ONE

Overview

Digital Metamorphosis and Economic Change

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Economic paradigms are shifting. Digital technologies are driving transformative change. Economies are experiencing an unfolding digital metamorphosis. Latest advances in artificial intelligence (AI) and related innovations are expanding the frontiers of the digital revolution. Digital transformation is accelerating as a consequence of the COVID-19 pandemic. The future is arriving faster than expected.

The new technologies hold immense promise. But they also pose new challenges. While digital technologies have dazzled with the brilliance and prowess of their applications, they have not so far delivered the expected dividend in higher aggregate productivity growth. And inequality has been rising. As these technologies transform markets, policies must rise to the challenges of change. The digital economy must be broadened to disseminate new technologies and productive opportunities among smaller firms and wider segments of the labor force. Policies must play their part to better harness the potential of innovation in our digital era

and turn it into a driver of stronger and more inclusive growth in economic prosperity.

This book is the second of a two-book research project that examines how today's technological change is transforming growth and distributional dynamics and reshaping public policy agendas. The project is a collaboration between the Brookings Institution and the Korea Development Institute.[1] It analyzes the implications of technological change from both global and country perspectives, including a specific focus on the Korean economy. The country perspective enriches the analysis by providing both affirmation of and contrast with trends observed at the global level.

World Going Digital

We are living in an era of exciting new technologies. It is often referred to in epochal terms—as a time of technological renaissance powered by brilliant new technologies, a second machine age, and a new industrial revolution.[2] Some scenarios see the world approaching a technological singularity of accelerating technological change—and a consequent economic singularity of a takeoff in productivity and economic growth.[3] While some characterizations of the ongoing technological change may be overly grand and visionary, the pace and scope of the advances being made are surely impressive.

Technology has been booming in recent decades, 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 farther. This latest wave of innovations can take the digital revolution to a whole new level.[4]

The automation and digitalization of economic activity is intensifying in the wake of the COVID-19 pandemic.[5] The pandemic may be remembered as the Great Digital Accelerator, marking an inflection point in the advance of digital transformation. It has reinforced firm incentives to automate production processes. Trade, commerce, and finance are going digital at a faster clip. Digital platforms are expanding their economic sway. Teleworking has increased sharply. Education and training have rapidly

shifted online. The use of automated and online processes is speeding up across most sectors of the economy.

This trajectory of further technological change was expected, but the pandemic is making it happen sooner. Even as economies recover from the pandemic, some of its effects will be long lasting. This is certainly the case with the pandemic's impetus to digital transformation. Prior to the pandemic, a paradigm shift toward digitalization was already well underway. The pandemic has accelerated the shift.

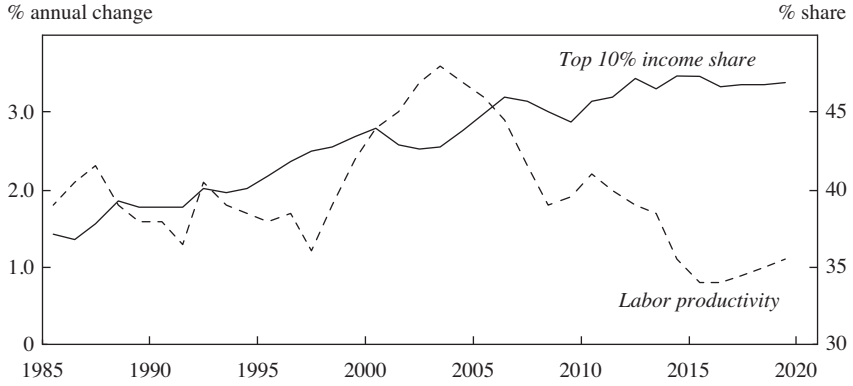
But Productivity Slowing and Inequality Rising

Technology is a key determinant of productivity and long-term economic growth. Paradoxically, as digital technologies have boomed, productivity growth has slowed rather than accelerated.[6] Economic growth has trended lower. Productivity growth has slowed significantly in advanced economies since the 1980s. The slowdown extends across Organization for Economic Cooperation and Development (OECD) economies. It is broad based, affecting more than two-thirds of the sectors.[7] For the past decade or so, productivity growth has slowed in many emerging economies as well. Over the five-year period 2013–2017, productivity growth was lower than the long-term average in about 65 percent of all countries.[8]

Meanwhile, income inequality within countries has been rising. Inequality has risen in all major advanced economies since the 1980s, and quite appreciably in several of them. There has been a particularly sharp increase in income concentration at the top end of the distribution. Trends in income distribution are more mixed across emerging economies, but many of them have also experienced rising inequality over the same period.

Inequality between countries has been falling, thanks to the rise of faster-growing emerging economies that are narrowing the income gap with advanced economies. But technological change poses new challenges for this economic convergence. Manufacturing-led growth in emerging economies has been propelled by their comparative advantage in labor-intensive manufacturing based on large pools of low-skilled, low-wage workers. This source of comparative advantage increasingly will matter less as automation of low-skilled work expands, disrupting traditional pathways to development.[9] The COVID-19 pandemic could add to the challenges emerging economies face in recalibrating their growth models by disrupting

FIGURE 1-1. Slowing Productivity Growth and Rising Inequality: United States, 1985–2019



Source: Qureshi (2020).

global supply chains and prompting stronger moves to reshore production in advanced economies.

The trends of slowing productivity growth and rising within-country inequality are vividly illustrated by the US economy. The United States has been the global leader in the digital revolution. Yet productivity growth has slowed considerably since the early 2000s (figure 1-1).[10] Over the last ten years, labor productivity growth has averaged less than half the growth rate of the decade prior to the slowdown. Total factor productivity growth shows a similar trend. Productivity growth picked up in the latter half of the 1990s, partly spurred by increased initial investment in the adoption of digital technologies. But this surge proved short-lived. Even as these technologies continued their advance in the subsequent two decades, and automation of production deepened and became more sophisticated, productivity growth slowed, settling into a longer-term trend of persistent weakness.

Concurrently, income inequality has been rising in the United States—and more sharply than in other major advanced economies (figure 1-1). Since the early 1980s, the share of the top 10 percent in national income has risen from 35 percent to 47 percent.[11] The income share of the top 1 percent has roughly doubled, from 11 percent to 21 percent. The share of the top 1 percent in wealth has risen from 23 percent to around 40 percent. Those with middle-class incomes have been squeezed. For the median worker, real wages have been largely stagnant over long periods. Real median wage growth has been weighed down not only by slower productivity

growth but also by wages lagging productivity growth and rising wage inequality. Job insecurity has increased, with mounting fears of a "robocalypse": large job/wage losses from automation.[12] As income inequality has risen, intergenerational economic mobility has declined.[13]

Rising inequality and related disparities and anxieties are stoking social discontent. They are a major driver of the increased popular disaffection and political polarization—and the rise of nationalist populism—that are so evident today.

The trends noted above reveal a striking contrast between the promise of brilliant new technologies and the actual economic and social outcomes. The national economic pie has been growing more slowly and more unequally. The benefits of technological transformation have been shared highly unevenly. This should not, however, lead to a Luddite backlash against technology. Technology itself is not the problem. On the contrary, the new technologies hold immense potential to boost productivity and economic growth, create new and better jobs to replace old ones, and raise human welfare. The challenge for policymakers is to better harness this potential.

Shifting Market Dynamics but Policies Slow to Catch Up

By its very nature, technological change is disruptive. It entails difficult transitions as it unleashes a process of—using Schumpeter's famous characterization—creative destruction.[14] 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 as it shifts dynamics across product and labor markets. The outcomes of slowing productivity growth and rising inequality are interconnected, and are closely linked to the way new technologies have interacted with the prevailing policy and institutional environment.[15]

Shifts in Product Markets

Business models and market structures are being reshaped by digital advances. How technology diffuses within the economy matters greatly for both productivity growth and income distribution. But the benefits of

digital innovations have so far not been diffusing widely across firms. They have been captured predominantly by a relatively small number of large firms. There is a pronounced gap between the digital "haves" and the "have-mores." Even the economy at the digital frontier—the United States—may be reaching only about a fifth of its digital potential.[16]

The slowdown in productivity fundamentally reflects a growing inequality in productivity performance between firms. For firms at the technological frontier, productivity growth has remained relatively robust. 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 nonfrontier firms, the increase was well below 10 percent.[17] Productivity divergence between firms is wider in more digital-intensive industries.[18]

Weakening competition is one important cause of this trend. Barriers to competition and related market frictions have prevented a broader diffusion of new technologies, contributing to a persistent rise in productivity and profitability gaps between firms. Evidence for OECD economies shows that in industries with diminished competitive intensity, technological innovation and diffusion have been weaker, interfirm productivity divergence has been wider, and aggregate productivity growth has been slower.[19]

The decline of competition in markets is reflected in a range 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.[20] The rise in market concentration and the decline in business dynamism are greater in industries that are more intensive users of digital technologies.

While these trends are observable broadly across advanced economies, they have been particularly pronounced in the United States. The share of the top four US companies in total sales has risen since the 1980s in all major sectors of the economy—and more sharply in digital-intensive sectors.[21] Markups over marginal cost for US publicly traded firms are estimated to have nearly tripled between 1980 and 2016, with the increase concentrated in high-markup firms gaining market share, indicating a strong rise in their market power.[22] Over roughly the same period, 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.[23] The distribution of returns on capital has become more unequal, with a relatively small number of firms reaping supernormal profits.[24] The share of young firms (five years old or less) in the total number of US firms has declined from about one-half to one-third.[25] American markets, a model of competition for the world, have been shifting toward more monopolistic structures.[26]

Digital technologies have led to increased market concentration because they promote 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."[27] The rise of the "intangible economy"—where assets such as data, software, knowledge embodied in patents, and other intellectual property matter more for economic success—has been associated with a stronger tendency toward the emergence of dominant firms.[28] 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, and Google. But they are increasingly affecting economies more broadly as digitalization penetrates business processes in other sectors, such as transportation, communications, finance, and commerce. In retail trade, for example, the big box stores, which previously had replaced mom-and-pop outlets, are now losing market share to online megastores such as Amazon.

These technology-driven forces producing higher market concentration have been reinforced by failures in competition policy. Competition policy has failed to adapt to the shift in market structures and the new challenges to keep markets competitive, notably those related to data and the digital economy. Antitrust enforcement has been weak in the face of rising monopoly power and takeover activity. Facebook alone, for example, has acquired more than seventy companies over roughly fifteen years, including potential competitors such as Instagram and WhatsApp.[29] Increased overlapping ownership, by large institutional investors, of companies that compete also has affected competition. Regulatory policies have not consistently supported competition, sometimes overregulating and restricting competition and sometimes deregulating without safeguards to protect competition.

Moreover, flaws in patent systems have acted as barriers to new or follow-on innovation and wider diffusion of knowledge embodied in new technologies. These systems, typically designed many decades ago, have

been slow to adapt to the knowledge dynamics of the digital era. In the United States, since the 1980s, the ownership of patents has become more concentrated in the hands of firms with the largest stock—mirroring broader patterns of market concentration—coupled with more strategic use of patents by market leaders to limit knowledge diffusion.[30]

Shifts in Labor Markets

In labor markets, an interplay between rapid technology-driven change and lagging policies that is similar to the interplay seen in product markets has been at work, limiting productivity gains from new technologies and exacerbating inequality. While product markets have seen rising inequality between firms, labor markets have seen rising inequality between workers.

Technology is transforming the nature and future of work. Automation and digital advances have shifted labor demand toward higher-level skills. In advanced economies, globalization has exerted pressure in the same direction. Demand has shifted, in particular, away from routine, middle-level skills that are more vulnerable to automation, as in jobs like clerical work and repetitive production. Job markets have seen an increasing polarization, with the employment share of middle-skill jobs falling and that of higher-skill jobs, such as technical professionals and managers, rising. The employment share of low-skill jobs has also increased, such as jobs in services like personal care that are hard to automate.

Over the two decades since the mid-1990s, the share of middle-skill jobs in total employment fell by about 9.5 percentage points in OECD economies on average, while the shares of high-skill and low-skill jobs rose by about 7.5 and 2 percentage points, respectively.[31] 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."[32]

Looking ahead, as AI advances, displacement risks will affect some higher-level skills as well, in contrast to previous waves of automation. However, the displacement risk at higher-level skills is likely to 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.[33] Higher-skilled workers typically also have greater ability to adjust by gaining new skills and new employment than less-skilled workers.

As demand for skills has shifted, adjustment on the supply side has been slow in equipping workers with skills that complement the new technolo-

gies and in supporting their transition to new tasks and jobs. Education and training have been losing the race with technology.[34] Even in an advanced economy such as the United States, almost two-thirds of workers do not have a college degree. Growth in the years of education completed slowed considerably in the United States around the 1980s. So just when demand for higher-level skills picked up as the digital revolution gathered steam, the attainment of those skills slowed. While precollege education gaps by family income level have narrowed, gaps in college and higher-level education have widened. The slowing of improvement in educational attainment around this period is observable more broadly across economies—both advanced and emerging.[35] Moreover, the capacity of systems for continuing education has been far exceeded by the fast-growing need for worker upskilling and reskilling. Access to retraining is typically more difficult for lower-skilled workers.

The lag in the supply of new and higher-level cognitive, technical, and managerial skills demanded by the digital economy has hampered technology diffusion across firms and broader productivity gains. Across industries, skills mismatches have increased: in OECD countries, on average around one-quarter of workers report a mismatch between their skills and those required by the job.[36] Workers with skills complementary to the new technologies have increasingly clustered in dominant firms at the technological frontier.

The changing balance between skills demand and supply has increased skill premia and wage differentials, contributing to higher labor income inequality and diminished job prospects for less-skilled workers. The skill premium has been rising since the 1980s and has more recently risen particularly sharply at the higher end of educational attainment—graduate and professional education. Skill-biased technological change is causing a "convexification" of returns to education and training.[37]

Wage inequality between firms has increased as well. Across OECD economies, increased interfirm inequality in firm productivity and profitability is mirrored by increased interfirm inequality in labor incomes.[38] As profitability gaps have widened between firms, so have wage gaps. Rent sharing also has contributed to wider wage differences between firms. Better-performing firms have reaped a higher share of total profits and have shared part of their supernormal profits with their workers. Between-firm wage inequality has risen more in industries that invest more intensively in digital technologies.

Although workers in firms at the technological frontier are earning more than those in other firms, gains from higher productivity at these firms have been shared unevenly, with wage growth lagging productivity growth. Wages have risen in the better-performing firms but by less than the rise in productivity. For most other firms, limited wage growth has reflected limited productivity growth, although even at these firms wage growth has tended to fall short of the meager gains in productivity. In the United States, between the mid-1970s and the mid-2010s, labor productivity rose by about 75 percent and average worker compensation in real terms rose by about 50 percent—with the productivity and compensation growth divergence increasing in the most recent decades. Over the same period, real compensation for the median worker rose by less than 15 percent, reflecting rising wage inequality.[39]

The decoupling of wages from productivity has contributed to a shift in income distribution from labor to capital. In the past couple of decades, most major economies have experienced both increasing inequality of labor earnings and declining shares of labor in total income.[40] In the United States, for example, the percentage share of labor in nonfarm business income fell from the mid-60s around 2000 to the mid-50s around 2015. Increased market concentration in product markets also has played a role in shifting income from labor to capital as it has reallocated labor within industries to dominant firms with supernormal profits and lower labor income shares.[41] Dominant firms are acquiring not only more monopoly power in product markets to increase markups and extract higher rents but also monopsony power to dictate wages in the labor market.[42] While employer market power has strengthened, worker bargaining power has weakened with a decline in unionization and erosion of minimum wage laws.

These developments in labor and product markets have reinforced the effect of the labor-substituting nature of many of the new technologies on the distribution of income between labor and capital. Production is shifting toward firms and processes using more capital (tangible and intangible) and less labor. The largest US firm in 2017 (Apple) had a market capitalization forty times as high as that of the largest US firm in 1962 (AT&T), but its total employment was only one-fifth that of the latter.[43] The shift of income from labor to capital has increased overall income inequality, as capital ownership is highly uneven.[44]

International trade and offshoring also have 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 farther up the skill spectrum also will face more competition from across borders.[45] Overall, globalization has played a significant role in the decline of the labor income share in advanced economies. However, its role has been much smaller than that of technology—about half or less.[46]

COVID-19 Reinforcing Technology-Driven Shifts in Market Dynamics

The COVID-19 pandemic is accelerating the digitalization of production, commerce, and work. As economies recover from the immediate crisis, the further advances in digital transformation can spur productivity and boost economic growth. But they can also reinforce the technology-driven shifts in product and labor markets that have in recent years inhibited productivity growth and increased economic inequality.

In product markets, the pandemic is intensifying the trend toward more monopolistic structures.[47] The big shift in demand toward online modes of business is adding to the pre-existing advantages of technologically advanced, well-positioned large firms. The pandemic is likely to disproportionately cull the ranks of smaller, less automation-intensive firms—also because smaller firms lack the liquidity and access to credit needed to survive in a crisis. While smaller firms struggle, tech giants are further increasing market shares. This is already evident in some industries, such as in retail trade, where an unfolding wave of bankruptcies is pushing more business toward big tech retail giants. Market dynamism and competition will face added challenges with more firm exits and fewer new entrants—and increased takeover opportunities. The reinforcement of the dominant positions of large firms associated with more demand shifting online will not be limited to the period of COVID-19 shutdowns but will extend into the future.

In labor markets, the pandemic is further tilting the balance against less-skilled, low-wage workers.[48] Firms are automating even more, especially in industries with business models more reliant on human contact and a less-skilled workforce. The further consolidation of economic activity in large firms in product markets will reinforce recent trends toward higher wage inequality and lower labor income share. Moreover, the pandemic has caused an overnight revolution in telework. The beneficiaries of telework are primarily higher-educated workers. Low-skilled workers have fewer options to telework, and they also face job losses as telework reduces demand for a range of personal and business services that employ them in large

numbers, such as office space maintenance, transportation, and hospitality. Even after the pandemic has passed, the number of people teleworking could be three to four times higher than before, with remote work potentially accounting for more than 30 percent of working time in advanced economies. Up to 25 percent more workers than previously estimated may need to switch occupations as a result of increased telework, e-commerce, and automation triggered by the pandemic.[49]

Rebooting Policies for the Digital Era

Digital technologies are reshaping markets, and the COVID-19 pandemic will accelerate this transformation. But technological change is not delivering its full potential to boost productivity and economic growth. And it is pushing income inequality higher, with the distribution of both capital and labor income becoming more unequal and income shifting from labor to capital. These outcomes are not inevitable, however. With more responsive policies, better outcomes are possible.

Digital technologies can be the source of as much as two-thirds—or perhaps even more—of potential productivity growth over the next decade.[50] How to realize the potential of these technologies to deliver stronger and more inclusive economic growth lies at the core of the forward policy agenda. Today's innovation economy must be broadened from its narrow confines to enable wider segments of firms and workers to contribute to and share in its promise. Innovation must be "democratized."[51]

Policies to reduce inequality are often considered narrowly in terms of redistribution—tax and transfer policies. This is of course an important element, especially given the erosion of the state's redistributive role in recent decades as tax progressivity has declined and social programs have 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 there is a much broader policy agenda of "predistribution" to make the growth process itself more inclusive.[52] Much of the reform agenda to achieve more inclusive outcomes from technological change is also an agenda to achieve stronger growth outcomes, given the linked dynamics between the recent rise in inequality and the slowdown in productivity.

Specific policy needs and priorities evidently differ across groups of economies, especially between advanced and emerging economies.

Broadly, there are five areas that need more focused attention from national policymakers.

First, as technology transforms the world of business, policies and institutions governing markets must keep pace. Competition policy should be revamped for the digital age to ensure that markets continue to provide an open and level playing field for firms, keep competition strong, and check the growth of monopolistic structures.

Antitrust enforcement should be strengthened. Laws and guidelines on mergers and acquisitions (M&As)—covering not only horizontal M&As but also nonhorizontal ones—and prevention of anti-competitive practices need to be reviewed and updated in light of the new dynamics of the digital economy. Recent congressional activity (antitrust hearings and legislative proposals) and filings of antitrust lawsuits against tech giants (Amazon, Apple, Facebook, and Google) in the United States, together with related actions in the European Union (EU), suggest that momentum may be building for reform of the antitrust legal framework and stronger enforcement.

The digital economy poses a range of new regulatory challenges that must be addressed. These include regulatory responses to proprietary agglomeration of data, competition issues relating to 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. An overarching issue is the regulation of data, the lifeblood of the digital economy. Issues relating to how data are handled—use, access, portability, openness while protecting privacy and security—matter for consumer protection but also for competition. To date, there has been more action on these issues in Europe than in the United States. The EU enacted the General Data Protection Regulation in 2018 and has proposed important new legislation—the Digital Services Act and the Digital Markets Act—as part of its Shaping Europe's Digital Future initiative.[53]

To strengthen institutional capabilities to address the competition policy challenges of the digital economy, some countries—such as Australia, France, Germany, and the United Kingdom—are now establishing or contemplating new regulatory bodies focused on digital markets.[54] These bodies would be tasked to develop procompetition standards, rules, and codes of conduct for digital markets (including approaches to addressing new competition issues that may arise as AI and machine learning algorithms advance), and could also serve as focal points for international coordination on regulation of digital markets. There are also emerging

proposals for similar reform in the United States.[55] As a related step, in July 2021, the Biden administration announced the establishment of a White House Competition Council to coordinate and advance government efforts to address overconcentration, monopolization, and unfair competition.

Second, the innovation ecosystem should be improved so that it spurs new knowledge and technological advances but also promotes their wide diffusion. In a knowledge-driven economy, its role is increasingly vital in continuing to push the technological frontier while at the same time fostering broader economic impacts from the new advances.

"The copyright and patent laws we have today look more like intellectual monopoly than intellectual property."[56] Patent systems should be reformed to better balance incumbent interests and the wider promotion and dissemination of innovation. This involves changing excessively broad or stringent protections, addressing the problems of patent thickets and patent trolling, aligning the rules with today's realities, and giving freer rein to competition that, ultimately, is the primary driver of technological innovation and diffusion. One possible reform is to replace the one-size-fits-all approach of current systems with a differentiated approach.[57] While a relatively long patent term may continue to be appropriate for some innovations, notably in pharmaceuticals that involve protracted and expensive testing, the case is less clear for digital technologies that have much shorter gestation periods and typically build on previous innovations in an incremental fashion.[58]

A rebalancing is needed also in investment in research and development (R&D). Public R&D investment has been falling in many countries: in the United States, for example, it has fallen from 1.2 percent of GDP in the early 1980s to half that level in recent years, with its share in total R&D investment declining from 45 percent to less than a quarter.[59] It should be revitalized, as it supplies the public good of basic research that produces broad knowledge spillovers and complements the focus of private R&D on narrower, applied research. Also, a robust public R&D program can influence the direction of technological change toward innovation that serves broader economic and social goals rather than the interests of narrow groups of investors. It can, for example, address the concern that the current private technological paradigm is geared toward "excessive automation," producing technologies that displace labor without much gain in productivity.[60] Correcting biases in the tax system that favor capital relative to labor would also help.[61]

Access to innovation financing should be broadened. Well-designed small business research and technology transfer programs can provide vital support to small and young firms that typically face greater hurdles in accessing innovation financing. In the United States, venture capital plays a major role in financing startups, but the industry is highly concentrated, with the top 5 percent of investors accounting for 50 percent of the capital raised.[62] Digital innovations in finance—Fintech—are now creating promising new financing possibilities for innovative entrepreneurs that public policy should foster.

Incentives provided to private R&D through tax relief should ensure that small and young firms are not at a disadvantage in accessing them. Best practices include payroll tax relief for researchers and refundable R&D tax credits. Support encouraging R&D collaboration between universities and firms can facilitate technological diffusion by providing smaller firms with access to sources of knowledge. Innovations are concentrated in high-income groups. Support for internship programs at firms to increase exposure to innovation among disadvantaged groups can boost overall innovation by helping the many "lost Einsteins" in these groups.[63]

Many breakthrough innovations developed commercially by private firms originate from government-supported research. Examples include Google's basic search algorithm, key features of Apple smartphones, and even the internet itself.[64] Governments should explore ways of better recouping some of their investments in research—not least to replenish their research budgets—producing a better balance in sharing risks and rewards of public research investment compared to the current paradigm, where risks are socialized but rewards are privatized. Ensuring that companies do not take advantage of loopholes in the tax system and pay adequate taxes on their profits is the obvious way. Other possibilities include requiring companies to repay research grants if their products succeed financially, or acquiring equity stakes in the commercialization of successful technologies directly supported by public research funds.[65]

Third, the foundation of digital infrastructure must be strengthened to broaden access to new opportunities in the digital economy. This calls for increased public investment and frameworks to encourage more private investment to improve digital access for underserved groups and areas. Broadband is becoming as much of a necessity in this century as electricity was in the twentieth century. But the digital divide remains wide within economies, a fact brought into starker relief by the COVID-19 crisis. Even

in the United States, the economy at the digital frontier, most sectors are less than 15 percent as digitalized as the leading sectors, and there are large gaps in access between major urban/industrial centers and other areas.[66]

In developing economies, the digital divide is still wider. Stronger digital infrastructure will be crucial for these economies as technology forces a shift toward growth models less reliant on low-skill, low-wage manufacturing. A robust digital infrastructure is essential to capturing the new growth opportunities that technology offers, such as the expanding trade in digitally deliverable services. Success in many countries in using mobile telephony to connect large populations to the formal economy, including to financial markets through expanding Fintech applications, illustrates the leapfrogging possibilities in development offered by the new technologies, given a supportive enabling environment.

Fourth, investment in skills must be boosted, with education and training programs revamped to emphasize skills that complement the new technologies. This will require innovation in the content, delivery, and financing of these programs, including new models of public-private partnerships. 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 twenty-first century are widening.[67]

With the fast-changing demand for skills and the growing need for upskilling, reskilling, and lifelong learning, the availability and quality of continuing education should be greatly scaled up.[68] This effort should span both the general education system and the institutions for vocational education. It should include expanded partnerships with employers, including exploring a larger role for apprenticeship arrangements—which have been used successfully in some European countries, notably Germany. To improve workers' access to retraining, one approach is through Lifelong Learning Accounts, allowing workers to accumulate rights to training that are portable across jobs.[69] Such accounts have recently been introduced at the national level in some countries, such as France and Singapore. More flexibility can be built into government student aid programs (grants, loans, tax incentives) so that they benefit not just first-time college entrants but also returning older adults.

Technology is changing not only which skills are in demand but also how skills are acquired. The potential of technology-enabled solutions must be harnessed. The COVID-19 pandemic has dramatically demonstrated the

scope for scaling up the use of online learning tools. Broader access to these tools will require a stronger foundation of digital infrastructure and digital literacy.

Fifth, labor market policies and social protection systems should be reformed to realign them with the changing economy and the nature of work. This means shifting the focus from backward-looking policies, such as stringent job protection laws that seek to keep workers in existing jobs (even as they are being rendered obsolete by technological change), to forward-looking policies that improve workers' ability to move to new and better jobs. Unemployment insurance schemes should better support workers in adjusting to change, retraining, and transitioning to new jobs. They should be designed to provide adequate coverage and encourage re-employment, complemented by enhanced placement services.

Other barriers to worker mobility and competition in labor markets, such as the ever-increasing professional licensing requirements and non-compete covenants in worker contracts, should also be addressed.[70] Well-functioning labor market institutions—collective bargaining, minimum wage laws, labor standards—are important to ensure that workers get a fair share of economic returns, especially at a time of rising market power of dominant firms.

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 with more frequent job transitions and more diverse work arrangements. This means greater portability and adaptability to address the needs of more people working independently. The gig economy is expanding.[71] The increased use of teleworking stemming from the pandemic will spur it further.

Finally, international cooperation needs to play its part. While the dominant part of the policy agenda to make technology work better for all lies at the national level, especially in the five areas discussed above, there is a complementary agenda at the international level. The rise of nationalist populism has increased protectionist sentiment. The pandemic can further stoke the backlash against globalization. Concerns about the security of critical supplies can spur more reshoring of supply chains. International cooperation will need to ensure that past gains in establishing an open, rules-based global trading system are shielded from these headwinds.

At the same time, new rules and cooperative arrangements must be devised to underpin the next phase of globalization led by digital flows to

ensure open access and fair competition.[72] This includes adequate disciplines for digital trade, cross-border data flows, and the fast-growing digitally deliverable services. The rise of multinational tech giants that can affect competition across national markets calls for increased international cooperation in competition policy. In a more knowledge-intensive globalization, well-balanced frameworks governing intellectual property—that reward innovation but prevent intellectual monopolies—take on added significance. International cooperation on tax matters becomes even more important in view of the new tax challenges of the digital economy.

The chapters that follow flesh out some key elements of the agenda summarized above, discussing in more detail the potential and the unfolding impacts of digital transformation, the opportunities and challenges it presents, and how responsive and creative policies can make it more productive and inclusive. The chapters approach these issues from both a global perspective and the perspective of a major individual economy: Korea.

Promoting Technology Diffusion

In chapter 2, Flavio Calvino and Chiara Criscuolo focus on technology diffusion dynamics in the digital era, reviewing a large body of research, including their own at the OECD. They document the uneven diffusion of digital technologies and widening productivity gaps across firms. Aggregate productivity growth has slowed not because innovation has slowed at the technological frontier but because the spread of innovation across firms has slowed. The shift to a digital and knowledge-based economy has created new challenges for firms, including the increasing importance of intangible assets, the need for complementary investments in human and organizational capital, and the winner-takes-all dynamics associated with the new technologies. To promote technology diffusion, the authors emphasize policies to boost competition in markets and address the new regulatory issues of the digital economy (especially those relating to data), improve knowledge production and sharing (including through sensible patent policies), upskill and reskill workers, and strengthen digital infrastructure.

A similar mix of policies will be important to harness the potential of AI, the new wave of technologies that mark the next phase of the digital revolution. Data and analyses on the diffusion and impact of AI are still

relatively scant. The productivity effects of AI will not fully materialize until a range of complementary innovations are developed and deployed. The new technologies may strengthen the importance of intangible capital and investments in higher-level skills and organizational changes, which may produce a J-curve effect on productivity and wider productivity dispersion between leading and lagging firms, and accentuate market dynamics toward more concentrated structures.[73]

In chapter 3, Minho Kim investigates the relationship between digital technologies, intangible capital, and productivity, using a large database of Korean firms in manufacturing and service industries. He finds that the adoption of digital technologies and investment in intangible capital boost productivity but require complementary innovations and investments in management practices (organizational capital) to deliver their full potential. Even though Korea is home to several leading high-tech companies, the diffusion of new technologies among smaller firms has been weak, limiting gains from digital transformation—which echoes the theme of chapter 2. Reviewing some policy initiatives in Korea to promote technology diffusion, the author calls upon policymakers to pay attention to the diversity of needs across firms, avoiding one-size-fits-all solutions.

Harnessing Digital Transformation in Finance

Digital transformation is also driving rapid change in financial markets. Innovations range from the use of smartphones and digital platforms for a variety of banking and investing services to blockchain and digital currencies. In chapter 4, Thomas Philippon examines the question of how to realize the potential of Fintech while managing associated risks. Digital innovations in finance are improving financial inclusion, lowering the cost of financial intermediation while offering new products and services, and introducing more competition into financial markets. They have the potential to significantly broaden access to finance and open new gateways to entrepreneurship.[74]

But the digital transformation of finance also creates new risks to cybersecurity, financial integrity, consumer protection, and financial stability. It poses new regulatory challenges, ranging from putting in place clear and consistent rules on data ownership and access, to tackling regulatory arbitrage, to developing capacities and tools to regulate the new world of

financial platforms and algorithms. Policymakers will need to adopt regulatory approaches that strike the right balance between enabling financial innovation and managing risks. Some countries—Australia, Canada, Japan, Korea, Singapore, and the United Kingdom, for example—are using a "sandbox" approach that encourages innovation and generates learning to inform the development of appropriate regulatory policies.

As in product markets, policymakers need to ensure that financial markets remain sufficiently competitive as digital finance expands. The finance industry now has three sets of players: traditional financial intermediaries such as banks, which are expanding investment in digitalizing their business; young Fintech firms that are trying to grow beyond their niche markets; and big tech firms that are becoming more involved in finance. The economies of scale and network effects associated with the technologies driving digital finance can potentially lead to increased concentration in financial markets, especially given the pre-existing advantages of big tech firms with large customer networks established through e-commerce platforms or information and communication services, vast collection of proprietary data, and use of advanced technologies such as AI and machine learning. Regulators will need to avoid excessive concentration and market dominance by a few financial services providers and their overlapping control over finance and other sectors of the economy.

Revamping Workforce Development

In labor markets, technology will continue to shift demand for skills. In chapter 5, Harry Holzer argues that labor market effects of digitalization and automation in coming years will be similar to what we have seen in recent decades—with both job displacements and rising inequality—only more so. The pace of these developments could well accelerate as automation intensifies in the aftermath of the COVID-19 pandemic. Also, advances in AI could increasingly displace workers higher up in the skill distribution than those previously affected. Against these challenges, workforce development policies will need to be rethought, with significant reform and adaptation to support workers and equip them with skills complementary with the new technologies.

The author discusses a range of policy reforms in the education and training system, including placing greater emphasis on "twenty-first-century skills" in K–12 education systems, making the acquisition of technical and higher-level skills at institutions of vocational and higher education more accessible, expanding opportunities for continuing education and lifelong learning, designing incentives to encourage employers to retrain rather than displace workers, and complementing improvements in training/retraining with enhanced workforce support services such as labor market information, career guidance, and placement assistance. The chapter also examines the role of other policies, such as provision of incentives for "good job" creation, wage subsidies or earned income tax credits for low-income workers to "make work pay," wage insurance, more "voice" for workers in the workplace and corporate governance, and changes in retirement and immigration policies that can all help address some of the effects of automation as well as the changing demographics and labor market institutions that complicate these effects. The author emphasizes policies that help workers adjust to automation and encourage (re)employment, drawing a contrast with policies—such as a universal basic income advocated by some—that may have the effect of paying workers to withdraw from the labor force, besides entailing high fiscal costs.[75]

The need for stepped-up worker retraining and lifelong learning is underscored by Sunghoon Chung and Sangmin Aum in chapter 6. Analyzing firm-level data for Korea, they find strong complementarity between firms' investment in the continuous learning of their workforce and successful digital transformation. As the digital revolution advances from information technology applications of recent years to major new innovations based on AI and other new technologies, the role of the firm in adapting and updating the skills of their workers will take on added importance, as will the use of technology-based delivery of learning content. The new technologies will demand complementary technical skills but also more soft skills such as critical thinking and problem solving, creativity, adaptiveness, communication, and teamwork. The role of institutions of formal education will remain important in the digital era, but the role of the firm as a teacher and supporter of learning will grow. Greater cooperation between these two suppliers of learning will be needed to better match skill supply and demand and support lifelong learning. Public policy should promote such cooperation.

Addressing Rising Inequality

Technology's implications for income distribution are an important concern. In chapter 7, François Bourguignon analyzes in detail the increase in income inequality in recent decades, particularly in advanced economies. The role of digitalization-led technological change in pushing inequality higher is examined through three channels: rise in earnings inequality as the new technologies favor higher-level skills and polarize labor markets; shift in income from labor to capital with rising automation; and shift toward more concentrated market structures and the associated rise in corporate rents. Absent countervailing policies, a "tsunami" of AI and other new innovations could exacerbate inequality. 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.[76] Continuing and large increases in inequality may not be a sustainable path given associated social and political risks.

While calling for adaptations in education and training systems to upskill and reskill workers for the digital era, as stressed by Holzer and by Chung and Aum, the author also argues for a key role for tax policy reforms. Tax policy can be deployed to prevent an excessive increase in disposable income inequality, help finance stronger safety nets for occupational transitions in the labor market, and influence the direction of technological change. The author proposes higher taxation of capital and more progressive taxation of household income. Some have suggested directly taxing robots and using fiscal incentives to favor specific types of innovations relative to others. The author cautions against such actions, which may be difficult to implement, create unintended distortions, and risk hurting an economy's innovation capacity. Re-establishing a better balance between the taxation of capital and labor against a history of tax changes that have favored capital would be a more efficient way to address biases in the current tax system that encourage excessive automation, incentivize more employment-friendly innovation, and help facilitate economic and social adjustments to new technology. Some international coordination would be essential if meaningful reform of capital taxation is to be implemented, given the high mobility of capital.

In chapter 8, Jungsoo Park analyzes technology and inequality dynamics in Korea, using both macroeconomic data and data at the level of firms,

workers, and households. Contrary to some other studies that show a declining labor income share in Korea in recent decades, he finds that the long-run labor share appears relatively stable if the large self-employed sector in Korea is correctly taken into account in calculating factor income shares. Skill-biased technological change seems to have been having offsetting effects on the incomes of higher- and lower-skilled workers, leaving the aggregate long-run labor income share relatively unchanged. Meanwhile, wage disparity has been rising. In particular, wage gaps have been widening between large firms well-positioned to take advantage of the new technologies and boost productivity and small firms that are lagging behind. The rising wage disparity has been pushing overall household income inequality higher. Another interesting finding is that rising female participation in the labor force also has been pushing inequality higher, by widening income gaps between multiple-income and single-income households.

The author stresses the need for improvements in the business environment to foster broader opportunities for firms and their workers to benefit from technological transformation. He calls on Korean policymakers to redirect policies regarding smaller firms away from overprotecting existing businesses (which leaves them uncompetitive) to promoting their productivity, competitiveness, and growth in the innovation economy and revitalizing firm dynamics. The social safety net should be strengthened to support necessary firm turnover and worker transitions. Also, redistribution policies should take into account ongoing shifts in labor market participation and demographic transition.

Conclusion

Digital technologies are a defining feature of our time as they drive transformative change. They are reshaping product and factor markets and profoundly altering business and work—and society at large. And we may be on the cusp of a significant deepening and acceleration of this transformation as AI spawns a new wave of innovations and the COVID-19 pandemic gives added impetus to automation and online processes.

Our era of an ever-expanding array of smart machines holds considerable promise. It creates new avenues and opportunities for a more prosperous future. But it also demands smarter policies to realize that promise.

Policies will need to be more responsive to change to capture potential gains in productivity and economic growth and to address rising inequality.

New thinking and adaptations are needed to realign institutions and policies with the digital economy. As technology reshapes markets and alters growth and distributional dynamics, policies must ensure that markets remain inclusive and support broad access to the new opportunities for firms and workers. Areas for policy attention include competition policy and regulation of data and digital platforms, the innovation ecosystem, digital infrastructure, regulation of Fintech, workforce development, social protection frameworks, and tax policies. The digital economy also calls for new frameworks for international collaboration in areas such as regulation of cross-border data flows and taxation of cross-border digital business.

An agenda to enable broader participation of firms in the innovation economy, widen the diffusion of new technologies, and build complementary capabilities in the workforce can deliver both stronger and more inclusive economic growth. These reforms can reduce inequality and economic insecurity more effectively than fiscal redistribution alone. In capturing the full promise of digital transformation, the growth and inclusion agendas are one and the same. Inevitably, major economic reform is politically complex, even more so in today's climate of increased political divisiveness. But one thing reform should not be paralyzed by is continued trite debates about conflicts between growth and inclusion. Research increasingly shows this to be a false dichotomy.

NOTES

1. The first book, *Growth in a Time of Change: Global and Country Perspectives on a New Agenda*, Brookings Institution Press, was published in 2020.

2. See, for example, Brynjolfsson and McAfee (2014) and Schwab (2016).

3. Nordhaus (2015).

4. West and Allen (2020).

5. Chernoff and Warman (2020).

6. It should be noted that current statistical methods may not fully capture the new value created in the digital space. The rising importance of intangibles in business and production processes adds to the measurement challenges (Brynjolfsson, Rock, and Syverson 2021). Overall, research shows that, even allowing for these measurement issues, the productivity slowdown is real, not illusory. See Derviş and Qureshi (2016). See also Qureshi (2016) for the debate among "techno-pessimists" and "techno-optimists" on the productivity growth potential of digital technologies.

7. McKinsey Global Institute (2018).

8. World Bank (2018). See also World Bank (2020).

9. Coulibaly and Foda (2020).

10. The productivity series in figure 1-1 shows five-year moving averages to smooth year-to-year fluctuations.

11. The income shares in figure 1-1 are based on pretax national income.

12. Autor and Salomons (2017).

13. Chetty and others (2017). The negative relationship between income inequality and intergenerational mobility has been famously captured in a curve termed the Great Gatsby Curve by Alan Krueger (2012).

14. Schumpeter (1950).

15. On the nexus connecting technology, policies, and the productivity and distributional outcomes, see Brookings Institution and Chumir Foundation (2019) and Furman and Orszag (2018b).

16. McKinsey Global Institute (2015).

17. Andrews, Criscuolo, and Gal (2016) and Orbis Database (Bureau Van Dijk n.d.). Frontier firms in this estimate are defined as the top 5 percent of firms with the highest labor productivity within each two-digit industry. Nonfrontier firms cover all other firms.

18. Berlingieri and others (2020).

19. See, for example, Andrews, Criscuolo, and Gal (2016), Cette, Lopez, and Mairesse (2016), and Égert (2016). These studies use panel data for a broad range of OECD economies and industries. For a recent review of research on the productivity slowdown, see Goldin and others (2020).

20. Qureshi (2019). See also Akcigit and others (2021).

21. Autor and others (2020).

22. De Loecker, Eeckhout, and Unger (2020).

23. Eggertsson, Robbins, and Wold (2018). Mordechai Kurz (2018) estimates that, between 1985 and 2015, as monopoly profits boosted the market value of corporate stocks and produced outsize capital gains, the share of total US stock market value reflecting monopoly power (what he terms monopoly wealth) rose from negligible levels to around 80 percent.

24. Furman and Orszag (2018a).

25. Decker and others (2017).

26. Philippon (2019) and Tepper (2019).

27. Autor and others (2020).

28. See Haskel and Westlake (2017) and Crouzet and Eberly (2019).

29. Reich (2020). In an influential article, Khan (2017) makes the case that the current US 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.

30. Akcigit and Ates (2019).

31. OECD Employment Database (OECD n.d.). See also World Bank (2019).

32. See Taylor and Ömer (2020) and Temin (2017).

33. Autor, Mindell, and Reynolds (2019) and Webb (2020).

34. Autor, Goldin, and Katz (2020) and Goldin and Katz (2008).

35. Barro and Lee (2013) and Morrisson and Murtin (2013).

36. Adalet McGowan and Andrews (2017).

37. Autor, Goldin, and Katz (2020).

38. Criscuolo and others (2020), Song and others (2019), and Berlingieri, Blanchenay, and Criscuolo (2017).

39. Stansbury and Summers (2018).

40. OECD (2018) and Schwellnus and others (2018). See also Gutiérrez and Piton (2020) for measurement issues relating to the labor income share and how they affect the estimated trend in some countries.

41. Autor and others (2020).

42. Council of Economic Advisers (2016) and Azar, Marinescu, and Steinbaum (2017).

43. West (2018).

44. The roles of uneven capital ownership and returns on capital as sources of inequality have been particularly emphasized by Thomas Piketty in his 2014 bestseller (Piketty 2014).

45. Baldwin (2019).

46. International Monetary Fund (2017). The study finds that, in advanced economies, technology accounts for about half of the decline in the labor income share, global integration accounts for about a quarter, and policies and institutions and other factors such as measurement issues account for the remainder.

47. Rose (2020).

48. Autor and Reynolds (2020).

49. McKinsey Global Institute (2021).

50. McKinsey Global Institute (2018).

51. Qureshi (2020) and Rodrik (2020).

52. Hacker (2011).

53. The 2018 regulation has become a model for several national laws outside the EU, for example, in Japan and Korea. For the proposed new legislation, see European Union (2020).

54. For the United Kingdom, for example, see Digital Competition Expert Panel (2019).

55. See Wheeler, Verveer, and Kimmelman (2020) and Stigler Committee on Digital Platforms (2019).

56. Lindsey and Teles (2017).

57. In advanced economies, patents typically carry terms of twenty years. Copyright protections typically run for seventy-plus years.

58. Roin (2014) and Qureshi (2018). See also Galasso and Schankerman (2015) on differentiating patent policy by firm size. In tailoring patents to different types of innovation and innovators, care must be taken not to complicate the patent regime excessively. More research on possible approaches is needed.

59. Shambaugh, Nunn, and Portman (2017).

60. Acemoglu and Restrepo (2019). The authors refer to these technologies as so-so technologies.

61. Acemoglu, Manera, and Restrepo (2020). The authors 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 US effective tax rate in the 2010s was 25.5–33.5 percent for labor and 5–10 percent for capital. See also Saez and Zucman (2019).

62. Lerner and Nanda (2020).

63. Bell and others (2019).

64. Mazzucato (2015).

65. Mazzucato (2015) and Rodrik (2015). Ideas such as government acquiring equity stakes are not without controversy. Government stakes could be "passive" and temporary, with the research investments focused in priority areas that entail high risks that private investors would not take on their own, and managed by independent entities shielded from day-to-day political pressures.

66. McKinsey Global Institute (2015).

67. United Nations (2019).

68. The need to scale up continuing education is reinforced by the aging of the workforce in many countries.

69. Fitzpayne and Pollack (2018).

70. In the United States, almost one in three workers requires a government occupational license (Council of Economic Advisers 2016). Noncompete restrictions cover about a quarter of all workers, with the ratio rising for higher-level technical and professional occupations (Shambaugh and Nunn 2018).

71. Brynjolfsson and McAfee (2017) and Sundarajan (2016).

72. Schwab (2019) and World Economic Forum (2019).

73. See also Brynjolfsson, Rock, and Syverson (2017).

74. See also Sahay and others (2020).

75. See also Holzer (2021) for detailed specific proposals focused on the United States.

76. Spence (2021) sketches a similar scenario, arguing that we should worry less about technological unemployment and more about inequality.

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