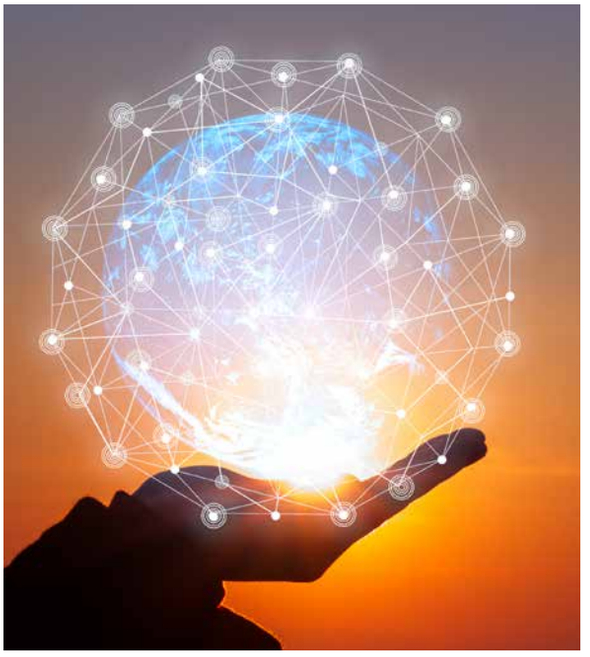
# The Enterprise Automation Imperative—

## Why Modern Societies Will Need All the Productivity They Can Get

Robert D. Atkinson and David Moschella



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## INTRODUCTION AND OVERVIEW

Despite vocal claims to the contrary, automating a large portion of today's U.S. and EU economies remains one of the most important technology opportunities of the 2020s. Increased automation—with its ability to significantly boost societal productivity—is needed to help modern nations address seemingly intractable challenges such as sluggish wage growth, aging populations, rising health care costs, environmental restorations, global competitiveness, and often-worrisome levels of public sector debt. Advances in public and private sector productivity are also needed to free up human capacity, talent, and ingenuity so the workforces of the future can more fully focus on the exciting possibilities of the Information Age.

Much of this automation must be led by large public and private sector enterprises because so many of today's most promising digital initiatives—including smart cities and grids, precision agriculture and medicine, shared ledgers, autonomous vehicles, robotics, machine learning, and artificial intelligence (AI)—can only be brought to fruition by large organizations and the sectors they serve. While easy-to-use services designed for consumers have dominated digital innovation thus far, global technology leadership will increasingly depend on complex changes in the ways many traditional enterprises and industries work.

**There is a risk society will turn away from automation at the very moment it is most needed.**

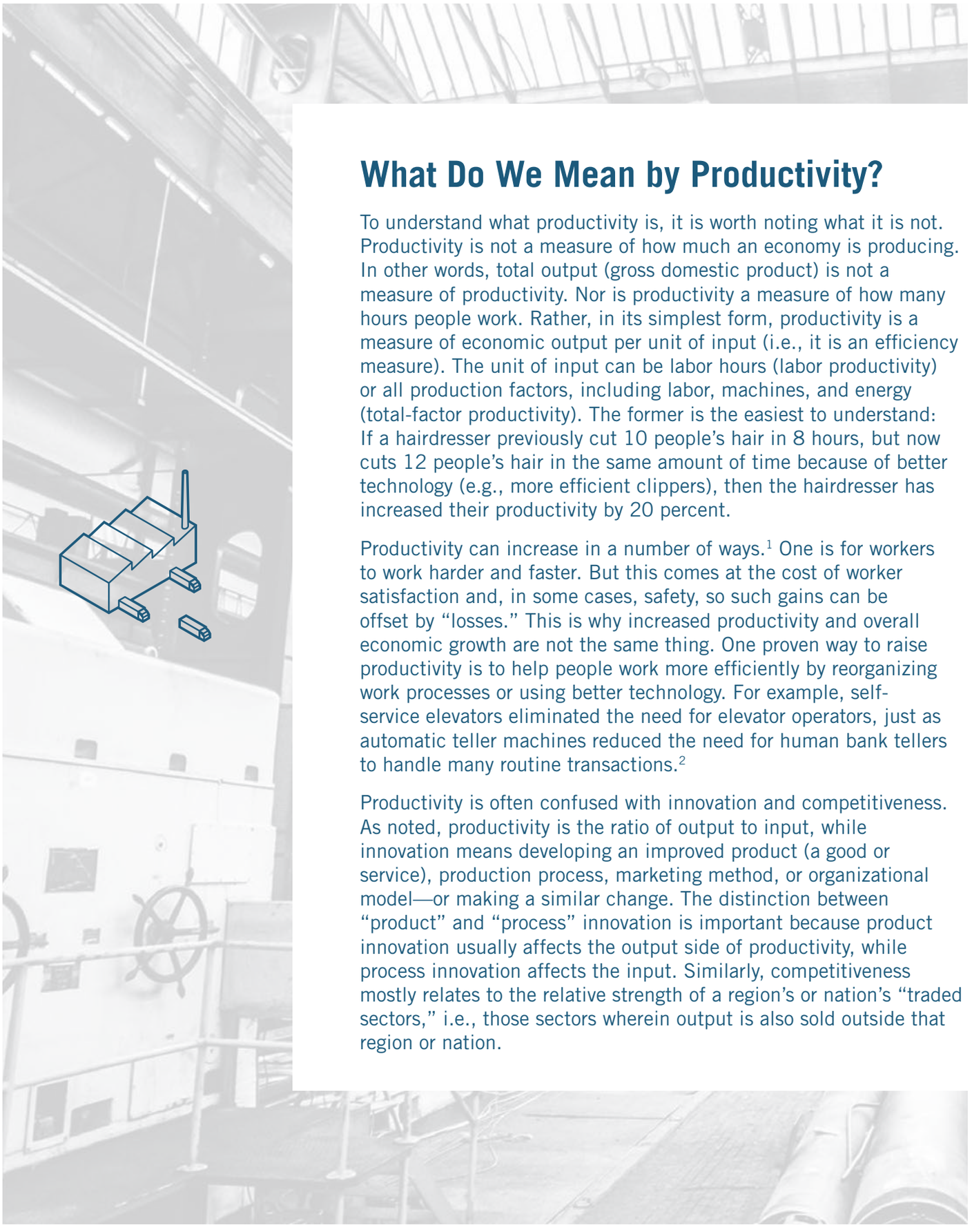
Unfortunately, today's automation debate is focused almost entirely on the potential downsides. From both the left and the right, we are constantly warned that new technologies—particularly AI and robotics—will destroy tens of millions of jobs, and even diminish human worth. This paper disagrees with these now widely shared perspectives. Although technology innovations will require, as they always have, difficult worker transitions, forecasts of massive job losses have been proven wrong ever since the dawn of Industrial Revolution. Today's labor and skills shortages—and aging populations—suggest the doomsayers are well along the path to being wrong again. While we could just dismiss the hype and say, "Here we go again," there remains the risk of society turning away from automation at the very moment it is most needed.

Of course, new technologies are not an instant cure-all. We have heard many times how, for example, e-health, e-government, and self-driving cars were just around the corner, only for reality to prove otherwise. But while the skeptics can make their case—and it is true there will be no quick fixes—two things make us optimistic over the longer term. First, today's automation technologies are almost uncannily well suited to meet the societal challenges listed above. This means that to bet against advanced automation is to bet against the future of digital technology itself—and this has generally been a losing wager. Second, we can already see that China, without the same constraints many Western economies face, is committed to establishing its own highly automated society, albeit not always in a manner more democratic nations would prefer.

Importantly, we want to state from the outset that we are not saying that increasing productivity is the only way public policy should respond to these challenges. Far from it. Clearly, much can be done to reduce income inequality, shrink the pay gap between CEOs and workers, close international and other tax loopholes, ease employment transitions, make U.S. health care more portable and affordable, and address similar concerns. However, as these are not technology policy issues per se, they are largely outside the scope of this paper. More fundamentally, without higher levels of productivity, we believe these efforts will likely fall short of meeting the societal challenges we have identified.

To inform both industry executives and technology policymakers about today's productivity challenge, ITIF and the Leading Edge Forum have launched a new research initiative. This initial paper argues that, contrary to common belief, enterprise automation is now a societal imperative—and modern nations will need all the productivity they can get to address today's ever-more-resource-constrained challenges. It further argues that without greater enterprise urgency, a significant public policy boost, and the requisite societal skills and support, Western competitiveness will likely suffer.

The paper begins with a discussion of the current trends in productivity and automation. It then shows why increasing public and private sector automation will be essential to Europe and the United States if they are to meet their financial and demographic challenges. We end on an optimistic note by explaining why fears of an increasingly jobless future are still largely unfounded. There's a great deal of work that needs to be done.



## What Do We Mean by Productivity?

To understand what productivity is, it is worth noting what it is not. Productivity is not a measure of how much an economy is producing. In other words, total output (gross domestic product) is not a measure of productivity. Nor is productivity a measure of how many hours people work. Rather, in its simplest form, productivity is a measure of economic output per unit of input (i.e., it is an efficiency measure). The unit of input can be labor hours (labor productivity) or all production factors, including labor, machines, and energy (total-factor productivity). The former is the easiest to understand: If a hairdresser previously cut 10 people's hair in 8 hours, but now cuts 12 people's hair in the same amount of time because of better technology (e.g., more efficient clippers), then the hairdresser has increased their productivity by 20 percent.

Productivity can increase in a number of ways.[1] One is for workers to work harder and faster. But this comes at the cost of worker satisfaction and, in some cases, safety, so such gains can be offset by "losses." This is why increased productivity and overall economic growth are not the same thing. One proven way to raise productivity is to help people work more efficiently by reorganizing work processes or using better technology. For example, self-service elevators eliminated the need for elevator operators, just as automatic teller machines reduced the need for human bank tellers to handle many routine transactions.[2]

Productivity is often confused with innovation and competitiveness. As noted, productivity is the ratio of output to input, while innovation means developing an improved product (a good or service), production process, marketing method, or organizational model—or making a similar change. The distinction between "product" and "process" innovation is important because product innovation usually affects the output side of productivity, while process innovation affects the input. Similarly, competitiveness mostly relates to the relative strength of a region's or nation's "traded sectors," i.e., those sectors wherein output is also sold outside that region or nation.

To be sure, these three factors can be closely related. For example, effective innovation can improve productivity and competitiveness. Consider how faster computer chips boost the productivity of the companies and people using devices with those chips—while also helping the chip manufacturers become more globally competitive. Likewise, productivity growth, especially in traded industries such as automobiles, can make nations more competitive by enabling their companies to sell in global markets at lower prices. But each of the three terms is distinct in important ways. For example, rising productivity does not make a nation more competitive when other nations are increasing their productivity even faster.

In most countries, policymakers prioritize competitiveness first, innovation second, and productivity last, if at all. But in modern economies, productivity is typically the most important driver of economic well-being. This is not just because the majority of jobs in most economies are in "non-traded sectors," wherein the benefits of productivity gains go more directly to workers and domestic consumers. It's also because these same gains often spread to traded industries because the companies that compete in traded sectors also tend to be heavy consumers of health care, transportation, telecommunications, and many other non-traded services.

Finally, there are two related measures of productivity: labor productivity and total factor productivity. Labor productivity is just as it sounds: the output of workers divided by the number of hours of work. Total factor productivity is a broader measure of the productivity of all factors of production, including workers, energy, and machines. For example, an economy might increase labor productivity by adding more machines, but total factor productivity could go up or down depending on whether the machines' output is worth the costs. This means total factor productivity is ultimately the more comprehensive measure, although it's often considerably more difficult to quantify. Even more confounding to the productivity-measurement community is the fact that digital technology is often a major driver of both cost cutting and value creation, as well as labor and factor productivity—and the resulting competitiveness—all at the same time.

## Today's Worrisome Productivity Slowdown

The EU and U.S. economies are in need of a productivity "booster shot" of the kind they experienced in the 1950s and early 1960s with electromechanical and materials innovations (steel, chemicals, plastics, etc.), and again in the 1990s with information and communications technology (ICT) innovations (personal computing, the Internet, broadband, etc.). Indeed, both economies are now in a productivity slump. Labor productivity—all the goods and services a country produces per hour of work—inched up in the United States at just 1.2 percent per year between 2008 and 2017. That is half the rate of the prior 13 years. Similarly, since the financial crisis, labor productivity in the 28 EU member states has grown at just 0.7 percent annually.[3] While there is some debate about whether the productivity slowdown is real or simply reflects measurement challenges, the body of evidence suggests the slowdown is not just a measurement effect.[4]

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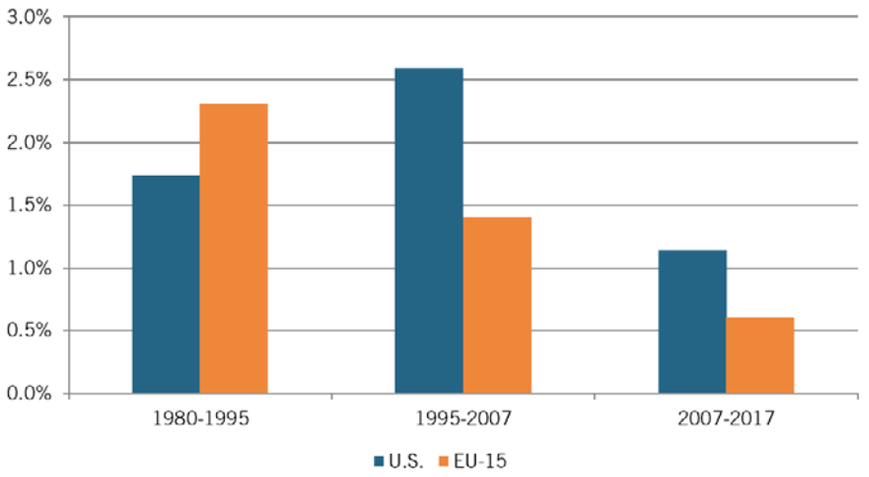
As will be discussed throughout this paper, this slowdown in productivity is one of the key reasons wage and gross domestic product (GDP) growth have stagnated in both regions, making it increasingly difficult for governments and residents to meet their civic and financial obligations. Too often, the result has been ever-rising public and private sector debt. And even with this borrowing, many nations and individuals feel increasingly squeezed in terms of both their time and finances.

**Figure 1: EU-15 and U.S. average annual labor productivity growth, 1980–2017[5]**



## Why Large Enterprises Must Drive Future Productivity Gains

One reason modern technology has yet to effectively reverse today's productivity shortfall is thus far the most potent digital innovations have focused on the consumer market in areas such as online retail, search, email, social media, voice, video, smartphones, etc. While the rate of consumer adoption in these areas has been extraordinary, because many of these services are free and used by people in their spare time, their impact on GDP—and hence productivity and wages—is often smaller than the great scale and financial success of the major tech firms might suggest. Moreover, from a GDP perspective, many free services mostly show up in terms of their associated advertising revenues, not the great many real benefits consumers enjoy. It's another reason traditional GDP estimates don't always portray the full societal picture.

However, the world is beginning to transition into a new kind of digital system, one that will increasingly incorporate capabilities such as smart products, pervasive sensors, high-speed and low-latency communications, autonomous operations, robotics, shared ledgers, AI, and machine learning. Many of these innovations will not arrive as services consumers can simply sign up for. Rather, they will require complex changes in the way businesses, governments, and entire sectors currently operate. This explains why the rate of enterprise change has been nowhere near that of the consumer sector, deflating much of the hype regarding an imminent "industry 4.0" revolution.

Yet, looking ahead, the changes will be profound. Consider today's vast office complexes—and the tens of millions of office workers within them—that often handle relatively standard financial transactions, insurance claims, telecom services, health care and government record-keeping, customer support, and many similar "white collar" workloads. Is this really the future? It's not difficult to imagine many of these services being built into increasingly intelligent software. Indeed, in the final section of this paper, we present our vision of an advanced highly automated economy wherein many of today's office workers are steadily redeployed, as more and more work takes place either in the cloud (virtually) or directly at the points of service (physically). It's a shift analogous to those of the past: from agriculture to manufacturing, and then manufacturing to services, with all the benefits and transition challenges of those earlier eras.

But in the near term, the priority is to both welcome and accelerate large enterprise automation. While it's understandable that skeptics will say this sounds a lot like the once-fashionable cheerleading for globalization, the opposite is being argued. Globalization was based on the belief that specialization and scale economies in traded goods would make everyone better off; but our automation vision is much more national, direct, and broad-based in nature. Every modern society should pursue its own productivity agenda for its own benefit in traded and non-traded sectors alike. This is why policymakers shouldn't just focus on technology's downsides, but rather, find

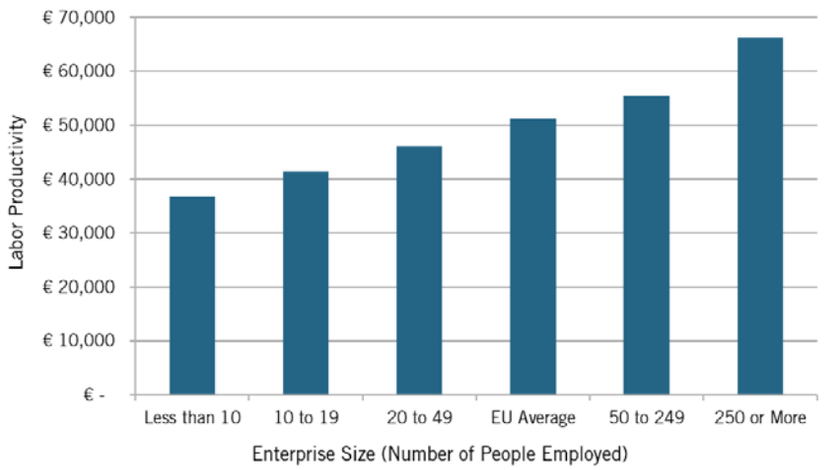
ways to increase the productivity of their own people. To explore this further, let's look at the current state of enterprise productivity in both the public and private sectors.

## The Importance of Improving Enterprise Productivity

We stress the importance of large organizations because they are responsible for the lion's share of economic activity. In the United States, around half of all private sector employment is in businesses of more than 500 workers. When the approximately 8 million state and federal U.S. government workers are included, that share increases to roughly 55 percent.[6] To effectively move the needle on productivity, two things must happen. Large enterprises need to become significantly more productive, and many traditional industries will need to be transformed into more efficient and scalable "ecosystems" and "platforms." Let's look at each, in turn.

At an individual-organization level, digital technology both enables and demands scale, which is why large enterprises have invested much more heavily in technology than most smaller firms have. For example, it often costs roughly the same to develop an advanced software application for a mid-size firm as for a larger one, but the latter can amortize those costs over a much larger revenue base. As Hitt, Wu, and Zhou showed in their paper examining information technology (IT) adoption by firms, ICT investments have high returns to scale because of their low marginal costs and higher fixed costs.[7] This is also why in both the EU and the United States, larger firms are on average more productive. (See figure 2.) Bart van Ark and Erik Monnikhof showed that, for example, large firms are more productive than smaller ones in France, Germany, Japan, the United Kingdom, and the United States.[8]

**Figure 2: Labor productivity and enterprise size in the European Union, 2015[9]**




However, the pace of digital transformation in large Western organizations, both public and private, often lacks urgency and can be frustratingly slow. The main challenges are occurring in two main areas. First, most large organizations are in the process of modernizing their underlying IT infrastructures, which means they are moving away from managing their own data centers and

packaged-software usage. Instead, they are "moving to the cloud," increasingly relying on third-party computing (from Amazon, Microsoft, and others) and software-as-a-service offerings such as Salesforce.com and Workday. While this shift from building to consuming IT is dramatically increasing the IT industry's overall economies of scale—and hence its overall productivity—because IT costs are typically less than 10 percent of total business costs, the adoption of cloud computing can only move the overall productivity needle so far.

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The second type of digital transformation is much more strategic in nature. Large enterprises see the potential to become much more data-driven in areas such as customer self-service, robotic process automation, algorithmic decision-making, "digital twins" (discussed later), and machine learning. The goal here is not just greater efficiencies, but entirely new forms of value creation. Consider the online music firm Spotify. Although delivering music online is highly efficient, doing so alone would be a relatively low-margin business. However, the ability to know (anonymously) exactly what music individuals are listening to and where they are located (at the postal-code level) creates powerful ways to promote new band releases, local concerts, and many other goods and services. For example, if someone in Topeka, Kansas, listens to a lot of Amy Winehouse, that person might like to know when an Amy Winehouse tribute singer might be performing nearby. Such simultaneous increases in both efficiency and value creation can provide a powerful investment payoff.

Today, participants in just about every industry believe they can leverage data in this way (and we fully agree, provided privacy regulations do not inhibit anonymized data analytics). However, the current pace of change is mixed, and often slowed by concerns regarding returns on investment, system interoperability, data sharing, regulatory compliance, available skill sets, internal politics, capital availability (for government enterprises), and other forms of inertia. Indeed, many enterprises see this sort of data-driven transformation as a long-term challenge for the 2020s. Despite this, China appears to be moving a good bit faster—and therefore, competitiveness concerns are rising. As one insurance industry executive told us, "If we had to compete directly with China in terms of cost per policy holder, we wouldn't stand a chance." Scary words to consider, especially as similar worries can be heard regarding electric cars, consumer appliances, payment systems, and many other areas.

## New Industry "Platforms" Are Particularly Vital

While changes within individual enterprises are essential to the productivity advances we envision, innovation at an industry and ecosystem level is often an even more powerful force. The reality is many industries that grew up in the pre-Internet era are still

structurally inefficient. Perhaps the best examples are those sectors that ultimately sell to consumers through dealers, agents, brokers, or some other form of human intermediary. Automobiles, insurance, and pharmaceuticals all fall into this category, just as trading stocks and booking travel once did.

Industries that rely heavily on human intermediaries are inevitably fragmented and find it difficult to reach their most efficient scale. Even more problematic, the lack of an ongoing digital connection to the end consumer makes it difficult—even impossible—to directly engage with customers and systematically collect the consumer experience information that makes innovative machine learning possible. As one pharmaceutical executive lamented, "Nike knows more about the consumers who buy their sneakers than we do about the patients who use our cancer drugs."

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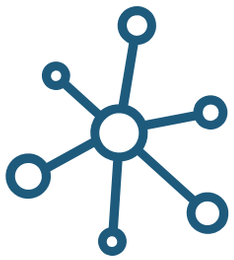


Similar scalability and data-collection problems exist within "the professions": doctors, lawyers, professors, accountants, and similarly advanced-knowledge workers. These highly educated individuals face a remarkably common set of challenges, including high costs, limited citizen access, rising workloads, the inability to keep up with their fields, concerns about fairness and bias, overwhelming paperwork, and increasing levels of individual burnout. Additionally, many professions have perverse productivity incentives, e.g., few professional associations favor changes that might result in a thinning of their ranks.

The simplest answer to both the inefficiencies of human intermediaries and the burnout of the professions is platforms. By "platform," we mean the establishment of online ecosystems wherein suppliers and consumers can easily come together at scale—with machine learning a natural byproduct. Amazon, Netflix, Uber, and Airbnb are, of course, among the iconic examples. But today, in most nations, such platforms don't exist (or are at a very small scale) in automobiles, insurance, health care, law, education, real estate, and other important sectors. Again, there are many reasons, including vested interests, antitrust, regulatory compliance, and overall inertia. In fact, the strength of these barriers is one reason many industry observers believe major changes will eventually need to be led by new, disruptive players. Consider Haven—the Amazon, J.P. Morgan, and Berkshire Hathaway entry into health care.

But the bottom line is in order to bring scale, efficiency, and intelligence to these traditional sectors, the current barriers will eventually need to be overcome—and how this type of transformation will play out remains one of the biggest strategic unknowns in the

market today. However, whether the shift to platforms is led by new or existing players, society has a compelling interest in bringing more automation and intelligence to these vital sectors. And as discussed below, the public sector has an important role to play—in transforming itself, and ensuring its policies support rather than resist the industry-sector and individual-enterprise transformations we have described.

## Governments Should See Themselves as "Societal Platform" Leaders

The platform dynamics previously described should be particularly interesting to governments, as many of the most important platform innovations of the future will be societal in nature. Included among these are the need for smart cities and utility grids; reliable identification and authentication; efficient payment and voting systems; coherent satellite and drone management; trusted shared ledgers and open data; more innovative defense and law enforcement; and the associated security, oversight, and standards-setting that comes with these important initiatives. Additionally, societal platforms are not just ends unto themselves. Once established, they will almost certainly enable a wide range of future public and private sector innovation.

While we tend to think of global technology leadership in terms of the large digital suppliers, such as the United States, China, Europe, Japan, Korea, and India, societal platforms might follow a different, more-local pattern of leadership—one in which smaller nations can have significant advantages. We say this because the required societal decisions and investments—and their cultural implications—will often be much more manageable in smaller, more cohesive nations than in, for example, the United States, Japan, or the larger European nations, with their layers of interests, bureaucracy and complexity.

**The emphasis on automating traditional businesses and establishing new societal platforms suggests a three-pronged public policy agenda.**

For example, Singapore might lead in the urban use of driverless cars, Iceland in leveraging national health care records, Estonia in digital IDs, Dubai in blockchains, the Netherlands in precision farming, the Nordic nations in cashless transactions, and Israel in desalinization and drones. It's easy to envision these efforts serving as laboratories for societal innovation larger nations—and everyone else—can learn from. (Future phases of this project will look at these international projects more closely.)

Taken together, the emphasis on automating traditional businesses and establishing new societal platforms suggests a three-pronged public policy agenda. First, government policies should support the transformation of large enterprises and their associated industries

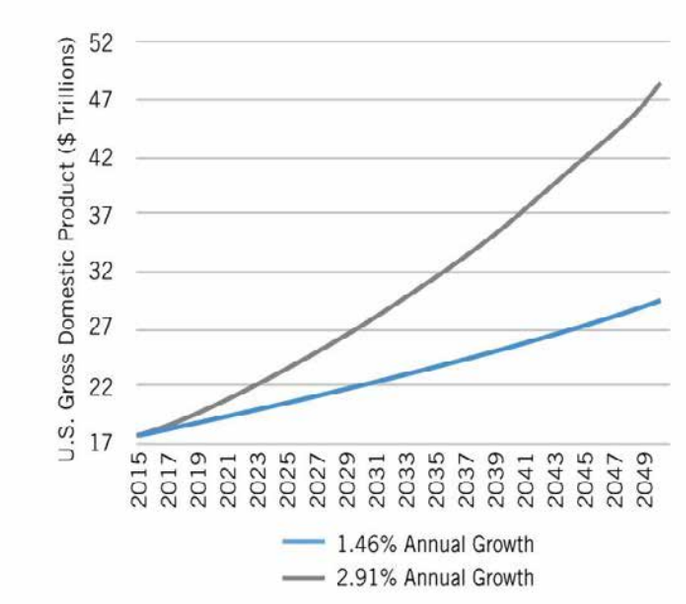
and ecosystems by ensuring laws, rules, regulations, incentives, political attitudes, and worker skills do not act as barriers to the needed changes. Equally importantly, governments should look around the world to see where innovative societal platforms are emerging, and embrace those learnings. Finally, governments at all levels should take those lessons to heart by stepping up the pace of their own automation.[10] Over the course of the 2020s, the effective pursuit of all three agendas will be the best way to help individual nations better cope with increasing societal challenges.

## Why Faster Productivity Growth Is So Important for Europe and the United States

Despite longer work hours and massive societal borrowing, citizens and governments are often under growing human and financial strain—and productivity gains are one of the few proven ways to relieve these pressures. As figure 3 shows, if U.S. productivity over the next 25 years grows at the same rate it did from 1995 to 2004—rather than at the lower rate of recent years—GDP and per-capita incomes would almost triple rather than grow by just 76 percent.[11] This would relieve most of the financial pressures the U.S. federal government—and many state and local administrations as well—is currently facing.

Additionally, such increases would have at least five major benefits for both the EU and the United States: 1) bringing more work back home and assuring more competitive economies; 2) making the ballooning costs of aging populations affordable; 3) boosting wages and living standards; 4) reducing debt-to-GDP levels; and 5) freeing up human capital and other resources for new societal tasks.

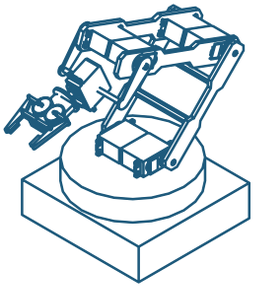
**Figure 3: U.S. economic growth from different productivity rates**



## Automation Will Improve Global Competitiveness and Bring Work Back Home

One major benefit of higher productivity is it helps nations' traded-sector firms compete globally. This is clearly true when productivity in traded-sector industries such as motor vehicles, appliances, and semiconductors increases faster than it does for foreign competitors. But it is also true, though more indirectly, when non-traded firms boost their productivity. This is because traded firms purchase many inputs (e.g., legal services, health care, transportation, etc.) from non-traded firms. When the productivity in these areas goes up, traded-sector firms pay less for their inputs, thereby making them more cost-competitive globally.

Higher productivity can also boost the reshoring of work back to the EU or the United States. Indeed, the coming wave of ICT innovations could give high-wage countries more of a productivity boost than lower-wage nations. Although using emerging technologies will often be less expensive in lower income regions, the relative price of the technology compared with labor costs will still be greater than in higher wage nations. Thus, the payback period in terms of actual labor cost savings will often be shorter in high-wage nations.[12]



This means long-standing centrifugal forces, wherein commoditized production has shifted from rich nations to lower cost ones, could slow—and even reverse—especially as smart manufacturing systems enable shorter and more customizable production runs. In a survey of 238 Citigroup clients, 70 percent believed automation would encourage companies to move their manufacturing closer to home.[13] The current trade tensions between the United States and China, along with increasing societal resistance to pervasive globalization, are, of course, further incentivizing such trends. The result may well be less shipping of goods around the world, which would also have important environmental benefits.

**Higher productivity can boost the reshoring of work back to the EU or the United States.**

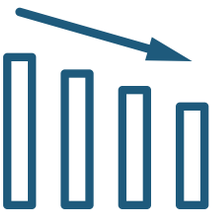
Moreover, reshoring is not just about manufacturing. Automated self-service and AI-backed chatbot-style customer support will increasingly reduce the need for labor-intensive offshore call centers and help desks, as more and more of this work gets automated. Similarly, over the last few decades, many large organizations—and even individual consumers—have become increasingly dependent on India and elsewhere for their IT skills and services. The widespread use of highly automated, self-managing cloud-based services, such as those from Amazon, Microsoft, and others, has the potential to significantly reduce some of these labor and skill dependencies, while improving trade balances.[14]

One thing is for sure, new technologies will create entirely new types of value, as software and data change how products are designed, built, operated, serviced, and improved. Within the technology

community, people increasingly talk about "digital twins," which is the concept that every product component and process has a virtual counterpart. For example, jet engines have traditionally been sold based on their cost and performance (and national origins). Although these factors are, of course, still critical, jet engines today generate huge volumes of operational data airlines are now using to improve fuel economy, load balancing, flight paths, and maintenance scheduling. Just about every major manufacturing sector is evolving in this data-driven way. And while a great deal of work remains, smart manufacturing is expected to provide a significant productivity boost, thereby further reducing the advantages of low-wage nations.[15]

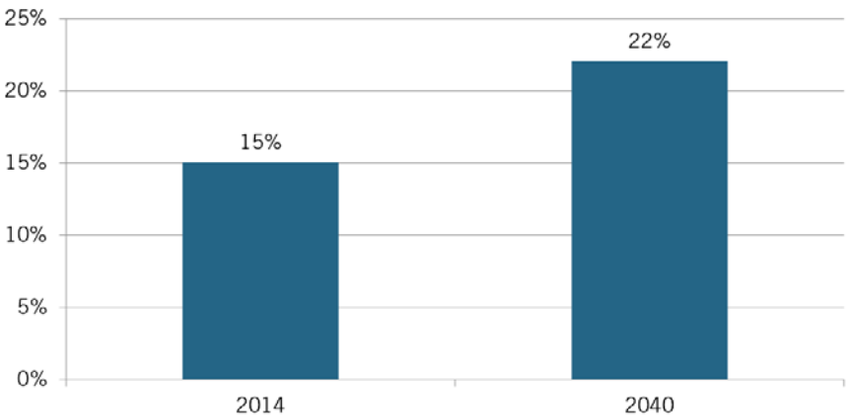
## Populations Are Aging, Sometimes Even Declining

Boosting productivity is critical to the future economic health of both the United States and Europe, in part because both populations are getting older. In the United States, the share of the population above 65 years old will increase from 15 percent in 2014 to 22 percent by 2040 (see figure 4).[16] By 2050, 29 percent of the EU population will be above that age. In Japan, Russia, parts of Eastern Europe, and elsewhere, populations are expected to steadily decline—a situation modern market economies have never really faced. And China is also aging. As is often said, China's challenge is to get rich before it gets old.



**If Europe's current low productivity growth rate of 0.7 percent persists, real output per capita would grow just 15 percent—not enough to cover increased retirement costs, let alone lift stagnant wages.**

**Figure 4: Percentage of U.S. population older than 65**




With more elderly citizens consuming and typically not producing, absent raising the retirement age, unless the remaining workers are much more productive, either their after-tax income will have to fall or retirees' total income will. Citigroup estimated that governments have promised much more to retirees than they will likely be able to pay. For example, the 20 Organization for Economic Cooperation and Development (OECD) nations have committed themselves to pay out $78 trillion in benefits, much of it unfunded.[17]

To see how important productivity is to this challenge, consider that if EU labor productivity were to grow over the next 25 years at its 1980–1995 average of 2.3 percent per year, real output per capita would increase by 73 percent, which is more than enough to pay for the increased retiree population, while at the same time ensuring after-tax worker incomes also continue to rise. However, if Europe's current low productivity growth rate of 0.7 percent persists, real output per capita would grow just 15 percent—not enough to cover increased retirement costs, let alone lift stagnant worker wages.[18]

Beyond these financial pressures, aging populations present new challenges in simply meeting the labor needs of society. In many regions today, businesses are already finding it difficult to hire enough people willing and able to pick crops, clean hotel and hospital rooms, work in stores and restaurants, maintain infrastructure, care for the aging, and similar difficult and often-low-wage work. These shortfalls will only get worse if immigration levels are reduced, which seems likely in many nations. High-tech automation in areas such as precision agriculture and labor-reducing robotics can surely help. For example, Japan expects the large-scale use of robots will be needed to cope with its particularly serious demographic challenges—a confluence of a sharply declining population, some of the world's highest life expectancies, and relatively low immigration levels.

## Living Standards Need to Be Raised

Higher productivity is the sine qua non of increasing living standards. As Paul Krugman famously wrote, "Productivity isn't everything, but in the long run it is almost everything."[19] Although income redistribution can certainly reduce societal inequalities, it is inherently limited by its inability to expand the "pie." For example, in a recent study on the relationship between productivity income inequality and poverty, Mahamat Hamit-Haggar and Malick Souare concluded, "These findings suggest that countries attempting to reach their objectives of eradicating poverty should pursue policies that foster productivity growth; and that productivity growth that is accompanied by progressive distributional change is even better for alleviating poverty."[20]

Without increased productivity, significantly raising living standards in a sustainable way will be impossible. As vice chairman of the Federal Reserve Bank Stanley Fischer stated, "There are few economic issues more important to our economy and others than productivity growth."[21] Remember, GDP divided by population defines "living standards," and the only way to raise per capita GDP is to boost either work hours or productivity.

The ability to increase work hours is limited in that there are only so many potential workers in an economy, and there is a limit to how many hours people can or should work in a year (or years people can or should have to work in their lifetime). And while increased immigration can increase economic growth, it doesn't boost per capita incomes unless it is focused on the highly skilled.[22] This leaves boosting societal productivity as the only sustainable path to increased prosperity. Indeed, the reason the United States enjoys one of the world's highest standards of living is output per person grew eight-

fold in the 20th century.[23] The average U.S. worker today produces in one hour what the equivalent worker a century ago produced in an entire day.

One reason incomes grow as productivity increases is productivity not only lets workers produce more with less, it also lets fewer workers produce the same output as before, thus freeing up people to produce more or different goods and services. For example, in 2010, the U.S. economy would have needed to employ 470,000 more gas station workers had gas station productivity not increased since 1987 through the spread of self-service stations. This productivity growth also meant lower real prices for gasoline—and those lower prices meant increases in real incomes for consumers. Similarly, the United States would have had to employ more than 3 million additional workers in general merchandise stores, and more than 1.1 million more in publishing had productivity in those sectors not grown.[24] We will return to this issue at the conclusion of this paper.

**Although income redistribution can certainly reduce societal inequalities, it is inherently limited by its inability to expand the "pie."**

Thus, productivity is the key to income growth. As Ocampo, Rada, and Taylor wrote, "[Historically], labor productivity increases have been the major contributing factor to growth in real GDP per capita."[25] And Rath and Madheswaran wrote that "labour productivity growth [is] the only route to enhance labour welfare in the long run."[26] All nations—even the wealthiest—need higher productivity. The United States, one of the richest nations, needs higher incomes for most of its households because median household annual income is only $54,000—certainly not enough to support the kind of life most Americans aspire to.

It is also clear that new industries, especially high-productivity technology ones, tend to have higher wages than more traditional sectors because skills and talent are typically more scarce, and the new industries are, almost by definition, focused on higher-productivity uses. The potential of IT in this regard is particularly important because of the way digital technology is now reshaping so many non-IT jobs. Today, not only are cutting-edge technology professionals in short supply, but there is also very strong demand for what we call "double-deep" workers: individuals who not only know their job function—be it marketing, engineering, accounting, human resources, customer service, or operating machinery—but also know how to use modern technologies within that function. Tens of millions of jobs are evolving in this manner, and skilled double-deep workers are demanding significant wage premiums.

Yet, despite this clear evidence of the link between skills, productivity, and income growth, many claim that productivity no longer benefits average workers because the gains flow mainly to

the top (i.e., the "one-percenters"). In fact, careful research shows this framing to be significantly overstated. As economist Stephen Rose has argued, analysis from the Congressional Budget Office (CBO) shows that the bottom 90 percent of U.S. earners in the past few decades did not get the 9 percent of growth Piketty and Saez originally claimed, but rather between 42 and 47 percent of the growth, depending on the definition of "income" and the price deflator used.[27] (Even Piketty and Saez, in newer and largely-unreported-on work, found their initial estimates to be wrong, and that these workers actually saw gains of around 36 percent.)[28]

To be sure, the workers did not see growth proportional to their income share because income inequality clearly grew.[29] But they did make significant gains. In other words, advocates of the view that productivity no longer benefits average American workers are wrong. Working- and middle-class wageworkers have gained—and are likely to continue to gain—from increases in productivity. (The availability of so many useful and entertaining "free" internet services is another highly important benefit to less well-off consumers, as long as they are digitally literate and can afford the devices and connectivity.) Moreover, to the extent policymakers are concerned with the growth of income inequality—as of course they should be—higher productivity makes it easier to pursue redistributive policies such as greater public spending and a more progressive tax code.

Let's be clear: Although the average American would have gained much more had income inequality not increased as much as it did, they would have gotten even less had productivity stalled completely. All the evidence suggests sustainable median real-wage increases are simply not possible unless productivity grows as well.

## Productivity Growth Makes Budget Deficits and National Debts More Manageable

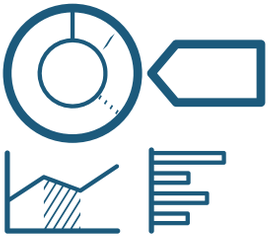
Higher productivity from automation will be critical to stabilizing government finances. In the United States, CBO estimates the annual federal budget deficit will increase to $1.38 trillion, and the national debt to $29.3 trillion, by 2029. CBO estimates the debt-to-GDP ratio will increase from less than 40 percent in the first half of the 2000s to at least 95 percent by 2029.[30] Across Europe, national debt levels vary widely, but levels similar to that of the United States exist across many of the Southern European countries; and even in the north, debt pressures are widespread, not even counting "quantitative easing"—debt's more modern reincarnation. High consumer debts are also a source of stress, constraints, and potential instability.

Eventually, the debt-to-GDP ratio will have to stabilize, and there are only a limited number of options for how this will play out. Governments could default on all or part of their debts, thereby creating significant economic turmoil. They could also raise taxes or cut spending, but raising taxes can hurt growth and competitiveness, while cutting spending, especially entitlements, can impose real hardships on people. Moreover, there is little evidence American or European voters, and hence their elected officials, want to do any of these things. Perhaps it's not surprising many now suggest governments simply print more money to pay off debts. However,

this would reduce real incomes, and could easily lead to unchecked spending increases.

This leaves growth. GDP can grow in two ways: more hours worked or higher productivity. We could increase the hours worked by liberalizing immigration or raising the retirement age. Both would raise GDP, but would do less to raise per capita GDP than would working to directly boost productivity.[31] In contrast, boosting productivity leads to higher GDP and increases in per capita incomes—and thus higher living standards—without asking people to work more than they already do.

In recent years, many have attacked the viability of the idea of pursuing more and more economic growth, arguing that it is incompatible with environmental sustainability. We disagree. Most of the innovations we envision—smart products and grids, cloud-based self-service operations, precision farming, and a general increase in optimization through machine intelligence—will have improved energy efficiency and sustainability built in. Indeed, meeting today's energy and environmental challenges will be much more difficult without the automation and transformations this paper has described—if for no other reason than they will make it more politically feasible for voters to accept the higher costs inherent to non-fossil-fuel energy. As we explain in the conclusion to this paper, the upsides of growth still far outweigh the downside alternatives.



For example, if the U.S. economy could sustain 3.4 percent productivity growth per year (a rate enjoyed for much of the 1960s), GDP would increase to $40 trillion by 2039. This added growth would generate an additional $2.4 trillion per year in federal tax revenues in 2039 from increased worker incomes, business profits, and other forms of national income.[32] It would also reduce the projected deficit from $2.6 trillion to $235 billion, and the projected debt-to-GDP ratio from 170 percent to 65 percent.[33]

Although these figures might seem unrealistic given the economic performance of the United States and the EU in recent years, when viewed in the context of this paper, there is a clear two-pronged path forward. First, the industries of today must become much more automated and intelligent—and thereby more efficient—in order to increase their productivity while simultaneously creating many important forms of new value. Powerful new societal platforms need to play a lead role in these developments.

While these enterprise and industry transformations will be essential, they are only half the story. As the need for labor in today's industries necessarily shrinks, major new forms of work, as well as entirely new occupations, must emerge to fill the gap. This new economic activity is needed—as it always has been—to generate high levels of future employment and rising GDPs. Although many have questioned whether major new industries will really emerge, this pessimism seems largely unwarranted. As discussed in this paper's concluding section, there is a great deal of work that needs to be done.

## We Need to Free Up Human Capacity to Address New Societal Challenges

The economic center of gravity of modern nations has clearly changed greatly over time—first from local agriculture to industrialized manufacturing, and then from manufacturing to services. Each of these phases has led to massive shifts in employment and the very nature of work—and has also featured often-painful transitions, recessions, and even depressions, as well as many claims that the loss of small farms or the closing of factories would never be offset by new opportunities. Yet, looking back, despite many ups and downs, overall employment levels and living standards have risen dramatically.

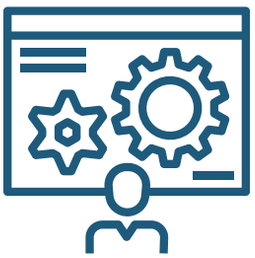
Given the societal progress we have seen, why are people so anxious about today's changes? Partly, it's the often-severe local impacts of globalization (and the distrust of "elites" this has caused); partly it's today's huge inequality and frustratingly slow wage growth; partly it's the relative ineffectiveness of many worker transition programs; and partly it's just the familiar fear of the unknown. The farmers of the late 19th century could not be expected to envision a world full of cars, planes, televisions, and air conditioners—just as the factory owners of the 1920s had no way of knowing someday there would be vast suburban shopping malls and organic juice bars, let alone this thing called the "Internet" and millions of "IT professionals." It's obviously much easier to point to actual job losses than imagine long-term employment expansion.

The Information Age clearly qualifies as another major economic shift. The ability of data and software to enhance human decision-making is analogous to the way machinery has greatly magnified physical human strength. Indeed, those who proclaim AI will destroy more jobs than it creates use this very same analogy. They argue that just as machines reduced the need for physical human work, and now computers are reducing the need for human brainpower, there will soon be no place left for humans to hide. So, this time they will surely be proven right?

Many people in the technology community refute this argument by pointing out that AI today is only effective in very narrow realms, and more-generalized machine intelligence will remain elusive for the foreseeable future.[34] They also note that in virtually every AI field—from playing chess to automating warehouses to performing surgery—the combination of humans and machines ("cobotics") outperforms machines alone. But, although all of these points are entirely true and well intentioned, it is a somewhat awkward argument for technologists to rely on in that it essentially minimizes the impact of AI, even as many of these same technologists spend their careers trying to maximize it.

## Why We Won't "Run Out of Work"

Rather than rely on the limitations of AI, which we believe are real, we reject the job-loss hypothesis on more fundamental, and—we think—firmer grounds. To say we will run out of jobs is the same as saying we will run out of needs only humans can meet. How likely is this? Consider the 10 societal challenges listed below:



1. **Transforming energy.** The shift away from fossil fuels to more renewable sources and the need to improve economies' overall energy efficiency will be one of the defining economic challenges of our time. Massive new infrastructures will need to be built, and older ones taken down.
2. **Transforming transportation.** We are in the early years of the shift to electric cars and, probably someday, electric planes and ships—and all of their supporting services and infrastructures. We will essentially reengineer the transportation systems on which the 20th-century economy was built.
3. **Transforming agriculture.** For health, environmental, national self-sufficiency, and other reasons, the way much of our food is grown must change—with precision agriculture; indoor, vertical, and saline farming; ocean aquaculture; and synthetic foods all showing great promise.
4. **Repairing the environment.** The damage to our air, soil, rivers, lakes, and oceans—and the natural systems they support—has been extensive, and will take many years to restore. Future sustainability is now highly dependent on the previously mentioned energy, transportation, and agricultural transformations.
5. **Coping with climate change.** If sea levels rise as much as many predict, the need to strengthen shore defenses, raise buildings, and even physically relocate large numbers of people will be among the most challenging engineering—and political—projects ever. Greater critical infrastructure resiliency is also needed to better cope with the expected increase in natural disasters
6. **Expanding health care coverage and quality.** Most of the world still lacks access to modern medical care—or even clean water. Billions of people almost never see a doctor. Diseases such as malaria continue to prove remarkably resistant to treatment.
7. **Caring for the elderly**. As people continue to live longer, and given aging and even declining populations, we will need to use technology to help people throughout their later years. However, there will still be a growing need for human caregivers.
8. **Revitalizing education and lifelong learning.** The quality of K-12 education needs to become much more consistent across society, and many important skills remain scarce. University costs are way too high for many families. Most experts expect an increasing need for lifelong learning.

9. **Improving the quality of social services.** With a range of social challenges, including crime, drug addiction, child and spousal abuse, mental health, and many others, society will need to devote significantly more resources, especially to the prevention of these and other problems. Additionally, more families should be able to afford taking more time off to care for their newborn children.

10. **Maintaining all of the above.** The more complex our energy, transportation, water, electrical, telecommunications, financial, computer, educational, social service, and other systems become, the greater the need for highly skilled maintenance, repairs, and improvements. Many nations are already finding it difficult to keep up with these ever-expanding obligations.

We could easily go on. And this list doesn't even include the need to raise living standards for billions of people, as well as support our ever-changing recreational, entertainment, personal-growth, and cultural interests. But even more than the massive number of workers that will be needed for these tasks, what strikes us most about these 10 areas is the nature of the work required, the vast majority of which will take place in the physical world at the actual points of service—be it rebuilding infrastructure or providing care for the elderly. More pointedly, how many of these tasks can be performed by robots and AI largely on their own? None that we can see. Conversely, how many can be aggressively pursued—and funded—without higher levels of societal productivity and automation? Very few, if any.

**To meet pressing 21st-century challenges, massive numbers of people will need to be re-skilled, redeployed, and fully engaged—which is why we are nowhere near "running out of work."**

When we combine this thinking with our earlier discussion about automating many traditional white-collar office tasks, we begin to see how the nature of employment will likely change during the Information Age. More and more work will take place either in the cloud (virtually) or directly at the point of service (physically). This means we shouldn't assume office workers will simply take on higher-value tasks, as today's routine tasks are already automated. Of course, many people will move up the value chain, but one of the main benefits—and transition challenges—of automation is it frees up human capacity so that it can be redeployed to new tasks such as those mentioned. Indeed, while people often speculate about "peak oil," we may be close to reaching "peak office." The relative emptiness of many corporate offices (as more people work from home and in the field), the struggles of once-high-flying office-space start-ups such as WeWork, and the growing interest in "vertical farming" (in older office buildings and factories) are also signs of a potential peak-office scenario.

Additionally, the 10 challenges do not include the new industries of the future. Although difficult to predict specifically, they will almost certainly be impressive in technology-driven areas such as new materials, biotechnology, customized 3D printing, printed electronics, personalized medicine, human augmentation, and many other areas. Equally important will be the entirely new skills and data-driven service opportunities that will come with these innovations and platforms. We are only in the very early stages of understanding just how much value new forms of information can unlock. Consider our Spotify and digital-twin discussions.

More fundamentally, the bigger and more complex economies become, the more future needs they generate. This relentless and ever-expanding generative capacity is the most fundamental reason fears of job loss have always been wrong in the past—and seem destined to be wrong once again. Perhaps someday super-smart human-like robots that can do literally everything people can do, while also meeting every unfilled human need, will emerge, but such speculation remains deep in the realms of science fiction. For the foreseeable future, if society is to meet these pressing 21st-century challenges, massive numbers of people will need to be re-skilled, redeployed, and fully engaged. This is why we are nowhere near "running out of work."

## Summary and Conclusion

As we try to conceptualize the overall economic impact of this new era of increasingly intelligent automation, we believe—and hope—the pattern will look something like the summary table below.

**Figure 5: Changing economic centers of gravity: 1950–2040**

| | 1950 - 1980<br>Mass Manufacturing | 1980 - 2010<br>A Services Economy | 2010 - 2040<br>The Information Age |
|---|---|---|---|
| **Innovation Focus** | Physical Products | Consumer & Professional Services | Automated Platforms |
| **Primary workplaces** | Factories, Natural Resource Extraction | Offices, Stores, Malls | Points-of-Service, Cloud |
| **Key Employees** | Blue Collar, Managerial | White Collar, Knowledge | Double-Deep, Technologists |
| **Lead industries** | Vehicles, Fossil Fuels, Housing, Appliances | Health, Finance, Retail, Internet Entertainment, Government, Non-profit | Smart Grids/Energy/ Agriculture, Health, Environment, New Sectors |

Although the figure is obviously oversimplified, we think the forecasted patterns are likely to hold true. More and more traditional work will be automated through enterprise, industry, and societal platforms; an increasing share of economic activity will take place either in the cloud or directly at the physical point of service; and the most in-demand workers will not just be software engineers, data scientists, or other digital technology specialists, they will also include tens of millions of skilled, double-deep employees. Finally, technology will not just transform existing industries, it will enable and create entirely new ones.

**To advance prosperity and people's potential, the Information Age should be embraced, not feared.**

Perhaps most importantly, at a time of considerable global uncertainty and potentially significant ruptures, these automation and productivity opportunities are mostly domestic in nature, meaning developed nations control much of their future in these areas. To advance human prosperity and potential, the Information Age should be embraced, not feared. This requires governments to adopt best practices from around the world, and actively encourage and engage in large-scale transformations. Public policy must also seek to ensure that citizens have the skills, education, and support they need to thrive in this exciting but challenging new era. Both ITIF and the Leading Edge Forum look forward to researching all of these matters further in order to advance the societal productivity agenda of the 2020s and beyond.[35]

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