills of the future, we can learn that market forecasters are typically inaccurate. To borrow the famous adage: "It's tough to make predictions, especially about the future."[6]

Figure 1: LIFE Magazine July 19, 2023
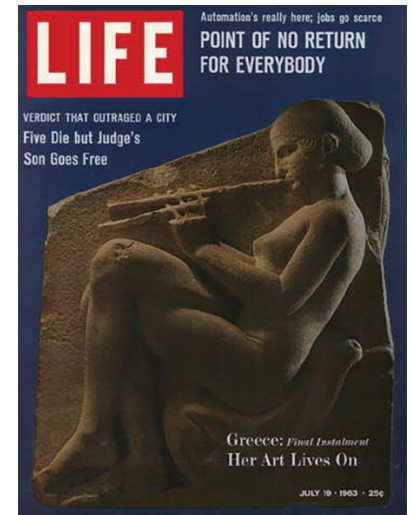
Source: "LIFE Magazine July 19, 1963," Original Life Magazines, last accessed Jan. 19, 2023. https://www.originallifemagazines.com/product/life-magazine-july-19-1963.

1. "LIFE Magazine July 19, 1963," Original Life Magazines, last accessed Jan. 19, 2023. https://www.originallifemagazines.com/product/life-magazine-july-19-1963.
2. "The Automation Jobless," *Time*, Feb. 24, 1961. https://content.time.com/time/subscriber/article/0,33009,828815,00.html.
3. Joel Mokyr, Chris Vickers, and Nicolas L. Ziebarth, "The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?" *Journal of Economic Perspectives*, 29: 3 (Summer 2015), pp. 31–50. https://www.aeaweb.org/articles?id=10.1257/jep.29.3.31.
4. Calestous Juma, *Innovation and Its Enemies: Why People Resist New Technologies* (Oxford University Press, 2016).
5. Adam Thierer, "AI Eats the World: Preparing for the Computational Revolution and the Policy Debates Ahead," *Medium*, Sept. 10, 2022. https://medium.com/@AdamThierer/ai-eats-the-world-preparing-for-the-computational-revolution-and-the-policy-debates-ahead-d608cdaba87.
6. "It's Difficult to Make Predictions, Especially About the Future," Quote Investigator, last accessed Jan. 19, 2023. https://quoteinvestigator.com/2013/10/20/no-predict.

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An examination of past Bureau of Labor Statistics (BLS) reports from the *Monthly Labor Review*, a journal BLS has published for over a century, offers some important lessons for ongoing efforts to predict the future of labor markets. Some BLS articles document just how wrong past predictions were.

In one such article from 1981, the Assistant Commissioner for Economic Growth and Employment Projections for BLS, discussed various BLS projection errors from the 1970s and explained how,

> differing assumptions can change the results, that underlying data and methods can cause errors, and that estimates should be carefully reviewed to take into account subsequent developments which could not be anticipated at the time the projections were prepared.[7]

The commissioner concluded with a humorous observation drawn from a 1977 article, stating: "[g]ive them a number or give them a date, but never both."[8] While humorous, this serves as a reminder of how economic forecasting often has more in common with sorcery than with science.

The reality of unstable economic forecasting is important to keep in mind when we turn to questions about potential labor market disruptions associated with modern technological change, especially fears surrounding AI and robotics. The challenge is even more formidable than BLS reports suggest because, beyond their inability to offer an accurate combination of numbers and dates, forecasters often do not possess the proper vocabulary with which to describe the jobs or workforce needs of a fast-moving future.

A 2020 report by a MIT blue ribbon commission on *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines* found that, "In 2018, 63% of jobs in new occupational titles had not yet been 'invented' as of 1940."[9] Importantly, "[m]any of these new jobs are directly enabled by technology," the report noted, and most of those new job descriptions would been hard to comprehend just a few generations ago.[10]

Consider what modern job boards teaches us about the ability of experts to predict the technological future. Glassdoor regularly publishes a list of best jobs in America, based on a mix of job openings, high work satisfaction and earning potential. What is most interesting about their list is how most of them would not have made any sense to economists or policymakers even a few decades ago. For example, Table 1 shows Glassdoor's 2022 best jobs list includes job titles such as: Full Stack Engineer, Dev Ops Engineer, Machine Learning Engineer, Software Engineer, and Java Developer.[11]

Returning to the old BLS reports from the 1970s and 1980s, one finds no mention of any jobs even remotely resembling those seen in Table 1. Unsurprisingly, reading through the BLS's mammoth 1969 report on "Tomorrow's Manpower Needs," there is also no mention of anything of the sectors or jobs that would eventually give us the

Table 1: Glassdoor's 10 Best Jobs in America for 2022

Rank	Job Title	Median Salary
#1	Enterprise Architect	$144,997
#2	Full Stack Engineer	$101,794
#3	Data Scientist	$120,000
#4	Devops Engineer	$120,095
#5	Strategy Manager	$140,000
#6	Machine Learning Engineer	$130,489
#7	Data Engineer	$113,960
#8	Software Engineer	$116,638
#9	Java Developer	$107,099
#10	Product Manager	$125,317

Source: "50 Best Jobs in America for 2022," Glassdoor, last accessed Jan. 19, 2023. https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm.

7.   Ronald E. Kutscher, "New Economic Projections Through 1990—An Overview," *Monthly Labor Review* (August 1981), p. 16. https://www.bls.gov/opub/mlr/1981/08/art2full.pdf.

8.   Edgar R. Fiedler, "The Three R's of Economic Forecasting—Irrational, Irrelevant, and Irreverent," *Across the Board* (June 1977), pp. 62-3.

9.   David Autor et al., *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines*, Nov. 17, 2020, p. 11. https://workofthefuture.mit.edu/research-post/the-work-of-the-future-building-better-jobs-in-an-age-of-intelligent-machines.

10. Ibid.

11. Glassdoor, "50 Best Jobs in America for 2022," last accessed Nov. 21, 2022. https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm.

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Digital Revolution.[12] While some government reports and academic papers from the early 1980s contain passing mention of the need for "computer skills," they often did so without offering much detail about what specific skills might be needed.

That is understandable because the analysts and forecasters of those eras did not possess an adequate mental frame to understand the nature of the skills or jobs that would be important in the future. Glassdoor's job titles would mean nothing to a labor market analyst or economist in 1980 attempting to forecast the future. They might have thought that a Full Stack Engineer was just a fancy name for a train conductor or factory engineer. Therefore, it should not be surprising that any predictions made today about the jobs or skills of the future will be off the mark when the future rolls around.
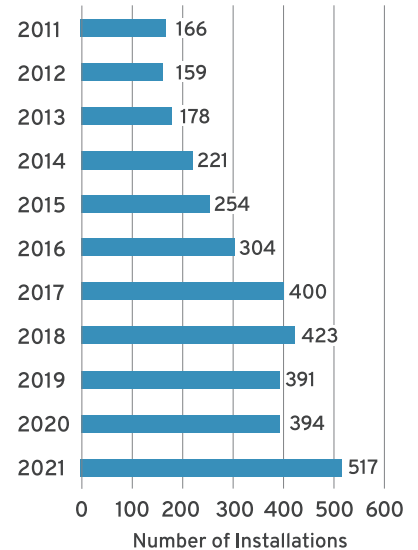
Why Isn't Everyone Already Unemployed?

Unfortunately, these realities have not slowed the steady stream of ominous media headlines and book titles like *Humans Need Not Apply* and *Rise of the Robots*, which suggest a lot of technologically induced unemployment is likely on the way.[13] Pundits and policymakers have responded by proposing extreme solutions like "robot taxes" and a new Federal Automation and Worker Protection Agency, which former New York City mayor Bill de Blasio floated to "oversee automation and safeguard jobs and communities" through a permitting process for any company seeking to increase automation that would displace workers.[14]

An MIT economist asks: "should we not be somewhat surprised that technological change hasn't already wiped out employment for the vast majority of workers?"[15] After all, many companies and sectors have been automating at an astonishing pace over the past decade. According to the International Federation of Robotics *World Robotics* 2022 report (Figure 2) worldwide installations of industrial robots grew by 31 percent in 2021 and they have doubled since 2015.[16]

However, there has been no obvious correlation between robotics and unemployment.[17] Instead, the use of robots in many firms and sectors has been accompanied by significant job *increases*. Amazon recently published a 10-year review of its use of robotics throughout its business operations.[18] The company's report notes that "speculation was rampant that Amazon was replacing people with robots […] but] We have more than 520,000 robotic drive units, and have added over a million jobs, worldwide."[19]

Figure 2: Annual Installations of Industrial Robots (1,000 Units)

Year	Installations
2011	166
2012	159
2013	178
2014	221
2015	254
2016	304
2017	400
2018	423
2019	391
2020	394
2021	517

Number of Installations

Source: World Robotics 2022

12. Bureau of Labor Statistics, "Tomorrow's Manpower Needs: National Manpower Projections and a Guide to Their Use as a Tool in Developing State and Area Manpower Projections," Bulletin of the United States Bureau of Labor Statistics, No. 1606 (1969).

13. Jerry Kaplan, *Humans Need Not Apply: A Guide to Wealth and Work in the Age of Artificial Intelligence* (New Yale University Press, 2015); Martin Ford, *Rise of the Robots: Technology and the Threat of a Jobless Future* (Basic Books, 2015).

14. Bill de Blasio, "Why American Workers Need to Be Protected from Automation," *Wired*, Sept. 5, 2019. https://www.wired.com/story/why-american-workers-need-to-be-protected-from-automation; Adam Thierer, "The Worst Regulation Ever Proposed," *AEIR*, Sept. 8, 2019. https://www.aier.org/article/the-worst-regulation-ever-proposed.

15. David H. Autor, "Why Are There Still So Many Jobs? *The History and Future of Workplace Automation*," Journal of Economic Perspectives 29: 3 (Summer 2015), p. 6. https://www.aeaweb.org/articles?id=10.1257/jep.29.3.3.

16. "World Robotics 2022," International Federation of Robotics, October 2022. https://ifr.org/downloads/press2018/2022_WR_extended_version.pdf.

17. Autor, p. 6. https://www.aeaweb.org/articles?id=10.1257/jep.29.3.3.

18. "10 Years of Amazon Robotics: How Robots Help Sort Packages, Move Product, and Improve Safety," Amazon, June 21, 2022, https://www.aboutamazon.com/news/operations/10-years-of-amazon-robotics-how-robots-help-sort-packages-move-product-and-improve-safety.

19. Ibid.

The same pattern holds for many other firms and sectors that have adopted more automation technologies.[20] "Technological change is simultaneously replacing existing work and creating new work. It is not eliminating work altogether," concluded the MIT *Work of the Future* report.[21] This finding should not be surprising because, as the report also noted, "[n]o compelling historical or contemporary evidence suggests that technological advances are driving us toward a jobless future," rather, the report concluded, "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."[22] The most recent large survey of the use of automation technologies found ambiguous effect on aggregate employment but a clearer influence in terms of raising skill requirements.[23] The authors note this result is "in line with the theory, which suggests that the use of advanced technologies involves a reassignment of labor from automated tasks to other complementary roles."[24] And such roles could include the "maintenance, programming, and operation of specialized machinery."[25]

Unfortunately, many forecasts and media reports continue to ignore these insights and place greater weight on worst-case scenarios. Even recent BLS predictions have continued to be off the mark and overly pessimistic in this regard. In 2015, BLS published its job projections for the decade between 2014-2024.[26] Two of the five sectors in which the agency forecasted major job losses were the information sector (27,000 predicted losses) and manufacturing (814,000 predicted losses).[27] Many pundits took those forecasted job losses as an article of faith. "Even though technology is revolutionizing many businesses," one Brookings Institution analyst argued, "it is doing so by transforming operations, not by increasing the number of jobs."[28]

Yet, contrary to these recent BLS forecasts and the gloomy predictions of many pundits, both the information and manufacturing sectors were adding jobs over the past decade as automation technologies expanded. Between 2011 and 2021, the information sector added 158,000 jobs while the manufacturing sector added 620,000 jobs.[29] These job totals might have been much higher if not for the COVID lockdowns and the challenges many employers are having finding workers to fill positions. The increased use of automation technologies by many firms both here and abroad often has more to do with a shrinking workforce brought on by various contributing factors, including population declines, changing demographics, and new work patterns.[30] The COVID lockdowns also led more workers to explore alternative

Gloomy Predictions Proven Wrong

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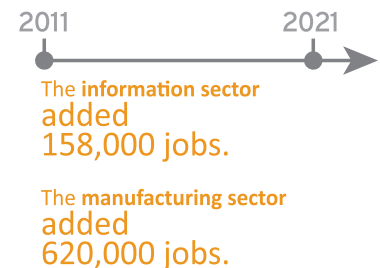
20. Sarah Chaney Cambon and Gwynn Guilford, "Laid Off Tech Workers Quickly Find New Jobs," *Wall Street Journal*, Dec. 27, 2022. https://www.wsj.com/articles/laid-off-tech-workers-quickly-find-new-jobs-11672097730.
21. Autor et al., p. 4. https://workofthefuture.mit.edu/research-post/the-work-of-the-future-building-better-jobs-in-an-age-of-intelligent-machines.
22. Ibid.
23. Daron Acemoglu et al., "Automation and the Workforce: A Firm-Level View from the 2019 Annual Business Survey," NBER *Working Paper* (Feb. 2022). https://www.nber.org/papers/w30659.
24. Ibid., p. 30.
25. Ibid., p. 30.
26. Bureau of Labor Statistics, "Employment Projections—2014-24," *News Release*, USDL-15-2327, Dec. 8, 2015, USDL-15-2327. https://www.bls.gov/news.release/archives/ecopro_12082015.pdf.
27. Ibid.
28. Darrell M. West, *The Future of Work: Robots, AI, and Automation* (Brookings Institution Press: 2018), pp. 69-70.
29. Bureau of Labor Statistics, "Employment by Major Industry Sector," last accessed Oct. 24, 2022, https://www.bls.gov/emp/tables/employment-by-major-industry-sector.htm.
30. Craig Webster, "Demography as a Driver of Robonomics," *Robonomics: The Journal of the Automated Economy* 1 (2021). https://journal.robonomics.science/index.php/rj/article/view/12.

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employment options and more remote work.[31] Meanwhile, across the entire economy, manufacturing employment has risen in 11 of the last 12 years.[32]

An additional element for consideration is the ongoing productivity slowdown. The economic expansion between 2007-2020 was one of the longest in history, but this period also saw the slowest productivity growth of any expansion. Thus, for whatever reason, not only are robots not taking our jobs, but they are also not doing so when we might most expect it and perhaps even need it.

The result of these and other social and economic factors has meant that many firms simply cannot find enough workers fast enough to fill their needs, even as they invest more in automation technologies.[33] For example, retailing giant Walmart has been ramping up its AI and robotic capabilities recently while simultaneously offering generous inducements to attract human workers for traditional jobs.[34] In 2022, the retailing giant created a program to attract and train new store managers with a promised starting wage of at least $65,000 a year.[35] Many current store managers already make more than $200,000 a year, according to the firm. Walmart is also offering truck drivers between $95,000 and $110,000 in their first year in an effort to meet a massive shortfall of long-haul drivers nationwide.[36] Many other firms of all sizes have been offering workers better salaries and other inducements to attract or retain them.[37] Finally, in late 2022, with concerns about the low labor participation rate becoming more of a political issue, the Biden Administration proposed new policy steps to encourage more workers to take unfilled jobs.[38]

Mistaken Recent Predictions about AI and Automation

These unexpected market dynamics help explain why even the best forecasters can be off the mark with predictions about automation and employment. In the 2015, experts published a report predicting that as many as 45 percent of jobs (representing about $2 trillion in annual wages) "can be automated by adapting currently demonstrated technologies."[39] That ominous forecast received plenty of media attention, with headlines lamenting that, "Robots May Shatter the Global Economic Order within a Decade."[40] Just two years later, however, those same analysts revised their models and found that, "[g]iven currently demonstrated technologies, very few occupations—less

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31. Eli Lehrer, "On Working from Home," *National Affairs* (Summer 2022). https://www.nationalaffairs.com/publications/detail/on-working-from-home.

32. Ed Gresser, "U.S. Manufacturing Has Risen in 11 of the Last 12 Years," PPI'S Trade Fact of the Week, Dec. 7, 2022. https://www.progressivepolicy.org/blogs/ppis-trade-fact-of-the-week-u-s-manufacturing-employment-has-risen-in-11-of-the-last-12-years.

33. Christopher Mims, "Meet the Army of Robots Coming to Fill in for Scarce Workers," *Wall Street Journal*, Oct. 15, 2022. https://www.wsj.com/articles/meet-the-army-of-robots-coming-to-fill-in-for-scarce-workers-11665806451.

34. Russell Redman, "Walmart to Automate All Regional Distribution Centers," Supermarket News, May 23, 2022. https://www.supermarketnews.com/retail-financial/walmart-automate-all-regional-distribution-centers.

35. Sarah Nassauer, "Walmart Anticipates a Store Manager Shortage Despite $200,000-a-Year Pay," *Wall Street Journal*, May 15, 2022. https://www.wsj.com/articles/walmart-cant-find-enough-store-managers-even-at-200-000-a-year-11652619602.

36. Melissa Repko, "Walmart Says It Is Raising Truckers' Pay and Starting a Training Program as It Grapples with a Driver Shortage," CNBC, Apr. 7, 2022. https://www.cnbc.com/2022/04/07/walmart-says-it-is-raising-pay-for-truck-drivers-starting-training-program.html.

37. Gabriel T. Rubin and Sarah Chaney Cambon, "Stay for Pay? Companies Offer Big Raises to Retain Workers," *Wall Street Journal*, Jan. 2, 2023. https://www.wsj.com/articles/stay-for-pay-companies-offer-big-raises-to-retain-workers-11672607138.

38. Annie Linskey, "White House Looks at Benefits to Lure Americans Back into Workforce," *Wall Street Journal*, Dec. 20, 2022. https://www.wsj.com/articles/white-house-looks-at-increasing-benefits-to-lure-americans-back-into-workforce-11671574992.

39. Michael Chui et al., "Four Fundamentals of Workplace Automation, McKinsey Digital, Nov. 1, 2015. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/four-fundamentals-of-workplace-automation.

40. Ambrose Evans Pritchard, "Robots May Shatter the Global Economic Order within a Decade," *The Telegraph*, Nov. 5, 2015. https://www.telegraph.co.uk/finance/economics/11978542/Robots-may-shatter-the-global-economic-order-within-a-decade.html.

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than 5 percent—are candidates for full automation."[41] It's easy to get a case of whiplash from watching such rapid reversals of job loss estimates, but the analysts deserve credit for at least revising their projections to take other factors into account.

Other predictions of pending automation-induced job dislocations continued to be cited regularly despite clearly being quite wrong. In 2013, researchers at the University of Oxford published a widely discussed study the surveyed hundreds of occupations and considered how likely it was they would be automated in coming decades due to computerization.[42] They analyzed 702 professions and estimated that 47 percent of U.S. jobs were at high risk of automation.

However, nine years later, those dour predictions have not come to pass. The president of the Information Technology and Innovation Foundation, argues that, in some ways, the opposite of what the Oxford publication predicted came true. Since 2013, the U.S. economy has added 16 million jobs and the unemployment rate was falling. Meanwhile, the profession that the Oxford report said faced the highest risk of technological disruption—insurance underwriters—instead saw employment grow 16.4 percent since 2013 while the occupation they said would be the least likely to be automated—recreational therapist—saw a decline of 8.9 percent. In reality, overall

> there was a negative correlation between the risk of job loss from computerization and actual job loss [...] but it was quite modest at 0.26. In other words, occupations with higher computerization risk scores were only slightly more likely to see job loss.[43]

Despite this, the tendency to forecast technological doomsday scenarios remains the dominant narrative in government and media even when they know what the historical data says. For example, in 2016, the Obama administration released a report titled *Preparing for the Future of Artificial Intelligence*, which included the admonition that, "[t]he track record of technology forecasts, in general, and AI forecasts, in particular," makes it very difficult to accurately predict the direction and velocity of AI-driven change.[44] The administration specifically referenced a 2012 report from a government contracting firm. This report evaluated over 1,000 science and technology forecasts from academia, industry, government, and other sources.[45] The meta-survey found an average success rate of just 33 percent, with short-term forecasts (35 percent) faring only slightly better than long-term predictions (27 percent).[46] Ironically, the roughly 200 forecasts for computer technology or robotics technology had among the highest success rates, yet neither group topped 40 percent.

Drawing on these findings, the Obama administration concluded that, "forecasts with time horizons beyond 10 years were rarely better than coin-flips."[47] Just two months

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41. James Manyika et al., "Harnessing Automation for a Future That Works," McKinsey Global Institute, Jan. 12, 2017. https://www.mckinsey.com/featured-insights/digital-disruption/harnessing-automation-for-a-future-that-works.

42. Carl Benedikt Frey and Michael Osborne, "The Future of Employment: How Susceptible are Jobs to Computerisation?" Oxford Martin Center, Sept. 1, 2013. https://www.oxfordmartin.ox.ac.uk/publications/the-future-of-employment.

43. Robert D. Atkinson, "Nine Years on, Predicted AI Job Loss Hasn't Happened," *Industry Week*, Oct. 3, 2022. https://www.industryweek.com/talent/labor-employment-policy/article/21252036/nine-years-on-predicted-ai-job-loss-hasnt-happened.

44. Obama Administration, *Preparing for the Future of Artificial Intelligence*, Oct. 2016, p. 23. https://obamawhitehouse.archives.gov/blog/2016/05/03/preparing-future-artificial-intelligence.

45. Carrie Mullins, "Retrospective Analysis of Technology Forecasting: In-Scope Extension," Tauri Group, Aug. 18, 2012, p. 17. https://apps.dtic.mil/sti/citations/ADA568107.

46. Ibid.

47. Obama Administration, *Preparing for the Future of Artificial Intelligence*. https://obamawhitehouse.archives.gov/blog/2016/05/03/preparing-future-artificial-intelligence.

later, however, the Obama administration published a second major report on *Artificial Intelligence, Automation, and the Economy*, and used the Oxford report's pessimistic forecasts as the basis of its analysis and recommendations.[48] This reflects the persistent tendency of policymakers to stress worst-case forecasts over real-world evidence.

Learning by Doing Remains Underappreciated

The question remains as to why, specifically, predictions about the future of jobs and skills so often wrong. More generally, it is also curious that so many people continue to believe the story that machines are going to do us in. Not only are the recent forecasts disproven by data, but several previous waves of automation that took place over the past 150 years give us other reasons to be humble when it comes to predicting the effects of technological change on employment.

From the early days of steam engines and mechanized looms, to the era of interchangeable parts and machine tools, on through to the electrification of factories and the mechanization of the assembly line, fears about automation were generally unwarranted in each past technological era. A recent study examined the effects of another type of automation technology—computer numerical control (CNC) machinery—on the workforce in the 1970s and beyond. The authors found that total employment rose and that "[w]orkers in exposed industries returned to school and relevant degree programs expanded."[49] Automation did indeed replace some manual tasks, but those workers learned new skills to produce even better CNC tools.

And yet still today, "journalists and even expert commentators tend to overstate the extent of machine substitution for human labor and ignore the strong complementarities between automation and labor that increase productivity, raise earnings, and augment demand for labor."[50] The fault lies in the simplifying assumptions forecasters make about skills, industries, technologies and the ways that they all might evolve in the future.

Worse still is a repeated underappreciation for the ways humans have consistently met adversity. People and organizations do not sit still in the face of technological change; they adapt. Where some see an ominous threat, many others sense an opportunity. "Historically, as some tasks have been automated. . . the freed-up labor has been redeployed to producing new goods and services or new, more effective production processes."[51] The process can be messy and gut wrenching for many people and professions, but people muddle through thanks to constant trial-and-error experimentation with new and better ways of doing and making things, including jobs and skills themselves.[52]

This is the central lesson of a 2015 publication, in which the author, James Bessen, digs deep into the process of how technological change affects economic growth

People adapt.

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48. Obama Administration, *Artificial Intelligence, Automation, and the Economy*, Dec. 20, 2016. https://obamawhitehouse.archives.gov/blog/2016/12/20/artificial-intelligence-automation-and-economy.
49. Leah Platt Boustan et al., "Automation after the Assembly Line: Computerized Machine Tools, Employment and Productivity in the United States," NBER, August 2022. https://www.nber.org/papers/w30400.
50. Autor, "Why Are There Still So Many Jobs," p. 3. https://www.aeaweb.org/articles?id=10.1257/jep.29.3.3.
51. Erik Brynjolfsson and Tom Mitchell, "What Can Machine Learning Do? Workforce Implications," *Science* 358:6370 (2017), pp. 1530–1534. https://www.science.org/doi/10.1126/science.aap8062.
52. Adam Thierer, "Muddling Through: How We Learn to Cope with Technological Change," *Medium*, June 30, 2014. https://medium.com/tech-liberation/muddling-through-how-we-learn-to-cope-with-technological-change-6282d0d342a6.

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broadly and workers more specifically.[53] The crucial part of the process is the continuous learning that happens as workers acquire new knowledge and skills in the face of technological change and evolving societal demands. The author admits this can be "a slow and difficult process," but there is no getting around it.[54]

Recounting his own struggles growing a desktop publishing business in the early 1980s, Bessen notes how, "[m]ost of the knowledge we gained was specific to the technology, the applications, and the organizations involved. Little of it could be obtained in classrooms; it had to be learned on the job."[55] That insight can be magnified across the entire modern economy. It is what countless organizations and individual workers have been doing increasingly for decades in response to a more fast-moving and globally connected economy.

Not only did economic forecasters in the 1960s and 70s not possess a vocabulary to describe the new sectors and jobs that came about during the 1980s and 90s, but Bessen suggests they also did not possess the foresight to envision the skills or programs that could teach us everything workers needed to know. Instead, firms and workers needed to figure out these things in real-time, and they have done so repeatedly throughout history. "Learning is the product of experience," a Nobel Prize-winning economist observed, and "can only take place through the attempt to solve a problem and therefore only takes place during activity."[56]

As Bessen argues, this simple but continuously underappreciated finding, "challenges a popular view that faster technical change is more likely to eliminate jobs."[57] Because human needs and wants are infinite, and because we go on adapting to meet those needs and wants through incessant experimentation, people find creative and often unexpected ways to create new jobs and skills—or reinvent old ones—over time.

Human-Machine Collaboration in the Real World

This insight explains why it is important to move away from abstract theorizing about automation and instead spend more time examining real-world case studies to figure out what we can learn about how workers and organizations can better adapt to technological change. That is what a new book on *Working with AI: Real Stories of Human-Machine Collaboration* does. The text presents dozens of detailed case studies of firms integrating algorithmic technologies in the workplace and repeatedly show how organizations are "practicing augmentation, not large-scale automation."[58]

Further, they find that "there is no immediate or impending threat of large-scale automation and a corresponding large-scale displacement of human labor on the horizon." Instead, the authors reiterate how the trend today swings in the opposite direction, as "many firms are struggling to find human employees."[59]

KEY TAKEAWAY

Because human needs and wants are infinite, and because we go on adapting to meet those needs and wants through incessant experimentation, people find creative and often unexpected ways to create new jobs and skills—or reinvent old ones—over time.

53. James Bessen, *Learning by Doing: The Real Connection between Innovation, Wages, and Wealth* (Yale University Press, 2015).
54. Ibid., p. 223.
55. Ibid., p. 31.
56. Kenneth J. Arrow, "The Economic Implications of Learning by Doing," Prepared Under Contract for the U.S. Office of Naval Research, *Technical Report* 101 (Dec. 7, 1961), p. 2.
57. James Bessen, "Automation and Jobs: When Technology Boosts Employment," Boston University School of Law, *Law & Economics Paper* 17-09 (Mar. 2018). https://scholarship.law.bu.edu/cgi/viewcontent.cgi?article=1809&context=faculty_scholarship.
58. Thomas H. Davenport and Steven M. Miller, *Working with AI: Real Stories of Human-Machine Collaboration* (The MIT Press, 2022), p. xv.
59. Ibid, p. xiv.

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Working with AI repeatedly returns to the theme of collaboration as the key to the process of firms and workers finding new positions, skills, and market opportunities. The common theme across the book's many case studies is: "they involve highly complex collaborations across a number of different groups and actors, both inside and outside a particular organization."[60] Complex collaborations represent a powerful learning process with many positive feedback loops. Humans building machines, improving them, and then learning from those systems is the formula that will power successful firms and entire economies in coming years. As the authors note, "the final output is usually better with the combination of human and machine expertise."[61]

These complex collaborations often require a melding of the business management and IT workers and teams within organizations. Organizational leaders and their "tech" people come together and figure out how to learn from each other and then from the powerful computational machines they increasingly integrate into their workplaces.

Consider how Cleveland Clinic doctors and scientists are already using AI and machine learning to improve patient care and save lives.[62] The Clinic's doctors and researchers are now able to share information from tissue samples with much larger teams of medical experts, who can—with the help of algorithmic systems—work together at a distance to better understand and use all the information they will have at their fingertips. They have also developed better AI-driven methods to detect irregular heartbeats and strokes, and diagnose degenerative brain disease (Alzheimer's, dementia, Parkinson's).[63] Everyone in the Clinic from management on down through the ranks has been learning in real-time how to use new algorithmic systems.

The only way to take full advantage of the explosion of medical knowledge gained from this process is with the power of machine reading and learning technologies. As the National Cancer Institute summarizes,

> what scientists are most excited about is the potential for AI to go beyond what humans can currently do themselves. AI can 'see' things that we humans can't and can find complex patterns and relationships between very different kinds of data.[64]

Sophisticated medical research centers like the Cleveland Clinic and the Mayo Clinic are on the cutting-edge of this field and are using complex collaborations of humans and machines to improve public health in a meaningful way and then also offering new types of care both at their facilities and with others at a distance. This is the future of medicine and patient care, but it would have been very hard to plan four decades ago.

Chess grandmaster Garry Kasparov wrote an excellent book about the benefits of this sort of human-machine collaboration. In 1997, he suffered the most humiliating human defeat to a machine in history when he lost a closely watched chess match with IBM's "Deep Blue" supercomputer. Though bitter at the time, Kasparov went on to document how human-machine collaboration was improving the game of chess

Complex collaborations represent a powerful learning process with many positive feedback loops.
Humans building machines, improving them, and then learning from those systems is the formula that will power successful firms and entire economies in coming years.

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60. Ibid., p. 197.
61. Ibid., p. 220.
62. Adam Thierer, "What I Learned about the Power of AI at the Cleveland Clinic," *Medium*, May 6, 2022. https://medium.com/@AdamThierer/what-i-learned-about-the-power-of-ai-at-the-cleveland-clinic-e5b7768d057d.
63. Ibid.
64. National Cancer Institute, "Can Artificial Intelligence Help See Cancer in New, and Better, Ways?" *Cancer Currents Blog*, Mar. 22, 2022. https://www.cancer.gov/news-events/cancer-currents-blog/2022/artificial-intelligence-cancer-imaging.

and human's playing capabilities. AI has also been shown to have improved human capabilities at the game of Go.[65]

In his 2017 book, *Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins*, Kasparov went beyond chess to explore how creative collaborations with machines would increasingly become the norm in the future. "Every profession will eventually feel this pressure, and it must, or else it will mean humanity has ceased to make progress," he argued.[66] "Romanticizing the loss of jobs to technology is little better than complaining that antibiotics put too many grave diggers out of work."[67] Yet, many concerned pundits look at AI and automation only as labor substituting instead of considering how it might be labor complimenting or enhancing.

The Challenge of Reskilling

It is unclear how we can make any safe predictions about future jobs or needed skills or how society can prepare for a future riddled with so much uncertainty. Although long-term technological unemployment has been proven a misguided fear, short-term technological disruption is a reality—and a politically sensitive one. Few policymakers will ever be comfortable with waiting to see how things adjust even though in many cases that might be the best course of action.

Reskilling or upskilling seem like the one thing everyone agrees on, but such efforts face many context-specific challenges. The risk also exists that experts will pick the wrong skills when looking to help dislocated workers. Many scholars do not agree on the nature or extent of the skills gap. As one expert notes, "the evidence highlights [...] just how difficult it is to measure worker skills, especially those relating to new technology."[68]

Others go further and question whether such a gap exists at all, or if society is focused on the wrong problems. An assistant professor in the School of Labor and Employment Relations at the University of Illinois at Urbana-Champaign, says that the way most people look workforce issues today, "encourages us to believe that the root of all labor-market problems lies in the low quality of labor supply—that is, in workers' lack of skills."[69] That is the wrong problem to focus on, he argues:

> The danger is not that we will run out of tasks humans can usefully perform or that required skill levels will be catastrophically high; it's that misguided anxiety about skill gaps will lead us to ignore the need to improve coordination between workers and employers. It's this bad coordination—not low-quality workers—that presents the real challenge.[70]

If this professor is correct, then the potential for policy missteps is even greater because, "pushing students and new workers to unilaterally make expensive investments in generic skill categories" will likely result in "inefficient investments, mistaken choices, and a large number of dead-end paths."[71] Regardless of where one stands on the

Reskilling: The Potential for Policy Missteps

❌ Experts could pick the wrong skills.

🛑 Scholars do not agree on the nature of the skills gap.

❓ Others question the existence of a gap at all.

65. Sukwoong Choi et al., "How Does Artificial Intelligence Improve Human Decision-Making? Evidence from the AI-Powered Go Program," April 2022. https://hyokang.com/assets/pdf/CKKK-AI-Go.pdf.
66. Garry Kasparov, *Deep Thinking: Where Machine Intelligence Ends and Human Creativity Begins* (Public Affairs, 2017), p. 41.
67. Ibid, p. 42.
68. James Bessen, "Employers Aren't Just Whining – the "Skills Gap" Is Real," Harvard Business Review, Aug. 25, 2014. https://hbr.org/2014/08/employers-arent-just-whining-the-skills-gap-is-real.
69. Andrew Weaver, "The Myth of the Skills Gap," MIT Technology Review, Aug. 25, 2017. https://www.technologyreview.com/2017/08/25/149485/the-myth-of-the-skills-gap.
70. Ibid.
71. Ibid.

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question of how real the skills gap is, the professor is certainly correct when asserting that, "economists and labor-market experts don't know the exact mix or level of skills that particular occupations demand."[72] Again, this suggests the need for policy humility.

Unfortunately, that humility has been sorely lacking throughout history. Past government retraining efforts have not fared well, yet policymakers have expanded them continuously.[73] One journalist asked "Why is the U.S. So Bad at Worker Retraining in a 2018 article.[74] This journalist highlights some of the notable retraining failures like the Job Training Partnership Act (JTPA) of 1982, the Workforce Investment Act of 1998 (WIA), the Workforce Innovation and Opportunity Act of 2014, and the many dozens that came before and after. Indeed, she states that "[a]s soon as one federal job-training program expires, another replaces it—despite history showing that large-scale efforts are all but impossible to pull off."[75]

Part of the problem, she notes, is that "policymakers often talk about a single workforce," when, in reality, there are many differences between white- and blue-collar workers and the many professions and skills among them. Unsurprisingly, this leads to both excessive overlap and a lack of coordination among federal training programs. A 2019, the U.S. Government Accountability Office (GAO) identified 47 federal employment and training (E&T) programs and "found that 44 had overlap with at least one other program in that they provided similar services to a similar population."[76] Unfortunately, the Department of Labor "continues to lack a strategic plan for E&T evaluations over a multi-year period," and the agency, "does not know whether actions to manage overlap are successful" the GAO reported.[77] Furthermore, "government job training programs (with the exception of apprenticeships) appear to be largely ineffective," concluded a 2019 report from the Trump administration's Council of Economic Advisers.[78]

There exists another potential problem with transitional strategies or restraining assistance that is even harder to measure or predict in advance. If such efforts are overly generous or poorly targeted, they could act as a disincentive for disrupted firms or workers to seek out alternative business or employment opportunities in fields that experts cannot identify in advance.

Consider another real-world example of how experts completely missed the boat when it came to predicting the high-tech jobs or skills of the future and what it means for reskilling efforts. In the post-World War II period, there existed an entire profession known as calculators. The 2016 film *Hidden Figures* depicted many such human calculators working in the space program. With the help of their trusty slide

The Need for Policy Humility

Regardless of where one stands on the question of how real the skills gap is, the assertion that "economists and labor-market experts don't know the exact mix or level of skills that particular occupations demand" is certainly correct.

72. Ibid.

73. David Muhlhausen, "So Far, Federal Job-Training Programs Have Been Outright Failures," *The Hill*, Mar. 14, 2017. https://thehill.com/blogs/pundits-blog/economy-budget/323885-thus-far-federal-job-training-programs-have-been-an; Chris Edwards and Daniel J. Murphy, "Employment and Training Programs: Ineffective and Unneeded," Downsizing the Federal Government, June 1, 2011. https://www.downsizinggovernment.org/labor/employment-training-programs#_ednref11; James Bovard, "The Failure of Federal Job Training," Cato Institute Policy Analysis 77, Aug. 28, 1986. https://www.cato.org/policy-analysis/failure-federal-job-training.

74. Lola Fadulu, "Why is the U.S. So Bad at Worker Retraining?" *The Atlantic*, Jan. 4, 2018. https://www.theatlantic.com/education/archive/2018/01/why-is-the-us-so-bad-at-protecting-workers-from-automation/549185.

75. Ibid.

76. U.S. Government Accountability Office, "Employment and Training Programs: Department of Labor Should Assess Efforts to Coordinate Services Across Programs," GAO-19-200 (Mar. 28, 2019). https://www.gao.gov/products/gao-19-200.

77. Ibid.

78. "Government Employment and Training Programs: Assessing the Evidence on their Performance" White House Council of Economic Advisers, (June 2019). https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/06/Government-Employment-and-Training-Programs.pdf.

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rules, these workers did the hard math for those companies and government agencies that required exceptional computational capabilities.

Then mainframes and microchips came along, and mechanical calculators replaced the human ones very quickly. Those mechanical calculators then went from being massive (mainframe computers that took entire buildings) to desktop sized (handheld calculators and personal computers) to miniature (first as nerdy wristwatches and now as smartphone apps). In the process, society stopped referring to a profession called "calculators" and today only refer to machines as such. It looks like a classic case of technological unemployment.

But the remarkable part of this story is what happened to those original "calculators." Once those displaced human calculators no longer had to work out hard math problems by hand, their time and abilities could be spent building better calculating machines. The result was the revolution in personal computing and digital technologies that continues today—and which produced the countless innovative American digital technology firms that are now dominant players in the modern global economy. In addition, the computing and information technology sector provides some of the best-paying jobs in the modern economy.

Now, put yourself in the position of a policymaker in the 1960s and ask how much transitional assistance or reskilling programs should have been provided for those human "calculators" who gradually lost their old jobs to computers over time. Moreover, could government retraining programs have identified the specific skills and professions that those human calculators ended up doing after machines took their jobs? At the time, government officials were more focused on assisting the more visible (and politically well connected) union jobs of the iron and steel era. The human calculators were out of luck and had to adjust faster. And they did.

Flexibility, Mobility & Dynamism are Crucial

Technological dislocations will still happen and will drive many policymakers to call for some sort of policies to help, at least in the short-term. Some transitional support mechanisms can help alleviate some of the pain associated with fast-moving technological change and help keep the door open to ongoing innovation. A certain level of unemployment assistance will always be needed to cushion that blow.

As public assistance moves from general to more targeted, however, it is hard to have much faith in the ability of politicians (or even skilled economists) to identify with much precision what "reskilling" or retraining should actually entail in practice. The track record for past programs is not encouraging. One scholar notes that "throwing more money at, or creating yet another new program to address, the challenges facing today's American workers promises to create higher costs and more distortions, not alleviate the concerns that are today mistakenly blamed on the 'free market'."[79]

Another researcher, correctly observes that we are in a new world in which "it's clear many workers are on the cutting edge of a new reality: work and learning must

One researcher, correctly observes that we are in a new world in which "it's clear many workers are on the cutting edge of a new reality: work and learning must exist side by side."

79. Scott Lincicome, *Empowering the New American Worker: Market-Based Solutions for Today's Workforce* (Cato Institute, 2022). https://www.cato.org/empowering-new-american-worker.

exist side by side."[80] There is no more one-and-done college degree or occupational credential that will necessarily cover a worker for life. Once again, ongoing learning will be crucial, even for very recent college graduates.[81] Further, this researcher notes, "[p]eople aren't retrained once, but instead many times during the course of their working lives.".[82] Yet it is clear that "the way we are accustomed to thinking about education and training is getting in the way of the solutions we need."[83]

The right mix of needed policies probably comes down to some combination of improved STEM funding/programs, tax deductions for worker retraining efforts,[84] better online learning programs, technical recertification programs (especially more flexible retraining partnerships facilitated through community colleges), portable benefits solutions,[85] and a renewed appreciation of how creative vocational apprenticeship models can advance real-time learning by doing. Many of these proposals have been floated for decades, including in a massive 1989 Department of Labor blue ribbon commission reports, which was formed during the presidency of Ronald Reagan.[86]

Removing barriers to economic dynamism is essential. Unfortunately, there has been a well-documented decline in economic dynamism recently, which refers to "the rate and pervasiveness of change across industries, geographies, and the labor market in an economy."[87] If policymakers want to facilitate greater real-time learning by doing to prepare workers for the future, then they must act to remove barriers to flexible work and labor mobility quickly.

Labor dynamism—movement from job to job, profession to profession, or from one geographic region to another—is particularly important to workers and the economy because it creates higher wages and better job opportunities.[88] An important recent study found that,

> wages grow more over the life-cycle in countries where job-to-job mobility is more common. A life-cycle theory of job shopping and accumulation of skills on the job highlights that a more fluid labor market allows workers to faster relocate to jobs where they can better use their skills, incentivizing accumulation of skills. Lower labor market fluidity reduces life-cycle wage growth by 20 percent and aggregate labor productivity by nine percent across the OECD relative to the US.[89]

One study identified several factors holding back economic dynamism and worker opportunities.[90] The report found that, since the 1980s, the new business startup rate has been trending downwards and the number of Americans employed in startups has fallen by one-half. There is less churn in many sectors, too, with incumbent firms

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If policymakers want to facilitate greater real-time learning by doing to prepare workers for the future, then they must act to remove barriers to flexible work and labor mobility quickly.

80. Jamie Merisotis, *Human Work in the Age of Smart Machines*, Kindle edition, (RosettaBooks, 2020), p. xiii.
81. Marc Zao-Sanders and Kelly Palmer, "Why Even New Grads Need to Reskill for the Future," Harvard Business Review, Sept. 26, 2019. https://hbr.org/2019/09/why-even-new-grads-need-to-reskill-for-the-future.
82. Merisotis, *Human Work*, p. xiii.
83. Ibid., p. 63.
84. Testimony of Michael Farren, "Bridging the Skills Gap," House Small Business Committee, Subcommittee on Economic Growth, Tax, and Capital Access Examining the Small Business Labor Market, 115th Congress (Sept. 17, 2017). https://www.mercatus.org/system/files/farren_-_testimony_-_bridging_the_skills_gap_-_v2.pdf.
85. Eli Lehrer, "The Future of Work," *National Affairs* (Summer 2016). https://www.nationalaffairs.com/publications/detail/the-future-of-work.
86. U.S. Department of Labor, *Investing in People: A Strategy to Address America's Workforce Crisis* (September 1989).
87. John W. Lettieri and Kenan Fikri, "The Case for Economic Dynamism and Why it Matters for the American Worker," Economic Innovation Group, 2022, p. 6. https://eig.org/dynamism.
88. Ibid.
89. Niklas Engbom, "Labor Market Fluidity and Human Capital Accumulation," NBER Working Paper, Jan. 2022. https://www.nber.org/papers/w29698.
90. Lettieri and Fikri, "The Case for Economic Dynamism."

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holding onto positions of dominance longer. And until the COVID pandemic hit, the job reallocation rate had been steadily falling, with most workers staying put in current jobs (and in their current geographic locations) longer than in the past. While the authors note that many factors are at work, the relationship between excessive red tape and declining dynamism deserves special attention. "[Regulatory] complexity is a gift to large incumbents and vested interests all the same," they find.[91] This report, along with many other books and articles, highlights how

> sclerosis and gatekeeping are detrimental because they prevent people from accessing economic opportunity. They raise the cost of building things—literally and figuratively—in the United States, diminishing the pace of progress and restricting how broadly the benefits of progress can spread."[92]

Occupational licensing rules are one of the most serious impediments to economic and labor dynamism because such rules limit new startup formation and flexible work patterns. In 2015, the Obama administration released a major report on the costs of occupational licensing rules, which identified how such rules impose a hidden tax on consumers of between roughly 3 and 16 percent.[93] That report also documented how licensing rules limit economic mobility by "creating barriers to workers moving across State lines and inefficiencies for businesses and the economy as a whole."[94] That Obama report summarized the massive body of research documenting how excessive occupational licensing requirements impose such costs on businesses, workers, and consumers.[95] Reducing the costs of starting and operating a business will help free up more time and resources to devote to finding new business models and worker positions.[96] Greater operating flexibility can also help boost wages and other benefits.

Fortunately, reforming archaic or ineffective regulatory policies and labor market restrictions is a highly non-partisan issue.[97] A *New York Times* columnist worries about "Why We Can't Build," while popular pundits speak of the need for a "new industrialist" movement and an "abundance agenda."[98] There is broad-based agreement among these Left-leaning pundits on the need for policy reforms that could help strengthen the workforce of the future, including various tax and immigration policy reforms, and comprehensive permitting/licensing relaxation. Even if experts can't agree on things like reskilling efforts or safety net programs, they should at least be able to work together to remove existing barriers to worker mobility and new startup formation.

Occupational licensing rules are one of the most serious impediments to economic and labor dynamism because such rules limit new startup formation and flexible work patterns.

91. Ibid., p. 20.
92. Eli Dourado, "Remove Barriers to Productivity," City Journal, March 18, 2022. https://www.city-journal.org/remove-barriers-to-productivity-to-stave-off-stagflation.
93. "Occupational Licensing: A Framework for Policymakers," US Department of the Treasury, Council of Economic Advisers, and US Department of Labor, July 2015, p. 4. https://obamawhitehouse.archives.gov/sites/default/files/docs/licensing_report_final_nonembargo.pdf.
94. Ibid.
95. "The State of Occupational Licensing: Research, State Policies and Trends," National Conference of State Legislatures, Oct. 11, 2017. https://www.ncsl.org/research/labor-and-employment/report-the-state-of-occupational-licensing.aspx.
96. Adam Thierer and Trace Mitchell, "Occupational Licensing Reform and the Right to Earn a Living: A Blueprint for Action," Mercatus Center at George Mason University, *Policy Briefs*, Apr. 20, 2020. https://www.mercatus.org/research/policy-briefs/occupational-licensing-reform-and-right-earn-living-blueprint-action.
97. Adam Thierer and Trace Mitchell, "Occupational Licensing Reform is Not a Partisan Issue," *Washington Examiner*, Sept. 12, 2019. https://www.washingtonexaminer.com/opinion/op-eds/occupational-licensing-reform-is-not-a-partisan-issue.
98. Ezra Klein, "Why We Can't Build," *Vox*, April 22, 2020. https://www.vox.com/2020/4/22/21228469/marc-andreessen-build-government-coronavirus; Noah Smith, "A New Industrialist Roundup," *Noahpinion*, Feb. 3, 2022. https://noahpinion.substack.com/p/a-new-industrialist-roundup; Derek Thompson, "A Simple Plan to Solve All of America's Problems," *The Atlantic*, Jan. 12, 2022. https://www.theatlantic.com/ideas/archive/2022/01/scarcity-crisis-college-housing-health-care/621221.

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Conclusion: The Case for Humility (and Optimism) in the Age of AI

When it comes to preparing workers for the future, the great lesson of history is that policymakers cannot plan for every contingency or easily devise policies or programs to address every potential need. A certain degree of humility remains essential because our "epistemic ignorance," or hubris concerning the limits of our knowledge, remains a chronic problem.[99] "We are demonstrably arrogant about what we think we know," and therefore, "[w]e overestimate what we know, and underestimate uncertainty."[100]

The equally chronic problem with technological forecasting, as a science fiction author noted twenty years ago, is its "tendency to excess" and "crisisization of everything possible."[101] Pessimistic bias runs deep in our veins and leads us to assume only the worst will happen. Yet, history proves that pessimism is generally unwarranted. Instead, "it is important to acknowledge the limits of our imaginations."[102]

Humility is needed in a more general sense. Advice like "do not go into professions that could get completely automated" sounds sensible until we try determining exactly how much automation we can accurately foresee in certain fields. For instance, an oft-cited 2013 study predicted that artists were one of the most future-proof jobs, after all. Recently, however, powerful AI foundational models like Dall-E and Stable Diffusion have given anyone the ability to generate works of art just by typing a few words into a suggestion box. One such AI-generated artwork even won first prize at the Colorado State Fair's annual art competition earlier this year.[103] This led to a slew of articles with titles like, "Will AI make artists obsolete?"[104] and, "Your Creativity Won't Save Your Job From AI."[105] On the other hand, the good news is that people are already discovering how to create unique new forms of art with those AI tools and opening new opportunities for humans to explore their inner creativity.[106] Once again, complex collaborations will likely take us by surprise.

There is another reason why humility is essential: Many AI and robotic applications are failing. Out of the gates, there was a lot of hype about driverless cars and delivery robots or drones, but also plenty of fears about how these automated technologies might affect professional drivers or pilots. Yet, the technologies have been slow to market for a variety of reasons.[107] Both Amazon and FedEx recently announced

KEY TAKEAWAY

There is another reason why humility is essential: Many AI and robotic applications are failing.

99.   Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (Random House, 2007), p. 138.

100. Ibid., 140.

101. Michael Crichton, "Why Speculate?" Speech before the International Leadership Forum, La Jolla, California, Apr. 26, 2002. http://web.archive.org/web/20070714204136/http://www.michaelcrichton.net/speech-whyspeculate.html.

102. Mokyr, et. Al., "The History of Technological Anxiety," p. 45

103. Kevin Roose, "An A.I.-Generated Picture Won an Art Prize. Artists Aren't Happy," *New York Times*, Sept. 2, 2022. https://www.nytimes.com/2022/09/02/technology/ai-artificial-intelligence-artists.html.

104. Ethan Zuckerman, "Will AI Make Artists Obsolete?" *Prospect*, Oct. 6, 2022. https://www.prospectmagazine.co.uk/science-and-technology/will-artificial-intelligence-make-artists-jobs-obsolete.

105. Derek Thompson, "Your Creativity Won't Save Your Job from AI," *The Atlantic*, Dec. 1, 2022. https://www.theatlantic.com/newsletters/archive/2022/12/why-the-rise-of-ai-is-the-most-important-story-of-the-year/672308.

106. Agnieszka Pilat, "I Make Art with A.I. Here's Why All Artists Need to Stop Worrying and Embrace the Technology," *Artnet News*, Oct. 27, 2022. https://news.artnet.com/opinion/artists-embrace-ai-dall-e-op-ed-2199088-2199088; Kevin Kelly, "Picture Limitless Creativity at Your Fingertips," *Wired*, Nov. 17, 2022. https://www.wired.com/story/picture-limitless-creativity-ai-image-generators.

107. Andrew J. Hawkins, "Driverless Cars Aren't Going Away, but We Need to Lower Our Expectations about Them," *The Verge*, Oct. 28, 2022. https://www.theverge.com/2022/10/28/23427129/autonomous-vehicles-robotaxi-hype-failure-expectations.

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they were scaling back their robotic delivery pilot programs.[108] Meanwhile, on the driverless car front, *Bloomberg* reported in late 2022 that, "Even After $100 Billion, Self-Driving Cars Are Going Nowhere."[109] Policy uncertainty is one roadblock to these automation tools, but social and technological challenges also limit their potential. Meanwhile, despite the fears of the Teamsters union, which for years has fought federal efforts to pass driverless cars legislation, driverless trucks from developers like Waymo still have "autonomous specialists" (aka, human programmers) in the driver's seat.[110] Therefore, even as truck drivers take their hands off the wheel increasingly to let machines do more of the driving, they will likely be moving their hands to keyboards to improve those systems further.

In sum, the future remains as uncertain as ever, and the relationship between humans and their machine creations continues to be dynamic and unpredictable. Many will cast this inherent uncertainty in a negative light, but it is why we should be optimistic about the future. AI and automation could help revolutionize work for the better in ways that most of us cannot currently imagine. New technological capabilities will give society new business models, new professions, and new roles— but likely many that experts are not likely able to currently envision or plan for today.

In the meantime, even a cursory review of the record of failed prognostications and forecasts from the past half century should make us wonder how so many smart people could have gotten things so wrong when predicting the future. Apparently, the only professions that have not benefited much from learning by doing are all the economists and consultants who apparently never learn anything from their endless string of poor predictions about technology and the future of markets and the workforce.

The future remains as uncertain as ever, and the relationship between humans and their machine creations continues to be dynamic and unpredictable.

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About the Author

Adam Thierer is a senior fellow in the Technology and Innovation Policy program at the R Street Institute in Washington, D.C.

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