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AN INCLUSIVE FUTURE? TECHNOLOGY, NEW DYNAMICS, AND POLICY CHALLENGES

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Zia Qureshi[1]

Introduction

Technological change, led by digital technologies, is a defining feature of our time. We are living in what has been aptly termed the digital era. The new technologies are reshaping economies—and societies. We may be on the cusp of a significant deepening and acceleration of the ongoing digital transformation of our economies and societies as artificial intelligence (AI) spawns a new wave of innovations. The COVID-19 pandemic has given added impetus to automation. The future is arriving at a faster pace than expected.

Advances in digital technologies hold great promise. They create new avenues and opportunities to boost economic prosperity and raise human welfare. But they also pose new challenges and risks. As the new technologies transform markets and nearly every aspect of business and work, they have highlighted, and can deepen, economic and social fault lines across advanced and developing economies.

One major fault line is economic inequality. Technological change can shift growth and distributional dynamics in ways that push inequality higher. Indeed, inequality has been rising in many countries over the period of the boom in digital technologies. Across economies, there is uneven participation in the new opportunities created by digital transformation. Many are being left behind, across industries, across the workforce, and across different segments of society.

Rising inequality and related disparities and anxieties have been stoking social discontent and are a major driver of the increased popular disaffection and political polarization that are so evident today. An increasingly unequal society can weaken trust in public institutions and undermine democratic

[1] I would like to thank Janina Curtis Bröker for research support.

governance. Mounting global disparities can imperil geopolitical stability. Rising inequality has emerged as an important topic of political debate and a major public policy concern.

Motivated by these developments, a current initiative at Brookings—Global Forum on Democracy and Technology—seeks to promote ideas, policies, and practices that would harness the new technologies in ways that support broad-based improvements in economic prosperity and strengthen democratic societies.[2] An important research workstream under this initiative focuses on technology's implications for inequality and on the policy agenda to promote more inclusive growth and development outcomes from current and prospective advances in technology.

There are important questions that must be addressed. In what ways is today's technological transformation contributing to higher inequality within economies? Should workers fear the new automation? What are the implications of the new technologies for global inequality and economic convergence between economies? What new challenges arise for public policy to manage technological change to build inclusive prosperity? What new thinking and adaptations are needed to realign institutions and policies with the digital economy, at national and global levels—and to shape technological change itself? This report, part of ongoing research on technology and inequality under the Global Forum project, addresses these questions.

Rising inequality in the digital era

The last three to four decades have been a period of rapid technological transformation, led by an expanding array of digital innovations. Ranging from increasingly sophisticated computer systems, software, and mobile telephony to digital platforms and robotics, these innovations have been reshaping markets and the worlds of business and work. New advances in AI, machine learning, cyber-physical systems, and the Internet of Things are driving digital transformation further. This latest wave of innovations can take the digital revolution to a whole new level.[3] And the automation and digitalization of economic activity are intensifying in the wake of the COVID-19 pandemic.[4] Indeed, the pandemic may be remembered as the Great Digital Accelerator.

Over this period of digital transformation, economic inequality has been rising. Income inequality has risen in most countries since the 1980s. Practically all major advanced economies have experienced a rise in income inequality, and the increase has been particularly large in the United States, the country at the leading edge of the digital revolution. Those with middle-class incomes have been squeezed. The typical worker has seen largely stagnant real wages over long periods—and increased anxiety about job loss from automation. Intergenerational economic mobility has declined.[5] Income distribution trends are more mixed in emerging economies but many of them—and most of the major emerging economies—also have experienced rising inequality. Figure 1 shows the trend in the Gini coefficient, a broad measure of inequality, in the major advanced and emerging economies that are members of the G-20.[6]

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[2] https://www.brookings.edu/global-forum-on-democracy-and-technology/.

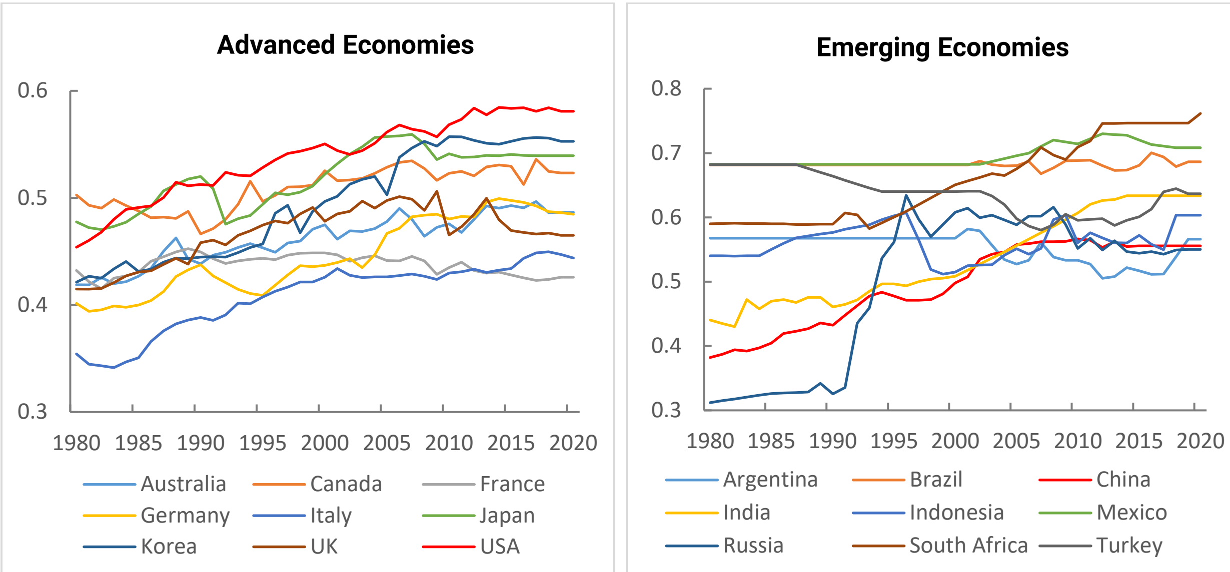
[3] West and Allen (2020).

[4] See Korinek and Stiglitz (2021), Chernoff and Warman (2020), and McKinsey Global Institute (2021).

[5] For the United States, see Chetty et al. (2017).

[6] The figure covers all individual G-20 economies except Saudi Arabia, for which income distribution data are limited. The figure shows the trend in inequality based on market income. Trends in inequality based on disposable income (taking into account taxes and transfers) are broadly similar, except that the *level* of disposable income inequality is lower than that of market income inequality, especially in advanced economies. For these economies, taxes and transfers typically reduce market income inequality on average by close to one-third.

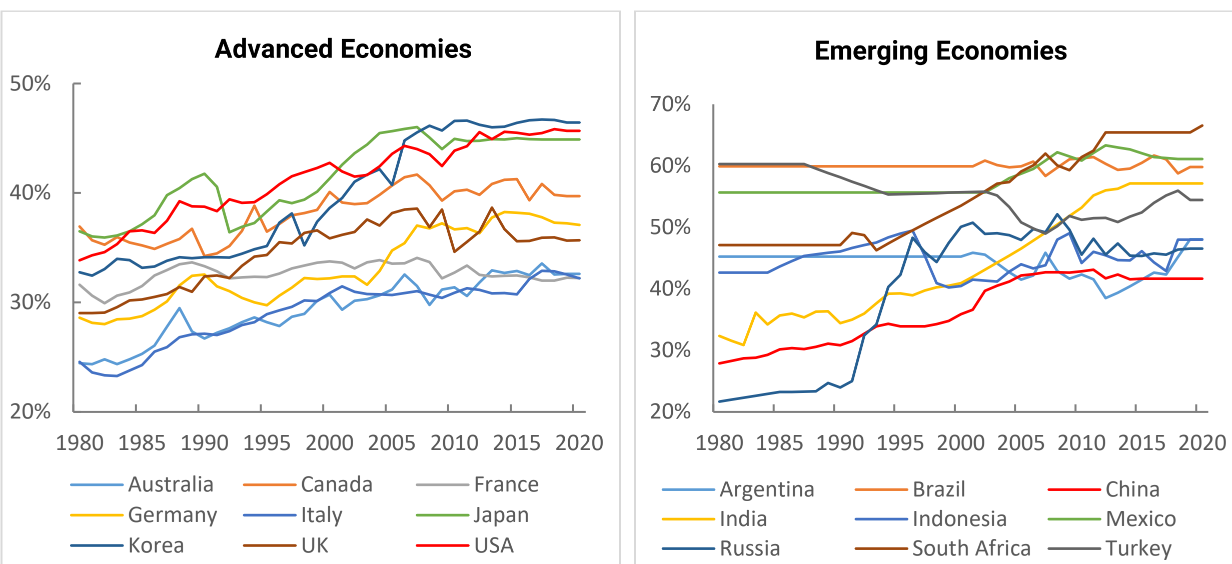
Figure 1. Rising income inequality: Gini coefficient, 1980–2020



Source: World Inequality Database.
Note: Pre-tax national income. Some datapoints are extrapolated.

There has been a particularly large increase in income concentration at the top end of the distribution. Figure 2 shows the trend in the share of the richest 10 percent of the population in national income for the G-20 advanced and emerging economies.

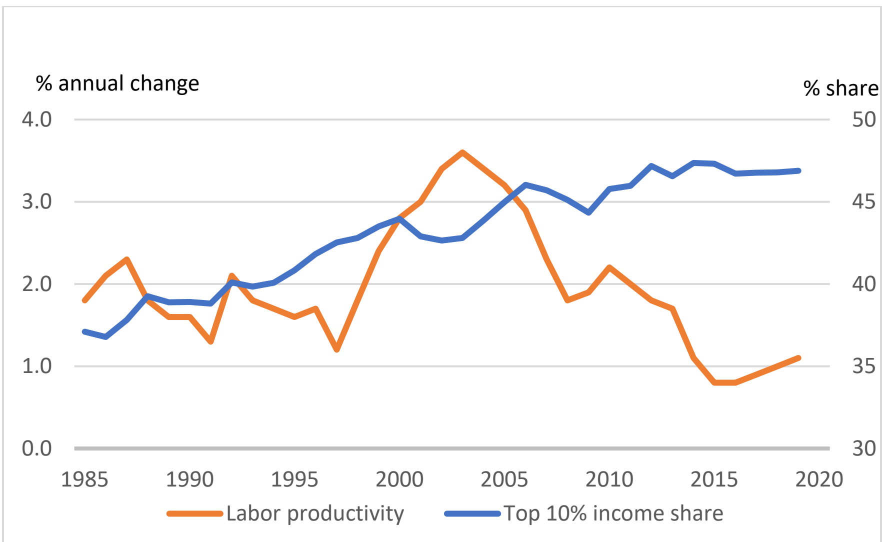
Figure 2. Rising income concentration at the top: richest ten percent share, 1980–2020



Source: World Inequality Database.
Note: Pre-tax national income. Some datapoints are extrapolated.

Not only has inequality been rising, the expected productivity dividend from digital technologies has not fully materialized. The potential of the new technologies to deliver higher productivity and economic growth is sizable (even dramatic, as Basu notes in Chapter 3). But, paradoxically, productivity growth has slowed rather than accelerated in many economies as digital technologies have boomed.[7] The productivity slowdown extends across OECD economies—and many emerging economies as well. Economic growth, consequently, has trended lower. The twin trends of rising inequality and slower productivity growth are vividly illustrated by the U.S. economy (Figure 3). Since the early 1980s, the share of the top 10 percent in income in the United States has risen from 34 percent to 46 percent (the income share of the top one percent has roughly doubled from 10 percent to 19 percent).[8] As for productivity growth, it slowed considerably after the early 2000s. Over the last decade-plus, it has averaged less than half the growth rate of the decade prior to the slowdown.[9]

Figure 3. Twin trends of rising inequality and slowing productivity growth: United States, 1985–2019



Source: Qureshi and Woo (2022)

While within-country inequality has risen in most countries in recent decades, inequality between countries has been falling.[10] Faster-growing emerging economies have been narrowing the income gap with advanced economies. But technological change poses new challenges for this global economic convergence. Manufacturing-led growth in emerging economies has been driven by their comparative advantage in labor-intensive manufacturing based on large populations of low-skilled, low-wage workers. This source of comparative advantage increasingly will erode as automation of low-skilled work expands, disrupting traditional pathways to development.[11]

[7] Current statistical methods may not fully capture the new value created in the digital space. However, research shows that, even allowing for such measurement issues, the productivity slowdown is real, not illusory. See Derviş and Qureshi (2016) for a summary discussion. See also Brynjolfsson et al. (2017).
[8] Wealth is still more concentrated, with the share of the top 1 percent rising from 23 percent to 36 percent since the early 1980s.
[9] The productivity series in Figure 3 shows five-year moving averages to smooth year-to-year fluctuations.
[10] Between-country income inequality captures per-capita income differences between countries.
[11] Coulibaly and Foda (2020).

Global inequality—the sum of within-country and between-country inequality—has declined somewhat since around 2000, with falling between-country inequality more than offsetting rising within-country inequality. But if global economic convergence slows, and within-country inequality continues to rise, the recent decline in global inequality could peter out or even reverse. Within-country inequality accounted for 68 percent of global inequality in 2020, up from 43 percent in 1980.[12] Looking ahead, how within-country inequality evolves will matter even more for global inequality.

Many factors affect income distribution—technology, globalization, and policies and institutions. Research has increasingly focused on technological change as a key driver of the rise in inequality observed in recent decades.[13] The benefits of current technological transformation have been shared highly unevenly. However, technology *per se* is not the problem. On the contrary, the new technologies hold immense potential to raise productivity, create new and better jobs to replace old ones, and underpin broad-based growth in incomes. The challenge is to better harness this potential.

Technological change is inherently disruptive, even more so when it is as far-reaching in its implications as the ongoing digital transformation. It inevitably creates winners and losers. Policies have a crucial role to play to improve the enabling environment for firms and workers—to broaden access to the new opportunities that come from technological change and to enhance capabilities to adjust to the new challenges. Unfortunately, policies and institutions have been slow to rise to the challenges of technological change.

The outcomes of rising inequality and slowing productivity growth are interconnected, and closely linked to the way new technologies have interacted with the prevailing policy and institutional environment.[14] As technology reshapes markets and alters growth and distributional dynamics, policies must ensure that markets remain inclusive and support wide access to the new opportunities for firms and workers. The digital economy must be broadened to disseminate new technologies and productive opportunities to smaller firms and wider segments of the labor force. This will both help avert rising inequality and capture the productivity dividend from digital transformation across wider swathes of the economy. Combating inequality as technology drives change, therefore, is not only a distributional issue; it is also about harnessing the new technologies to promote more inclusive—and stronger—economic growth.

Changing market dynamics

How policy should respond must be informed by how technology is changing market dynamics and affecting business and work. The transformations occurring are profound, across product and labor markets.

Digital technologies are altering business models and reshaping product market structures. How technology diffuses within the economy influences both productivity growth and income distribution. So far, the benefits of digital innovations have been captured mostly by a relatively small number of large firms. Evidence for OECD economies shows that the slowdown in productivity, at its root, reflects a growing inequality in productivity performance between firms. For firms at the technological frontier,

[12] Chancel et al. (2022).
[13] See, for example, Qureshi (2020a) and Bourguignon (2022).
[14] On the nexus connecting technology, policies, and the productivity and distributional outcomes, see Brookings Institution and Chumir Foundation (2019) and Furman and Orszag (2018).

productivity growth has remained relatively strong. But it has slowed considerably in the vast majority of other firms, depressing aggregate productivity growth. Over a fifteen-year period since 2000, labor productivity among frontier firms in OECD economies rose by around 45 percent; among non-frontier firms, the increase was well below 10 percent.[15] Even the economy at the digital frontier—the United States—may be reaching only about a fifth of its digital potential.[16]

One important factor behind this trend is weakening competition. Barriers to competition and related market frictions have prevented a broader diffusion of new technologies. In industries with diminished competitive intensity, technological innovation and diffusion have been weaker, inter-firm productivity divergence has been wider, and aggregate productivity growth has been slower.[17] In the case of the United States, for example, the erosion of competition is reflected in a variety of indicators: rise in market concentration in industries, higher markups showing increased market power of dominant firms, these firms' supernormal profits (rents) that account for a rising share of total corporate profits, low churning among high-return firms, and decline in new firm formation and business dynamism. Between 1985 and 2015, rents (profits in excess of those under competitive market conditions) are estimated to have risen from a negligible share of national income to about one-fifth.[18]

Why is market concentration rising? As Basu notes in Chapter 3, one key factor is digital technologies that produce a winner-takes-all form of competition. They offer first-mover advantages, strong economies of scale and network effects, and the leverage of big data that encourage the rise of "superstar firms."[19] The rise of "the intangible economy"—where assets such as data, software, and other intellectual property matter more for economic success—has been associated with a stronger tendency toward the emergence of dominant firms.[20] The winner-takes-all dynamics are most marked in the high-tech sectors, as reflected in the rise of tech giants such as Apple, Facebook (now Meta), and Google. But they are increasingly evident in other sectors as digitalization penetrates the economy, such as in the rise of Amazon in trade.

Failures in competition policy have reinforced these technology-driven forces producing higher market concentration. As Basu points out in Chapter 3, competition policy has failed to adapt to the shift in market structures and the new challenges to keep markets competitive in the digital economy.[21] Antitrust enforcement has been weak in the face of rising monopoly power and takeover activity. Also, flaws in patent systems have acted as barriers to new or follow-on innovation and wider diffusion of new technologies.[22] These systems, typically designed many decades ago, have been slow to adapt to the knowledge dynamics of the digital era.

As in product markets, technology has been unleashing major changes in labor markets but policies have been slow to respond to this transformation. While product markets have seen rising inequality between firms, labor markets have seen rising inequality between workers. Automation and digital advances are

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[15] See Andrews et al. (2016) and Calvino and Criscuolo (2022). Frontier firms in this estimate are defined as the top 5 percent of firms with the highest labor productivity within each two-digit industry. Non-frontier firms cover all other firms.
[16] McKinsey Global Institute (2015).
[17] Andrews et al. (2016).
[18] Eggertsson et al. (2021). See also Akcigit et al. (2021), De Loecker et al. (2020), Qureshi (2019), Philippon (2019), and Tepper (2019).
[19] Autor, Dorn, et al. (2020).
[20] Haskel and Westlake (2017) and Crouzet and Eberly (2019).
[21] See also Khan (2017), which argues that the current U.S. antitrust legal framework is ill-equipped to address the competition policy challenges of the digital economy, such as those posed by business models based on online platforms like that of Amazon.
[22] Akcigit and Ates (2019). See also Qureshi (2018).

changing the nature of work and shifting labor demand away from routine low- to middle-level skills to new, higher-level skills. On the supply side, however, adjustment has been slow in equipping workers with skills that complement the new technologies and supporting their transition to new tasks and jobs. Education and training have been losing the race with technology. In Chapter 2, Autor examines in detail the shifting dynamics in labor markets and implications for jobs and wages.

The lag in adapting the supply of skills to changing demand has hampered the broader adoption of innovations that require new skills, limiting productivity gains. Mismatch between the skills available and the skills needed has been growing. Workers with skills complementary to the new technologies have increasingly clustered in dominant firms at the technological frontier. The shifts in labor demand have increased skill premia and wage differentials, contributing to higher labor income inequality and diminished job prospects for less-skilled workers. The skill premium has risen since the 1980s and has more recently increased particularly sharply at the higher end of educational attainment—graduate and professional education. Skill-biased technological change has contributed to a "convexification" of returns to education and training.[23] Job markets have seen increasing polarization, with demand shifting away in particular from routine, middle-level skills that are more easily automatable. In the United States, for example, as much as 50-70 percent of the increase in earnings inequality between 1980 and 2016 may be due to the automation of tasks formerly done by human workers.[24] Part of the workforce displaced from middle-skill jobs is having to move to lower-skill, lower-productivity, lower-wage jobs, giving rise to an "inverse Lewis economy."[25]

How will AI, the next phase of the digital revolution, affect the relative demand for skills and earnings inequality? In Chapter 2, Autor discusses the potential effects, while underscoring the uncertainty associated with how the scope of AI capabilities may evolve. As AI advances, displacement risks could affect some higher-level skills as well, in contrast to previous waves of automation. However, the displacement risk at higher-level skills may apply more at the task level than at the level of entire jobs or occupations as has been the case with low- to middle-level skills.[26] Higher-skilled workers typically also have greater ability to adjust by gaining new skills and new employment than less-skilled workers.

Along with rising wage inequality, there has been a growing decoupling of wages from productivity. In the United States, for example, wage growth has lagged well behind productivity growth in recent decades.[27] Industries experiencing higher market concentration and earning higher economic rents have seen a greater decoupling of wages from firm profitability and larger drops in labor's share of income. Dominant firms are not only acquiring more monopoly power in product markets to increase markups and extract higher rents but also monopsony power to dictate wages in the labor market.[28] While employer market power has increased, worker bargaining power has weakened with a decline in unionization and erosion of minimum wage laws.

The decoupling of wages from firm profitability has reinforced the effect of the labor-saving nature of many of the new technologies in shifting income from labor to capital. In recent decades, most major economies have experienced declining shares of labor in total income.[29] The shift in income from labor to

23 Autor, Goldin, and Katz (2020). See also Shambaugh et al. (2017).
24 Acemoglu and Restrepo (2021).
25 Taylor and Ömer (2020). See also Temin (2017).
26 See also Autor et al. (2019), Lane and Saint-Martin (2021), and Holzer (2022).
27 Stansbury and Summers (2018).
28 Azar et al. (2017) and Council of Economic Advisers (2016).
29 OECD (2018) and Schwellnus et al. (2018).

capital increases overall income inequality, as capital ownership is highly uneven.[30] Globalization (international trade, offshoring) also has contributed to the shift in income toward capital in advanced economies by putting downward pressure on wages, especially of lower-skilled workers in tradable sectors. The expanding digital trade—the new phase of globalization—can add to these pressures. With a growing range of digitally deliverable services, workers further up the skill spectrum also will face more competition from across borders.[31] Overall, globalization has played a significant role in the decline of the labor income share in advanced economies, although the role of technology has been more dominant.[32]

Some of the technology-driven labor market trends seen in advanced economies in recent decades are not as marked in developing economies. There is less evidence of job polarization and trends in labor income share are more mixed. But as Basu argues in Chapter 3, this could change increasingly as developing economies experience stronger and deeper impacts of the digital revolution.

In sum, technological transformation has been altering market dynamics in ways that push inequality higher within countries, especially in advanced economies. This has been happening through three channels: more unequal distribution of labor income with rising wage inequality; shift in income from labor to capital; and more unequal distribution of capital income with rising market power and rents. Looking ahead, absent countervailing policies, AI and related new waves of digital technologies and automation could increase inequality further. Even as new technologies increase productivity and produce greater economic affluence, and new jobs and tasks emerge to replace those displaced to prevent large technological unemployment, inequality could reach much higher levels.[33] Continuing and large increases in inequality may not be a sustainable path given associated social and political risks.

Slowing economic convergence?

What is the outlook for inequality *between* countries? This will depend importantly on how technological change affects economic convergence between developing and advanced economies.

Since the Industrial Revolution, manufacturing has powered the rise of economies—first the rise of today's advanced economies and subsequently that of China and other successful emerging economies of East Asia. In a development paradigm that came to be known as the "flying geese" model, as economies moved up the manufacturing ladder and wages there rose, lower-skill manufacturing tasks shifted to economies with lower wage costs.[34] This process over time helped economic convergence between the early industrializers and those that followed. But as Rodrik discusses in Chapter 4, automation and digitalization are disrupting this development and convergence paradigm.

As new technologies increasingly automate routine lower-skill production tasks, comparative advantage based mainly on low-cost, low-skilled labor will fade. Some of the manufacturing tasks in global value chains (GVCs) that were previously offshored to low-wage-cost developing economies could be reshored to advanced economies. The expected migration of low-skill tasks from China (the world's largest

[30] Piketty (2014) places particular emphasis on uneven capital ownership and returns on capital as sources of inequality.
[31] Baldwin (2019).
[32] International Monetary Fund (2017). See also Autor et al. (2021).
[33] Spence (2021) sketches a similar scenario, arguing that we should worry less about technological unemployment and more about inequality.
[34] Akamatsu (1962).

manufacturer) to other economies as China's labor costs rise may not happen as these tasks become automated and remain in China. These trends could strengthen and consolidate the position of existing major manufacturing hubs in North America, Europe, and East Asia.

The new technologies, born in advanced economies, are shifting manufacturing and GVCs toward higher capital and skill intensity. Leading manufacturing firms in developing economies engaged in exporting are adopting these technologies in order to be able to compete, limiting employment generation (especially for the less skilled) from this higher-productivity segment of industry in economies whose factor endowments would warrant less capital- and skill-intensive technologies. On the other hand, smaller firms that absorb most workers in these economies remain engaged in low-productivity activities, many in the informal economy and in petty service sectors. Also, technology is driving an increasing servicification of manufacturing. Along the manufacturing value chain, the contribution of services is growing as the value added by upstream and downstream activities rises relative to that of production and assembly.[35] But these upstream and downstream activities—such as research and development, design, branding and marketing, and user services embedded in products—are intensive in higher-level and specialized skills and digital infrastructure and technologies that typically are in short supply in developing economies. These trends mean that industrialization may not play the same role in generating good, productive jobs for these economies' large and rapidly growing populations of less-educated workers as it did before.

There are already signs of what Rodrik calls "premature deindustrialization."[36] Newly industrializing, middle-income countries are experiencing declines in manufacturing employment shares starting at much lower levels of industrialization and per-capita GDP than did advanced industrialized countries, limiting the role manufacturing has played historically in drawing labor from traditional occupations such as farming into higher-productivity jobs and driving economies' structural transformation.

Analyzing these trends in Chapter 4, Rodrik concludes that convergence between developing and advanced economies will likely slow. If that happens, it would mean a slower decline in between-country income inequality than seen in recent decades—and, potentially, a stalling or even reversal of the decline in global inequality seen since about 2000 if within-country inequality continues to mount.

Disruptive technologies will certainly make the traditional route to development through manufacturing much tougher. But as Rodrik notes (and also Basu in Chapter 3), developing economies that better adapt to the new challenges can still sustain strong growth and continue long-term convergence. They can continue to carve out international comparative advantage in industries and supply chains and also take advantage of increasing domestic demand fueled by their growing populations and rising middle classes. Indeed, by 2030, emerging and developing economies could account for more than half of all global consumption (35 percent excluding China).[37] The growth of demand within these economies could also attract more investment from outside that aims to locate production closer to points of growing consumption. For example, increasingly, Chinese manufacturing firms relocating to Africa serve local markets.

Even as new technologies limit opportunities in traditional manufacturing, they can open new avenues for growth. Digital platforms and logistics technologies are lowering transaction costs to connect to global markets. They are increasing opportunities for countries to tap into the growing international trade in digitally deliverable services. Countries rich in natural endowments can move up the value chain from

[35] McKinsey Global Institute (2019).
[36] Rodrik (2016). See also Hallward-Driemeier and Nayyar (2018).
[37] McKinsey Global Institute (2019).

simple commodity exporting to agricultural and food processing and horticulture and can better exploit tourism possibilities. African economies, for example, may have sizable potential for growth in industries that depart from the traditional smokestack manufacturing model of industrialization.[38] The new technologies offer leapfrogging possibilities in development, such as in education, health, finance, and communications. For example, African economies have seen rapid growth in mobile telephony and pioneered innovations in digital finance to link large populations to financial markets and the formal economy.

New challenges for public policy

The digital revolution and the latest advances in AI are transformative in their implications for markets and economies. The implications for public policy are equally significant. As the authors in this report argue, the transformations that are occurring call for new thinking and major adaptations in policies. Indeed, Basu (Chapter 3) makes the case for a radical overhaul of policies and institutions—and points to new challenges for the discipline of economics to better understand the deeper structural shifts that are taking place.[39]

Public policy has been behind the curve on these new challenges. It will need to be more responsive to change in order to better capture potential gains in productivity and economic growth from the new technologies and combat rising inequality. Large and persistent increases in inequality are not a pre-ordained outcome of technological change. More inclusive outcomes are certainly possible if public policy plays its part. The digital economy must be broadened from its narrow confines to enable wider segments of firms and workers to contribute to and share in its promise.

Public policy to reduce inequality is often viewed narrowly in terms of redistribution—taxes and transfers. This is indeed an important element, especially in view of the erosion of the state's redistributive role in recent decades as tax progressivity declined and social programs felt the pressure of tighter fiscal constraints. In particular, systems for taxing income and wealth should be bolstered in light of the new distributional dynamics. But, as the authors in this report point out, there is a much broader policy agenda of "predistribution" that can make the growth process itself more inclusive—by improving opportunities for and capabilities of smaller firms and less-skilled workers as technology transforms product and labor markets. Such reforms can reduce inequality and economic insecurity more effectively than fiscal redistribution alone.[40] Much of the reform agenda to achieve more inclusive growth from technological change is also an agenda to achieve stronger growth, given the linked dynamics between the recent rise in inequality and the slowdown in productivity (as discussed above).[41]

One area of reform is business regulation, especially competition policy that needs a revamp to ensure that markets continue to provide an open and level playing field and check the growth of monopolistic structures in the digital era. Basu (Chapter 3) notes the need to realign antitrust laws with the new market dynamics, with a view to protecting not just consumers but also small businesses and workers. Other new

[38] Newfarmer et al. (2019).
[39] On these new challenges for the economics discipline and policymaking, see also Agrawal et al. (2019).
[40] The term "predistribution," coined by Jacob Hacker (2011), embodies the idea that public policy should try to prevent high income inequality from occurring in the first place rather than reducing it through the tax and transfer system once it has occurred, as happens under redistribution.
[41] For a discussion of the reform agenda to combat inequality along similar thematic lines, see also Blanchard and Rodrik (2021) and Rodrik and Stantcheva (2021).

regulatory challenges of the digital economy that should be addressed include issues relating to the regulation of data (the lifeblood of the digital economy), digital platforms that have emerged as gatekeepers in the digital world, and market concentration resulting from tech giants that resemble natural or quasi-natural monopolies because of economies of scale and network effects associated with digital technologies. In Europe, steps are being taken to address some of this reform agenda—the General Data Protection Regulation enacted in 2018 and the forthcoming Digital Services Act and Digital Markets Act.[42] Some reform momentum has been building also in the United States but legislative success so far has remained elusive.

The authors also consider broader systemic reform. Autor (Chapter 2) suggests a shift from pure shareholder capitalism toward broader stakeholder capitalism, emphasizing the need to better balance narrow shareholder interests with worker interests.[43] Basu (Chapter 3) considers some more radical ideas to widen stock ownership and profit sharing, especially as automation shifts income from labor to capital.

Another key area of reform is adapting education and training systems to put more emphasis on skills—cognitive, technical, professional, managerial—that will be in demand in the digital era, as emphasized by Autor (Chapter 2) and Basu (Chapter 3). Programs for worker upskilling, reskilling, and lifelong learning should be boosted, including expanded partnerships with employers. The role of the institutions of formal learning will remain important in the digital age, but the role of the firm in adapting and updating the skills of their workers will take on added significance. Also, persistent inequalities in access to education and (re)training must be addressed. While gaps in basic capabilities across income groups have narrowed, those in higher-level capabilities that will drive success in the 21st century are widening.[44] The potential of technology-enabled solutions such as online learning should be better harnessed. Reducing the digital divide by investing in a stronger foundation of digital infrastructure and literacy will enable wider societal access to new opportunities in the digital economy, in learning as well as in business.

Improvements in labor market institutions—labor standards, minimum wage laws, collective bargaining—are important to ensure that workers get a fair share of economic returns, especially at a time of rising market power of dominant firms (Autor, Chapter 2). Unemployment insurance schemes should better support workers in adjusting to change, retraining, and transitioning to new jobs. Worker benefits systems, covering benefits such as pensions and health care, which traditionally have been based on formal long-term employer-employee relationships, will need to adjust to a job market characterized by more frequent job transitions and more diverse work arrangements (including an expanding gig economy). How social contracts provide opportunity, risk sharing, and security needs to be rethought for the digital age.

Policymakers also need to pay attention to the innovation system itself that generates new technologies (Autor, Chapter 2; Rodrik, Chapter 4). Policy-created distortions, such as high taxation of labor relative to capital, that bias innovation toward "excessive automation"—that destroys jobs without enhancing productivity—should be corrected.[45] Flagging public investment in research and development (R&D) should be revitalized to strengthen support for innovation that serves broader economic and social goals rather than the interests of narrow groups of investors, including more labor-friendly innovation. Aging patent systems should be updated to the new innovation dynamics of the digital economy, better balancing

[42] European Union (2020).
[43] See also Schwab (2021).
[44] United Nations (2019).
[45] Acemoglu et al. (2020) find that, in the United States, labor is taxed much more heavily than capital and that this difference has increased in recent years. They estimate that the U.S. effective tax rate in the 2010s was 25.5-33.5 percent for labor and 5-10 percent for capital. See also Acemoglu and Restrepo (2020) and Saez and Zucman (2019).

incumbent interests with the wider promotion and diffusion of innovation.[46] In today's increasingly knowledge-driven economies, it is not only the capacity of the innovation ecosystem to spur new knowledge and technological advances but also to disseminate them widely that will matter more.

Developing countries face the challenge of recalibrating their growth models as technology disrupts traditional pathways to development. As possibilities for manufacturing to continue to absorb large numbers of low-skilled workers in higher-productivity jobs diminish, the creation of higher-quality jobs in services will become more important. In what Rodrik (Chapter 4) terms the "good-jobs development model," productivity growth and employment generation will depend increasingly, not on just a few large leading firms in manufacturing, but on improving the prospects of the many small and medium enterprises that employ the bulk of the labor force at the bottom of the skill distribution and that are mostly engaged in services.

Upgrading the workforce, developing skills complementary to digital technologies, and building a stronger digital infrastructure will be important, both for success in continuing to capture growth opportunities in the changing landscape of manufacturing and for success in developing high-end, higher-productivity services. At the same time, developing countries need to step up their own R&D efforts to adapt the new technologies to better fit their factor endowments, so that they complement less-skilled labor rather than replace it. Rodrik (Chapter 4) calls for more attention to the development of "appropriate technology." Drawing an analogy with the successful efforts by developing countries several decades ago to adapt to their conditions innovations in agriculture originally developed in advanced countries, Acemoglu (2020) says that they now need a Green Revolution for AI and digital technologies.

Much of the above policy agenda to make technology work better for all lies at the national level, but there are new challenges also at the international level. Not only must past gains in establishing a rules-based international trading system be shielded from increased protectionist pressures and ascendant nationalist populism; new rules and cooperative arrangements must be devised to ensure open access and competition in the next phase of globalization led by digital flows. This includes adequate disciplines for digital trade, digitally deliverable services, data privacy and security, digital intellectual property, and tech giants and digital platforms that can affect competition across national markets. International cooperation on tax matters is important in a world of high capital mobility; it becomes even more so in view of the new tax challenges of the digital economy.

Over the years, global policymaking and institutions have not kept pace with advancing globalization and structural transformations in the global economy. They now face the challenge of catching up with rapid digital globalization. Putting in place a framework for global digital governance will be central to realigning global economic governance with today's needs. In Chapter 3, Basu underscores the need to refit global governance, outlining a broader, more ambitious vision.[47]

Conclusion

The title of this report poses a question: can an inclusive future be envisioned in the digital era? The answer to that question is yes. The challenge lies in harnessing transformative change spawned by the digital revolution to promote broad-based improvements in economic prosperity. Public policy in general has

46 "The copyright and patent laws we have today look more like intellectual monopoly than intellectual property" (Lindsey and Teles, 2017). See also Qureshi (2020b).
47 See also Schwab (2019).

been slow to rise to the challenge. Policies have lagged shifting growth and distributional dynamics as technology reshaped markets, business models, and the nature of work. The result has been both a failure to capture the full productivity potential of the new technologies and a failure to counteract some of the consequences of these technologies that increase economic inequality. With more responsive policies, better outcomes are possible.

The reform agenda spans product and labor markets to enable broader participation of firms and workers in the opportunities created by the new technologies. It includes competition policy and regulatory frameworks, education and training, labor market policies and social protection, and policies to reduce the digital divide. It also includes tax policy reform. A theme unifying much of this reform agenda is that, in capturing the full promise of digital transformation, economic growth and inclusion are not competing but complementary objectives.

In many of these areas of national policy reform, more research, fresh thinking, and experimentation will be needed in light of the profound technology-driven changes the economies are facing. At the international level, new global frameworks and rules will be needed as globalization goes increasingly digital.

Technology can potentially slow global economic convergence by altering patterns of comparative advantage. But as it disrupts some traditional pathways to growth and development, it also offers new opportunities for developing countries that successfully adapt their growth models to the new technological paradigm.

Adapting to the new technologies is a big challenge for policymakers. But that is not the only challenge. A related challenge is to shape technological change itself to put it to work for broader groups of people and better meet the needs and interests of economies and societies.

References

Acemoglu, Daron (2020). "How the Other Half Automates," *Project Syndicate,* April 24, 2020.

Acemoglu, Daron, Andrea Manera, and Pascual Restrepo (2020). "Does the U.S. Tax Code Favor Automation?" *Brookings Papers on Economic Activity,* Spring 2020.

Acemoglu, Daron, and Pascual Restrepo (2020). "The Wrong Kind of AI? Artificial Intelligence and the Future of Labor Demand," *Cambridge Journal of Regions, Economy and Society*, 13(1):25– 35.

Acemoglu, Daron, and Pascual Resptrepo (2021). "Tasks, Automation, and Rise in U.S. Wage Inequality," NBER Working Paper 28920, National Bureau of Economic Research, Cambridge, MA.

Agrawal, Ajay, Joshua Gans, and Avi Goldfarb (Eds.) (2019). *The Economics of Artificial Intelligence: An Agenda,* University of Chicago Press.

Akamatsu, Kaname. 1962. "A Historical Pattern of Economic Growth in Developing Countries." The Developing Economies 1, no. S1, pp. 3–25.

Akcigit, Ufuk, and Sina Ates (2019). "What Happened to U.S. Business Dynamism?" NBER Working Paper 25756, National Bureau of Economic Research, Cambridge, MA.

Akcigit, Ufuk, Wenjie Chen, Federico Díez, Romain Duval, Philipp Engler, Jiayue Fan, Chiara Maggi, Marina Tavares, Daniel Schwarz, Ippei Shibata, and Carolina Villegas-Sánchez (2021). *Rising Corporate Market Power: Emerging Policy Issues.* IMF Staff Discussion Note SDN/21/01, International Monetary Fund, Washington, DC.

Andrews, Dan, Chiara Criscuolo, and Peter Gal (2016). "The Best Versus The Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy," *OECD Productivity Working Paper,* No. 5, OECD Publishing, Paris.

Autor, David, David Mindell, and Elisabeth Reynolds (2019). *The Work of the Future: Shaping Technology and Institutions,* MIT Task Force on the Work of the Future, Cambridge, MA.

Autor, David, David Dorn, Lawrence Katz, Christina Patterson, and John Van Reenen (2020). "The Fall of the Labor Share and the Rise of Superstar Firms," *Quarterly Journal of Economics,* 135 (2): 645-709.

Autor, David, Claudia Goldin, and Lawrence Katz (2020). "Extending the Race between Education and Technology," *AEA Papers and Proceedings,* Vol.10: 347–51.

Autor, David, David Dorn, and Gordon Hanson (2021). "On the Persistence of the China Shock." *Brookings Papers on Economic Activity*, forthcoming.

Azar, José, Ioana Marinescu, and Marshall Steinbaum (2017). "Labor Market Concentration," NBER Working Paper No. 24147, National Bureau of Economic Research, Cambridge, MA.

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

Blanchard, Olivier, and Dani Rodrik (Eds.) (2021). *Combating Inequality: Rethinking Government's Role,* MIT Press.

Bourguignon, François (2022). "Digitalization and Inequality," in *Shifting Paradigms: Growth, Finance, Jobs, and Inequality in the Digital Economy,* Zia Qureshi and Cheonsik Woo (Eds.), Brookings Institution Press.

Brookings Institution and Chumir Foundation (2019). *Productive Equity: The Twin Challenges of Reviving Productivity and Reducing Inequality.* Report. Washington, DC.

Brynjolfsson, Erik, Daniel Rock, and Chad Syverson (2017). "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics," NBER Working Paper 24001, National Bureau of Economic Research, Cambridge, MA.

Calvino, Flavio, and Chiara Criscuolo (2022). "Going Digital: Technology Diffusion in the Digital Era," in *Shifting Paradigms: Growth, Finance, Jobs, and Inequality in the Digital Economy,* Zia Qureshi and Cheonsik Woo (Eds.), Brookings Institution Press.

Chancel, Lucas, Thomas Piketty, Emmanuel Saez, Gabriel Zucman et al. (2022). *World Inequality Report 2022,* World Inequality Lab wir2022.wid.world.

Chernoff, Alex and Casey Warman (2020). "COVID-19 and Implications for Automation," NBER Working Paper 27249, National Bureau of Economic Research, Cambridge, MA.

Chetty, Raj, David Grusky, Maximilian Hell, Nathaniel Hendren, Robert Manduca, and Jimmy Narang (2017). "The Fading American Dream: Trends in Absolute Income Mobility since 1940," *Science,* 356 (6336): 398-406.

Council of Economic Advisers (2016). "Labor Market Monopsony: Trends, Consequences, and Policy Responses," The White House, Washington DC.

Coulibaly, Brahima, and Karim Foda (2020). "The Future of Global Manufacturing," in *Growth in a Time of Change: Global and Country Perspectives on a New Agenda,* Hyeon-Wook Kim and Zia Qureshi (eds.), Brookings Institution Press.

Crouzet, Nicolas, and Janice Eberly (2019). "Understanding Weak Capital Investment: The Role of Market Concentration and Intangibles," NBER Working Paper 25869, National Bureau of Economic Research, Cambridge, MA.

De Loecker, Jan, Jan Eeckhout, and Gabriel Unger (2020). "The Rise of Market Power and the Macroeconomic Implications," *Quarterly Journal of Economics,* 135 (2): 561-644.

Derviş, Kemal, and Zia Qureshi (2016). "The Productivity Slump – Fact or Fiction: The Measurement Debate," Research Brief, Brookings, Washington, DC.

Eggertsson, Gauti, Jacob Robbins, and Ella Getz Wold (2021. "Kaldor and Piketty's Facts: The Rise of Monopoly Power in the United States," *Journal of Monetary Economics,* 124(Supplement): S19-S38.

European Union (2020). *Shaping Europe's Digital Future,* European Commission, Luxembourg.

Furman, Jason, and Peter Orszag (2018). "Slower Productivity and Higher Inequality: Are They Related?" Working Paper 18-4, Peterson Institute for International Economics, Washington, DC.

Hacker, Jacob (2011). "The Institutional Foundations of Middle Class Democracy," *Policy Network,* May 6, 2011.

Hallward-Driemeier, Mary, and Gaurav Nayyar (2018). *Trouble in the Making? The Future of Manufacturing-Led Development,* World Bank, Washington, DC.

Haskel, Jonathan, and Stian Westlake (2017). *Capitalism without Capital: The Rise of the Intangible Economy,* Princeton University Press.

Holzer, Harry (2022). "Automation, Jobs, and Wages: Should Workers Fear the New Automation," in *Shifting Paradigms: Growth, Finance, Jobs, and Inequality in the Digital Economy,* Zia Qureshi and Cheonsik Woo (Eds.), Brookings Institution Press.

International Monetary Fund (2017). *World Economic Outlook,* April 2017, Chapter 3 on "Understanding the Downward Trend in Labor Income Shares," Washington, DC.

Khan, Lina (2017). "Amazon's Antitrust Paradox," *Yale Law Journal* 126, no. 3, pp. 710-805.

Korinek, Anton, and Joseph Stiglitz (2021). "COVID-19 Driven Advances in Automation and Artificial Intelligence Risk Exacerbating Economic Inequality," *BMJ,* 2021;372:n367.

Lane, Marguerita, and Anne Saint-Martin (2021). The Impact of Artificial Intelligence on the Labor Market: What Do We Know So Far? OECD Social, Employment, and Migration Working Papers, No. 256, OECD Publishing, Paris.

Lindsey, Brink, and Steven Teles (2017). *The Captured Economy: How the Powerful Enrich Themselves, Slow Down Growth, and Increase Inequality,* Oxford University Press.

McKinsey Global Institute (2015). *Digital America: A Tale of the Haves and Have-Mores,* McKinsey & Company.

McKinsey Global Institute (2019). *Globalization in Transition: The Future of Trade and Value Chains,* McKinsey & Company.

McKinsey Global Institute (2021). *The Future of Work after COVID-19,* McKinsey & Company.

Newfarmer, Richard, John Page, and Finn Tarp (2019). *Industries without Smokestacks: Industrialization in Africa Reconsidered,* Oxford University Press.

Organization for Economic Cooperation and Development (2018). *OECD Economic Outlook,* Volume 2018, Issue 2, Chapter 2 on "Decoupling of Wages from Productivity: What Implications for Public Policies?" OECD Publishing, Paris.

Philippon, Thomas (2019). *The Great Reversal: How America Gave Up on Free Markets,* Harvard University Press.

Piketty, Thomas (2014). *Capital in the Twenty-First Century,* Harvard University Press.

Qureshi, Zia (2018). "Intellectual Property, Not Intellectual Monopoly," *Project Syndicate,* July 11, 2018.

Qureshi, Zia (2019). "The Rise of Corporate Market Power," *Up Front,* May 21, 2019, Brookings, Washington, DC.

Qureshi, Zia (2020a). "Inequality in the Digital Era," in *Work in the Age of Data,* BBVA, Madrid.

Qureshi, Zia (2020b). "Democratizing Innovation: Putting Technology to Work for Inclusive Growth," Report, Brookings, Washington, DC.

Qureshi, Zia, and Cheonsik Woo (2022). "Overview: Digital Metamorphosis and Economic Change," in *Shifting Paradigms: Growth, Finance, Jobs, and Inequality in the Digital Economy,* Zia Qureshi and Cheonsik Woo (Eds.), Brookings Institution Press.

Rodrik, Dani (2016). "Premature Deindustrialization," *Journal of Economic Growth,* 21(1): 1-33.

Rodrik, Dani, and Stefanie Stantcheva, (2021). "Economic Inequality and Insecurity: Policies for an Inclusive Economy," Report prepared for International Commission chaired by Olivier Blanchard and Jean Tirole on Major Future Economic Challenges, Republic of France, June 2021.

Saez, Emmanuel, and Gabriel Zucman (2019). *The Triumph of Injustice: How the Rich Dodge Taxes and How to Make Them Pay,* W.W. Norton.

Schwab, Klaus (2019). "Globalization 4.0: A New Architecture for the Fourth Industrial Revolution," *Foreign Affairs,* January 2019.

Schwab, Klaus (2021). *Stakeholder Capitalism: A Global Economy that Works for Progress, People, and Planet.* World Economic Forum. Wiley, New Jersey.

Schwellnus, Cyrille, Mathilde Pak, Pierre-Alain Pionnier, and Elena Crivellaro (2018). "Labor Share Developments over the Past Two Decades: the Role of Technological Progress, Globalization and "Winner-Takes-Most" Dynamics," Economics Department Working Paper, No. 1503, OECD Publishing, Paris.

Shambaugh, Jay, Ryan Nunn, Patrick Liu, and Greg Nantz (2017). "Thirteen Facts about Wage Growth," The Hamilton Project, Brookings, September 2017.

Spence, Michael (2021). "Winners and Losers in the Digital Transformation of Work," *Project Syndicate,* February 25, 2021.

Stansbury, Anna, and Lawrence Summers (2018). "Productivity and Pay: Is the Link Broken?" Working Paper No. 18-5, Peterson Institute for International Economics, Washington, DC.

Taylor, Lance, with Özlem Ömer (2020). *Macroeconomic Inequality from Reagan to Trump: Market Power, Wage Repression, Asset Price Inflation, and Industrial Decline,* Cambridge University Press.

Temin, Peter (2017). *The Vanishing Middle Class: Prejudice and Power in a Dual Economy,* MIT Press.

Tepper, Jonathan (2019). *The Myth of Capitalism: Monopolies and the Death of Competition,* Wiley & Sons.

United Nations (2019). *Human Development Report 2019: Beyond Income, Beyond Averages, Beyond Today - Inequalities in Human Development in the 21st Century,* New York.

West, Darrell, and John Allen (2020). *Turning Point: Policymaking in the Era of Artificial Intelligence,* Brookings Institution Press.

2 The labor market impacts of technological change: From unbridled enthusiasm to qualified optimism to vast uncertainty

David Autor[1]

Introduction

Citizens in industrialized countries believe that digital technology is fostering inequality and that this problem is likely to worsen in the decades ahead.[2] Although public and expert opinions often diverge on economic questions, survey data confirm that academic economists share this worry. A 2017 Chicago Booth poll found that 35 to 40 percent of leading U.S. economists believe that robots and artificial intelligence are likely to substantially increase long- term unemployment rates.[3] What is the economic basis for this concern? In this review, I consider the evolution of economic thinking on the relationship between digital technology and inequality across four decades, encompassing four intellectually related but distinct paradigms.

I start from the premise that what workers earn in a market economy depends substantially, though not exclusively, on their productivity–that is, the value they produce through their labor. Their productivity depends in turn on two things: first, their capabilities (concretely, the tasks they can accomplish); and second, their scarcity. The fewer workers that are available to accomplish a given task and the more that employers need that task accomplished by workers (rather than by, for example, machines or algorithms),

[1] This paper has been prepared for the Brookings Institution's Global Forum on Democracy and Technology. I thank Daron Acemoglu, Lauren Fahey, Zia Qureshi, and Bryan Seegmiller for thoughtful comments that improved the paper.
[2] Smith and Anderson (2017); Wike and Stokes (2018).
[3] See https://www.igmchicago.org/surveys/robots-and-artificial-intelligence-2/. European economists are somewhat less pessimistic, however. See https://www.igmchicago.org/surveys/robots-and-artificial-intelligence/

the higher is the workers' economic value and thus their potential earnings. In conventional terms, the skill premium depends upon the supply of skills and the demand for skills.

Stated in these terms, what is the role of technology–digital or otherwise–in determining wages and shaping wage inequality? The answer is not obvious, and the successive evolution of thinking on this topic reflects the subtlety of the question. I present four answers below, corresponding to four strands of thinking on this topic, and discuss the distinct implications of each. I refer to these four paradigms as the education race, the task polarization model, the automation-reinstatement race, and the era of Artificial Intelligence uncertainty. The nuance of economic understanding has improved across each of these epochs. Yet, traditional economic optimism about the beneficent effects of technology for productivity and welfare has eroded as understanding has advanced. Given this intellectual trajectory, it would be natural to forecast an even darker horizon ahead. I refrain from doing that, however, because forecasting the "consequences" of technological change treats the future as a fate to be divined rather than an expedition to be undertaken. I conclude by discussing the opportunities and the challenges we collectively face in shaping this future.

The education race

Perhaps the most influential conceptual frame for understanding how technology shapes wage inequality originates with a short article published in 1974 by Dutch economist and Nobel Laureate, Jan Tinbergen, and subsequently popularized by Goldin and Katz's magisterial book.[4] Tinbergen was intrigued by the observation that the wages of Dutch workers with post-high school education (which he called 'third-level' education) had been rising over the course of many decades despite vast increases in their supply. This pattern is hard to rationalize in a standard competitive setting since it seemingly implies that the demand curve for skilled labor is *upward* sloping.

To interpret these facts, Tinbergen offered a simple but remarkably powerful analogy. Modern economies face an ongoing race between the demand for and supply of skill, with technological change propelling the demand curve outward and the educational system racing to push the supply curve outward to match it.[5] In this telling, when the demand curve pulls ahead in the race, inequality between more and less-educated workers—college and non-college workers in the contemporary setting–rises, since more-educated workers are becoming relatively scarce. Conversely, when the supply of college-educated workers surges, as occurred during the 1970s, for example, when American men could defer the Vietnam draft by enrolling in college,[6] earnings inequality between college and non-college workers falls. Notably, there is no "equilibrium" quantity of education that holds inequality constant in this framework. Rather, technologically advancing countries must keep raising educational attainment cohort by cohort to keep pace with the moving target of rising skill demands. Or, quoting Lewis Carroll's Red Queen, "it takes all the running you can do, to keep in the same place."

[4] Tinbergen (1974) and Goldin and Katz (2008). Seminal work by Robert Solow in the 1950s demonstrated that technological progress was the central force behind rising aggregate productivity. But Solow did not consider inequality. "Labor" is an undifferentiated commodity in the Solow-Swan model, meaning that wage inequality was not a meaningful construct in this model.

[5] In Tinbergen's words, there is a "'race' between the demand for skill—that is, demand for third-level manpower—driven by technological development and supply of it due to increased schooling."

[6] Card and Lemieux (2001b).

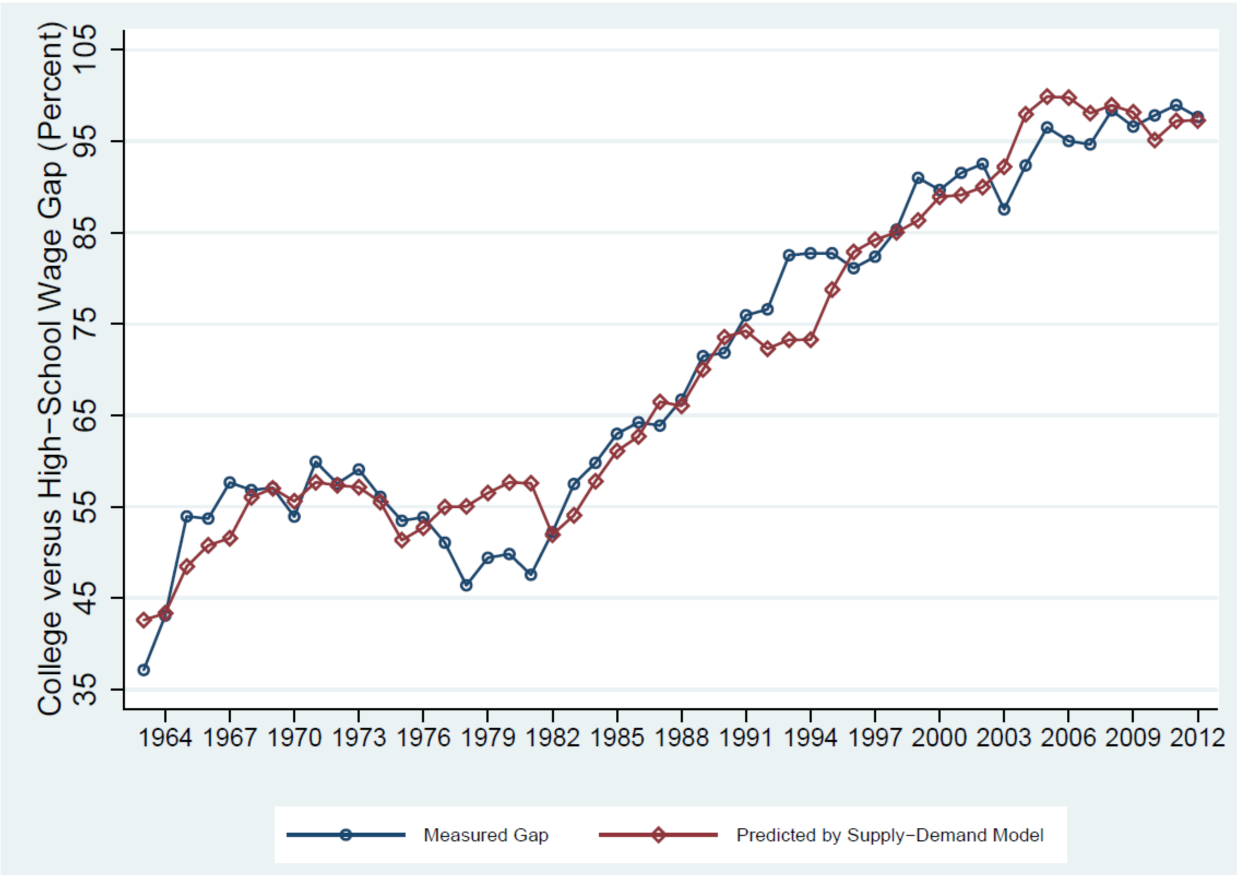
Tinbergen's metaphor of a race between education and technology, now formalized mathematically, has proved remarkably powerful. A series of papers and books, commencing with Katz and Murphy (1992), demonstrates that the evolution of inequality between education groups (generally, college-educated versus non-college) in many advanced countries is remarkably well explained by two forces: steadily rising demand for college workers, who are needed to perform increasingly sophisticated and skill-intensive jobs (presumably, the technological developments that Tinbergen had in mind); and booms and busts in the rate of college attendance among young adults that affect supply.[7]

Figure 1, reproduced from Autor (2014), illustrates the capacity of this simple model to rationalize the evolution of the U.S. college/high-school earnings premium over the nearly five decades between 1963–2012. The model can explain both why the college premium fell during the 1970s as the rate of college attainment was rising rapidly, and further, why the college premium surged in the 1980s when college attainment of younger cohorts of U.S. adults plateaued. In fact, this model can in broad brushstrokes explain the evolution of inequality between college and non-college workers in the U.S. over the course of nearly two centuries.[8]

Of course, the college versus non-college earnings premium is only one component of wage inequality; most earnings inequality occurs among workers of the same education levels. The data show, however, that the growth of educational earnings gaps is the predominant contributor to rising earnings inequality over the last four decades. Specifically, Autor et al. (2020b) estimate that the growth of education-earnings differentials explains approximately 60 percent of the growth of overall earnings inequality between 1980 and 2017 and 40 percent of the growth between 2000 and 2017. Hence, if we can understand the causes of rising educational earnings inequality, we understand a lot about the sources of the overall rise in earnings inequality.

[7] This model is further developed, elaborated, and applied in Autor et al. (2020b, 2008, 1998); Card and Lemieux (2001a); Goldin and Katz (2008); Goldin et al. (2007); Goldin and Margo (1992); and Katz and Autor (1999).
[8] Cf. Autor et al. (2020b).

Figure 1: Supply of college graduates and U.S. college-high school premium, 1963–2012



Source: Autor (2014).
Note: Figure uses March CPS data for earnings years 1963 to 2012. The series labeled "Measured Gap" is constructed by calculating the mean of the natural logarithm of weekly wages for college graduates and non-college graduates and plotting the (exponentiated) ratio of these means for each year. This calculation holds constant the labor market experience and gender composition within each education group. The series labeled "Predicted by Supply-Demand Model" plots the (exponentiated) predicted values from a regression of the log college/non-college wage gap on a quadratic polynomial in calendar years and the natural log of college/non-college relative supply. See Autor (2014) for details.

The empirical success of the education-race model raises a foundational question: What is it about technology that raises the demand for better-educated workers? The model does not directly address this question. Taken (too) literally, it portrays technological progress as an autonomous force that intrinsically makes highly educated workers more productive and hence more in demand. To be sure, researchers have added considerable nuance to this framework as they have applied it. For example, Goldin and Katz (1998, 2008) offer theory and detailed historical evidence that early industrial-age factories primarily demanded *less-skilled* workers. But as factories adopted continuous-process methods requiring sophisticated machinery, they increasingly demanded more educated workers with the expertise needed to operate these sophisticated factories.[9] The education race model's simplicity is both a strength and a limitation. The model can explain much with little—specifically, the evolution of two centuries of educational

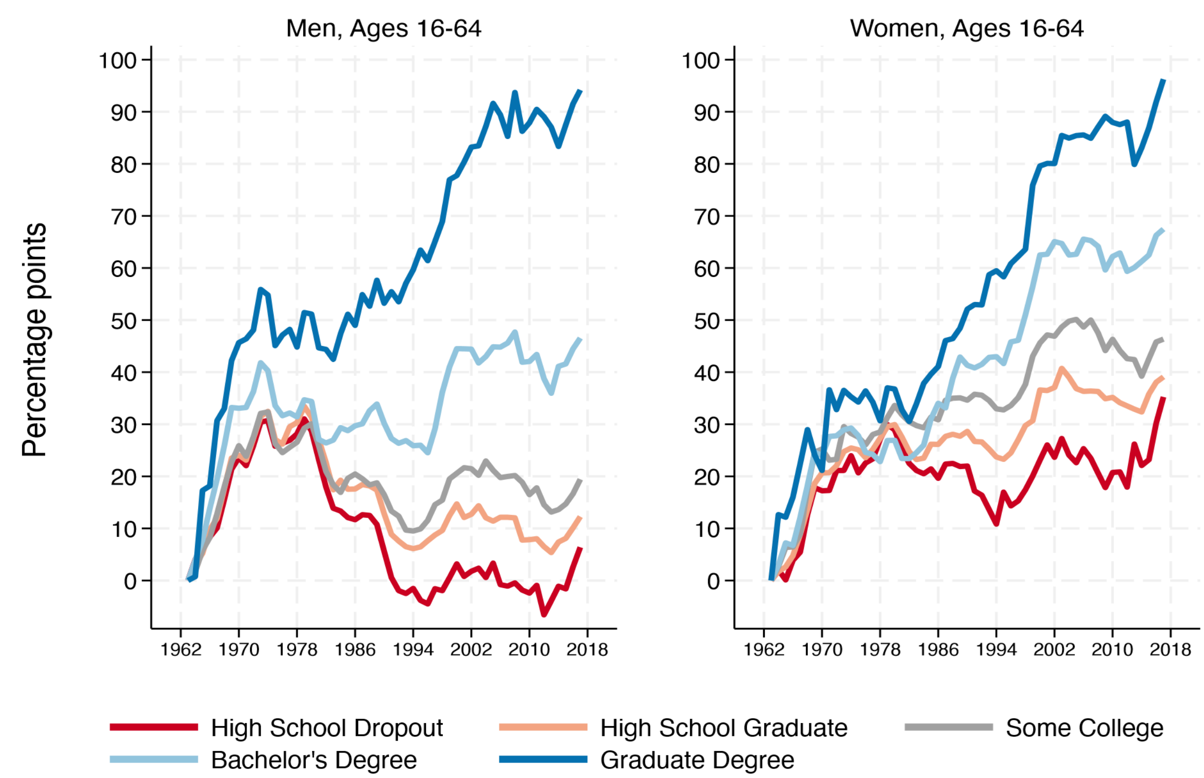
[9] In a related vein, Krusell et al. (2000) argue that technological change became more skill-demanding when improvements in the quality-adjusted price of industrial equipment accelerated in the 1970s.

inequality as a function of only two factors: changes in educational supply and an ongoing (though not directly measured) technologically-propelled increase in educational demand. The limitation is that the model lacks an underlying notion of *why* technology affects skill demand. Specifying this notion is left to successor models that build on Tinbergen's foundation.

Beyond its simplicity, another feature of the education-race model has proven conceptually appealing but less empirically relevant. Technological change in the education-race model, *as conventionally applied,* affects labor demand only by *raising* (i.e., augmenting) the productivity of specific skill groups (e.g., college or non-college workers). In economic terms, this means that technological change in the simplest education-race model is *factor-augmenting*—it makes at least some workers better at the work that they do. The labor market impacts of factor-augmenting technological change are somewhere between benign and benevolent: benign because no worker is made directly worse off (setting aside envy or other social externalities); and benevolent because, under conventional assumptions, *all* workers benefit from technological progress, at least to some degree.[10] Thus, although technological change can raise inequality in the education-race framework (i.e., when demand surges ahead of supply), it does so by augmenting some workers more than others—which is not a terrible problem to have.

[10] Formally, all workers necessarily benefit so long as capital is elastically supplied and college and non-college workers are (at least) weakly substitutable for one another, meaning that when a skill group becomes more productive (e.g., due to technological augmentation), employers demand more of that group. Considerable evidence supports the assumption that college and non-college workers are substitutable in this sense (Katz and Autor, 1999).

Figure 2: Cumulative percentage point changes in real mean weekly earnings of full-time, full-year workers ages 18–64, United States, 1963–2017



Source: Autor (2019).
Note: Figure uses March Current Population Survey Annual Social and Economic Supplement data for earnings years 1963 to 2017. Series correspond to percentage point changes since 1963 in (composition-adjusted) exponentiated mean real (constant $2019) log wages for each group, using data on full-time, full-year workers ages 16 to 64. Data are sorted into sex-education-experience groups of two sexes, five education categories (high school dropout, high school graduate, some college, college graduate, and post-college degree), and four potential experience categories (0–9, 10–19, 20–29, and 30–39 years). Educational categories are harmonized following the procedures in Autor et al. (2008). Log weekly wages of full-time, full-year workers are regressed in each year separately by sex on dummy variables for four education categories, a quartic in experience, three region dummies, black and other race dummies, and interactions of the experience quartic with three broad education categories (high school graduate, some college, and college plus). The (composition-adjusted) mean log wage for each of the 40 groups in a given year is the predicted log wage from these regressions evaluated for whites, living in the mean geographic region, at the relevant experience level (5, 15, 25, or 35 years, depending on the experience group). Mean log wages for broader groups in each year represent weighted averages of the relevant (composition-adjusted) cell means using a fixed set of weights, equal to the mean share of total hours worked by each group over 1963–2005. All earnings numbers are deflated by the chain-weighted (implicit) Personal Consumption Expenditure price deflator and exponentiated for plotting purpose. Earnings of less than 67 per week in 1982 dollars are dropped. Allocated earnings observations are excluded in earnings years 1967 forward using either family earnings allocation flags (1967–1974) or individual earnings allocation flags (1975 earnings year forward).

This implication of the model—that technological change at least weakly augments every worker's productivity—is not well supported by the data. Figure 2, reproduced from Autor (2019), depicts the steep rise of earnings inequality by education group. Between 1979 and 2017, the real weekly earnings of full-time, full-year working men with a post-baccalaureate degree rose by 43 percent, and earnings for men with a four-year degree but no graduate study rose by 12 percent. Conversely, real earnings *fell* substantially among men without a four-year degree: by 10 percent among men with some-college; by 21 percent among men with exactly a high school diploma; and by 25 percent among men without a high school diploma (real earnings rose among women of all educational levels, though the increases were very modest among the least educated women). *If* the supply of non-college men and women had increased steeply in this period, these earnings declines could be consistent with the education-race model. But in reality, the share of working-age adults possessing less than a four-year degree dropped sharply.[11] All else equal, this should have raised the relative wage of non-college workers, yet the opposite occurred.

Though not the standard approach, it is entirely possible to generalize the education-race model so that technological change can either augment or replace factors. Specifically, one can introduce factor-replacing technological change that reduces the real wages of non-college workers by reallocating tasks from non-college to college workers (or vice versa). The task polarization model, outlined below, provides a foundation for understanding when and why such task reallocation might occur.

In short, while the rising wages of college-educated workers in the face of rising relative supply is consistent with the education-race model—corresponding to a case in which technology pushes demand outward faster than supply is rising—the substantial, sustained fall in the real earnings of non-college workers is less consistent with this model. Other factors aside from technology may be at play, of course, such as declining unionization, falling real minimum wages, or accelerating globalization. Nevertheless, I will argue below that technological change is at least partly responsible, but not in a form that is easily captured in the canonical education-race model.

The task-polarization model

Building on this conceptual foundation, a subsequent literature takes up a central question that the education-race model leaves unanswered: *Why* do recent waves of technology appear to complement more-educated workers?[12] In answering this question, this research helps to explain why the real earnings of some skill groups have fallen, even while technological change has augmented the productivity and earnings of other skill groups. In short, this framework offers a more nuanced but less benign view on the effects of technological change on earnings levels, inequality, and the value of skills.

The starting point of the task-polarization model ("task model") is to conceptualize the process of accomplishing a job as performing a series of tasks. For example, the tasks that go into writing a research paper might include managing a research team, collecting data, developing and testing hypotheses, performing calculations, crafting a report, proofreading that report, and distributing it to recipients. The second step is to ask which tasks will be carried out by machines and which by workers. In the pre-digital era, most research and writing tasks would have been accomplished more or less manually with human labor plus books, calculators, typewriters, and postal mail. Human expertise would also be heavily applied to leading and managing teams, interpreting data, forming and testing hypotheses, and writing the report.

Computerization changes this picture by reallocating many of these tasks from human tasks to machine tasks, for example, collecting (machine-readable) data, performing calculations, proofreading, and distributing the report. Notice that in this new division of labor, computers accomplish a distinctive subset of tasks, those involving routine codifiable activities that can be fully described by a set of rules and procedures, encoded in software, and carried out by non-sentient machines. Tasks such as data gathering

[11] The share of labor hours supplied by workers with high school or lower education fell from more than 75 percent in 1963 to less than 40 percent in 2017. Conversely, the share of labor hours supplied by workers with a bachelor's or post-college degree rose from less than 15 percent to more than 35 percent (Autor, 2019).
[12] Acemoglu and Autor (2011); Autor et al. (2003).

(from machine-readable sources), calculation, and certain types of error-checking are well-suited for computerization because they follow deterministic scripts. Conversely, it has proved far more challenging to program computers to lead teams, develop and test novel hypotheses, draw robust conclusions, and write compelling reports conveying the findings (though this is changing, more on this below). The simple reason is that these tasks are not well described by tightly specified scripts that machines can faithfully execute to achieve successful results—at least, not without substantial reliance on human expertise and judgment. Accordingly, such "non-routine" tasks are performed primarily by workers rather than machines. Paired with computers, workers can focus their efforts primarily on the tasks that machines cannot accomplish, which opens the possibility for faster work, better work, or both.

This simple framing offers two refinements relative to the education-race model. First, it embraces the reality that automation directly *replaces* human labor in accomplishing a subset of tasks—something that does not happen in the canonical education-race model. An immediate implication is that workers whose most valuable skills are collecting data, performing calculations, proofreading documents, etc. are potentially made worse off because computers directly substitute for their skills. Concretely, because the real cost of symbolic processing (i.e., what computers do) has been falling by double-digits annually for decades,[13] what workers can now earn by carrying out these once well-remunerated but now fully automated information processing tasks is essentially zero.[14]

A second strength of the task framework is that it offers a plausible explanation for *why* computerization seems to complement more educated workers. Observe that in the paper-writing example above, many of the tasks that are *not* computerized would be considered high-skill tasks: leading a team, forming a hypothesis, crafting a paper, etc. These "non-routine cognitive" abstract-reasoning (e.g., expert judgment, creativity) and interpersonal (e.g., leadership, management) tasks have proven hard to automate because, simply put, we do not know "the rules." As the philosopher Michael Polanyi observed, "We know more than we can tell,"[15] meaning that there are many things that we regularly accomplish—riding a bicycle, making a compelling argument, recognizing a current friend's face in their baby photograph—that we understand tacitly but not explicitly how to do. People can achieve mastery through tacit knowledge because they learn by doing. A child does not need to read up on the physics of gyroscopes to learn how to ride a bicycle—simple trial and error will do it. For a computer program to successfully accomplish a task, however, the computer programmer must usually specify *all* the relevant steps, branches, and exceptions in advance. For this reason, "non-routine" abstract-reasoning and interpersonal communication tasks have remained largely out of reach for machines (again, until recently).

The argument goes one step further: Not only are abstract-reasoning and communication tasks not substituted by computers, they are generally *complemented*. The productivity and earnings power of workers who specialize in abstract reasoning, expert judgment, and interpersonal interactions and leadership rises as the inputs into their work—information access, analysis, and communication—becomes less expensive and more productive. Thus, computerization increases the productivity of better-educated workers whose jobs rely on information, calculation, problem-solving, and communication, e.g., doctors, architects, researchers, and stock analysts. But this is a double-edged sword: Computerization increases the productivity of highly educated workers by displacing the tasks of the middle-skill workers who in many cases previously provided these information-gathering, organizational, and calculation tasks

[13] Nordhaus (2007).

[14] Concretely, there is no positive price at which an employer would hire someone to add columns of numbers, route telephone calls between exchanges, or look up the current trading price of a group of stocks—yet, these tasks used to comprise many full-time jobs (see Feigenbaum and Gross (2020) on the automation of telephone operators).

[15] Polanyi and Sen (1966).

(e.g., sales workers, office workers, administrative support workers, and assembly line production workers).

However, not all tasks that are hard to automate would be classified as high-skill tasks. Tasks such as waiting tables, cleaning rooms, picking and boxing items, or assisting elderly people to perform acts of daily living, require dexterity, sightedness, simple communications, and common sense, all of which draw on substantial reservoirs of tacit knowledge.[16] Such tasks are commonly found in personal services jobs, e.g., food service, cleaning, security, entertainment, recreation, and personal care. Computerization has generally not substituted for workers in performing such jobs. But neither has it strongly complemented them. Rather, it leaves this work largely untouched, neither automating the central tasks of this job nor augmenting the workers doing it. Moreover, because a large fraction of adults can, with modest training, perform the core tasks of many non-routine manual jobs, such jobs will generally not pay high wages even when demand is rising, except when the labor market is very tight (as is currently the case).

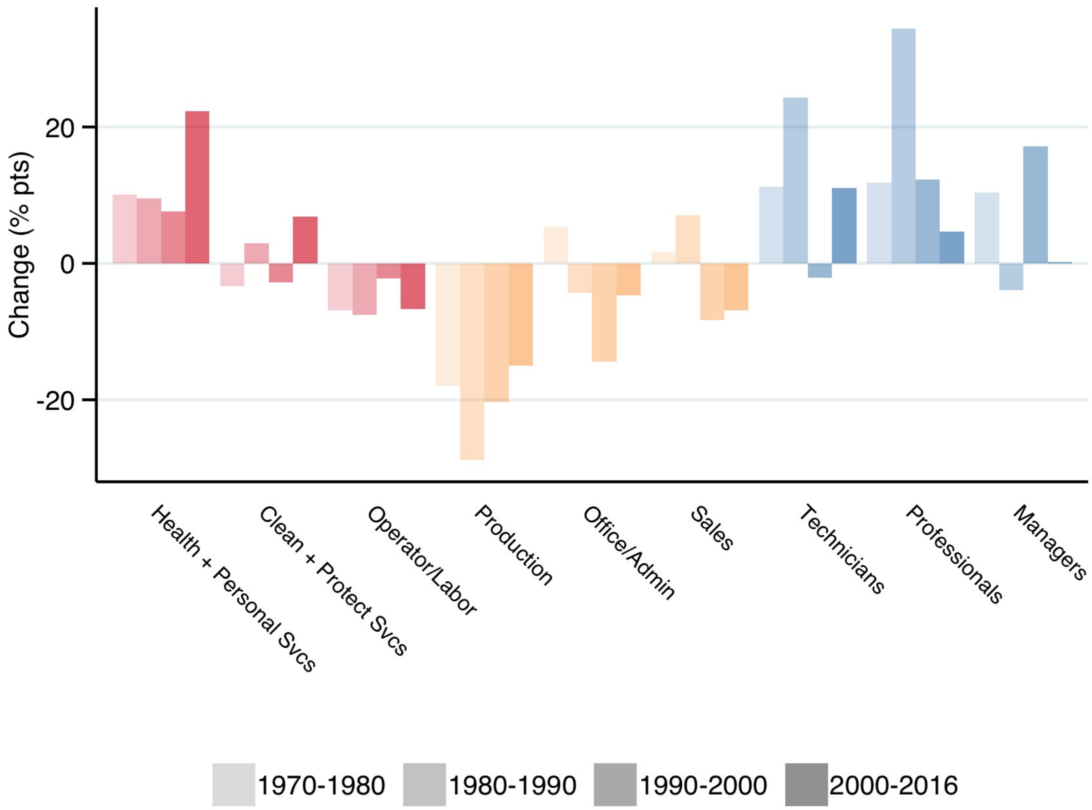
There is now a vast literature testing the task framework empirically, extending it theoretically, and of course, critiquing it vigorously.[17] A central implication of this framework, one that receives ample empirical support, is that across firms, industries, and countries, computerization spurs a “polarization” of job growth into traditionally high-wage and traditionally low-wage occupations at the expense of the middle tier. We see this clearly in the U.S. data: At the high end of the labor market, a growing cadre of high-education, high-wage occupations offer strong career prospects, rising lifetime earnings, and significant employment security. At the other end, low-education, low-wage occupations, often in personal services, provide little economic security and limited career earnings growth. Traditional middle-tier jobs in production, operative, clerical and administrative support, and sales are in decline. Figure 3, reproduced from Autor (2019), documents this pattern for the U.S. Figure 4 shows an analogous pattern in European data over a shorter time period.[18]

[16] A hotel employee cleaning a guest room must determine which items are personal and which are trash. A soda can found on the floor is likely trash; a similarly situated perfume bottle likely fell there by accident.

[17] Acemoglu and Autor (2011); Acemoglu and Restrepo (2021); Autor and Dorn (2013); Autor et al. (2006); Deming (2017); Goos and Manning (2007); Goos et al. (2009, 2014); Gregory et al. (2021); Harrigan et al. (2021); Levy and Murnane (2004); and Michaels et al. (2014).

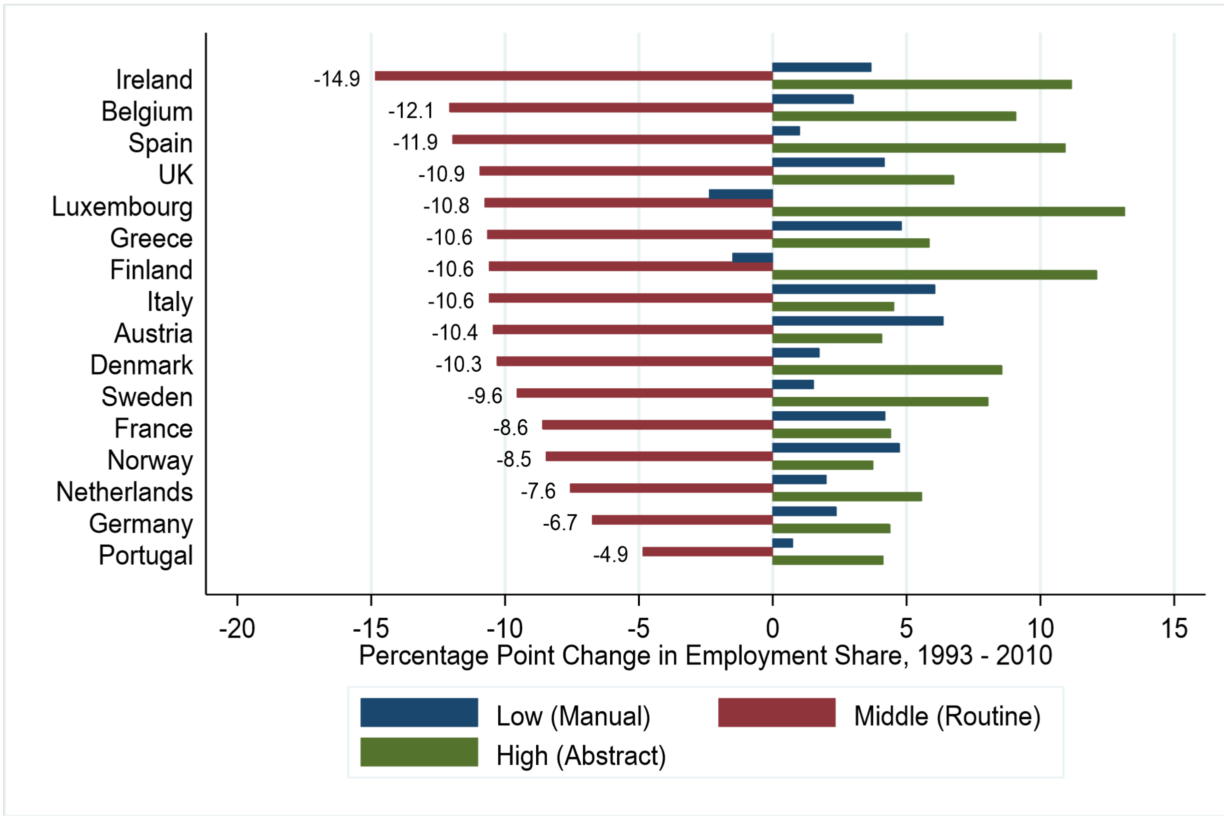
[18] Goos et al. (2014). Polarization does not, however, describe the experience of developing countries, where the skill levels associated with different tasks are quite different and computerization is less pervasive and still relatively expensive in comparison with human labor (Maloney and Molina, 2016).

Figure 3: Percent changes in occupational employment shares among working-age adults, United States, 1970–2016



Source: Autor (2019)
Note: Data source is as in Figure 2. Sample consists of all persons aged 16 to 64 who reported having worked at least one week in the earnings years, excluding those in the military. For each individual, hours worked are the product of usual hours worked per week and the number of weeks worked last year. Individual hours worked are aggregated using CPS sampling weights. Occupational classifications are harmonized following Dorn (2009) and updated through 2017.

Figure 4: Change in occupational employment shares in European Union Countries, 1993–2010

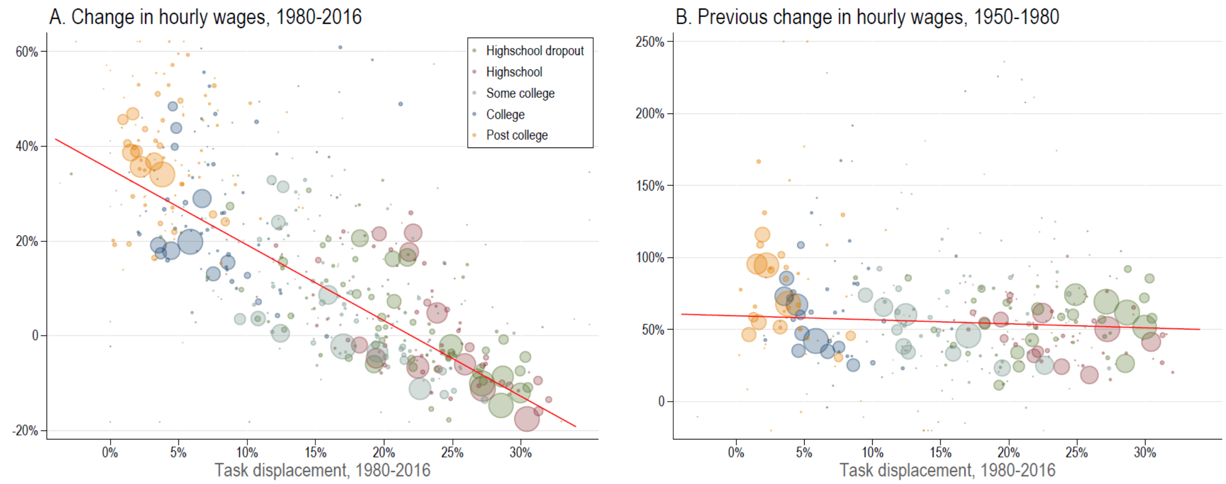


Source: Goos et al. (2014).

The evidence on occupational change is clear. The implications of the task framework for wages are, however, more nuanced. For highly educated workers, those performing non-routine analytic and interpersonal tasks, the task framework unambiguously predicts higher earnings. By the same logic, one might surmise that wages in middle-skill routine-task-intensive occupations should fall while wages in lower-skill service occupations should remain unaffected. This can occur, but the prediction is ambiguous. The reason why is that when wages in middle-skill occupations fall, workers who would otherwise do those jobs will tend to enter previously lower-paid service occupations, thus placing downward pressure on wages in those occupations as well.[19] Thus, while the task model unambiguously predicts the U-shaped pattern of occupational growth seen in Figures 3 and 4, it is formally ambiguous as to whether this also leads to a U-shaped pattern of wage growth.[20]

[19] Some workers will also transition into higher-paid occupations. However, degree and credential requirements for these occupations (e.g., law degree, medical degree, engineering certification) will constrain rapid entry.
[20] Autor and Dorn (2013); Böhm (2020); Böhm et al. (2019).

Figure 5: Exposure to task displacement and changes in real wages by demographic group, United States, 1980–2016 and 1950–1980



Source: Acemoglu and Restrepo (2021).
Note: Each marker corresponds to one of 500 demographic groups, defined by gender, age, education, race, and native/immigrant status. Marker sizes indicate the share of hours worked by each group and different colors indicate education levels.

Recent work by Acemoglu and Restrepo (2021) makes progress on this empirical challenge by taking a fresh approach to measuring wage impacts.[21] Rather than studying wage changes in the occupations that workers do *at present*, they instead study the exposure of different demographic groups to displacement of routine tasks according to the industries and occupations in which these groups worked in 1980, before polarization got underway. The simple idea is that if workers of given education, age, gender, and race/ethnicity tended to work in routine-task-intensive jobs in 1980 (e.g., production occupations, clerical occupations), and the industries that employ them apply computers to automate those tasks, then the onset and evolution of widespread computerization over the ensuing decades would be expected to place downward pressure on their earnings. Evidence for this mechanism is seen in Figure 5, which reports a striking downward sloping relationship between exposure to routine task replacement in 1980 and changes in wages by demographic group between 1980 and 2016 (Panel A). Equally striking is that this downward-sloping relationship is *not* present in the three prior decades, as shown in Panel B. This adds to the case that the negative relationship in Panel A reflects the adverse effect of routine-task displacement on the earnings of workers who, in earlier decades, tended to specialize in routine-task-intensive jobs.

Notice, however, that this evidence does not imply that *most* workers are harmed by computerization. For example, in Panel A of Figure 5, only a subset of workers—those most exposed to task displacement—appear to have lost ground (in real earnings terms) between 1980 and 2016. This subset is almost entirely made up of workers with high school or lower education, consistent with the evidence in Figure 2 that real wages of non-college workers have stagnated or fallen over the last four decades.[22] For the majority of

[21] Kogan et al. (2021) develop an alternative approach to assessing wage impacts by exploiting panel data on the evolution of earnings among individual workers whose occupations are exposed to automation technologies.
[22] In a similar vein, Autor (2019) shows that the polarization of occupational structure primarily reflects the movement of non-college workers out of middle-skill occupations and into traditionally low-paid services. College-educated workers remain highly concentrated in professional, technical, and managerial occupations.

workers, however, real earnings growth was positive in these decades, reflecting in part the productivity gains emanating from computerization (though many other factors are at play).

The task model thus underscores that technological change, like most economic transformations, creates both winners and losers. Akin to the education-race model, the task model also implies that computerization has contributed to rising inequality. Unlike the education-race framework, however, the task framework further implies that a substantial component of this effect stems from the adverse impacts of technological change on the earnings of less-educated workers rather than (exclusively) the positive effect of factor-augmentation on the earnings of high-skill workers. How large is that contribution? Acemoglu and Restrepo (2021) estimate that 50 to 70 percent of the increase in earnings inequality between education, sex, race, and age groups during 1980 through 2016—and the entirety of the fall in real wages of men without high school—are due to the adverse effects of automation on worker groups that were initially more specialized in routine task-intensive work.

New work and task reinstatement

An important limitation of the task framework in its basic form is that it conceptualizes the set of tasks as static—meaning that none are added or subtracted, it is only their allocation between workers and machines that shifts as technology and education evolve. This is a convenient fiction, but it has significant downsides. First, casual empiricism suggests that work is continually evolving, with demands for new skills and expertise that were previously unimagined (e.g., drone pilots, artificial intelligence programmers, vegan chefs, and executive coaches). Second, if the set of tasks were truly static, then it seems likely that advancing automation would inexorably crowd humans into an ever-diminishing subset of tasks, perhaps finally making human labor altogether obsolete, as envisioned by Susskind (2020). While one should not categorically exclude the possibility that this could occur, it does not accurately reflect the last century of technological change, during which the world of work has grown more complex, varied, and intellectually interesting.[23]

An ingenious 2011 paper by Jeffrey Lin brings concrete evidence to these informal observations.[24] Using historical Census documents from 1965 through 2000, Lin shows that the Census Bureau regularly captures novel job titles based on the occupational descriptions that survey respondents supply on their Census forms. While many of these novel write-ins are, of course, simply idiosyncratic descriptions or misspellings, the Census Bureau filters out the chaff to identify bona fide new job titles, reported by a significant number of Census respondents. Lin's work makes two contributions: first, it provides representative evidence on the appearance of "new work"; second, it offers a methodology for systematically capturing new work hiding in plain sight in the Census Bureau's existing data infrastructure.

What precisely is new work? Table 1, drawn from Autor et al. (2021b), list examples of new titles added to the Census Bureau's internal occupational classification manual in each decade between 1940 and 2018.[25] The left-hand column reveals, as intuition would suggest, that many new titles—such as textile chemists (added in 1960) or controllers of remotely piloted vehicles (added in 1980)—involve operating, installing, maintaining, integrating, or selling new technologies. While technology-related new titles are

23 Autor (2015).
24 Lin (2011).
25 New titles introduced in a given decade, say 1940, correspond to those captured by the Census Bureau in the preceding decade, i.e., between 1931 and 1940.

commonplace, just as prevalent are new titles that do *not* relate to a technological innovation but instead reflect changing tastes, incomes, and demographics (right-hand column). For example, beauticians (added in 1950), hypnotherapists (added in 1980), and sommeliers (added in 2000) provide specialized services. Surely, many new "gig" titles will soon enter this list of titles: on-demand personal driver (Uber and Lyft); warehouse pick worker (Amazon); and on-demand shopper (Instacart), among others.

Table 1: Examples of new occupational titles added to the U.S. Census Bureau's Classified Index of Occupations between 1940 and 2018

YEAR	EXAMPLES OF TITLES ADDED	
1940	Automatic welding machine operator	Gambling dealer
1950	Airplane designer	Beautician
1960	Textile chemist	Pageants director
1970	Engineer computer application	Mental-health counselor
1980	Controller, remotely piloted vehicle	Hypnotherapist
1990	Certified medical technician	Conference planner
2000	Artificial intelligence specialist	Chat room host/monitor
2010	Wind turbine technician	Sommelier
2018	Pediatric vascular surgeon	Drama therapist

Source: Autor et al. (2021b).

How does new work relate to the task-polarization framework elaborated above? Building on Lin's observations, Acemoglu and Restrepo (2018b) fuse the notion of new work (more precisely, new tasks) into the canonical task model. In their extended framework, automation displaces workers from existing job tasks as before; but now, new task creation potentially "reinstates" demand for workers by generating new tasks that require human expertise.[26] Thus, akin to the education-race model, the competing forces of *task automation* and *task displacement* determine the net effect of technological change on labor demand: if automation outpaces reinstatement, labor demand falls; and conversely, if reinstatement outpaces automation, labor demand rises.[27]

[26] While in the long run, these tasks may also be automated, it appears plausible that many novel activities are first accomplished and perfected by workers before they are subsequently routinized and automated.

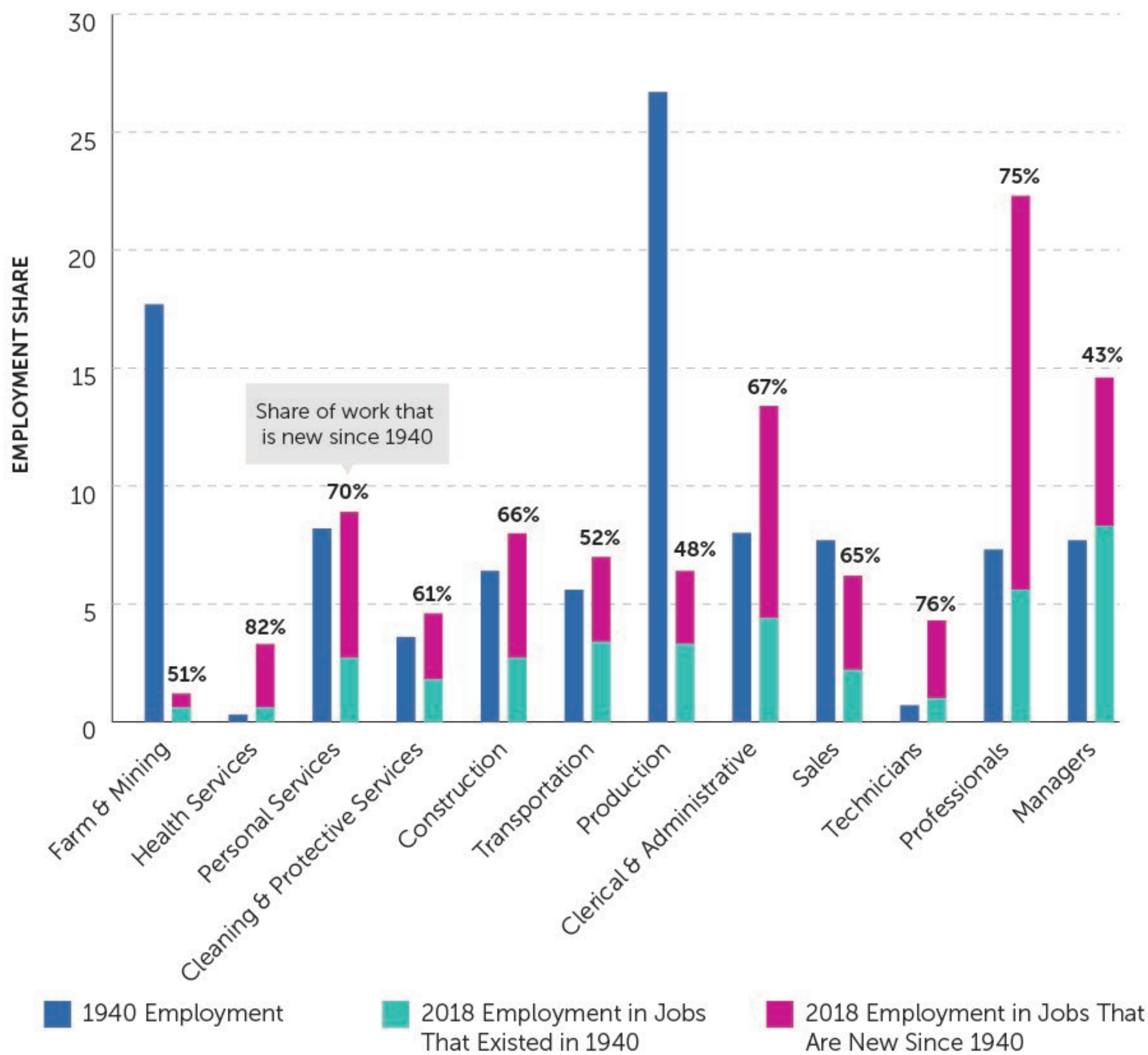
[27] This explanation oversimplifies for brevity. The net effect of automation and reinstatement depends not only on the relative speed of these forces but also their impact on aggregate labor demand through the productivity growth channel. Automation can raise labor demand even while displacing worker tasks if the resulting productivity boost raises demand sufficiently to offset employment losses due to task displacement. Logically, the impacts of automation and reinstatement may differ by skill group, as explored in Acemoglu and Restrepo (2021) and Autor et al. (2021b).

Of course, knowing that old work is being automated and new work is being created does not tell us which effect dominates in net, which occupations or skill groups are most positively or negatively affected, and what underlying forces guide this process. Evidence is now emerging on these questions, though much more is needed. Employing an indirect measure of task change based on changes in labor's share of income by industry, Acemoglu and Restrepo (2019) conduct a macroeconomic analysis of task displacement and task reinstatement for two long time intervals, 1950–1987 and 1987–2017. Their analysis suggests that these two forces—automation and task reinstatement—were roughly in balance in the first time interval of 1950–1987, but that automation subsequently outpaced task reinstatement in the second time interval of 1987–2017, which is consistent with labor's falling share of national income occurring simultaneously.[28]

To analyze representative evidence over a substantial time horizon, Autor et al. (2021b) build on the approach pioneered by Lin (2011) to analyze data on new work creation in eight decades of U.S. data from 1940 through 2018. These data suggest that new work is quantitatively important. Autor et al. (2021b) estimate that more than 60 percent of employment in 2018 was found in job titles that did not exist in 1940, as shown in Figure 6.[29] The introduction of new work, however, is *not* uniform across skill groups. Between 1940 and 1980, most new work that employed non-college workers was found in construction, transportation, production, clerical, and sales jobs–which are squarely middle-skill occupations. In the subsequent four decades (1980–2018), however, the locus of new work creation for non-college workers shifted away from these middle-tier occupations and towards traditionally lower-paid personal services. Conversely, new work creation employing college-educated workers became increasingly concentrated in professional, technical, and managerial occupations. In combination, these patterns indicate that new work creation has polarized, mirroring (and in part driving) the aggregate polarization of employment seen in Figure 3.

[28] Autor et al. (2020a); Karabarbounis and Neiman (2014). Acemoglu and Restrepo (2018b) offer a general theory of new work creation based on changes in the relative price of capital and labor, where declines in the price of labor spur labor-using innovations (and hence task reinstatement) and, conversely, declines in the price of capital spur capital-using automation innovations (and hence task displacement).
[29] Using data from Lin (2011), Acemoglu and Restrepo (2018b) estimate a similar fraction of employment in new work for the shorter time interval of 1980 to 2015.

Figure 6: More than 60 percent of jobs done in the United States in 2018 had not yet been "invented" in 1940



Source: Autor et al. (2022).
Note: This figure compares the distribution of employment in 1940 and 2018 across all major occupations, distinguishing between employment in new job titles added between 1940 and 2018 versus job titles that were present in 1940.

What explains the shifting locus of new work creation across occupations and skill groups during these decades? Autor et al. (2021b) document three critical forces. One is the introduction of automation innovations. Building on foundational work by Kogan et al. (2021) and Webb (2020), they document that automation innovations erode employment in occupations that are most exposed to them. But not all technological innovations are directed at automation. Using U.S. utility patent data, Autor et al. (2021b) develop a method to distinguish among innovations that *automate* the tasks that workers supply versus those that *augment* the outputs or services that their work generates. For example, the introduction of photocopying would constitute an automation innovation since it replaces the labor inputs of workers who previously duplicated documents using more cumbersome means (e.g., carbon paper). Conversely, the introduction of an electronic workbook for performing calculations (i.e., a spreadsheet) would constitute an augmentation innovation since it enhances the services provided by financial analysts, allowing them to conduct faster and deeper analyses.[30] In contrast to the role of automation technologies, Autor et al. (2021b) document that *augmentation* innovations spur employment growth in the occupations most exposed to them. Given that many occupations are simultaneously exposed to both augmentation and automation innovations, this finding is particularly striking.[31]

Alongside these two faces of innovation—automation and augmentation—Autor et al. (2021b) analyze a third factor affecting new work creation: demand and supply forces that directly shape when and where new work emerges. When occupations are exposed to adverse demand shocks, for example, the contraction of manufacturing employment in the U.S. in the face of the China trade shock of the 1990s and 2000s,[32] not only does employment contract but the pace of introduction of new occupational titles slows. Conversely, when demand for an occupation expands, as for example has occurred in many personal care and healthcare occupations in the face of population aging, employment rises, *and* the pace of new work introduction accelerates.

While much remains to be understood about the potential of new work creation to temper the task-eroding consequences of automation, it is clear that new work plays a critical role in shaping and tempering the long-run consequences of technological change for labor demand.

The present era of Artificial Intelligence uncertainty

The task framework outlined above is well-suited to understanding the economic consequences of the last four decades of advancing digital computing. But how well does it fit the current era of Artificial Intelligence (AI)? Does AI fundamentally change the relationship between technological change, labor demand, and inequality—and if so, how do we characterize these changes analytically? The task framework provides a natural starting point both for considering what AI may do, and for understanding how AI differs from the technologies that preceded it.

The task framework encompasses two conceptual pieces. One is the notion of "tasks" as units of work that can be accomplished by workers, machines, or potentially by service providers in other countries.[33] The second is a specific characterization of what tasks computers can accomplish—in particular, routine tasks in the terminology of Autor et al. (2003). What makes a task routine is that it follows an *explicit*, fully specified set of rules and procedures. Tasks fitting this description can in many cases be codified in computer software and executed by machines. Conversely, tasks that rely on what Polanyi and Sen (1966) called "tacit" knowledge (e.g., riding a bicycle, telling a clever joke) have historically been challenging to program because the explicit steps for accomplishing these tasks are often not formally known.

[30] This example also highlights that many innovations contain elements of both automation and augmentation. The spreadsheet was surely an augmentation innovation for analysts, but it might also have been an automation innovation for routine bookkeepers.

[31] Mann and Püttmann (2021) find that automation technology has a net *positive* effect on employment in local labor markets, driven by job growth in the service sector. Conversely, Komlos (2016) conjectures that the forces of creative destruction have become more destructive, leading to smaller net contributions to GDP and labor demand.

[32] Autor et al. (2021a).

[33] See Grossman and Rossi-Hansberg (2008).

Artificial intelligence overturns the second piece of the task framework—specifically, the stipulation that computers can accomplish only explicitly understood (i.e., routine) tasks. AI tools surmount this longstanding constraint because they can be used to infer tacit relationships that are not fully specified by underlying software. For example, it is extraordinarily challenging to explicitly define what makes a chair a chair: must it have legs, and if so, how many; must it have a back; what range of heights is acceptable; must it be comfortable; and what makes a chair comfortable, anyway? Writing the rules for this problem is maddening. If written too narrowly, they will exclude stools and rocking chairs. If written too broadly, they will include tables and countertops. In a well-known paper, Grabner et al. (2011) argue that the fundamental problem is that what makes a chair a chair is its suitability for sitting upon. But what makes something "suitable" for sitting is as elusive as the original problem. Given this morass, this chair classification task would be categorized as "non-routine" for purposes of conventional computing—a human task rather than a machine task.

Fast forward to the present and AI can now "solve" this classification problem. It does not solve it by following explicit rules, however. Instead, it learns the solution inductively by training on examples. Given a suitable database of tagged images and sufficient processing power, AI can infer what image attributes are statistically associated with the label "chair" and can then use that information to classify untagged images of chairs with a high degree of accuracy.[34] What rules does AI use for this classification? In general, we do not know because the rules remain tacit. Nowhere in the learning process does AI formally codify or reveal the underlying features (i.e., rules) that constitute "chair-ness." Rather, the classification decision emerges from layers of learned statistical associations with no human-interpretable window into that decision-making process.[35] And herein lies an irony: Polanyi's paradox survives the paradigm shift in computing, but with a twist. In the pre-AI era, programmers struggled to imbue computers with the tacit knowledge needed for accomplishing non-routine tasks; in the present AI-era, computers can readily acquire this tacit knowledge, but they cannot (in almost all cases) communicate that knowledge explicitly to people. That is, computers now know more than they can tell us.[36]

Returning to the task model, how does the relaxation of the tacit knowledge constraint affect our predictions of what machines and people will do in the future? One potential answer is that the task model is now irrelevant given that machines are increasingly capable of accomplishing non-routine tasks.[37] An alternative answer is that the task model remains conceptually and empirically valuable because it provides an analytic tool for rigorously studying the interactions between human and machine capabilities in accomplishing work[38]—though it makes fewer crisp predictions about what tasks are likely to be automated in the years ahead. I see three questions as particularly relevant:

- Looking through the lens of the task framework, what work tasks will AI prove capable of accomplishing in the years (and decades) ahead? AI's applicability is in my assessment sufficiently vast that I find it harder to say what AI *cannot* do than what it *can and will* do.[39] It is commonly argued, for example, that because AI is blissfully unaware of the rich context of many real-world

[34] Brynjolfsson and Mitchell (2017); Brynjolfsson et al. (2018).
[35] Schematically, AI learns by adjusting connection weights among layers of (virtual) nodes on an information network. The representation of the decision-making process in this network has essentially no relationship to the formal structure of the problem as a human would understand it.
[36] The field of explainable AI seeks to make the tacit knowledge acquired by AI explicit. See, for example, https://en.wikipedia.org/wiki/Explainable_artificial_intelligence.
[37] See Bresnahan (2021) for a strident argument that the task model is irrelevant in the AI era, and perhaps was irrelevant in all prior eras.
[38] Acemoglu and Restrepo (2018a); Autor (2013).
[39] See Marcus and Davis (2019) for a counterargument.

problems, it cannot accomplish the high-stakes, multifaceted decision tasks that humans regularly undertake in their work. This argument would be convincing if humans were highly effective and reliable at making such decisions. But the evidence strongly suggests that they are not.[40]

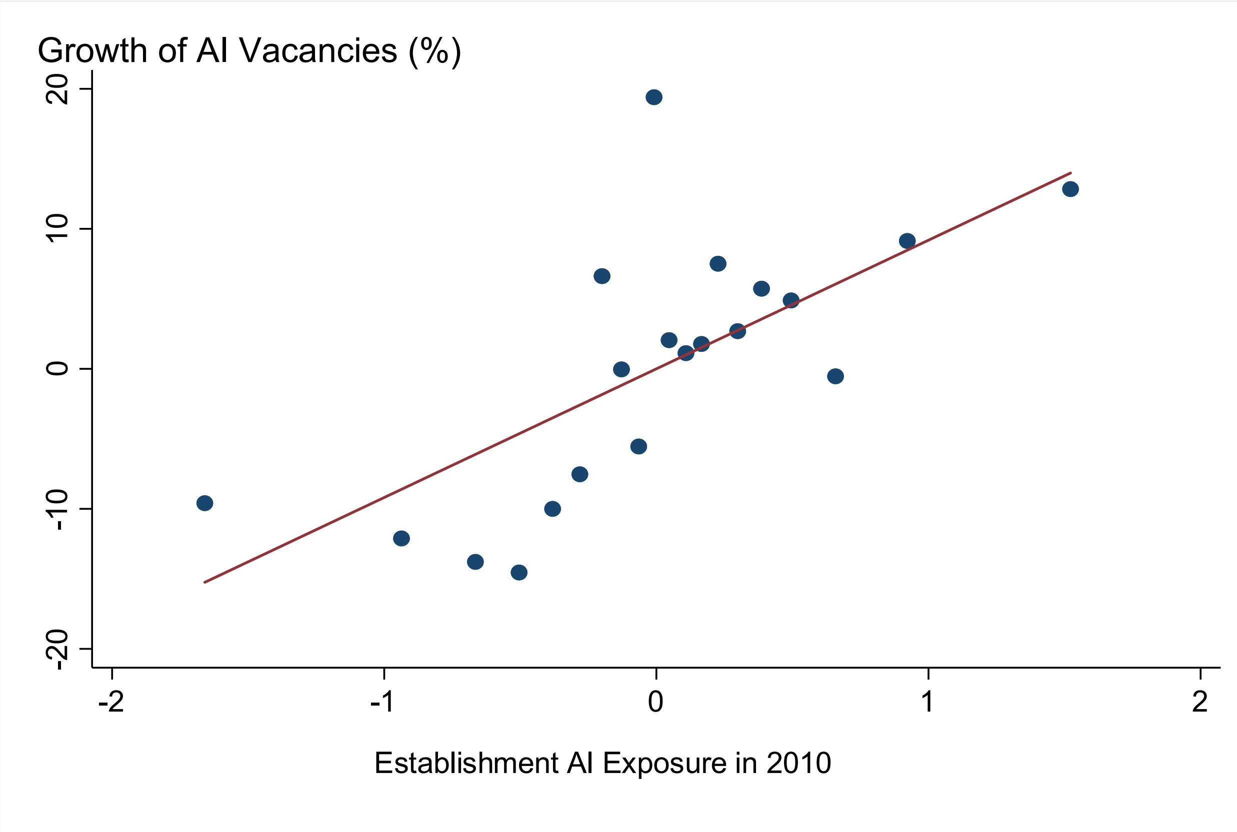
- Second, what new demands for human skills and capabilities will emerge as AI displaces a growing set of traditional human work tasks? As per the discussion above, I am certain that such new work tasks will emerge, and that many forms of human capability and expertise will become newly valuable. Because technological advances have always generated new demands for human specialization, as have rising societal wealth and ongoing changes in norms, tastes, and institutions, I do not foresee a moment when labor scarcity (and hence, labor income) is eliminated. Simultaneously, many currently valuable human capabilities will eventually be rendered obsolete. This will be costly for many and disruptive for society in general. These disruptions are *also* characteristic of technological upheavals, but because of the rapidity with which AI is evolving, they may be particularly acute.

- Third, while the task framework offers a useful starting point for analyzing the impact of AI on labor markets and inequality, it is unlikely to be encompassing enough to reflect all relevant labor market impacts of AI. And it is certainly insufficient to capture many of the broader societal impacts. How do we get a fuller analytical grasp on the terrain ahead? Works by Agrawal et al. (2018), Bresnahan (2021), and Korinek and Stiglitz (2018) offer different lenses on these questions that bring different issues into focus. We are only at the start of the intellectual journey to understand AI's implications for work and inequality, so it would be premature to proclaim that we have already found the most promising route to that destination.

A small but rapidly growing literature that includes Babina et al. (2020), Brynjolfsson and Mitchell (2017), Brynjolfsson et al. (2018), Felten et al. (2018, 2019), and Webb (2020) applies a task approach to analyze the labor market impacts of AI adoption.[41] These recent papers make an important break with prior task-based studies. Earlier incarnations of this literature often focused specifically on whether routine tasks were substituted by computers and non-routine tasks were complemented. Thus, they applied both the general task framework *and* the specific characterization of the intrinsic capabilities and limitations of procedural computing supplied by Autor et al. (2003). In contrast, recent works studying the labor market impacts of AI apply the task framework generally but do not for the most part characterize analytically precisely what AI can do—which makes sense because such a characterization remains elusive.[42] Instead, these papers develop or apply expert or crowd-sourced assessments of the tasks for which AI is currently suitable to determine which tasks, occupations, firms, and industries are most AI-exposed.

[40] Kahneman et al. (2021).
[41] Though not specifically focused on AI, recent papers by Atalay et al. (2020) and Deming and Noray (2020) present novel, closely related analyses.
[42] Qualifying these generalizations, Brynjolfsson and Mitchell (2017) and Brynjolfsson et al. (2018) offer a rubric for assessing the suitability of job tasks to machine learning (their SML index), while Agrawal et al. (2018) offer a formal characterization of what tasks AI accomplishes. Specifically, they argue that AI is essentially a prediction machine—a tool that forecasts the immediate (or long-term) future based on past inputs.

Figure 7: U.S. establishments whose tasks structures in 2010 were more suitable for AI subsequently posted relatively more AI vacancies between 2010 and 2018



Source: Acemoglu et al. (2020).
Note: This figure shows the relationship between establishment-level AI exposure in 2010, computed using the Felten et al. (2018) method, and establishments' subsequent increase in posting of job positions requiring AI skills between 2010 and 2018. The solid line corresponds to a regression with 2010 establishment vacancies as the weight. The coefficient is 9.19, standard error is 1.21, and regressor is standardized. Each bin represents about 50,000 establishments. This analysis excludes vacancies in AI-producing sectors of the economy, specifically Information (NAICS code 51) and Business Services (NAICS code 54).

Acemoglu et al. (2020) offer one recent example. This study uses establishment-level job vacancy postings from the online job-posting aggregator Burning Glass Technologies to assess the impacts of recent AI adoption on the demand for workers who perform non-AI jobs. For this analysis, the study defines "AI jobs" as those that advertise specific expertise requirements in contemporary AI tools.[43] Conversely, non-AI jobs are the (vast) remainder that do not demand AI-specific skills but nevertheless may be affected by it. This could include a whole range of jobs, from financial analysts, to pharmacists, to pilots, to warehouse managers. Drawing on AI-suitability indexes developed by Brynjolfsson et al. (2018), Felten et al. (2018), and Webb (2020), the paper first predicts which establishments are likely to adopt AI as a function of the suitability of their job task structures (visible in job postings) in the pre-AI era. Consistent with this prediction, the paper documents that establishments whose occupational structures in 2010 made them

[43] Examples include Machine Learning, Computer Vision, Machine Vision, Deep Learning, Virtual Agents, Image Recognition, Natural Language Processing, Speech Recognition, Pattern Recognition, Object Recognition, and Neural Networks, among many others.

suitable for AI *did* in fact differentially increase posting of vacancies for workers with AI skills as AI took off between 2010 and 2018, as is shown in Figure 7.

With these predictions in hand, Acemoglu et al. (2020) explore whether AI adoption (spurred by AI-suitability) is affecting hiring in non-AI jobs. The answer is a qualified yes. They find that as AI-exposed establishments adopted AI between 2010 and 2018 (particularly after 2014), they differentially changed their mix of job skill requirements in *non-AI* positions—suggesting that non-AI job tasks were affected—and modestly reduced hiring in non-AI positions simultaneously. This evidence confirms that AI's imprint can already be seen at the firms and establishments whose preexisting task structures make them more suitable for using AI. Yet, Acemoglu et al. (2020) find that AI is not so far having detectable labor market impacts at the aggregate occupation or industry level, though such affects appear likely in the future. In net, these conclusions are evocative but not dramatic; they hint at potential *aggregate* effects of AI but do not so far confirm them.

"Aggregate effects" is a pregnant phrase: What might those effects be? Here, I speculate:

1. One such aggregate effect is that further improvements in AI's capabilities may accelerate the process of task automation relative to task augmentation. Broadly, this will mean that labor's share of national income will decline further, beyond what has already occurred over the last two decades as documented in Autor et al. 2020a, and, concomitantly, the share of national income paid to owners of capital (i.e., machines, robots, algorithms, etc.) will grow. Ironically, this process of aggregate labor displacement can occur without any reduction in wage inequality among workers—or with wage inequality rising even further. Specifically, all workers could get a smaller slice of the aggregate economic pie while the proportional difference among those slices remained just as pronounced. This fall in labor's share of national income does *not*, however, necessarily imply that employment will fall. So as long as people need to work for a living, falling wages do not preclude stable or rising employment.[44] Additionally, a fall in the labor share does not necessarily mean a decline in wages; the same capabilities that make AI labor-displacing could in theory generate sufficient productivity growth that average wages would rise even as labor's share of national income falls. In this case, the size of the pie grows faster than labor's share of that pie shrinks. Nevertheless, a fall in labor's share of national income is problematic, the simple reason being that the ownership of capital is far more concentrated than the ownership of labor (i.e., absent coercion, each person owns only their own labor). Thus, a substantial fall in labor's share of national income implies a dramatic rise in *income* inequality—that is, wage plus non-wage income—even absent a change in *wage* inequality.

2. A second scenario—which could in theory co-occur with the one above—is that, spurred by advancing AI, the twin forces of task-automation and task-augmentation reshape the set of tasks (and associated worker skills) that are complemented and substituted by technologies. While the last four decades of conventional computing capabilities have fomented occupational polarization and rising wage inequality, this need not be true going forward, or at least not to the same degree. It is a near-certainty that AI will increasingly be deployed to accomplish mid- and high-level decision-making tasks that have historically been performed by managers and professionals. This is already occurring in finance and investing, inventory management, credit issuance, fraud detection, and even some fields of design. An expanding set of these expert and semi-expert tasks will almost surely become technologically equivalent to the "routine tasks" of earlier years: equally well accomplished by

[44] For those skeptical of this point, note that employment rates are generally higher in poor than rich countries and that hours worked per capita tend to fall among both men and women as countries become wealthier (Bick et al., 2018).

machines, and with greater rapidity and at lower cost. Accordingly, it is possible that even those with moderately high levels of educational attainment—those, for example, with a bachelor's but not a post-graduate degree—will find that their primary work tasks are increasingly substituted by AI.

That some of their tasks are substituted does mean that these workers' skills are necessarily devalued. It is in part by displacing a subset of human tasks that, in many cases, automation makes the remaining set of worker tasks more valuable (imagine the value of a statistician stripped of her computer or a construction crew denied use of power tools). Whether workers' skills are complemented or substituted by new technologies depends in part on their ability to adapt to changing task demands. Economists have long understood that education makes people better at adapting to, and capitalizing on, novel circumstances.[45]

But this resilience is not guaranteed. At the turn of the twentieth century, high school graduates were an elite education group who commanded substantial premia as bookkeepers and clerks. In essence, they were the leading "information technology" of big business in that era.[46] Today, however, there is little difference in the wages paid to high school graduates and those without a high school degree. Thus, the high-school credential has lost much of its market value, except as a waypoint on the road to higher education.[47]

Still, there is an upper limit to this substitution process at present. While there is no consensus on the topic, many experts do not expect artificial general intelligence (AGI) to emerge for some decades, if at all.[48] Assuming this expectation is correct (which I believe it is), humans will continue to have comparative advantage in creativity, judgment, hypothesis formation, contextual thinking, causal analysis, communication, emotional intelligence, and many more arenas, the importance of which we likely do not fully appreciate and the difficulty of which we surely vastly underestimate. I feel confident that the *most* skilled workers will likely continue to be complemented by advances in computing and AI—such as workers who invent, design, research, lead, entertain, and educate. But this observation is not limited to those with elite educations. People effortlessly do extraordinary things on an ongoing basis, such as applying common sense to tease apart otherwise intractable problems, drawing generalizable inferences from *small* data, and using abductive reasoning to form plausible interpretations of a spare set of observations. Such quotidian tasks are currently beyond the frontier of the most advanced AI, and yet children accomplish them effortlessly.[49] Recalling Polanyi's observations that we know more than we can tell, I would add that we do not fully comprehend how much it is that we humans are not telling.

3. I similarly do not expect AI to rapidly reach deep into the ranks of low-paid service occupations, those comprising the left-hand side of the occupational polarization plot shown in Figure 3. There are three reasons why not. First, most service occupations demand dexterous, fluid, adaptive interactions with people and the environment, whether in care jobs, services, entertainment, etc. Automating these activities will require substantial advances in low-cost robots that can navigate in the highly variable human environment rather than in the predictable engineered environment of a factory floor. These advances will take place much more slowly than advances in AI, which depend primarily on more of the same ingredients—more data, greater computing power. Second, while machines will surely slowly

[45] Schultz (1975).
[46] Goldin and Katz (2008).
[47] Goldin and Katz (2008); Card (2009).
[48] Fijelland (2020).
[49] Marcus and Davis (2019).

gain many of these human-like capabilities, their cost may remain high relative to the low cost of labor performing those same activities. This cost comparison makes the economics of automating many service tasks less attractive.[50] Third, many low-paid service tasks—such as caregiving, coaching, and advising and selling—are unattractive targets for automation not only because the technical challenge is steep but because personal attention from another human being is intrinsically part of the service.

4. Finally, while it is easy to imagine which tasks and what jobs will succumb to automation, it is far harder to forecast what and where new work will emerge. Millions of workers are currently employed in order-fulfillment and ride-hailing jobs that were in effect created by e-commerce and mobile telephony. Similarly, the U.S. Bureau of Labor Statistics maintains information on "green jobs" associated with the transformation of the power sector.[51] Many of these occupations are relatively new or rapidly growing, such as solar plumbers, solar site assessors, and specialized plumbers, pipefitters, and steamfitters. Artificial intelligence itself has created a host of new skill demands and occupational specialties, as documented in Acemoglu et al. (2020). As discussed in Autor et al. (2021b), new innovations almost always generate new work as people deploy, master, maintain, refine, and improve new technologies, tools, and services. Nor does new work generation depend exclusively on innovation. Autor et al. (2021b) further demonstrate that changes in demographics, tastes, and income levels also drive the generation of new work.

What these observations imply is that the work of the future is not an empty set—not even remotely. In Autor et al. (2022), we write that "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 impact of robotics and automation on 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." It is that adaption that creates both challenge and opportunity. The problem that industrialized countries face in the immediate decades ahead is not a shortfall in the quantity of jobs. It is rather that many of the jobs may be of low quality, use only generic human capacities, and provide little opportunity for skills acquisition, specialization, and rising lifecycle productivity. This is not a new problem, however. It has been unfolding over four decades. And in general, the U.S. has adapted to it poorly.

Conclusions and policy implications

I began by asking what the role of technology–digital or otherwise–is in determining wages and shaping wage inequality. I presented four answers corresponding to four strands of thinking on this topic: the education race, the task-polarization model, the automation-reinstatement race, and the era of AI uncertainty. The nuance of economic understanding has improved substantially across these epochs. Yet,

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50 An exception to this dictum is that service tasks that are done at large scale may attract automation. For example, Amazon, which employs hundreds of thousands of warehouse workers, has invested heavily in robotics to automate part of the product fulfillment process. Similarly, White Castle restaurants have deployed fryolator-operating robots in some of their many stores. This same economic logic may drive robotics in table-waiting, hotel room cleaning, shelf-stocking, and checkout operations, even though all are low-paid tasks that require substantial human flexibility. The attractiveness of automation will increase if the cost of human labor in these tasks rises—a healthy economic process. The scenario to be concerned about is one where automation makes formerly scarce labor broadly abundant (and hence cheap); not one in which scarce labor makes automation more attractive at the margin.

51 https://www.bls.gov/green/overview.htm.

traditional economic optimism about the beneficent effects of technology for productivity and welfare has eroded as understanding has advanced. Fundamentally, technological change expands the frontier of human possibilities, but we should expect it to create many winners and losers, and to pose vast societal challenges and opportunities.

What are the policy implications of these observations? The question is so broad that almost any answer is bound to appear vague and inadequate. Recognizing this challenge, Autor et al. (2022) sketch a long-form policy vision, focusing on three domains of policy: education and training; labor market institutions; and innovation policy itself.

A paramount objective of policy should be to use education and training to build pathways to better jobs. Inventing new ways of accomplishing existing work, new business models, and entirely new industries drives rising productivity and new jobs. But innovation in technology alone will not generate broadly shared gains absent complementary reforms. It is equally important to invest in educating and training the workforce to ensure that workers have the skills and opportunities to fill jobs that are in demand. Training workers can also improve access to good jobs for workers who may face barriers to these jobs, and it can also help improve the quality of existing jobs by creating opportunities for career ladders.[52]

A second focus for policy should be to reform the governmental, nongovernmental, and private sector institutions that translate—or fail to translate—rising productivity into shared prosperity. Over more than four decades, the link between rising productivity and commensurate improvements in job opportunities and earnings has been decoupled for the majority of U.S. workers. The poor quality of jobs available to workers lacking four-year college degrees or specialized credentials provides one of the starkest examples of this failure. Low-wage U.S. workers earn substantially less than low-wage workers in almost all other wealthy industrialized countries.[53]

The divergence between the upward path of productivity growth and the near plateauing of median wage growth among U.S. workers is not an inevitable consequence of technology, globalization, or market forces. Rather, a set of U.S.-specific institutional and policy choices failed to blunt—and in some cases magnified—the consequences of technological and globalization pressures on the U.S. labor market. To contend effectively with these challenges requires institutional and policy reforms that realign labor market opportunities with the rising productivity and societal wealth that the U.S. has reaped from decades of innovation and investments in human and physical capital. These reforms include crafting and enforcing fair labor standards, setting well-calibrated federal minimum wage policies, extending the scope and flexibility of the unemployment insurance system, and transforming the U.S. employer-based health insurance provision into a system with portable benefits. Furthermore, the U.S. needs to re-evaluate its devotion to pure shareholder capitalism—which has arguably helped fuel the drive to curtail wages and benefits for low-wage workers. While shareholder capitalism can plausibly be credited with some of the productive dynamism of the U.S. economy, it needs to be balanced with greater emphasis on creating a system that bolsters the skills and compensation of all workers.

A third and final productive domain for policy is to directly shape innovation itself to speed productivity growth and complement the skills of the labor force. It is well known that the U.S. has a strong national innovation system, fueled by federal R&D investments, to develop fundamental science and new technologies that has led to scientific leadership and new industries. Less recognized, however, is the crucial link between those new industries as complements to the inevitable loss of jobs that results from

52 This paragraph excerpts from Autor et al. (2022), p79.
53 This paragraph and the next excerpt from Autor et al. (2022), p101-102.

productivity-enhancing technologies. New industries grew out of a flourishing innovation ecosystem that created new companies and applications, alongside older industries that increased mechanization and automation as they matured. Yet we have let those important R&D investments lag and potentially wither at a large scale, with corresponding effects on the labor market. Through increased and targeted R&D investments supported by a reinvigorated federal R&D program, as well as a tax policy that keeps workers and social challenges at the forefront, the country's innovation system can be put to work for a broader number of people and regions than it has in recent decades.[54]

Although I would prefer to end this essay with optimistic assurances, I will instead end with one uncertainty, one certainty, and one admonition. The uncertainty is that we have less clarity about our technological future than we did two decades ago. AI has extended the frontier of technological possibility towards boundaries that are barely visible at present. The tasks that machines will be able to accomplish, the rate at which new innovations may emerge, and the speed with which socially impactful technological innovations may diffuse is unknown. But the range of possibilities has surely gotten broader, and our certainty about the boundaries has accordingly diminished.

The certainty is that these technological advances will expand the set of desirable possibilities that are within the reach of humanity. We can leverage the potential of AI to help tackle some of humanity's most pressing challenges: climate change, disease, poverty, malnutrition, and inadequate education. But whether we will successfully realize this potential, or instead squander it or, worse, disastrously misuse it, is highly uncertain and, I would argue, fundamentally indeterminate.

The admonition is this: Given the potential applicability of AI to a vast set of purposes, we should not simply be asking what AI will accomplish but what we want it to accomplish. How do we use AI most productively to complement workers, raise productivity, and more broadly, tackle humanity's most pressing challenges? Simultaneously, how do we blunt or reshape the commercial incentives to use AI for socially counterproductive objectives such as displacing workers, preying upon people's cognitive and emotional frailties, or consolidating the power of governments or corporations to exercise social control?[55] As we ponder our uncertain AI future, our goal should not merely be to predict that future, but to create it.

[54] This paragraph excerpts from Autor et al. (2022), p121.
[55] Acemoglu and Restrepo (2020).

References

Acemoglu, D., Autor, D., Hazell, J., and Restrepo, P. (2020). AI and Jobs: Evidence from Online Vacancies. National Bureau of Economic Research, Working Paper 28257. Forthcoming in *Journal of Labor Economics*.

Acemoglu, D. and Autor, D. H. (2011). Skills, Tasks and Technologies: Implications for Employment and Earnings. *Handbook of Labor Economics*, 4(11):1043–1171.

Acemoglu, D. and Restrepo, P. (2018a). Modeling Automation. *American Economic Review: Papers and Proceedings*, 108:48–53.

Acemoglu, D. and Restrepo, P. (2018b). The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *American Economic Review*, 108(6):1488–1542.

Acemoglu, D. and Restrepo, P. (2019). Automation and New Tasks: How Technology Displaces and Reinstates Labor. *Journal of Economic Perspectives*, 33(2):3–30.

Acemoglu, D. and Restrepo, P. (2020). The Wrong Kind of AI? Artificial Intelligence and the Future of Labor Demand. *Cambridge Journal of Regions, Economy and Society*, 13(1):25– 35.

Acemoglu, D. and Restrepo, P. (2021). Tasks, Automation, and the Rise in U.S. Wage Inequality. Technical Report, National Bureau of Economic Research.

Agrawal, A., Gans, J., and Goldfarb, A. (2018). *Prediction Machines: The Simple Economics of Artificial Intelligence*. Harvard Business Press.

Atalay, E., Phongthiengtham, P., Sotelo, S., and Tannenbaum, D. (2020). The Evolution of Work in the United States. *American Economic Journal: Applied Economics*, 12(2):1–34.

Autor, D. (2013). The “Task Approach” to Labor Markets: An Overview. *Journal for Labour Market Research*, 46(3):185–199.

Autor, D., Dorn, D., and Hanson, G. H. (2021a). “On the Persistence of the China Shock.” *Brookings Papers on Economic Activity*, forthcoming.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., and Van Reenen, J. (2020a). The Fall of the Labor Share and the Rise of Superstar Firms. *The Quarterly Journal of Economics*, 135(2):645–709.

Autor, D., Goldin, C., and Katz, L. F. (2020b). Extending the Race between Education and Technology. In *AEA Papers and Proceedings*, volume 110, pages 347–51.

Autor, D., Mindell, D., and Reynolds, E. (2022). *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines*. Cambridge: MIT Press.

Autor, D., Salomons, A., and Seegmiller, B. (2021b). New Frontiers: The Origin and Content of New Work, 1940 –2018. Technical Report, MIT Working Paper.

Autor, D. H. (2014). Skills, Education, and the Rise of Earnings Inequality among the “other 99 Percent”. *Science*, 344(6186):843–851.

Autor, D. H. (2015). Why Are There Still So Many Jobs? The History and Future of Workplace Automation. *Journal of Economic Perspectives*, 29(3):3–30.

Autor, D. H. (2019). Work of the Past, Work of the Future. *AEA Papers and Proceedings*, volume 109, pages 1–32.

Autor, D. H. and Dorn, D. (2013). The Growth of Low Skill Service Jobs and the Polarization of the U.S. Labor Market. *American Economic Review*, 103(5):1553–1597.

Autor, D. H., Katz, L. F., and Kearney, M. S. (2006). The Polarization of the U.S. Labor Market. *American Economic Review*, 96(2):189–194.

Autor, D. H., Katz, L. F., and Kearney, M. S. (2008). Trends in U.S. Wage Inequality: Revising the Revisionists. *The Review of Economics and Statistics*, 90(2):300–323.

Autor, D. H., Katz, L. F., and Krueger, A. B. (1998). Computing Inequality: Have Computers Changed the Labor Market? *The Quarterly Journal of Economics*, 113(4):1169–1213.

Autor, D. H., Levy, F., and Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, 118(4):1279–1333.

Babina, T., Fedyk, A., He, A., and Hodson, J. (2020). Artificial Intelligence, Firm Growth, and Industry Concentration. *Firm Growth, and Industry Concentration (November 22, 2020)*.

Bick, A., Fuchs-Schündeln, N., & Lagakos, D. (2018). “How Do Hours Worked Vary with Income? Cross-Country Evidence and Implications.” *American Economic Review*, 108(1), 170-99.

Böhm, M. J. (2020). The Price of Polarization: Estimating Task Prices under Routine-Biased Technical Change. *Quantitative Economics*, 11(2):761–799.

Böhm, M. J., von Gaudecker, H.-M., and Schran, F. (2019). Occupation Growth, Skill Prices, and Wage Inequality. Discussion Paper No. 12647.

Bresnahan, T. (2021). “Artificial Intelligence Technologies and Aggregate Growth Prospects” in Diamond, John, and George Zodrow (eds.), *Prospects for Economic Growth in the United States,* Cambridge University Press.

Brynjolfsson, E. and Mitchell, T. (2017). “What Can Machine Learning Do? Workforce Implications.” *Science,* 358(6370):1530–1534.

Brynjolfsson, E., Mitchell, T., and Rock, D. (2018). “What Can Machines Learn, and What Does It Mean for Occupations and the Economy?” *AEA Papers and Proceedings*, 108, pages 43–47.

Card, D. and Lemieux, T. (2001a). Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis. *The Quarterly Journal of Economics*, 116(2):705– 746.

Card, D. and Lemieux, T. (2001b). Going to College to Avoid the Draft: The Unintended Legacy of the Vietnam War. *American Economic Review*, 91(2):97–102.

Card, D. (2009). Immigration and Inequality. *American Economic Review*: *Papers & Proceedings*, 99(2), 1-21.

Deming, D. J. (2017). The Growing Importance of Social Skills in the Labor Market. *The Quarterly Journal of Economics*, 132(4):1593–1640.

Deming, D. J. and Noray, K. (2020). Earnings Dynamics, Changing Job Skills, and STEM Careers. *The Quarterly Journal of Economics*, 135(4):1965–2005.

Dorn, D. (2009). Essays on Inequality, Spatial Interaction, and the Demand for Skills (Doctoral Dissertation, University of St. Gallen).

Feigenbaum, J. and Gross, D. P. (2020). Answering the Call of Automation: How the Labor Market Adjusted to the Mechanization of Telephone Operation. National Bureau of Economic Research, Working Paper 28061.

Felten, E., Manav, R., and Seamans, R. (2018). A Method to Link Advances in Artificial Intelligence to Occupational Abilities. *American Economic Association Papers and Proceedings*, 108(54):54–57.

Felten, E., Raj, M., and Seamans, R. C. (2019). The Effect of Artificial Intelligence on Human Labor: An Ability-Based Approach. In *Academy of Management Proceedings*, volume 2019, page 15784. Academy of Management Briarcliff Manor, NY 10510.

Fjelland, R. (2020). "Why General Artificial Intelligence Will Not be Realized." *Nature: Humanities and Social Sciences Communications*, 7(1): 1-9.

Goldin, C. and Katz, L. F. (1998). The Origins of Technology-Skill Complementarity. *The Quarterly Journal of Economics*, 113(3):693–732.

Goldin, C. and Katz, L. F. (2008). *The Race Between Education and Technology*. Harvard University Press.

Goldin, C., Katz, L. F., et al. (2007). Long-Run Changes in the Wage Structure: Narrowing, Widening, Polarizing. *Brookings Papers on Economic Activity*, 38(2):135–168.

Goldin, C. and Margo, R. A. (1992). The Great Compression: The Wage Structure in the United States at Mid-Century. *The Quarterly Journal of Economics*, 107(1):1–34.

Goos, M. and Manning, A. (2007). Lousy and Lovely Jobs: The Rising Polarization of Work in Britain. *Review of Economics and Statistics*, 89(1):118–133.

Goos, M., Manning, A., and Salomons, A. (2009). Job Polarization in Europe. *American Economic Review: Papers & Proceedings*, 99(2):58–63.

Goos, M., Manning, A., and Salomons, A. (2014). Explaining Job Polarization: Routine-Biased Technological Change and Offshoring. *American Economic Review,* 104(8):2509–2526.

Grabner, H., Gall, J., and Van Gool, L. (2011). What Makes a Chair a Chair? In *CVPR 2011*, pages 1529–1536. IEEE.

Gregory, T., Salomons, A., and Zierahn, U. (2022). Racing With or Against the Machine? Evidence on the Role of Trade in Europe. *Journal of the European Economic Association, 20(2): 869-906*.

Grossman, G. M. and Rossi-Hansberg, E. (2008). Trading Tasks: A Simple Theory of Offshoring. *American Economic Review*, 98(5):1978–97.

Harrigan, J., Reshef, A., and Toubal, F. (2021). The March of the Techies: Technology, Trade, and Job Polarization in France, 1994-2007. *Research Policy,* 50(7).

Kahneman, D., Sibony, O., and Sunstein, C. R. (2021). *Noise: A Flaw in Human Judgment*. Little, Brown.

Karabarbounis, L. and Neiman, B. (2014). The Global Decline of the Labor Share. *The Quarterly Journal of Economics*, 129(1):61–103.

Katz, L. F. and Autor, D. H. (1999). Changes in the Wage Structure and Earnings Inequality. *Handbook of Labor Economics*, 3:1463–1555.

Katz, L. F. and Murphy, K. M. (1992). Changes in Relative Wages, 1963–1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Kogan L., Papanikolaou, D., Schmidt, L.D., and Seegmiller, B. (2021). "Technology-Skill Complementarity and Labor Displacement: Evidence from Linking Two Centuries of Patents with Occupations." NBER Working Paper No. 29552, December.

Komlos, J. (2016). "Has Creative Destruction Become More Destructive?" *The B.E. Journal of Economic Analysis & Policy,* 16(4).

Korinek, A. and Stiglitz, J. E. (2018). Artificial Intelligence and its Implications for Income Distribution and Unemployment. In *The Economics of Artificial Intelligence: An Agenda*, pages 349–390. University of Chicago Press.

Krusell, P., Ohanian, L. E., Ríos-Rull, J.-V., and Violante, G. L. (2000). Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Econometrica* 68(5):1029– 1053.

Levy, F. and Murnane, R. J. (2004). *The New Division of Labor: How Computers are Creating the Next Job Market*. Princeton University Press; Russell Sage Foundation, Princeton, N.J.

Lin, J. (2011). Technological Adaptation, Cities, and New Work. *The Review of Economics and Statistics*, 93(2):554–574.

Maloney, William F., and Carlos Molina. (2016). "Are Automation and Trade Polarizing Developing Country Labor Markets, Too?" World Bank Policy Research Working Paper 7922.

Mann, K., and Püttmann, L. (2021). "Benign Effects of Automation: New Evidence from Patent Texts." *The Review of Economics and Statistic*s.

Marcus, G. and Davis, E. (2019). *Rebooting AI: Building artificial intelligence we can trust*. New York: Vintage Press.

Michaels, G., Natraj, A., and Van Reenen, J. (2014). "Has ICT Polarized Skill Demand? Evidence from Eleven Countries over Twenty-Five Years." *Review of Economics and Statistics*, 96(1):60–77.

Nordhaus, W. D. (2007). Two Centuries of Productivity Growth in Computing. *The Journal of Economic History,* 67(1):128–159.

Polanyi, M. (1966). *The Tacit Dimension.* New York: Doubleday.

Schultz, T. W. (1975). "The Value of the Ability to Deal with Disequilibria". *Journal of Economic Literature*, 13(3): 827-846.

Smith, A. and Anderson, M. (2017). *Automation in Everyday Life.* Pew Research Center.

Susskind, D. (2020). *A World Without Work: Technology, Automation, and How We Should Respond*. Metropolitan Books, New York, N.Y.

Tinbergen, J. (1974). Substitution of Graduate Labor by Other. *Kyklos*, 27(2):217–226.

Webb, M. (2020). "The Impact of Artificial Intelligence on the Labor Market." Working paper.

Wike, R. and Stokes, B. (2018). "In Advanced and Emerging Economies Alike, Worries about Job Automation." Pew Research Center, Global Attitudes & Trends.

3 Digital technology and globalization: The promise and pitfalls

Kaushik Basu[1]

Introduction

The global economy is changing, but not in the way it routinely does—a generally upward drift that occasionally picks up speed, causes some turbulence, slows down on its own, and eventually returns to the normal trajectory. What it seems to be doing now is navigating a turning point, the kind that happens once in a few centuries. These turning points and shifts beneath the ground give rise to existential risks. In the past we have (by the very fact that we are here) managed to negotiate these tectonic shifts of the economy and survived. But that is in no way guaranteed. The last comparable change was in the eighteenth century when the Industrial Revolution gave rise to hope and promise, but also to despair and pitfalls, with soot and smog from factories darkening the skies, children toiling in factories for twelve and even fourteen hours a day instead of being in school and learning, thereby ensuring that they would grow up into an adulthood of poverty, and all this happening with technological change enabling a higher potential for growth.

One reason we emerged prosperous out of the one hundred odd years of the Industrial Revolution is that human beings managed to rise to the occasion in two ways. First, they came up with radical policies, like the numerous new laws and regulations that were initially implemented in Britain and then spread to the rest of the world, which caused a lot of chagrin to begin with. Second, there was a rise in radical ideas and in our scientific capacity to understand how the economy functions. It may not altogether be a coincidence that the Industrial Revolution overlapped with some of the most important breakthroughs in economic theory, from Adam Smith's *Wealth of Nations* in 1776, to the works of Stanley Jevons, Leon Walras, David Ricardo, John Stuart Mill, and others.

We stand today at a juncture where we once again need both, to acquire a deeper understanding of how the world economy functions or, more pertinently, how its functioning is changing, and to conceptualize and implement new policies to manage the new economy. There is a lot of research that is going on along these lines; and that is as it should be. Research, by its very nature, is a wasteful activity. Much of it does

[1] This paper has been prepared for the Brookings Institution's Global Forum on Democracy and Technology. I am grateful to Alaka Basu, Janina Curtis Bröker, and Zia Qureshi for valuable comments and suggestions.

not yield any result of any significance, but this wastage, if we want to call it that, is necessary to get the one or two hits that can transform the world, by helping us navigate the turbulence.

The aim of this paper is to provide some of the building blocks for this enormous and collective intellectual enterprise. We know what the sources of the challenge are. Like in past similar episodes, the current change arises from the bunching of technological breakthroughs. By their very nature, rapid technological advances give rise to hope and new possibilities, but their very novelty means that there are also new anxieties and uncertainties.

This time, the core of the technological advance is to do with information technology, computer science, and the digital revolution including Artificial Intelligence (AI). This has affected all walks of life, from how we work, produce, and trade to how we talk and confer, and whom we form political and social unions with. These changes have caused great turbulence to our economy: disquiet among the laboring classes that have had to contend with loss of jobs and rising wage inequality, trade tensions, efforts to de-globalize, and supply chain holdups. They have also created political polarizations of an acuteness rarely seen before.

The COVID-19 pandemic is too recent to be the root cause of this, but it has certainly added fuel to a fire that was smoldering. In a perverted way, the pandemic is a boon to the researcher and the perceptive policymaker. It has acted like a magnifying glass, making some of the problems, such as economic disparities and supply chain vulnerabilities, more acute and thereby helping us see and diagnose them better. A special challenge thrown up by the current crisis is that of vulnerability, as distinct from chronic poverty, and this creates the need for novel, global policies.[2] In the analysis below I try to take advantage of this to better understand what is happening and discuss how we may deal with the challenges.

What the next sections try to do is to briefly review the changes in the economy and look beyond what is visible to the naked eye to the ways the ground beneath our feet is shifting. These shifts represent the deep drivers of the new challenges to our economy and polity. The paper then goes on to discuss the need for novel policy measures and speculate what they may look like.

The digital revolution and the pandemic: In the eye of the storm

A lot has been written on the COVID-19 pandemic and how it has shaken up the global economy. I do not want to revisit this large topic but want to comment on one vital connection between the digital revolution and the COVID-19 pandemic. The latter has hastened some of the processes that had been started by the digital revolution. To understand this better requires us to resurrect an old idea in economics—that of learning-by-doing.[3]

However, before getting into this, it is important to take stock of the fault lines beneath the global economy that had begun forming well before the pandemic happened. As the *Global Economic Prospects* of the World Bank, released in January 2019, made clear, the economic situation in the world looked grim. The report painted a bleak picture, drumming in the main message with its subtitle–“Darkening Skies”–and cutting the growth projection for the advanced economies in 2020 to 1.6 percent (down from an estimated 2.2 percent growth in 2018). And the European Central Bank sounded the alarm over the eurozone economy,

[2] Hassoun (2022).
[3] Arrow (1962).

caused by Brexit and rising protectionism, exemplified by the trade war between the United States and China.[4]

Trouble has been brewing over the last four or five decades, coinciding with the revolution in information technology and computer science. As with all innovation, right from the discovery of fire and the making of stone implements to today's digital breakthroughs, it results in saving labor. Instead of us toiling with our hands, more and more tasks are taken over by tools, machines, and new technology. Added to this long march of labor-saving technology, the technological revolution this time around has also given rise to what may be referred to as "labor-linking" technology. By using digital connectivity, we can have workers sitting in faraway lands, creating goods and services for consumers and users in some other nation, while working for corporations which may be located in yet another place.

The twin advance of labor-saving technology and labor-linking technology has meant a steady erosion in the share of national income going to workers in rich and upper-middle-income countries. Several papers have documented this trend.[5] The erosion in the demand for labor has caused inequality to rise,[6] and has had a large political and social fall-out, with a spike in political polarization and greater social conflict.

What this has done to low-income and lower-middle-income economies is interesting. As the demand for traditional labor has been declining with technological advance, the poorer economies, with their low wages, have not been hit as directly as the advanced economies. But, with diminishing demand for labor, competition across these economies has increased. Economies with better digital connectivity, better trained workers, and sufficient law and order so as not to disrupt economic activity have taken a larger share of the global work. This has been creating new winners and losers among the currently developing economies. I argue later that this will intensify in the future. And, eventually, it will become a global problem, causing yawning gaps in inequality in all nations and across nations, with the owners of capital, stocks and shares, and the holders of intellectual property seeing their incomes rise and the working classes (or "former" working classes, as work diminishes) becoming impoverished.

Moreover, technological change is driving a rising wage-premium for high-skilled workers. This is happening particularly in advanced economies and could increasingly happen in developing economies as the latter experience stronger and deeper impacts of the digital revolution. It is causing an income chasm to appear not just between the capitalist class and the workers, but between the high-skilled workers and the rest of the working class.[7]

The arrival of COVID-19 in late 2019 has caused a lot of suffering, in terms of health and economy. Under normal circumstances, this would inflict pain but then allow society to return to normal. What is different with this pandemic is that the return to "normal" may not be an option. This is because the pandemic came in the midst of major shifts in the global economy caused by the digital revolution. The cracks that were beginning to appear beneath our economy may have been widened beyond repair and hardened by COVID-19. The expression frequently used by economists, unmindful of the fact that it is probably a contradiction in terms, is the "new normal." The digital revolution, speeded up by the pandemic, is forcing us to adjust to a new world and a new normal.

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[4] https://www.theguardian.com/business/2019/oct/24/germany-eurozone-stagnation-economy-output-recession
[5] Autor, Katz, and Krueger (1998); Karabarbounis and Neiman (2014); Basu (2016).
[6] Bourguignon and Morrisson (2002); Milanovic (2010).
[7] Autor (2019); Coulibaly and Foda (2020).

There is a lot of speculation about what the new global economy will look like. Some argue that this shock will make us wary of globalization and we shall see a retreat of globalization, or a steady de-globalization. There is also a school of thought that argues that GDP growth is damaging the world beyond repair and that it will have to slow down if we are to survive and create a sustainable world.

I want to express disagreement with both the de-globalization thesis and the de-growth conjecture. It is true that disruptions in supply chains in the wake of the pandemic, reflected in various vital shortages from computer chips and truck drivers to automobiles and healthcare supplies, have made nations wary of globalization. The labor market disruptions caused by the falling demand for labor have also made some political leaders take up positions against outsourcing. But these objections are not viable in the long run. To act on these emotions and close down the use of labor in developing countries is like discovering a vital input for production in a far country and then vowing not to use it. If a country does not use the cheap labor now available thanks to the advance of labor-linking technology made possible by the digital revolution, it is arguable the country will get outcompeted in the final product market by other countries that are willing to use this resource because those other countries will be able to produce the final goods at a lower cost as a result. So, a country practicing labor market protectionism will either soon learn of this trade disadvantage and give up on protectionism or, in case it holds on to this policy cussedly, get outcompeted by other countries and get pushed to the margins of the global economy. In either case, globalization will persist.

Indeed, there is reason to believe that globalization will gain pace. This is for an unexpected reason to do with the COVID-19 pandemic. This pandemic has given us a crash course in the use of digital technology—Zoom to give lectures, WebEx to have meetings without having to travel great distances to meet up in person, Amazon to buy goods instead of driving to shops and malls, and Uber to fetch car rides instead of waiting by the roadside with flailing arms. The idea of learning-by-doing has jumped out of our books and journals and gone from being a theoretical idea to an inherent part of modern life. Over the last two years, we have become conversant in doing long-distance work without leaving our home. The digital technology, which has been with us for a few decades, has suddenly risen to a level of familiarity that would have been impossible without being compelled to learn and do the way we were forced to because of the pandemic.

After a few de-globalization bumps that will no doubt occur in the short run, we are likely to see a sharp rise in outsourcing for goods and services, since we have all learned how simple it is. This will have major implications for the kind of economy and, more generally, polity and society we are about to encounter.

Let me turn now to the conjecture of a growth slowdown, and why I believe this is unlikely. Major technological advances cause turbulence, but if we manage to navigate the turbulence and come out of it, as humanity has done in the past, we end up growing faster rather than slower. Table 1 is a reminder of this in the context of the Industrial Revolution. Maddison's (2007) estimates suggest that, for two to three hundred years preceding the Industrial Revolution, the world was used to an average annual growth rate of 0.32 percent. This was more or less so until the early decades of the Industrial Revolution, before the benefits of better technology spread widely.

After the dust and chaos of the Industrial Revolution settled, the new laws and regulations were in place, and a dramatic change in our economic life followed this technological advance spanning roughly one century from the mid-18th century to the mid-19th century. This is captured by the second column of Table 1. Western Europe transformed from a virtually stagnant economy to one bounding ahead at a growth rate of 2.11 percent. From 1870 to the eve of World War I, the global economy had an annual growth rate of

2.12 percent. Growth accelerated further in the post-war period. In short, post-Industrial-Revolution global economic growth was more than eight times the growth that was normal before the revolution.

Table 1: Growth takeoff after the Industrial Revolution

GDP growth rates (percent per annum)			
Country/Region	1500-1820	1870-1913	1973-2003
Western Europe	0.40	2.11	2.19
United States	0.86	3.94	2.94
China	0.41	-0.37	7.34
India	0.19	0.38	5.20
Africa	0.15	1.32	2.97
World	0.32	2.12	3.17

Source: Maddison (2007).

A simple extrapolation of this would suggest that our recent normal global growth of 3.17 percent per annum could rise to roughly 25 percent per annum after the dust and fury of the ongoing digital revolution settle.

Our first reaction to this would be that this is impossible. How can the whole world grow at an annual rate as high as that? While there is reason to be skeptical of mechanical extrapolation, one must also be skeptical of one's immediate reaction. If before the Industrial Revolution people were told that the world, which had been growing at around 0.3 percent for hundreds of years, would be growing at 2 percent after the revolution, that would have been dismissed as fiction or fantasy. Another reason not to dismiss the potential for high growth this time lies in the fact that the concept of GDP is of course a creation of economists.[8] We can conceive of GDP very differently. I return to this in section 4.

We are at a stage of development where we have to entertain a wide range of possibilities that challenge our imagination, if only so that we are prepared to deal with it to ensure that we do not go the route that the dinosaur went.

Challenges for the discipline of economics

During the eighteenth and nineteenth centuries, as the shape of the global economy changed, our understanding of how the economy functions grew in leaps and bounds. It is time to put on that scientific hat again. This is a short section because no one quite knows where such scientific inquiry will go. All one can do is to emphasize the need for fundamental work. Like Thomas Kuhn's (1962) "normal science," "normal economics" is important. The discipline has advanced a lot by gathering data, analyzing them

[8] Mitchell (2005).

with standard statistical methods and through the lens of conventional theory, and finding various links between our actions and their consequences.

This normal economics has to continue, but we also need to focus a part of our energy to unearthing and understanding the deeper structural shifts that are taking place. In economics, as in all disciplines, we make many assumptions, and write them down explicitly. Our textbooks are full of axioms and assumptions written in bold. What we are prone to forget or, worse, be unaware of are the assumptions that are hidden in the woodwork.[9] Thus, in general equilibrium theory, to explain what makes trade and exchange possible and enables markets to reach equilibria and Pareto optimality, we write down explicitly various assumptions, such as the absence of externalities, the convexity of human preferences, technology eventually facing decreasing returns to scale, and so on. But for trade and exchange to be possible, we also need people to be able to talk and communicate. However, we do not write down, among the various axioms, the following:

Axiom: Can talk. That people can talk and communicate is taken for granted.

This is just one example. There are numerous such assumptions that are hidden in the woodwork of the economist's model of the market economy that play a critical role but get no mention. As Mazzucato (2021, p. 20) notes in her influential book, following a line of thought that goes back to Karl Polanyi (1944), "[M]arkets are embedded in rules, norms and contracts affecting organizational behavior, interactions and institutional designs." An economy does not succeed by fiscal and monetary policies and trade and competition policies alone. Our norms and culture matter—are the people trustworthy, do they punch their trading partners on the nose and try to run away with their endowment? We take answers to such questions for granted.

For the most part, this does not matter because these normative and cultural traits tend to be fairly constant. But when the world hits a major turning point, they are more likely to change. The axiom "Can Talk" is harmless to leave dormant when our modes of communication are constant, and we understand one another because the same words convey the same meaning. This can indeed be a safely undisturbed assumption for centuries. But when digital connectivity opens up conversation across groups where the meanings of words can be different, the assumption that people can communicate comes under strain and may begin to malfunction. This can, in turn, not only damage the economy,[10] but also create strains on democracy since communication is vital for the functioning of democratic institutions.[11] Minimally we need the law either in written form or as an unwritten, shared understanding concerning the code of behavior, as was the case with the Rhetra, the Spartan constitution.

We may then need to build our models from more basic assumptions, so that we can modify the social and cultural axioms and track their consequences on the economy as well as on society and polity.

[9] Basu (2000).
[10] The connection between these informal links and the economy and, more specifically, the functioning of markets gets little attention in mainstream economics. But personal relations, the bilateral trades and barters that corporate leaders do with other corporate leaders, and with political leaders, can affect market outcomes, promote collusion, and create power blocks. There has been some recent analysis of the interface between this and economic outcomes (Khan, 2017b, Ferguson, 2020), but there is still a long way to go. There are also some interesting studies on the unusual forms of interaction between norms and the law, with the law not just being ignored but backfiring when it contradicts prevailing norms (Acemoglu and Jackson, 2017).
[11] Monga (2021).

Another implicit assumption in much of traditional economics is that people are endowed with exogenously given desires and ambitions, captured in models under the ubiquitous concept of the utility function or, in game theory, the payoff function. In reality, many of our ambitions are not exogenous at all but "created targets." Once people realize that dribbling a ball past others and kicking it through the goalposts is watched and cheered by people, that can become a target. Scoring a goal for my team can become an ambition that is not an instrument for getting the exogenous desires we have—for more money, and to buy more apples and oranges and clothes and cars. Scoring a goal for my team can be an end in itself, so exciting that we practice for hours and are willing to sprain our ankles to achieve this objective.

Among life's many created targets, an important one is patriotism. In certain forms this can play a positive role in promoting cooperation, but in its more aggressive form, it can be a trigger for war, supremacy, and mass killing. In our traditional model, it is baffling that people are willing to lay down their lives for the nation. But the whipping up of patriotism is a created target. To persuade people to risk their lives to kill others, we would normally have to financially compensate them with huge sums. But political leaders, sitting in their comfort zones, know that once patriotism is whipped up, that is not necessary. Patriotism is good fiscal policy.

A lot of modern life is the outcome of created targets such as the above, but this gets little attention in economics, and that in turn handicaps our understanding of society and the economy.

We know from other disciplines that the unearthing of implicit assumptions can yield rich dividends. Euclid developed geometry carefully by laying down the axioms as clearly as he could. But there was (at least) one axiom that he used unwittingly, namely, that everything was happening on a plane. This did not make a big difference for humans in the days of limited and slow travel. But if we continued to use Euclidean geometry to make calculations into the age of air travel over our spherical earth, we would have had accidents and disasters. The unearthing of the hidden assumption of Euclid and the emergence of geometry for spherical surfaces in the nineteenth century was crucial for the modern age.

The unearthing of assumptions is a big research agenda, and it is not my intention to try to speculate in a short paper about where this might go. But I point this out to emphasize that the time has come for fundamental research, the sort that enabled us to navigate the Industrial Revolution and may play a role in our surviving the digital revolution. A key research question going forward is how the digital revolution challenges some of the assumptions we normally make in economics, explicitly or implicitly.

The shape of things to come and the policy challenge

Even as we grapple with our understanding of the changes that are occurring, we can begin to form a broad idea of the way the world is going and some of the policies we need to adopt to adjust to the changing global economy. The global economy is clearly undergoing a major transformation. One simple indicator that says a lot is the flow of data between countries. Between 2005 and 2015, cross-border data flows rose 45 times.[12] This immediately tells us how much scope there is for outsourcing and for cross-country collaboration in terms of work and the production of goods and services.

[12] Meltzer (2020).

This creates the potential for boosting trade, productivity, and economic growth.[13] But it also creates the scope for market capture by the early investors taking advantage of being the first movers and reaping the economies of scale and network effects associated with the digital technologies. Indeed, there are data showing that big corporations, such as Amazon, made losses for several years after their founding, with the aim of capturing markets first and making profits later.[14] To quote Khan (2017a, p. 716), "With its missionary zeal for consumers, Amazon has marched towards monopoly by singing the tune of contemporary antitrust."

As already mentioned, technological advances create both opportunities and dangers. It is close to certain that the turmoil of digital advance will create new winners and losers across countries, firms, and workers—a dynamic that is already in play. Once again, we can return to the Industrial Revolution to see how dramatically the landscape of economic progress changed. This is summed up in Table 2.

The shares of global GDP that went to France, Germany, UK, and U.S. in 1700 were 5.3 percent, 3.7 percent, 2.9 percent, and 0.1 percent, respectively. These did not move too much into the Industrial Revolution. By 1820, France and Germany had virtually the same shares as 120 years ago. UK, where the Industrial Revolution came first, took a larger share, namely, 5.2 percent. U.S., which was still being populated by European settlers, also grew to have a larger share. However, by 1870 and certainly by 1950, the landscape changed the world over. China and India had shrunk into minor players. Europe grew and U.S. grew dramatically. The map of the world was transformed.

Table 2: Change in global economic map after the Industrial Revolution

Share of global GDP (percent)				
Country	**1700**	**1820**	**1870**	**1950**
France	5.3	5.1	6.5	4.1
Germany	3.7	3.9	6.5	5.0
United Kingdom	2.9	5.2	9.0	6.5
United States	0.1	1.8	8.9	27.3
China	22.3	32.9	17.1	4.6
India	24.4	16.0	12.1	4.2

Source: Maddison (2007).

Arguably, the landscape will change once again, thanks to the ongoing digital revolution. But before getting into this, we must ask a prior question. Is the kind of growth escalation as I speculated in the last section viable? Can our growth be much higher without us destroying the environment? I think the answer is yes and the clue lies in the content of GDP.

When we speak of a higher GDP, the lay person thinks of more food, clothes, cars, homes, planes, and luxury yachts. But GDP consists of not just these kinds of goods but anything that we value. Thus better

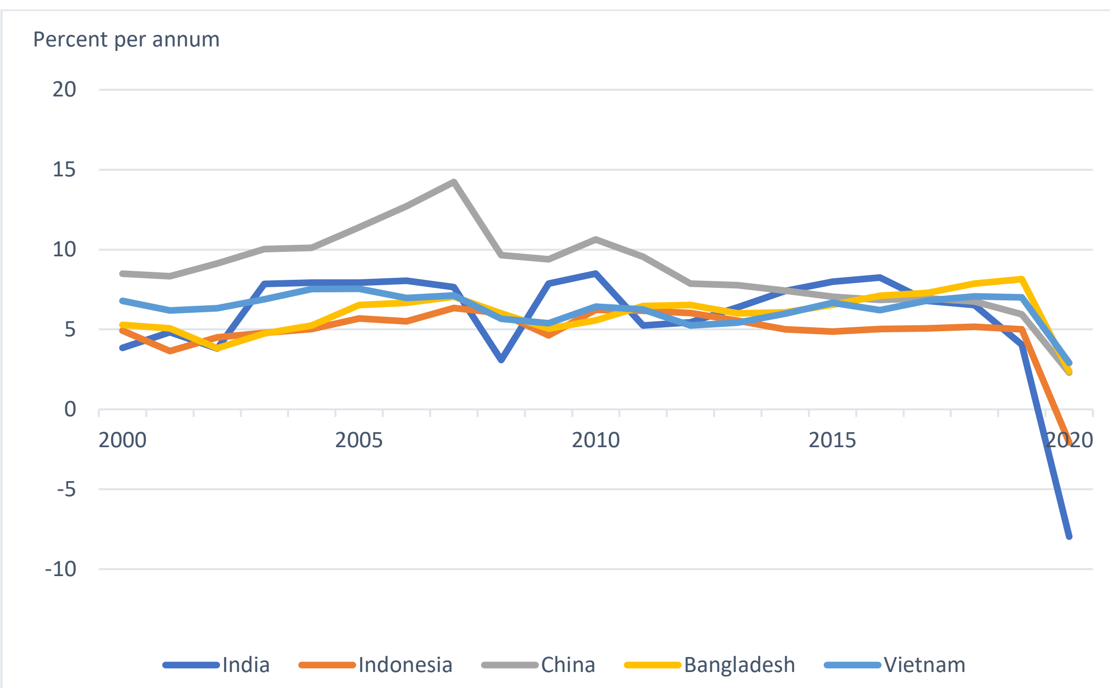
[13] Qureshi (2020).
[14] Khan (2017a).

health, high-quality leisure, more music, more art, more services being created in the digital space that people enjoy, and more time to ponder and savor the mysteries of the universe are also constituents of GDP, although some of these more intangible items are not adequately captured by current measures of GDP. The scope for better health, for instance, is immense. If basic health care is extended to all and major breakthroughs are made conquering disease, putting an end to pain and increasing life expectancy, we can have a much higher GDP, where a huge part of the GDP is the consumption of better health. Hence, it is in principle possible to see GDP growth, properly measured, increase by leaps and bounds, as it did after the Industrial Revolution, and for the environment not to be destroyed because the content of GDP also changes sharply and for the better.

For such a transformation to be viable, we need policy shifts, from small but smart changes to big and bold leaps. As we saw with the Industrial Revolution, there were dramatic shifts between the growth leaders and the growth laggards. There are bound to be new winners and losers emerging out of the digital revolution—and the more immediate crisis caused by the pandemic. It is too early to tell who they will be, but the turmoil is obvious by eye-balling recent growth charts. Figure 1 illustrates what is happening in a selection of five Asian economies: India, Indonesia, China, Bangladesh, and Vietnam.

All of them have seen a big plunge over the last two years shown in Figure 1, 2019 and 2020. The cause of this is the COVID-19 pandemic, but the effects on the countries have been very different. The biggest hit seems to have been taken by India, followed by Indonesia, and then China. The two countries that have weathered the crisis the best are Bangladesh and Vietnam. We have to keep in mind that Vietnam was the last to see a COVID-19 surge among these five countries; so, its growth may yet take a beating with a lag.

Figure 1: GDP growth rates in selected economies, 2000-2020



Source: World Bank Development Indicators.

Nevertheless, it seems that Vietnam and Bangladesh are well poised to emerge from the crisis, winning over a part of the global manufacturing that was earlier located in China and may be ready for a move in search of cheaper labor. India's position is more ambiguous. India's growth saw an upswing from roughly 2003. It took a hit in 2008 from the Great Recession but recovered in one year and then rose again—making India the fastest-growing country not just in this cluster of five countries but among almost all countries in the world. Its overtaking of Chinese GDP growth in 2014 made global news. However, India's growth has been on a monotonic decline since 2016 and has taken a bigger hit than most other countries from the pandemic.

India has fundamental strengths and has the potential to re-emerge as a major global growth driver, even though its politics is currently under strain. For China, after its relentless growth for three decades, a slowdown is only to be expected. Indonesia is making strenuous efforts to draw in some of the new global capital flows and may see an upswing, but question marks remain. Among this cluster of countries, the two well-poised for a growth sprint are Vietnam and Bangladesh. Both of these countries had created certain favorable pre-conditions to be ready to take advantage of the new opportunities that are arising now.

For Vietnam, its *Doi Moi* reforms played a prominent role. Under this program, Vietnam cut down many of the bureaucratic costs of doing business, eased barriers to investment and trade, and entered into several international agreements to integrate with the global economy, starting with a trade agreement with the U.S. in 2000. And, perhaps most importantly, it invested heavily in education and the building up of human capital. Bangladesh too, spurred by the early activism of non-governmental organizations such as the Grameen Bank and BRAC, saw its human capital and standard of living rise faster than one would expect in a poor country. In terms of life expectancy at birth, it has now reached 73 years, higher than India's 70. It also has had a lot of success in drawing women into the labor force. This, plus the fact that it revamped some of its dated labor laws, meant that Bangladesh was ready to occupy some of the space vacated by China in labor-intensive manufacturing as a result of rising labor costs.

These are however short-run expectations. Much will depend on how countries manage to design and implement the deep policy shifts made necessary by the digital revolution. I do not want to speculate about who the long-run leaders will be; instead, I want to dwell on the kinds of policy shifts that are needed.

First, it is inevitable that the demand for traditional labor will continue to decline. The low-income and lower-middle-income countries may not feel this pressure for another five or even ten years, since they may be able to attract a larger share of the globe's shrinking need for traditional labor by virtue of their low wages. But the pressure will eventually come to their shores as digital machines and robots continue their march on traditional labor.

There are two key measures needed to address the new challenges. The first is the preparedness of human beings to switch to more creative labor. More and more people will have to be engaged in creative work: the production of music, art, and literature; mathematics and science; research to discover new technologies, new medicines, better health care, and new methods of environmental preservation; and skill and organizational adaptations as digitalization and AI continue to transform work and business. This in turn will hinge on countries' capacities to move from traditional education to training the mind for more creative work and instill skills compatible with the new technologies.

The recent history of South Korea's economy illustrates some of this transformation. Rich countries have less growth potential than poorer ones. But among rich countries, South Korea stands out. This is mainly because of its investment in human capital. With 3,319 patent applications per million population in 2019,[15] South Korea is head and shoulders above other countries. Japan had the second-highest number, with 1,943, while China and the U.S. had 890 and 869, respectively. In April 2019, South Korea became the first country to launch a nationwide 5G campaign, and South Korean firms plan to capture a 15 percent share of the global 5G market by 2026.[16] Moreover, South Korea has gone some distance toward solving a market failure that plagues all countries: teacher selection. In most countries, school teachers are paid less than they should be, given that the effect of a good education cascades down to future generations. Good teachers are thus a bit like good climate policy: future generations benefit, but they have no influence over today's decisions. South Korea has drawn some of its most talented people into teaching, and schoolteachers are among the country's richest people. And it has emphasized scientific, professional, and creative skills for the future in its education and training. This has played a significant role in the country's success in intellectual property creation and preparation of its workforce to harness technology to achieve high growth.

The second measure to counter the decline in the demand for traditional labor is the need for radical policies to redistribute income and wealth. The fact that machines are replacing drudge labor should not be a problem, and in fact it should be a matter to celebrate, since we will be free to spend our time and energy on better things. The reason why this is a problem is that every time machines displace labor, the incomes of workers are displaced by the incomes of those who own the machines or have patents on the new technology. This is what is making the rise of technology move in tandem with the growing chasm between the income of the rich and the poor. But this is not innate or inevitable. It is of our making. The structure of property rights, and the fact that once you own shares you own them forever unless you volunteer to sell, are our creations and we need to think of changing some of these if we want to avoid rising inequality.

We are at a stage of history where we have to consider radical policies, or rather policies which look radical to us because we think of the status quo as somehow the normal. Several commentators have written about the mega profits that the Big Tech and Big Pharma are making, the rising market power that they wield, and the need to use antitrust laws more effectively.[17] We should certainly try to do this, and in fact do it in novel ways that respond to the new dynamics of the digital economy, keeping in mind that antitrust laws are means to protect not just consumers but also the workers and the small businesses that are increasingly compelled to use the mega digital platforms in ways that undermine competition.[18] But that in itself is unlikely to go very far in this new world. The reason is that the main strength of the new digital technology is the increasing returns to scale and network effects that come with it. To break up Google and Amazon into a hundred digital platforms will mean destroying the very basis of advantage that these platforms create—one place to do all our search.

We need to go beyond antitrust laws to more radical policies, such as having laws which compel corporations to have dispersed shareholdings. A corporation making disproportionate profits would not be a social problem, putting democracy under strain, if the profits were owned by a large number of shareholders, each owning a small slice of the pie.[19] And we may have to go further with the idea of profit-sharing. A part of the profit in a nation should be treated as shares owned by all the people. This is an old idea that goes back to Weitzman (1984), but it is time to resurrect it not as pure theory but to be designed

[15] https://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2020.pdf.
[16] http://www.keia.org/sites/default/files/publications/kei_aps_gillispie_200316.pdf.
[17] See, for example, Khan (2017a).
[18] Naidu, Posner, and Weyl (2018).
[19] Basu (2021a).

for actual implementation.[20] We know from past experience that the profit motive is an important driver of human enterprise and hard work. So, it will be folly to nationalize all enterprise. What we can do, however, is treat a part of all profit as collectively owned by all the people. Hence, when, with the rise of machines and robots, wages become profit, a part of this will flow back to workers in the form of returns on the share of profit owned by them.

Some of this scheme of what may be called "universal basic shareholding" can be replicated with a well-designed system of taxing profit and transferring some of the revenue to the less well-off. In many situations, this may be a less radical and, for that reason, an easier way to reach a similar end. However, for the morale of workers, it may be better for them to actually be owners of some fraction of corporations, which is what the holding of shares will mean.

The race between new policy and human ingenuity is eternal. We have to keep in mind that if some of the policy changes being suggested above materialize, people will also strive to figure out ways to counter them. For one, even if some countries implement such changes, people may circumvent them by parking money in other countries. Moreover, the inequality between countries may rise, offsetting the flattening out of inequality within countries. This takes us to the subject of politics and global policy.

Politics and economics

The reforms needed today go beyond economics. With globalization, we have problems of supply chains spanning multiple nations, but this also means that if one nation flounders, the whole world's production suffers a setback. But with this and with the many other forms of economic intertwining of nations that are happening under globalization, there are new social and political risks that are beginning to emerge. There are the direct risks like the power a nation acquires by being a link in a supply chain. It can use the threat of cutting off the link and bringing global production to a halt. In short, the world is becoming open to new forms of economic warfare.

The problems, however, go beyond the economic sphere. As I have argued above, with the current digital revolution and the learning-by-doing experience that we have all had thanks to the COVID-19 pandemic, the pace of globalization is likely to pick up, even though there may be some short-term de-globalization stumbles en route. As that happens, there will be more moves to create monetary unions like the eurozone. In addition, climate change is bound to cause large swathes of people to move and relocate. The intermingling of peoples and cultures that all this is giving rise to is creating new tensions, leading to the appearance of new and unexpected power bases,[21] with political polarization and the spawning of intergroup friction.

This dynamic was articulated eloquently by Vaclav Havel in his Indira Gandhi Prize acceptance speech delivered in New Delhi on February 8, 1994: As globalization progresses, people's "antipathy to other communities grows stronger as well. The more the diverse, autonomous cultures are drawn into a single vortex of contemporary civilization, the more vigorous is their need to defend their original autonomy, their otherness, their authenticity." But not knowing where to vent their anger, "they defend their

[20] Moene and Ray (2016); Basu (2016).
[21] The closest conceptualization of this in the social sciences is the idea of "protean power," which springs from "improvisational and innovative responses to uncertainty that arise from actors' creativity and agility in response to uncertainty" (Seybert and Katzenstein, 2018, p. 4).

authenticity against a substitute enemy—against the authenticity of another. Again, I would compare it to conditions inside a prison. When I was there, I often observed that the prisoners took their hatred of prison or their jailers out on one another."[22]

Just as we realized in the 17th century that we cannot have a single economy with multiple money-creating authorities, and each nation began to set up its own unique central bank, we are at a juncture in the world where a minimal architecture of global governance is becoming critical. In the same Indira Gandhi Prize event in Delhi, Havel expressed this sentiment, hinting at the need for global governance, when he said, "The only way to begin is by seeking a new spirit and a new ethos of co-existence."

A minimal global constitution is a difficult but not impossible target. The belief that an exogenous state is necessary for order to prevail is flawed for a philosophical reason, namely, that, in the final analysis, there is no exogenous state. That is an illusion. All laws are nothing but words—some ink on paper, or inscription on basalt (as was the case with the Code of Hammurabi), or digital jottings stored in cyberspace. In the end, the power of the law comes from our ability to create endogenous enforcement mechanisms. This perspective has begun to spawn an important literature on minimal social contracts and conventions and the extent to which these can be self-enforcing.[23] Furthermore, we have had some success in creating partial global conventions in various specialized fields, such as for labor under the initiative of the International Labour Organization and for trade led by the World Trade Organization. We have also seen the first steps toward coordinated global climate initiatives, broadly under the United Nations Framework Convention for Climate Change.

It is time to go further, stepping into the domains of social and cultural norms and wealth redistribution. Most effort to flatten out some of the great inequalities has been at the level of the nation thus far. We use the income tax, wealth tax, and, in some cases, inheritance tax to reduce inequality by effecting redistribution within the nation. But some of the greatest inequities today cut across national boundaries and need to be addressed. We need powerful nations that also have a moral commitment to engage in this. Nevertheless, there will be huge, vested interests that will try to stall such efforts. In the end, such an initiative will have to come from ordinary people with leadership provided by international think tanks and thought leaders. They can, in turn, create pressure on international multilateral organizations to shoulder some of the responsibility.

The aim should be to build a social contract covering all nations or, in effect, a minimal global constitution.[24] This will be much slimmer than a national constitution, since we have to try to tread on as few toes as possible, but there can be no looking away from the fact that this will entail wading into some controversial matters.

The need for this can be seen from an imaginary (and maybe not so imaginary) example. We often take the view that people should be free to practice their own culture, religion, and norms as long as they do not try to stop others from doing the same. This sounds like a noble axiom but it may not be as innocuous as appears at first sight. Suppose in a pre-globalized world people live on different islands and each island develops its own norm on which side of the road you drive on. Some drive on the left and some on the right. Over time, this becomes so ingrained that it becomes like a religion. Now suppose globalization

[22] Havel (1994).
[23] See, for instance, Hadfield and Weingast (2013); Gaus (2018); Moehler (2018); Vanderschraaf (2019, 2021); and Basu (2018, 2021b).
[24] The need for this and the challenges in carrying this out have been discussed in many works (see Sarat, Douglas, and Merrill, 2011; Breyer, 2015; and Hadfield, 2016).

occurs and people move to occupying common space. Clearly, we cannot leave people free to practice their own norms, namely, which side of the road they drive on. To look away from this problem or to leave individuals to sort the problem out on their own terms will cause accidents, violence, and street fights. We need to recognize the problem, sit together to confer, and reach agreements. We may say that we will all drive on the X side and for those who will incur a cost because they were used to driving on the Y side, we will make sure that they gain on some other dimension of this minimal global constitution as a kind of compensation.

A global social contract or constitution, in today's globalized world, will clearly have to delve into both politics and economics, such as giving the world's leaders collectively the right to intervene even militarily if there is grave injustice in a country, and creating systems of wealth and income transfers from the rich to the poor across the globe, not as occasional acts of charity but as a constitutional compulsion. There are institutions that try this, such as the UN Global Compact that helps firms and corporations adopt collectively responsible norms of behavior, and of course the UN Charter, which has some of the features of a constitution, but not enough. For one, it does not have the overarching reach of a national constitution, such as that of the U.S.[25] It includes all "peace-loving states" (Article 4.1), leaving it a bit ambiguous about the treatment of non-peace-loving states.

The need for a more ambitious global constitution covering all nations and people and with a remit responsive to our time becomes greater as the world gets globalized in novel ways, thanks to the advance of digital technology. This gives rise to new issues and intricacies, including those in global digital governance. It will not be easy to bring the diverse powers and interests of the world to a common table to work out even a minimal constitution, but the costs of not doing so are so great that we no longer have the luxury to look the other way.

Coordination and cooperation across individuals and groups is important at this critical juncture of the world. As I argued above and elsewhere, the need for this goes beyond the nation. On the one hand, there is need for this at the community level and, on the other hand, at the global level, cutting across nations. This is hard but not as impossible as appears at first sight. The state is, in the final analysis, an endogenous institution, created by human beings to facilitate coordination among themselves. It is possible to mimic some of this at the global level, even without having an overarching state. Hope lies in the fact that drawing up and agreeing to a constitution even for nations, especially the larger ones, had once seemed like a hopeless dream. But we did succeed in many large nations, be it the U.S. in 1789 or India in 1950.

[25] Doyle (2012).

References

Acemoglu, D. and Jackson, M. O. (2017), "Social Norms and the Enforcement of Laws," *Journal of European Economic Association,* vol. 15.

Arrow, K. J. (1962), "The Economics of Learning by Doing," *Review of Economic Studies*, vol. 29.

Autor, D. (2019), "Work of the Past, Work of the Future," in American Economic Association *Papers and Proceedings,* vol. 109.

Autor, D., Katz, L. and Krueger, A. (1998), "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics*, vol. 113.

Basu, K. (2000), *Prelude to Political Economy: A Study of the Social and Political Foundations of Economics*, Oxford University Press, Oxford and New York.

Basu, K. (2016), "Globalization of Labor Markets and Growth Prospects of Nations," *Journal of Policy Modeling*, vol. 38.

Basu, K. (2018), *The Republic of Beliefs: A New Approach to Law and Economics*, Princeton University Press, Princeton.

Basu, K. (2021a), "The Ground beneath our Feet," *Oxford Review of Economic Policy*, vol. 37(4), Winter 2021.

Basu, K. (2021b), "Conventions, Morals and Strategy: Greta's Dilemma and the Incarceration Game," *Synthese*, forthcoming.

Bourguignon, F. and Morrisson, C. (2002), "Inequality among World Citizens: 1980 to 1992," *American Economic Review*, vol. 92.

Breyer, S. (2015), *The Court and the World: American Law and the New Global Realities*, Knopf, New York.

Coulibaly, B. and Foda, K. (2020), "The Future of Global Manufacturing," in H.-W. Kim and Z. Qureshi (eds.), *Growth in the Time of Change: Global and Country Perspectives on a New Agenda*, Brookings Institution Press, Washington, D. C.

Doyle, M. (2012), "Dialectics of a Global Constitution: The Struggle over the UN Charter," *European Journal of International Relations*, vol. 18.

Ferguson, W. (2020), *The Political Economy of Collective Action, Inequality, and Development*, Stanford University Press, Stanford.

Gaus, G. (2018), "Self-organizing Moral Systems: Beyond Social Contract Theory," *Politics, Philosophy and Economics*, vol. 17(2).

Hadfield, G. (2016), *Rules for a Flat World: How Humans Invented Law and How to Reinvent it for a Complex Global Economy*, Oxford University Press, Oxford and New York.

Hadfield, G. and Weingast, B. (2013), "Law without the State: Legal Attributes and the Coordination of Decentralized Collective Punishment," *Journal of Law and Courts*, vol. 1.

Hassoun, N. (2022), "Human Development, Vulnerability, and Creative Resolve," Background paper for *Human Development Report, 2022*, UNDP, New York.

Havel, V. (1994), Acceptance Speech for the Indira Gandhi Prize, http://old.hrad.cz/president/Havel/speeches/1994/0802_uk.html

Karabarbounis, L. and Neiman, B. (2014), "The Global Decline of the Labor Share," *Quarterly Journal of Economics*, vol. 129.

Khan, L. (2017a), "Amazon's Antitrust Paradox," *The Yale Law Journal*, vol. 126.

Khan, M. H. (2017b), "Introduction: Political Settlements and the Analysis of Institutions," *African Affairs*, 1-20.

Kuhn, T. (1962), *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.

Maddison, A. (2007), *Contours of the World Economy: 1-2030 AD: Essays in Macroeconomic History,* Oxford University Press, Oxford.

Mazzucato, M. (2021), *Mission Impossible: A Moonshot Guide to Changing Capitalism*, Harper Collins, New York.

Meltzer, J. (2020), "The Digital Transformation of International Trade," in H.-W. Kim and Z. Qureshi (eds.), *Growth in the Time of Change: Global and Country Perspectives on a New Agenda,* Brookings Institution Press, Washington, D. C.

Milanovic, B. (2010), *The Haves and the Have-Nots: A Brief and Idiosyncratic History of Global Inequality,* Basic Books, New York.

Mitchell, T. (2005), "The Work of Economics: How a Discipline Makes its World," *European Journal of Sociology*, vol. 47, no. 2.

Monga, C. (2021), "The Interim Balance Sheet of Democracy: A Machiavellian Memo," in Basu, K. and Hockett, R. (eds.), *Law, Economics, and Conflict*, Cornell University Press, Ithaca, NY.

Moehler, M. (2018), "Diversity, Stability and Social Contract Theory," *Philosophical Studies*, vol. 176.

Moene, K. O. and Ray, D. (2016), "The Universal Basic Share and Social Incentives," *Ideas for India,* https://www.ideasforindia.in/topics/poverty-inequality/the-universal-basic-share-and-social-incentives.html.

Naidu, S., Posner, E. and Weyl, G. (2018), "Antitrust Remedies for Labor Market Power," *Harvard Law Review*, vol. 132.

Polanyi, K. (1944), *The Great Transformation*, Beacon Press, Boston.

Qureshi, Z. (2020), "Technology, Change, and a New Growth Agenda," in H.-W. Kim and Z. Qureshi (eds.), *Growth in the Time of Change: Global and Country Perspectives on a New Agenda*, Brookings Institution Press, Washington, D. C.

Sarat, A., Douglas, L., and Merrill, M. (Eds.), (2011), *Law Without Nations,* Stanford University Press.

Seybert, L. and Katzenstein, P. (2018), "Protean Power and Control Power," in Katzenstein, P. and Seybert, L. (eds.), *Protean Power: Exploring the Uncertain and Unexpected in World Politics***,** Cambridge University Press, Cambridge.

Vanderschraaf, P. (2019), *Strategic Justice: Conventions and Problems of Balancing Divergent Interests*, Oxford University Press, New York.

Vanderschraaf, P. (2021), "Contractarianisms and Markets," *Journal of Economic Behavior and Organization*, vol. 181.

Weitzman, M. (1984), *The Share Economy*, Harvard University Press, Cambridge, MA.

World Bank. (2019). *Global Economic Prospects: Darkening Skies,* January 2019, Washington, DC.

4 Prospects for global economic convergence under new technologies

Dani Rodrik[1]

Introduction

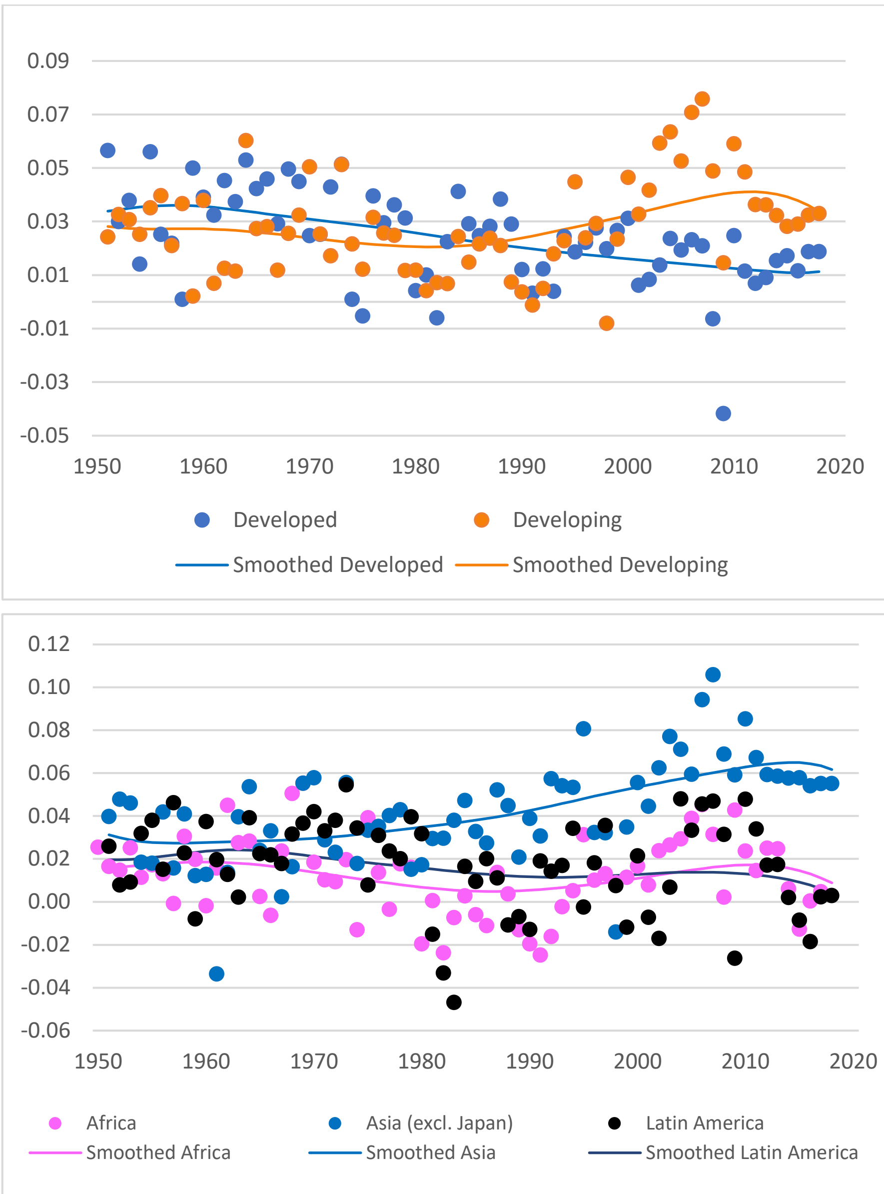
Prior to the COVID-19 pandemic, developing countries appeared to be generally on a converging path with income levels in the wealthiest countries. The good news on economic performance seemed to extend beyond the East Asian growth miracles and the phenomenal Chinese poverty reduction experience. Many nations in South Asia, Latin America, and, notably, sub-Saharan Africa witnessed growth spurts in the 1990s or early 2000s. For the first time since the end of World War II, developing nations as a group were growing more rapidly than the advanced nations (Figure 1). The evidence pointed to the presence of a robust, if slow, process of what economists call "unconditional convergence," meaning that there was a systematic tendency for lower-income countries to grow more rapidly than richer economies regardless of their policies, institutions, or geographic circumstances (i.e., unconditionally).[2]

With the pandemic, all of this has been thrown into doubt. Not only are poverty rates on the increase again, but the expectation is that developing countries will remain scarred for some time, with lingering effects on health, education, public debt, and investment and significant setbacks for medium-term economic performance. The World Bank now expects developing country-growth rates to fall behind advanced-economy growth rates in the years ahead (that is, convergence to turn into divergence), with the lowest-income countries suffering the most severe blows.[3]

[1] This paper has been prepared for the Brookings Institution's Global Forum on Democracy and Technology. I am grateful to Xinshen Diao, Mia Ellis, and Margaret McMillan, collaborators on joint work on which I draw in this paper.
[2] See Patel et al. (2021) and Kremer et al. (2021).
[3] World Bank (2021).

While the effects of COVID-19 are undeniable, there are reasons to believe that the pre-pandemic growth performance of the developing world was fragile and unsustainable. The trends depicted in Figure 1 suggest that growth rates were already beginning to sag prior to the pandemic. The optimism about developing countries had to be tempered with the recognition that the factors that drove the most recent growth wave in Latin America, sub-Saharan Africa, and important cases such as India differed significantly from those behind classic growth accelerations à la East Asia.

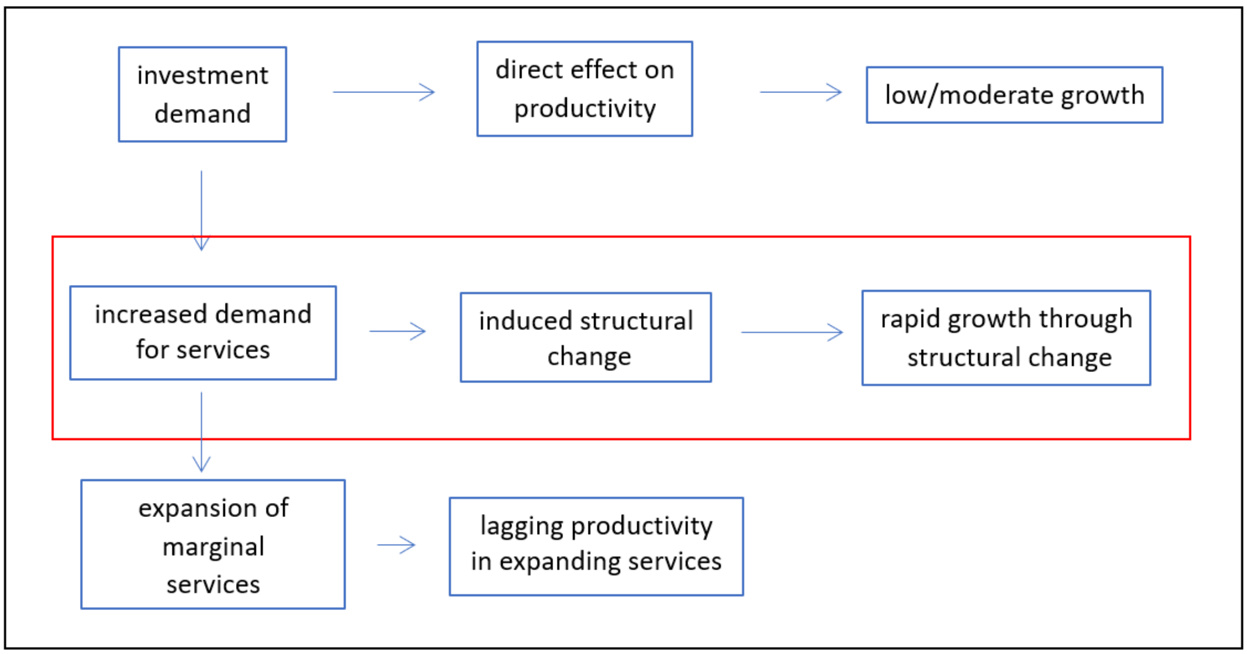
Figure 1: Growth rates in different country groups, 1950-2018



Source: Maddison data set updated with World Bank, World Development Indicators.

In particular, industrialization did not play much of a role in the recent convergence experience; growth increased not because of rapid industrialization but despite its absence. Structural transformation did take place, but it took the form of labor moving out of agriculture into urban services. My colleagues and I have interpreted this as a type of demand-driven growth.[4] The initial source of the demand boost varied in different cases: Public investment, animal spirits of private business, external transfers, increase in farmers' incomes, and commodity booms all played some role. Rising incomes spurred demand for services, and urban services expanded. Since labor productivity in services tends to be higher than in much of agriculture, there was a corresponding increase in economy-wide productivity. However, in the absence of supply-side impetus for productivity growth in services, diminishing returns set in. Structural change driven by services is self-extinguishing and rapid growth cannot be sustained (see Figure 2 for a graphical depiction of the process).

Figure 2: The demand-led growth model



Source: Diao et al. (2019).

Growth works differently when it is driven by industrialization—as it has in almost all cases of rapid and sustained economic convergence. There are three key factors that make manufacturing special. First, organized, modern manufacturing activities tend to exhibit rapid unconditional convergence in labor productivity.[5] In other words, manufacturing is subject to an endogenous process of productivity dynamics and catch-up. Second, large segments of manufacturing have tended to be intensive in low-educated labor. Consequently, manufacturing can absorb significant amounts of a developing country's labor force and faces limited constraints on the supply side. Third, manufactured products can be exported, so demand constraints—arising from low productivity and incomes in the home market—are unlikely to bind either. These three characteristics are key to understanding why industrialization has historically avoided the pitfalls of diminishing returns and has been able to foster self-sustaining growth. Together, they have turned the manufacturing sector into a powerful growth escalator.

[4] Diao et al. (2019).
[5] Rodrik (2013).

Technological change and premature de-industrialization

The question, then, is whether a renewed industrialization drive is feasible for low-income countries once the pandemic's immediate effects are overcome. In principle, the answer should be yes. China is no longer the low labor cost country it once was, and it has rapidly moved to more sophisticated manufactures. The product lines it used to dominate could in principle now migrate to labor-abundant countries in South Asia and sub-Saharan Africa, extending the "flying geese" model beyond East and Southeast Asia. And even though the benefits of hyper-globalization are increasingly in question in the U.S. and in many parts of Europe, developing country policy makers on the whole remain keen to make the best of the world economy and plug into global or regional value chains. The Washington Consensus may have fallen into disrepute, but its key tenets remain very much alive in the developing world.

On the other hand, there are many signs that manufacturing is not the growth escalator it once was. Historically, rapidly growing countries could move a third or more of their labor force from farming into manufacturing, reaping the benefits of significant economy-wide productivity gains. Since 1990, practically no country outside of East and Southeast Asia has managed to reach or sustain employment levels in manufacturing exceeding 20 percent of the labor force, with the vast majority of developing nations falling far short of this threshold.[6] The phenomenon of "premature de-industrialization" seems to have taken over the developing world. Middle-income countries are experiencing declines in manufacturing employment shares at much lower levels of industrialization and of per-capita GDP, while low-income countries are finding it virtually impossible to replicate the experience of previous generations of manufacturing success stories.[7]

Moreover, in the few low-income countries where industrialization seems not to have run out of steam, its quality is very poor. A recent paper finds that low-income Africa has not yet experienced premature de-industrialization.[8] But employment growth in these relative success stories (such as Ethiopia, Ghana, and Kenya) seems limited to unregistered/informal parts of manufacturing, with formal manufacturing still remaining in the grasp of premature de-industrialization.[9]

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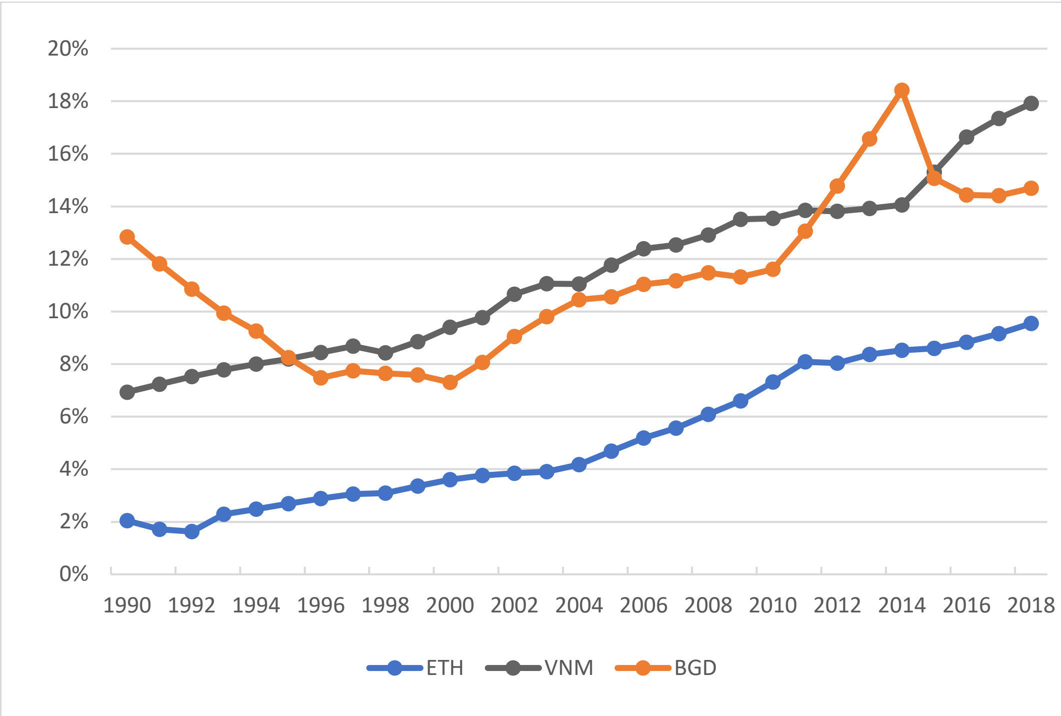
[6] Mauritius and Turkey are the only exceptions to this rule that one can identify in the de Vries et al. (2021) database on sectoral employment and value added.
[7] Rodrik (2016).
[8] Kruse et al. (2021). See also Kunst (2019). This paper documents four stylized facts about premature de-industrialization. First, the jobs that have disappeared are mostly of the unskilled type. Second, the disappearing jobs have tended to be concentrated among formal jobs, both within manufacturing and elsewhere. Third, premature de-industrialization has been driven by occupations which are intensive in tasks that are suitable to automation by information and communications technology (ICT). Fourth, high- and middle-income countries have been the most affected, while low-income countries appear to have avoided premature job losses in manufacturing so far.
[9] See Kruse et al. (2021).

Figure 3: Manufacturing employment shares in three countries



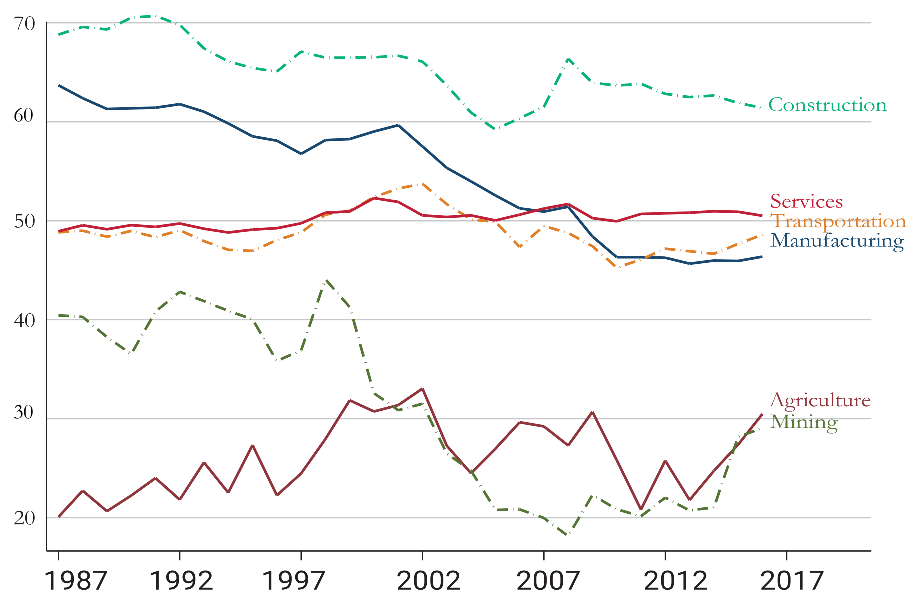
Source: Based on data from Kruse et al. (2021).
Note: ETH is Ethiopia, VNM is Vietnam, and BGD is Bangladesh.

Figure 3 compares trends in manufacturing employment in Bangladesh, Ethiopia, and Vietnam. Vietnam has followed prior East Asian examples in managing to draw significant employment into formal manufacturing. At first sight, the progress of manufacturing in the non-Southeast Asian examples looks comparable to that in Vietnam. Ethiopia started from a very low level of industrialization and has managed to increase manufacturing employment from 2 percent of total employment in 1990 to nearly 10 percent in 2018. But Ethiopia is also a case in point of informalization of manufacturing. As I will discuss below, very little of the employment growth has taken place in the formal-organized parts of the sector, where we can expect technological dynamism and rapid catch-up. As for Bangladesh, manufacturing remains hampered by over-specialization in a very narrow segment of production (ready-made garments) and limited backward linkages. Significant diversification out of traditional export products seems hard to achieve, for technological reasons I will discuss later. There is also a sizable dip in manufacturing employment in Bangladesh after 2013, which is presumably linked to the international repercussions of the Rana Plaza disaster – the collapse of the garment complex that killed more than a thousand workers.

Why are latecomers outside East and Southeast Asia finding it so difficult to ride the industrialization bandwagon? One reason may be hyper-globalization itself. The beneficiaries of the earlier waves of globalization—from Japan in the 1950s to China during the 1990s—had the advantage that their home markets remained relatively insulated from international competition, thanks to a combination of high trade barriers at home and significant trade costs. Internationally competitive industries could be built on the back of protection (both man-made and natural) of domestic markets. Later industrializers have had considerably less space to grow and diversify their manufacturing industries. Success in international markets today requires plugging into global value chains that not only present limited opportunities for backward or forward linkages at home but are actually predicated on the absence of such linkages.

Technological change is the second, and probably more important reason. Since the 1980s, innovation in advanced economies' manufacturing sectors has taken a predominantly labor-saving form. As Figure 4 shows, while labor shares in U.S. value added have dropped generally, the sharpest and most sustained drop has taken place in manufacturing. Acemoglu and Restrepo (2019) find that this stands in sharp contrast to the experience of the earlier period of 1947-87, during which the labor share in manufacturing actually rose somewhat. They attribute a significant part of the shift to the acceleration of the displacement of labor by technological innovations such as automation. Note that hyper-globalization may have played a role here as well: Competition from labor-abundant countries was one impetus for the introduction of labor-saving technologies in the advanced economies.

Figure 4: The labor share of value added in different sectors in the United States, 1987–2017

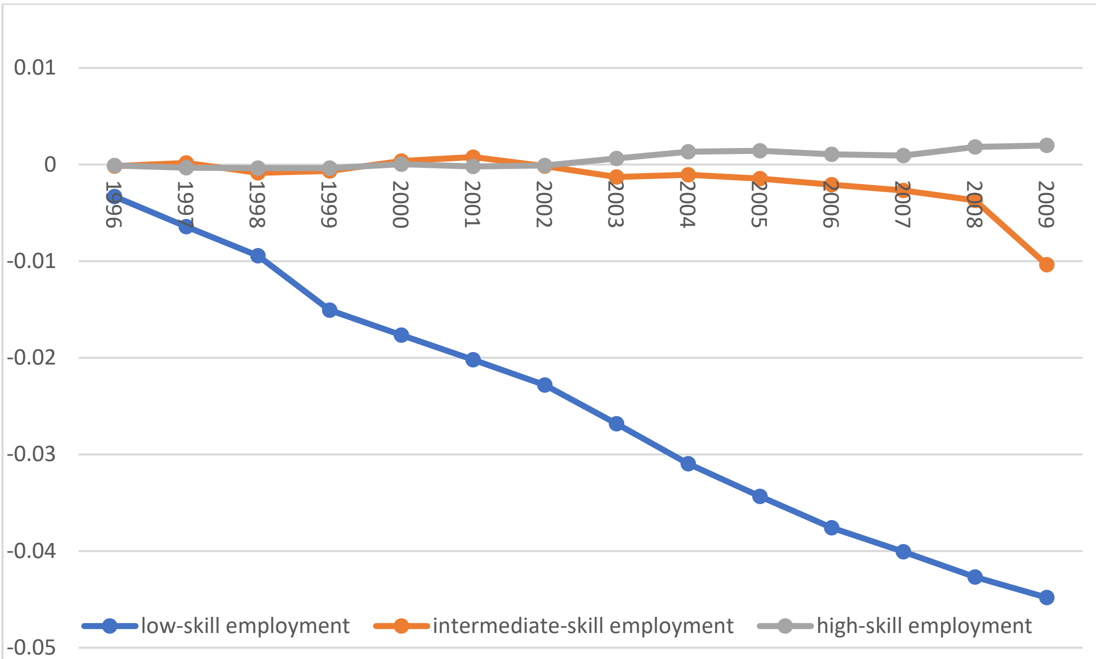


Source: Acemoglu and Restrepo (2019).

Moreover, the evidence indicates that the displacement effect operated most strongly for the least-educated workers. This is shown in Figure 5, where the average time trend of labor intensity of manufacturing is charted for a group of forty, mostly richer, economies (controlling for income and demographic characteristics of individual countries). Employment is broken into three categories of workers: low-skill, medium-skill, and high-skill. The chart shows that almost all of the decline in labor intensity has taken place in the low-skilled category—precisely the type of workers for which developing countries have a comparative advantage.[10]

[10] A recent ILO report details some of the technological transformations that are disrupting employment patterns, even in the more successful Southeast Asian economies. It estimates, for example, that "over 60 per cent of salaried workers in Indonesia, the Philippines, Thailand and Viet Nam occupy E&E [electrical and electronics] positions at high risk of automation" (ILO, 2016).

Figure 5: Labor-intensities of manufacturing, by skill type

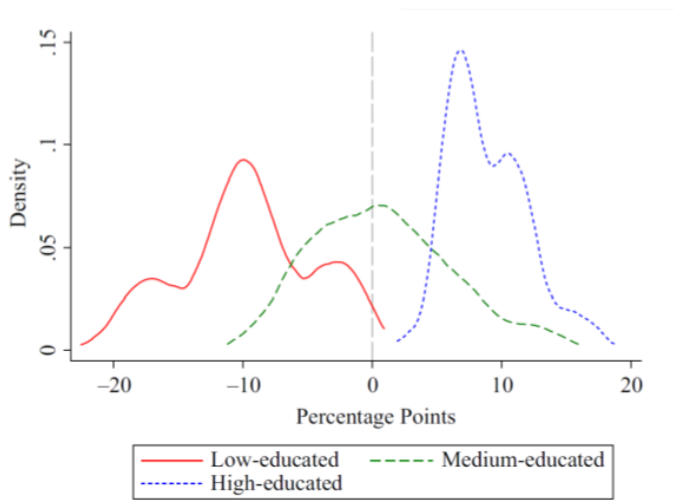


Source: Rodrik (2016). Groningen Growth and Development Center data (2014 update, employment).
Note: Vertical axis shows estimated year coefficients (in log-points) for employment of different skill types—estimated from a regression of employment intensity on time, income, and demographic indicators, by labor skill type.

The bulk of innovation takes place in the rich economies. Developing countries that want to compete by adopting the latest technologies need to import them from abroad. That means that production techniques—and the relative demand for low-skill labor—in the most advanced sectors of developing countries will be determined largely by innovation trends beyond their borders. There may be some substitutability between low-educated workers, on the one hand, and skilled workers and capital, on the other. But in practice there will be limited room to deploy production techniques that are significantly more intensive in low-skill labor.

Recent work by Reijnders et al. (2021) documenting the transformation of labor demand patterns within global value chains (GVCs) is important in this context. Reijnders et al. (2021) use world input-output tables—taking into account input use across national borders—to track production that enters world trade either directly or indirectly, and to examine changes in labor use of different skill types. Their database covers 40 advanced and developing economies and a rest-of-the world region, spanning all production and trade flows in the world. They document an increasing bias against low-educated labor. The low-educated share of total labor compensation in GVCs has declined by around 10 percentage points on average between 1995 and 2007, while the share of highly-educated workers has increased by a corresponding amount (Figure 6). Their econometric results similarly show a very strong downward trend over time in the factor share of low-educated workers. The cumulative drop in the low-skill labor share over this period is very large—amounting to nearly a third of the 32 percent in the base year of 1995.

Figure 6: Changes in labor demand, by type of workers, in global value chains



Source: Reijnders et al. (2021).
Note: Changes in wage bill shares in GVCs of manufacturing goods, 1995-2007. Kernel density of change in labor cost shares for low-, middle-, and high-educated workers. Change over the period 1995-2007 (in percentage points).

These results underline the impact that the transformation in technology in the advanced economies has already had on poorer economies that are importers of technology. It should not be surprising that GVCs have been a key vehicle for the introduction of labor-saving technologies in poor nations. Economists and policy makers have long seen plugging into GVCs as a way of facilitating technology transfer from more advanced economies.

Reijnders et al. (2021) undertake a simulation for each country to determine the respective employment contributions of three drivers: reallocation (shifting of GVC production across countries, and in particular offshoring); substitution (the change in factor mix due to shifts in relative wages); and technological bias (i.e., shifts due to the factor bias of technological change). Their results suggest that low-income countries were in general beneficiaries on account of the reallocation effect. But, importantly, the factor bias of innovation served to depress employment of low-educated workers in all countries. The substitution factor, while generally benefiting low-educated workers (as their relative wages fell), is quantitatively small. A summary of their results for some key developing economies is reproduced in Table 1.[11]

[11] Note that these simulations hold constant the overall scale of output of GVCs. So GVC employment in India, for example, may have grown on account of the general increase in GVC output. Maloney and Molina (2019) find little evidence that automation has replaced labor in most developing countries. They argue that the introduction of robots in advanced countries has had the likely effect of crowding in operators and assemblers in developing countries, thanks to offshoring of production through FDI, offsetting any replacement effect. Pahl (2020) undertakes a different decomposition, distinguishing among the growth of *global demand* for final manufacturing goods, growth in the *GVC competitiveness* of a country (measured as the share of a country in serving demand), and a change in *technology* (workers needed per unit of output). This study finds that increase in global demand helped employment (especially in countries such as China, Vietnam, and India), while changes in unit labor requirements significantly moderated employment growth. Similarly, Sen (2019) finds that "[t]rade integration has a positive impact on manufacturing employment via the scale and composition effects, but a negative impact via the labor intensity effect."

Table 1: Simulated employment effects of GVCs, by skill category, 1995-2007

	Low-educated			Middle-educated			High-educated		
	Reallo	Subst	Bias	Reallo	Subst	Bias	Reallo	Subst	Bias
India	6.2	8.1	−26.9	27.3	−3.3	0.9	73.5	−2.8	31.4
China	49.1	12.3	−31.3	28.2	−5.3	−1.5	54.3	−1.8	38.6
Indonesia	22.7	10.7	−30.4	42.6	−3.7	1.2	52.6	−2.4	31.7
Romania	6.9	10.2	−27.4	6.3	−6.3	7.4	−11.2	−1.5	37.6
Lithuania	−44.1	7.0	−26.6	−45.5	−4.5	2.7	−44.6	−2.1	37.9
Latvia	−26.9	12.1	−27.3	−29.3	−4.6	0.0	−43.5	−3.5	36.0
Brazil	23.8	7.5	−26.1	153.3	−2.9	0.7	55.5	−2.5	31.3
Bulgaria	23.7	9.5	−27.3	35.5	−6.4	8.6	38.1	−2.3	37.1
Estonia	−27.3	11.5	−27.4	−39.3	−4.5	0.3	−48.3	−3.0	36.1
Mexico	−5.0	7.0	−17.6	53.5	0.5	−4.3	3.7	−5.3	24.7
Turkey	−30.3	9.5	−24.7	75.0	−5.5	4.3	78.7	−3.2	34.6

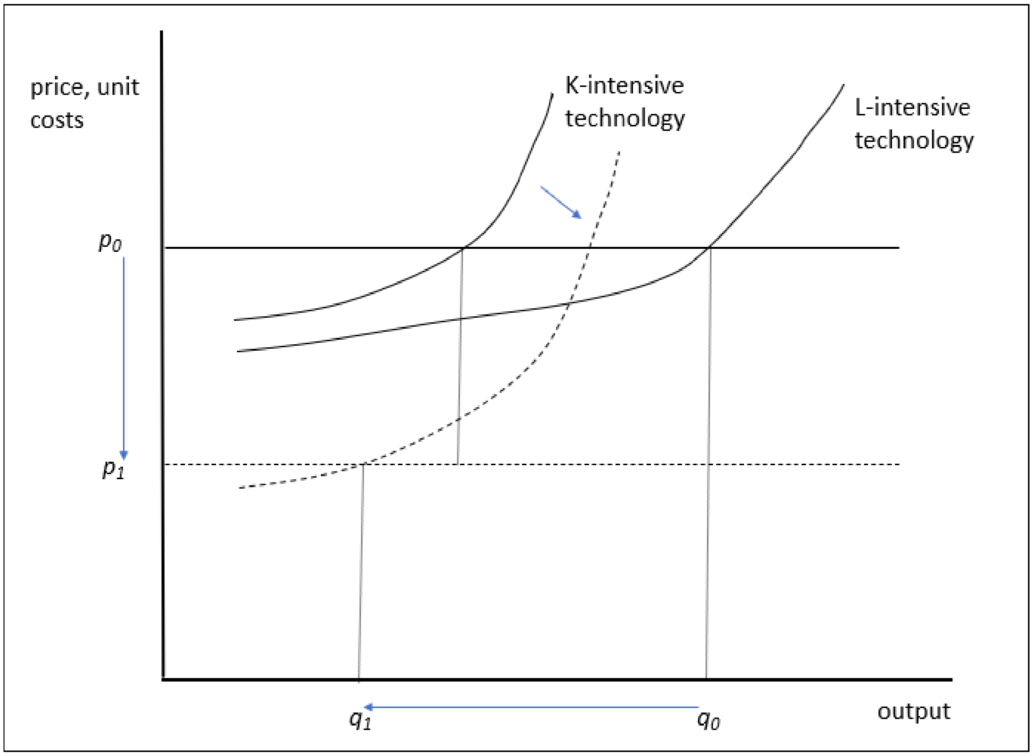
Source: Reijnders (2021).
Note: *Reallo* is reallocation, *Subst* is substitution, and *Bias* refers to skill-biased technological change.

We now have a clearer sense of why the manufacturing-led growth model has broken down. One of the key features that made manufacturing such a powerful income escalator was its capacity to absorb relatively less skilled labor. This has been particularly important for lower income countries since low-skilled labor is the one resource that they are well endowed in. What has now changed is that manufacturing exhibits this feature less and less. Manufacturing is no longer labor-absorbing in quite the way it was.

The analytics of technological choice and employment

To see the consequences of the kind of technological change developing countries are confronted with, it helps to use a simple analytical framework. With the help of Figure 7, we will contrast the output and employment implications of prevailing technologies before and after the introduction of labor-saving innovation.

Figure 7: Consequences of labor-saving innovation



Source: Diao et al. (2021).

To begin with, assume that there are two kinds of manufacturing production methods ("technologies") that are available for adoption, one that is capital-intensive and another that is labor-intensive. Their respective unit costs of production in our representative developing country are shown by the upward-sloping curves in Figure 7. As drawn, costs are lower initially for the labor-intensive method. This is meant to capture developing countries' abundance of labor and hence relatively low-cost of labor. It is more efficient for manufactures producers in the developing economy to adopt the labor-intensive technology. We further assume the country is a price-taker in world markets. In this initial equilibrium, facing a world price of p_0, the country uses the labor-intensive technology to produce output level q_0.

Now suppose there is technological change in the rest of the world, but that (for simplicity of exposition) this affects only the capital-intensive production method. The capital-intensive production method becomes more efficient and its unit cost curve shifts down to the new dashed curve in Figure 7. The unit costs of the labor-intensive method remain unchanged. We assume that producers in the advanced economies use the capital-intensive method. The reduction in their costs translates into a reduction in world prices from p_0 to p_1. Note that the drop in world prices is bigger than the reduction in the costs of the capital-intensive method in the developing country (i.e., it is larger than the vertical distance between the old and new unit cost curves for the capital-intensive method). The reason is that developing countries face higher costs of capital (and of other inputs complementary to capital, such as skills and infrastructure), and they may also face higher transaction costs in adopting more capital-intensive technologies. This captures the idea that innovation that is biased towards capital helps advanced economies more than labor-abundant low-income countries.

Now consider the choices that producers in the developing country have to make. At the new world price p_1, the labor-intensive method is no longer competitive: Its unit costs are everywhere above p_1. So, if they want to compete with global producers, they need to make the shift to the capital-intensive production method. And even with that shift, the output level now is q_1, which is way below q_0.

The framework clarifies how innovation in advanced economies that is biased against labor (and against low-educated labor in particular) hits developing economies. There is a triple-whammy:

- First, there is a <u>loss of comparative advantage</u> in labor-intensive manufactures. This is reflected in the reduction in manufacturing output from q_0 to q_1.

- Second, there is a <u>reduction in labor-employment intensity</u>. This is captured in the shift from the labor-intensive method to the capital-intensive method. Note that the magnitude of this effect can be larger in the developing countries than in the advanced economies, to the extent that the latter were already using the more capital-intensive production method in the initial equilibrium.

- Third, there is a <u>reduction in employment buoyancy</u>. This is shown by the steeper rise in the cost curve for the capital-intensive production method. Since capital itself and the complementary inputs (skills, infrastructure) are scarce and expensive in developing countries, output and employment will respond more sluggishly to positive profitability "shocks" such as better institutions or a more competitive currency.

These are the three distinct effects that undermine the viability of industrialization-led growth under new technologies.

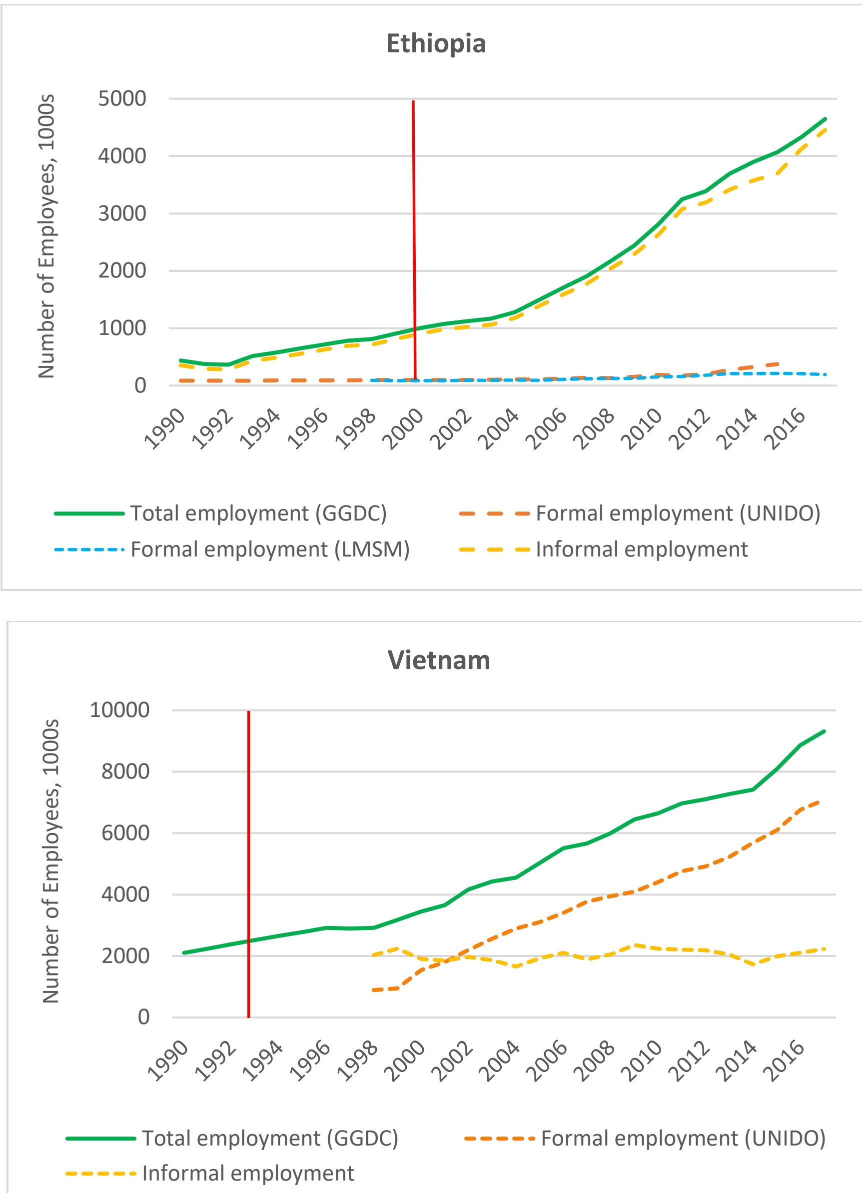
Country illustrations

The model I have just sketched out was motivated by the recent experience with industrialization in Africa. As I have noted, not all countries there have experienced de-industrialization, and there are some relative success stories. But even in those success cases, the pattern of industrialization appears to be stunted and very different from the classic East Asian model. In particular, growth of manufacturing employment is driven by small, informal firms instead of the more modern enterprises that are able to absorb technology and enhance productivity. There are larger firms, with good productivity performance. But those are not the ones that absorb employment. In short, the firms that have good productivity performance do not generate employment, while those that do create employment tend to exhibit poor productivity.

Figure 8 compares the structure of manufacturing employment in Ethiopia, one of the "successful" African industrializers, with that in Vietnam. Both countries experienced an increase in overall employment in manufacturing (though the scales on the vertical axes are different), but the compositional differences could not be more striking. In Vietnam, it is formal employment that has expanded rapidly, while informal employment has remained static. In Ethiopia, the situation is the mirror opposite: The rise in employment is driven almost entirely by informal employment, while formal employment is both low and has remained stagnant.

In Diao et al. (2021) we examined firm-level data to try to understand what is happening in Ethiopia (and in Tanzania, where industrialization has been less noteworthy but the outcomes with respect to informality are very similar to Ethiopia). The striking feature in both cases is the divergence in employment and productivity performance across different categories of firm size. There is a sharp dichotomy between larger firms that exhibit superior productivity performance but do not expand employment much, and small firms that absorb employment but do not experience any productivity growth. The problem lies not so much with the productivity performance of the larger firms, which is more than adequate, but in their inability to generate employment opportunities. The labor absorbing firms, by contrast, are the smaller ones on significantly worse productive trajectories.

Figure 8: Structure of manufacturing employment in Ethiopia and Vietnam



Source: Diao et al. (2021).
Note: The vertical red line indicates the start of the country's growth acceleration. Data sources are: Groningen Growth and Development Center (GGDC); United Nations Industrial Development Organization (UNIDO); and Large and Medium Scale Manufacturing (LMSM) surveys (Ethiopia). Informal employment is derived from GGDC-UNIDO.

Conventional explanations for industrial dualism can go only so far to explain this pattern of industrial dualism. Financing constraints are unlikely to bind for firm growth, since smaller firms are less productive to begin with. Labor costs cannot be a large part of the story since the payroll shares in value added in both Tanzanian and Ethiopian manufacturing are exceedingly low overall (11-12 percent). And a poor business environment or weak institutions cannot account for why firms that do well on productivity grounds do so poorly in employment.

An important part of the problem might have to do with the nature of technologies available to African firms, in line with the framework I outlined previously. We find that the relatively large firms in the manufacturing sectors of Tanzania and Ethiopia are significantly more capital-intensive than what would be expected on the basis of their income levels or relative factor endowments. This is especially true of the larger, most productive firms, where capital intensity approaches (or exceeds) levels observed, for example, in the Czech Republic, a country that is around twenty times richer. Perhaps surprisingly, exporting firms or the traditionally labor-intensive textiles and clothing firms do not exhibit lower capital-labor ratios than other manufacturing firms on average. And capital-labor ratios have increased much more rapidly in Ethiopian and Tanzanian manufacturing than in the economy as a whole.

Hence, high levels of capital intensity (and possibly of skill intensity as well, though we do not directly measure that) seem to be an important reason behind the poor employment performance of productive firms. Essentially the conundrum faced by African firms is this: competing with established producers on world markets is only possible by adopting technologies that make it virtually impossible for significant amounts of employment to be generated.

This kind of Sophie's choice is increasingly evident in contemporary discussions of industrialization policy in low-income countries—though the implied tradeoff between competitiveness on world markets, on the one hand, and employment generation in formal economic activities, on the other, is rarely noted.

Consider, for example, Bangladesh. This country has been enormously successful in producing ready-made garments (RMG) for export, turning itself into the world's second largest exporter of RMG behind China. But as every study of the country's economy points out, Bangladesh's manufacturing sector remains heavily concentrated, and diversifying out of RMG has proved difficult. A recurrent theme in such analyses is the need for greater investment in digital and automation technologies to move up the value chain. Despite the export orientation, the overall share of informal employment in textiles and garments remains above 90 percent.[12] A McKinsey report points to the polarization of Bangladeshi industry, in ways that are reminiscent of the African story: "Bangladesh's advanced manufacturers are characterized by a high degree of entrepreneurship and strategic management; these firms have made investments in productivity improvement, digitization, automation, and sustainability, and they operate according to international best practices. In contrast, the small operators that make up the majority of the market typically focus on CMT [typically less automated cut, make, and trim mode of operation]..."[13]

While capital-labor ratios are still generally low in the Bangladeshi RMG industry compared to other manufacturing activities, they have been rising rapidly in recent years as machines have been replacing low-educated workers.[14] Not surprisingly, Bangladesh has also experienced a rapid rise in the skill premium, indicating a surge in demand for a skilled workforce that complements physical capital.[15] An

[12] Asian Development Bank (2016a).
[13] McKinsey (2021).
[14] Asian Development Bank (2016b).
[15] Bidisha et al. (2021).

Asian Development Bank study of labor market constraints in Bangladesh summarizes the situation this way:

"*Although labor in Bangladesh is abundant, a shortage in skilled workers is perceived to be a major constraint on manufacturing production. The shortage is particularly acute for medium-scale, export-oriented enterprises. Manufacturing goods now overwhelmingly dominate Bangladesh's export basket, but a significant proportion of it comprises a very low domestic value addition because of limited backward linkages. Upgrading technology, adopting superior technology, and effective learning in the workplace are important to improve productivity...*"[16]

The need to invest in skills, automation, and digital technologies, in Bangladesh as well as in other comparable countries, is not particularly controversial. But the apparent fact that these factors have now become the binding constraints on fostering and deepening industrialization in low-income countries is precisely what undercuts industrialization's historical role as a vehicle for rapid growth. Rapid convergence is achieved not by relying on a country's scarce factors and capabilities but its abundant ones. Low-cost, plentiful labor is no longer the asset it once was on international markets.[17]

Implications for economic growth, convergence, and growth strategy

The global pace and direction of technological change are determined largely by decisions taken in advanced economies. In a just and well-ordered world, those decisions would internalize the consequences for the development prospects of the poorer parts of the world. There would be adequate investment in technologies that are more appropriate to the factor endowments of low-income nations— technologies that complement low-educated labor rather than replace it.

The reality is that prevailing incentives in the rich economies go in the opposite direction. Tax rates on capital are generally low (and often negative, to encourage investment) while tax rates on labor tend to be high. This naturally encourages automation rather than labor use. The ethos in Silicon Valley and the innovation community similarly favors labor-replacing technologies. Governments do have tools at their disposal that could be used to reverse these biases and to steer technology in a more labor- and development-friendly direction.[18] In other areas, such as military technologies or green technologies, such tools are routinely deployed to shape the direction of innovation. Investment in appropriate technologies could be viewed as a global public good insofar as it fosters economic development and poverty reduction.

As desirable as a move in this direction would be, if governments in the advanced economies have failed so far to make the necessary changes in their innovation regimes even when their own workers are at stake, it is perhaps not realistic to expect that they will do so to advance the cause of economic development in the rest of the world. Therefore, we need to consider the growth prospects of developing nations against a background of largely unfavorable trends in innovation.

[16] Asian Development Bank (2016a, p. 2).
[17] See McKinsey (2018) for a discussion of how likely automation trends could eventually make it more profitable to manufacture garments in advanced countries than in today's lowest-cost producers such as Bangladesh. Similarly, an ILO report notes that "automated cutting machines are now becoming a widely available technology, and robots capable of sewing – called "sewbots" – will soon change the calculus of TCF [textiles, clothing, and footwear] production" (ILO, 2016). These sewbots will be deployed in "destination markets" such as China, Europe, and the United States and will directly compete with producers in developing economies.
[18] Acemoglu (2021); Rodrik and Stantcheva (2021).

Note first that the post-pandemic growth prospects of developing nations do not rest solely on industrialization. Growth "fundamentals" such as education, skills, improved institutions, and governance also matter. These fundamentals are the classic drivers of (conditional) convergence. As long as developing countries invest in these fundamentals, longer-term convergence will be possible. But even in the most favorable scenario, convergence is likely to occur at a slower pace than in the past, when rapid, labor-absorbing industrialization was still possible.[19]

The fundamental question facing low- and middle-income countries in the years ahead is no different from that confronted by advanced economies: Where will the good, productive jobs come from? Societies at all levels of income will face the challenge of creating jobs that can serve as pathways to the middle class.

In developing countries, non-traditional agriculture and some services can fill part of the void left by declining potency of manufacturing. Within agriculture, low-income countries retain considerable potential for productivity improvement and diversification into cash or export crops. But it is difficult to envisage a future world in which agriculture will absorb more, rather than less, of the economy's labor force. In all likelihood, a more productive agriculture will mean a greater outmigration of labor from the countryside, as it has traditionally. So, agriculture will not provide the answer to the question of good jobs.

As for services, they come essentially in two varieties. There is first the high-productivity, tradable type of services such as ICT services, business services, finance, etc. These are generally intensive in skills (which are in short supply) and cannot absorb much labor. Even in economies that have done well in ICT and business services, such as India and the Philippines, there has been little labor absorption into these sectors. Then there is the low-productivity, non-tradable type made up of petty, largely informal activities. This is the part of the economy that currently absorbs the bulk of the urban labor supply. But unlike manufacturing or tradable activities in general, these services cannot individually act as growth poles since they cannot deliver the structural transformation and productivity increases needed for robust, long-term growth. Nor can they expand without turning their terms of trade against themselves. Given the limits of the home market, continued expansion in one segment relies on the expansion of all the others, resulting in limited gains from sectoral "winners."

What we can conclude from these considerations is that growth policies will have to be reoriented. The implications are summarized in Figure 9, where I contrast what I call the "good-jobs development model" with traditional growth policies, on the one hand, and social protection and poverty-reduction strategies, on the other.

The traditional model of export-oriented industrialization is based on nurturing productive manufacturing firms that act as growth leaders. As I have discussed, future growth policies will need to have different priorities. Instead of focusing on the most productive segment of firms, the next generation of growth strategies will have to target small- and medium-sized firms with the potential to enhance both productivity and employment and which are necessarily mostly in services. Traditional "industrial policies" will have to be modified and extended to parts of the informal economy. Economic growth will be possible only by raising productivity in smaller, informal firms that employ the bulk of the poor and lower-middle classes. At the same time, sustainable poverty reduction and enhanced economic security will remain possible only by creating more productive, better jobs for workers at the bottom of the skill distribution.

[19] Rodrik (2014).

Figure 9: The good-jobs development model

		At what stage of the economy does policy intervene?		
		Pre-production	Production	Post-production
Which segment of the economy do we care about?	Low productivity	Investments in education and health		Cash transfers; full-employment macro policies
	Middle productivity		Promotion of higher-quality jobs in services; employer-linked training policies; job-creating customized business incentives; "appropriate technologies"	Safety nets
	High productivity	Innovation systems, intellectual property rules, trade agreements	Subsidies, R&D incentives	Corporate tax incentives

Source: Author.
Note: Colors indicate different development models: traditional social protection and poverty-reduction model; traditional growth and industrial policies model; and the good-jobs development model.

In short, the growth policies of the future will need to look more like social policy, albeit with a much more productivist, firm-oriented bent.

At the global level, we may need to revive the idea of "appropriate technology." If present trends continue, innovation in the advanced nations will remain biased against workers with low education and undermine the comparative advantage of developing nations. New technologies that are labor-friendly can be considered a global public good from a development perspective. Hence the promotion of such technologies must be placed on the agenda of global discussions alongside other major global public goods, such as decarbonization and pandemic control.

References

Acemoglu, Daron, "AI's Future Doesn't Have to Be Dystopian," Boston Review, 2021, https://bostonreview.net/forum/science-nature/daron-acemoglu-redesigning-ai.

Acemoglu, Daron, and Pascual Restrepo, "Automation and New Tasks: How Technology Displaces and Reinstates Labor," Journal of Economic Perspectives, Volume 33, Number 2, Spring 2019, pp. 3-30.

Asian Development Bank, Bangladesh: Looking Beyond Garments, Manila, 2016 (2016a).

Asian Development Bank, Bangladesh: Consolidating Export-Led Growth, Manila, 2016 (2016b).

Bidisha, Sayema Haque, Tanveer Mahmood, and Mahir A. Rahman, "Earnings inequality and the changing nature of work: Evidence from Labour Force Survey data of Bangladesh," WIDER Working Paper no. 7, 2021. https://www.wider.unu.edu/publication/earnings-inequality-and-changing-nature-work

De Vries, Gaaitzen, Linda Arfelt, Dorothea Drees, Mareike Godemann, Calumn Hamilton, Bente Jessen-Thiesen, Ahmet Ihsan Kaya, Hagen Kruse, Emmanuel Mensah and Pieter Woltjer, "The Economic Transformation Database (ETD): Content, Sources, and Methods," WIDER Technical Note 2/2021, 2021.

Diao, Xinshen, Margaret McMillan, and Dani Rodrik, "The Recent Growth Boom in Developing Economies: A Structural-Change Perspective," in Machiko Nissanke and José Antonio Ocampo, eds., The Palgrave Handbook of Development Economics: Critical Reflections on Globalization and Development, Palgrave Macmillan, 2019.

Diao, Xinshen, Mia Ellis, Margaret McMillan, and Dani Rodrik "Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms," NBER Working Paper 28344, February 2021. https://www.nber.org/papers/w28344

International Labour Organization (ILO), ASEAN in Transformation: How Technology is Changing Jobs and Enterprises, July 2016.

Kremer, Michael, Jack Willis, and Yang You, "Converging to Convergence," unpublished paper, June 2021. https://www.nber.org/books-and-chapters/nber-macroeconomics-annual-2021-volume-36/converging-convergence

Kruse, Hagen, Emmanuel Mensah, Kunal Sen, and Gaaitzen de Vries, "A Manufacturing Renaissance? Industrialization Trends in the Developing World," WIDER Working Paper 2021/28, February 2021. https://www.wider.unu.edu/publication/manufacturing-renaissance-industrialization-trends-developing-world

Kunst, David, "Premature Deindustrialization through the Lens of Occupations: Which Jobs, Why, and Where?" Tinbergen Institute Discussion Paper, No. TI 2019-033/V, Tinbergen Institute, Amsterdam and Rotterdam, 2019.

Maloney, William F., and Carlos Molina, "Is Automation Labor-Displacing in the Developing Countries, Too? Robots, Polarization, and Jobs," World Bank Working Paper, July 25, 2019. https://openknowledge.worldbank.org/handle/10986/33301

McKinsey & Co., "Is apparel manufacturing coming home? Nearshoring, automation, and sustainability – establishing a demand-focused apparel value chain" (by Johanna Andersson, Achim Berg, Saskia Hedrich, Patricio Ibanez, Jonatan Janmark, and Karl-Hendrik Magnus), October 2018, https://www.mckinsey.com/~/media/mckinsey/industries/retail/our%20insights/is%20apparel%20manufacturing%20coming%20home/is-apparel-manufacturing-coming-home_vf.pdf.

McKinsey & Co., "What's next for Bangladesh's garment industry, after a decade of growth?" March 25, 2021, https://www.mckinsey.com/industries/retail/our-insights/whats-next-for-bangladeshs-garment-industry-after-a-decade-of-growth.

Pahl, Stefan, "Global Value Chains and Economic Development," Groningen University Theses on Economics and Business, 2020.

Patel, Dev, Justin Sandefur, and Arvind Subramanian, "The New Era of Unconditional Convergence," Center for Global Development Working Paper, Washington, D.C., February 2021. https://www.cgdev.org/publication/new-era-unconditional-convergence

Reijnders, Laurie S. M., Marcel P. Timmer, Xianjia Ye, "Labour demand in global value chains: Is there a bias against unskilled work?" The World Economy, 44(9), January 2021.

Rodrik, Dani, "Unconditional Convergence in Manufacturing," Quarterly Journal of Economics, 128 (1), February 2013, 165-204.

Rodrik, Dani, "The Past, Present, and Future of Economic Growth," in Franklin Allen and others, Towards a Better Global Economy: Policy Implications for Citizens Worldwide in the 21st Century, Oxford University Press, Oxford and New York, 2014.

Rodrik, Dani, "Premature Deindustrialization," Journal of Economic Growth, 21(1), March 2016.

Rodrik, Dani, "New Technologies, Global Value Chains, and the Developing Economies," Pathways for Prosperity Commission Background Paper Series, no. 1, Oxford University, 2018.

Rodrik, Dani, and Stefanie Stantcheva, Economic Inequality and Insecurity: Policies for an Inclusive Economy, Report Prepared for Commission Chaired by Olivier Blanchard and Jean Tirole on Major Future Economic Challenges, Republic of France, June 2021 https://drodrik.scholar.harvard.edu/files/dani-rodrik/files/rodrik_and_stantcheva_report_for_macron_commission.pdf.

Sen, Kunal, "What Explains the Job Creating Potential of Industrialisation in the Developing World?" The Journal of Development Studies, 55:7, 2019, 1565-1583.

World Bank, Global Economic Prospects: A Strong But Uneven Recovery, Washington, D.C., June 2021.

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