THINK LIKE AN ENTERPRISE: WHY NATIONS NEED COMPREHENSIVE PRODUCTIVITY STRATEGIES

Robert D. Atkinson

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BY ROBERT D. ATKINSON | MAY 2016

ABSTRACT

Increased living standards depend on increased productivity. But productivity growth will lag unless governments implement smart productivity policies. To be effective, these policies need to go beyond the conventional solutions grounded in neoclassical economics and embrace four other key components: incentives, including tax policies, to encourage organizations to adopt new *tools* to drive productivity; policies to spur the advance and take-up of systemic, *platform* technologies that accelerate productivity across industries; a research and development strategy focused on spurring the development of productivity-enabling technologies such as robotics; and sectoral productivity policies that reflect the unique differences between industries.

Finally, for nations to put sophisticated productivity policies in place, the single most important step is to establish productivity as the principal economic policy goal, ahead of other factors such as stable prices or low unemployment. Part I of this report provides an overview of productivity, including what it is, why nations need to accelerate it, and how it grows through shifts in enterprises and technology. It then examines the current debates about whether productivity kills jobs (it does not) and whether it still benefits workers as it has in the past (it does). The report then reviews productivity performance in nations and analyzes the debate about the future of productivity—ranging from stagnation to exponential acceleration. Part II provides a framework for thinking about national productivity policies. Finally, Part III lays out a comprehensive agenda for spurring productivity growth, which most nations can use as a guide in tailoring their own national productivity policy agendas.

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INTRODUCTION

Paul Krugman famously wrote, "Productivity isn't everything, but in the long run it is almost everything."[1] He is right: Increased living standards depend on increased productivity. But what can policymakers do to raise productivity? Most economists would start their answers by tamping down expectations, arguing that government can do little, other than perhaps to get out of the way. This is why Krugman went on to conclude, "So what are we going to do about productivity growth? Nothing."[2] Others offer only vague palliatives like spurring competition, increasing public spending on education and science, and improving macroeconomic policy. But policymakers desiring higher productivity would be well advised to look beyond such advice from purveyors of the "dismal science," because conventional economics is of little help in understanding the sources of productivity growth, much less in providing useful or actionable advice on productivity policy.

Without a sophisticated understanding of and practice of productivity policy, nations' productivity performance will lag their productivity potential.

Fortunately, other schools of economic thought, particularly *innovation economics*, and other disciplines, such as business administration, have discovered a myriad of ways in which public policies can drive productivity growth. Moreover, this work shows that a nation's productivity growth will in fact lag unless governments implement smart and comprehensive productivity policies. These policies include the traditional advice of simply getting market conditions right and providing factor inputs to firms, such as a skilled workforce. But they also go beyond the conventional solutions, which are grounded in a neoclassical economics framework that imposes a straitjacket on policymakers. The conventional theory holds that the only thing government can do is to remove barriers and to fix policy failures so that firms reacting to price signals can do whatever they may choose to drive productivity.

This overly passive framework ignores the complexity and enterprise-like nature of economies, which actually require more strategic productivity policies. Because they do, any effective productivity policy needs to go beyond the standard limits to embrace four other key components:

1. Incentives, including tax policies, to encourage organizations to adopt new tools to drive productivity. The array of market failures is considerable when it comes to firms developing and adopting better tools to drive productivity. In particular, governments should use the tax code to provide incentives for the acquisition of new capital equipment.

2. Policies to spur the advance and take-up of systemic, platform technologies that accelerate productivity across industries. Many of the information technologies central to driving productivity have chicken-or-egg network effects, which mean that adoption will lag unless governments adopt technology-specific policies.

3. A research and development (R&D) strategy focused on spurring the development of productivity-enabling technologies such as robotics. The most important factor driving future productivity will be the development of better tools, including machines and materials. Governments need to focus a much larger share of their R&D budgets on advancing technologies that will reduce the need for labor.

4. Sectoral productivity policies that reflect the unique differences between industries. In terms of productivity and productivity policy, industries differ in significant ways. Generic market condition or factor supply policies do not reflect these key differences. Any effective national productivity policy will need to have to be grounded in sector-based productivity strategies.

Finally, for nations to put sophisticated productivity policies in place, the single most important step is to establish productivity as the principal economic policy goal, ahead of other factors such as stable prices or low employment. After that, nations need to establish the institutional capacity to conduct sophisticated productivity analysis, including sectoral analysis. Only after such analysis will nations be positioned to identify the right policies for productivity growth. Without a sophisticated understanding and approach to productivity policy, nations' productivity performance will lag behind their potential.

For nations to put in place sophisticated productivity policies, the single most important step is to establish productivity as the principal economic policy goal, ahead of other factors such as stable prices or low employment.

It is impossible to estimate the potential productivity gains that nations can achieve by putting in place sophisticated and comprehensive productivity policies as described in this report, but it is entirely reasonable to believe that the gains could be significant. In fact, if the United States and other developed nations were to adopt these policies, it is quite possible they could raise their annual labor productivity growth rates by 1 percentage point or more.[3] The gains for less-developed nations, which are further from their production-possibility frontiers, are likely to be at least double that.

Part I of this report provides an overview of productivity, including what it is, why nations need to accelerate it, and how it grows through shifts in enterprises and technology. The report then examines the current debates about whether productivity kills jobs (it does not) and whether it still benefits workers as it has in the past (it does). Getting this debate is critical because a growing, if not already prevalent, meme holds that robots are about to replace workers on an unprecedented scale. Not only is this view utterly wrong, it is also dangerous, for if people believe it then policymakers are much less likely to want to put the productivity policy "pedal to the metal."

The report then reviews productivity performance in the United States and other developed and developing nations. It analyzes the debate about the future of productivity—ranging from stagnation to exponential acceleration—and concludes that if nations adopt productivity policies, the best they can hope for is a revival of the strong productivity growth rates many enjoyed in the 1950s and 1960s.

Part II provides a framework for thinking about national productivity policies, including how the prevailing neoclassical and neo-Keynesian economic doctrines provide a poor guide to productivity policy and why market forces alone will not maximize productivity.

Public goods, externalities and other enterprise failures, and system interdependencies for development and adoption of productivity-enhancing tools all prevent markets from maximizing productivity on their own.

Finally, Part III lays out a comprehensive agenda for spurring productivity growth, which most nations can use as a guide in tailoring their national productivity policy agendas. This agenda includes policy recommendations related to market framework conditions, factor inputs, organization incentives, productivity-focused R&D investments, systemic chicken-or-egg issues, industry-specific sectoral policies, and the ways in which governments need to organize themselves to advance effective productivity policies.

PART I: OVERVIEW OF PRODUCTIVITY

This section provides an overview of productivity, defining it and explaining why nations benefit when they raise it.

What Is Productivity?

To understand productivity, it is worth explaining what it is not. Productivity is not a measure of how much an economy is producing. In other words, total output (gross domestic product, or GDP) 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 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 of productivity). The former is the easiest to understand: If a barber previously cut 10 people's hair in eight hours, but now cuts 12 people's hair in the same amount of time because of better technology (e.g., more efficient clippers), then she has increased her productivity by 20 percent.

Despite the simplicity of the concept, many people use the term incorrectly. Some argue that moving jobs to low-wage nations raises productivity because it lowers prices. But lower prices are not the definition of higher productivity. In fact, moving jobs to low-wage nations likely reduces productivity, because firms in those places typically use fewer machines than firms in high-wage nations and are less efficiently organized. Others believe that working longer drives productivity. But though more inputs might produce more outputs, they do not change the ratio that defines productivity.

Productivity can increase in a number of ways. One is for workers to work harder and faster. But this comes at the cost of worker satisfaction and in some cases safety, so gains are offset by losses. A better way to raise productivity is to help workers work more efficiently by reorganizing work processes and providing better tools, or by using better technology or business models to completely eliminate the need for some work. (For example, automatic elevators obviated the need for elevator operators.)

Productivity is often confused with innovation and competitiveness.[4] As noted, productivity is the ratio of output to input. But innovation means developing an improved product (a good or service), production process, marketing method, or organizational method. The distinction between product and process innovation is important because

product innovation usually affects the output side of productivity whereas process innovation affects the input side. Despite what some say, competitiveness is a more complicated concept. It relates to the economic health of a region's or nation's traded sectors, the output of which can be purchased by consumers outside the region or nation.[5]

To be sure, the three factors are related. For example, more innovation can support productivity and competitiveness. Likewise, productivity can make economies more competitive. But each of the three is distinct in important ways. For example, rising productivity in a country's nontraded sectors would do little to improve the competitiveness of its traded sectors. In most nations, policymakers prioritize competitiveness first, innovation second, and productivity last, if at all. But as described below, for most economies, especially large and mid-sized ones, productivity is the most important driver of economic well-being. This is not only because the majority of jobs in most economies are in nontraded sectors where the benefits of productivity gains go directly to workers and domestic consumers, but most productivity gains come not from particular globally traded industries getting larger, but by all industries boosting productivity. This is true because the lowest-productivity industries in most economies are large, nontraded sectors such as health care and retail. Even within the manufacturing sector, historically a strong contributor to productivity growth, less-traded industries such as food manufacturing are productivity laggards.

Without increased productivity, it will be impossible to raise living standards in a sustainable way.

Last are two related measures of productivity: labor productivity and total factor productivity. Labor productivity is as it sounds: the output of workers divided by the number of hours of work. Total factor productivity is broader and is a measure of the productivity of all factors of production, including workers, energy, and machines. 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 its cost.

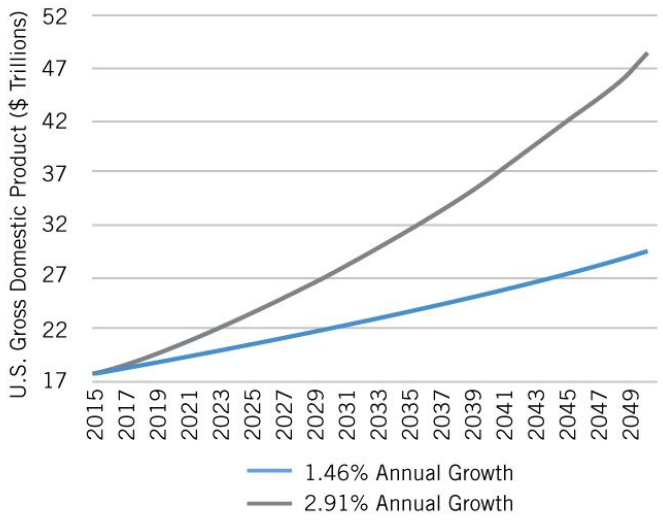
Why Nations Need Productivity Growth

Why should governments make productivity growth their principal economic policy goal? The simple answer is that without increased productivity, raising living standards in a sustainable way will be impossible. As Vice Chairman of the Federal Reserve Bank Stanley Fischer states, "There are few economic issues more important to our economy and others than productivity growth."[6] Remember that GDP divided by population is the definition of living standards, and that the only way to raise per-capita GDP is to either boost work hours or to boost productivity. The ability to boost 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 work in a year, or years people can or should have to work in their lifetimes. And increased immigration cannot boost per-capita incomes. This leaves boosting productivity—increasing the combined efficiency of all assets—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 because output per person grew eight-fold in the 20th century.[7] The average U.S. worker today produces in one hour what the average worker a century ago produced in an entire day.

One reason incomes grow as productivity increases is that productivity not only lets workers produce more with less, it also lets fewer workers produce the same output as before, thus freeing up others 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 if gas station productivity had not increased since 1987 through the spread of self-service stations. Similarly, it would have had to employ more than 3 million more workers in general merchandise stores, and more than 1.1 million more in publishing.[8] This productivity growth meant lower real prices for gasoline than had productivity not grown, and those lower prices meant increases in real consumption and incomes for gas consumers.

Thus, productivity is the key to income growth. As Ocampo, Rada, and Taylor write, "historically, labor productivity increases have been the major contributing factor to growth in real GDP per capita."[9] Rath and Madheswaran write that "labour productivity growth [is] the only route to enhance labour welfare in the long run."[10] 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 enjoy the kind of life most Americans aspire to. If U.S. productivity grows over the next 25 years at the rate it grew from 1995 to 2004, rather than at the previous lower rate, U.S. GDP (and per-capita incomes) would almost triple, increasing by 180 percent, rather than growing by just 76 percent (see figure 1).[11] In other words, at that faster rate, by 2060, the average American would produce more in 30 minutes than their great-great-grandfathers did in a full day in 1900.

Figure 1: U.S. Economic Growth from Different Productivity Rates



The need for higher productivity is obviously much more acute in developing economies, where the average per-capita income is just $6,000 per year. Even China, which has experienced robust growth for the last two decades, enjoys a meager per-capita income of just $7,600.[12] Much faster productivity is the path to enable billions of people to enjoy materially better lives.

Productivity growth is also vital to eradicating poverty, particularly in developing nations. In a study of the Indian economy from 1983 to 2003, Ahsan and his colleagues find that "increases in long-term labor productivity are positively correlated with a decrease in poverty."[13] As they write, "neither the employment intensity of growth nor the employment rate across (Indian) states is found to be significant in reducing poverty. Rather, it is the growth in labor productivity that has the largest impact."[14] Also, as discussed, the commonly accepted view that productivity growth has not benefited lower-income workers in America is not true.

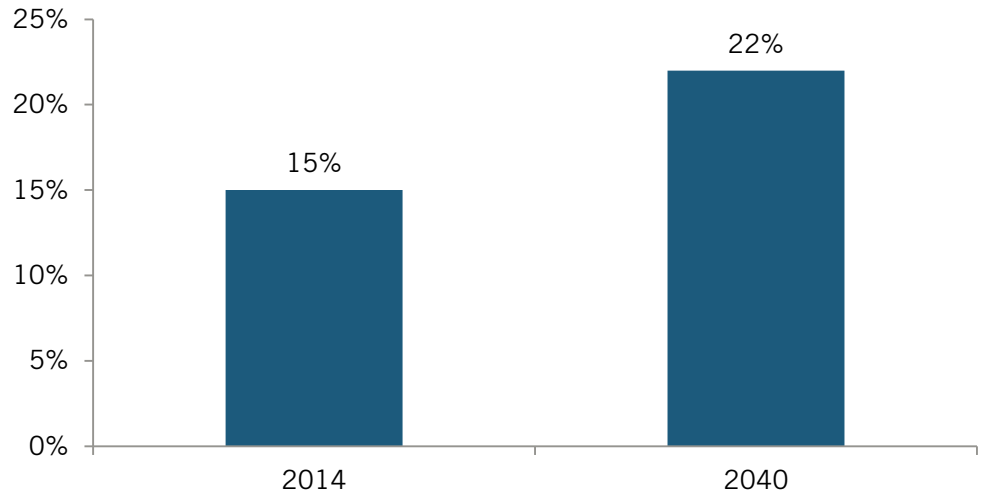
Something that does not get as much attention as it should is the role of productivity in improving job quality. In the United States, more than half of all workers (52 percent) report being unhappy at work and only 24 percent of those making under $15,000 say they are satisfied.[15] According to Gallup, only 13 percent of workers worldwide actually enjoy going to work.[16] Among the most important contributors to worker satisfaction were meaningfulness of the job, opportunity to use skills, and the work itself.[17] Worker satisfaction will increase if productivity advances eliminate jobs that are inherently less safe or meaningful. Although it is only one data point, it is revealing that so many people who try out for the U.S. TV show *The Voice* (a show that lets people compete to see who has the best singing voice and win a recording contract) are working in low-wage, not particularly rewarding jobs. For them, a career as a singer represents the culmination of all their dreams. Many if not most people, even in rich nations such as the United States, work at jobs because they have to, not because they want to. Higher productivity will let more workers work at jobs they truly want to do and help get rid of jobs they do not want to do.

The average U.S. worker today produces in one hour what the average worker a century ago produced in an entire day.

Many nations need to focus on productivity growth for another reason. In many of them, the ratio of workers to dependents will fall as more people reach retirement age. In the United States, for example, the share of the population above 65 will increase from 15 percent to 22 percent by 2040 (see figure 2).[18] Citigroup estimates that governments have promised much more than they will likely be able to pay retirees, 20 Organization for Economic Cooperation and Development (OECD) nations having committed themselves to pay out $78 trillion in benefits, much of it unfunded.[19] This means that unless the remaining workers are much more productive, either their after-tax income will fall or retirees' total income will. Moreover, as the McKinsey Global Institute makes clear, projected growth in global labor markets is expected to slow; for GDP to continue to grow at robust rates, then, productivity growth will have to become a much larger component of growth.[20]

Higher productivity plays a key role in increasing governments' fiscal health. Higher productivity leads to higher incomes, which in turn lead to higher tax payments from companies and individuals. Moreover, higher productivity leads to reduced expenditures (on items such as income support for low-income individuals). This is why increasing the real rate of U.S. GDP growth over the next decade from 2.8 percent per year to 4 percent—the country's annual growth rate from 1993 to 2000—would, all else being equal, cut the cumulative budget deficit in half, $6.8 trillion, in the same period. Every tenth of a percentage point increase in productivity adds $50 billion to federal budget 10 years later.

Figure 2: Percentage of U.S. Population Older Than 65



Finally, higher productivity helps a nation's traded-sector firms compete globally. This is clearly true if productivity in traded-sector industries like motor vehicles or semiconductors increases faster than it does for their foreign competitors. It is also true, though to a lesser extent, if nontraded firms boost productivity. This is because traded firms purchase inputs from nontraded firms (e.g., legal services, janitorial services, logistics, etc.). If these firms' productivity goes up, then traded-sector firms pay less for inputs, making them more cost-competitive globally. In short, productivity growth is the single most important economic policy objective.

With the increased income from productivity growth, people will be able to afford a host of individual and collective benefits. Individually, they could afford better housing, improved health care, more education, and many other benefits. Collectively, higher productivity enables societies to invest more in solving pressing challenges, such as global warming, rebuilding and expanding infrastructure, and providing more resources for social services.

Why Productivity Does Not Kill Jobs

Although productivity growth is the main driver of increases in living standards, a growing chorus of voices in the wake of the Great Recession asserts that societies can no longer afford productivity because it kills jobs. The new narrative is that productivity driven by increasingly powerful IT-enabled "machines" is the cause of slow job growth, and that accelerating technological change will only make things worse. Many policymakers now believe that they cannot afford to support policies that boost productivity because productivity gains come at the expense of needed job growth. If productivity advances come with employment retreat, then policymakers would be well within their rights to be concerned about supporting policies to advance productivity. Fortunately, they need not worry because there is no trade-off.

Yet the large and growing chorus of "tech kills jobs" voices persists. Lawrence Summers recently said that he no longer believed automation would always create new jobs. "This isn't some hypothetical future possibility," he said, "This is something that's emerging

before us right now."[21] Financial pundit Nouriel Roubini asks forebodingly, "Rise of the Machines: Downfall of the Economy?" Joseph Stiglitz states, "It doesn't have political appeal to say the reason we have a problem [job losses] is we're so successful in technology."[22] Paul Krugman writes, "A much darker picture of the effects of technology on labor is emerging. In this picture, highly educated workers are as likely as less educated workers to find themselves displaced."[23] Moshe Vardi, a professor at Rice University, predicts that with the development of artificial intelligence that global unemployment will reach 50 percent.[24] Mike Rettig of the Brookings Institution asks with mirth, "Will the last human worker please turn out the lights?"[25] In the *New Yorker,* Gary Marcus writes, "as machines continue to get smarter, cheaper, and more effective, our options dwindle. So don't bother polishing up that resume, rather here's a link to the unemployment office."[26] Robert Reich argues that robots will "take away good jobs that are already dwindling. They will in short supplant the middle class."[27] Even President Obama alluded to the dark side of technology when he said that consumers contribute to the problem of joblessness every time they go to an ATM rather than a live bank teller or check in for a flight using an electronic kiosk.[28]

If productivity advance comes with employment retreat, then policymakers would be well within their rights to be concerned about supporting policies to advance productivity. But they need not worry, for there is no trade-off.

Perhaps no one has done more to advance the idea that productivity kills jobs than MIT professors Erik Brynjolfsson and Andrew McAfee. In their popular book, *The Race Against the Machine: How the Digital Revolution Is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*, they write that workers are "losing the race against the machine, a fact reflected in today's employment statistics." Appearing on the TV show *60 Minutes*, giving TED talks, writing articles, and being quoted extensively, they claim that productivity will lead to mass joblessness and that even most of the remaining workers still employed will be worse off than before. The claim has become widely accepted. They even go so far as to argue we are headed toward a future in which a massive lumpen-proletariat will have to be on the government dole, a lucky few may be spared to work for table scraps, and an elite class of "robot" owners will get all the cake.

To start with, all these statements are odd, because if technology-led productivity growth really has been the culprit behind America's anemic job growth since 2009, one would expect that America's productivity growth rate would be higher than normal. In fact, U.S. productivity growth since the end of the Great Recession has been at historic lows—about half the rate than previously, in fact—and, as discussed later, this low rate does not appear to be a result of mismeasurement. If anything, estimates of U.S. productivity growth have recently been overstated. What the pundits are attributing to anemic productivity growth has its roots in the painful and slow recovery from the greatest financial crisis since the Great Depression. If U.S. employment had grown from 2008 to 2015 at the same rates it did in the mid-2000s, 1.9 million more jobs would be available in the economy today.

However, such flare-ups of techno-pessimism are not new. Throughout American history, whenever unemployment rates have risen, machines have been blamed. In the wake of the recession ending in 1897, Congress called on the Bureau of Labor Statistics (BLS) to conduct a study of more than 60 industries, titled "Hand and Machine Labor," in which technology had replaced labor.[29] As America struggled to break free from the Great

Depression in the late 1930s, Congress debated legislation to require the secretary of labor to create a list of all labor-saving devices and estimate how many people could be employed if these devices were eliminated. Similarly, after the recession of 1953 and 1954, the Congressional Joint Economic Committee held extended hearings on automation and jobs. And, in the midst of the 1961 recession, President John F. Kennedy created an Office of Automation and Manpower in the Department of Labor on the theory that "the major domestic challenge of the Sixties" was "to maintain full employment at a time when automation, of course, is replacing men." In all these cases, employment growth rebounded quite nicely once the recessions ended. As it did, concern about technology killing jobs abated, at least for the time being.

Today's pessimistic views that productivity kills jobs suffer not only from a lack of historical perspective, but also from a fundamental flaw in logic. That flaw is not that people who lose their jobs will get jobs making the new machines. No rational organization spends money to increase productivity unless the savings are greater than the costs. If the number of jobs in the company making the machines is the same as are lost in the companies using the machines, then costs could not have fallen.

Today's pessimistic views that productivity kills jobs not only suffer from a lack of historical perspective, they suffer from a fundamental flaw in logic.

So it is not that jobs will be created in the new robot firms, but that they will be created across the economy from the new demand that higher productivity enables. To see how, we need to look at second-order effects, something techno-pessimists do not do. If jobs in one firm or industry are reduced or eliminated through higher productivity, then by definition production costs go down. These savings are not put under the proverbial mattress, they are recycled into the economy, in most cases though lower prices or higher wages. This money is then spent, which creates jobs in whatever industries supply the goods and services that people spend their increased savings or earnings on. As a side note, the same logic is true for profits as well. Even if all the savings went to profits, these are distributed to shareholders who in turn spend at least some of this money, creating demand that is met by new jobs. Even if the shareholders do not spend all of it, the savings reduce interest rates, which leads to new capitalized spending (e.g., car loans and mortgages) and investment, which in turn creates jobs in the firms producing this additional output. Moreover, because of competitive pressures in industries, firms do not have unlimited pricing power. If they did, they could just raise prices now. Competitive markets force firms to pass savings along in the form of lower prices (or higher wages).

Some will argue that people will not spend the money from lower prices or higher wages, and therefore jobs will not be created. But most Americans would have little problem finding ways to spend their added income if their take-home pay increased from a doubling or even tripling of productivity. In fact, the first thing most would likely do is break out their shopping lists. To see where the new jobs from higher productivity would likely be created, we only have to look at how those in the top-income quintile—versus those in the middle—spend their money. According to the Bureau of Labor Statistics, top-income households spend a larger share of their income on things like education, personal services, hotels and other lodging, entertainment, insurance, air travel, new cars and trucks, furniture, and major appliances. So, if U.S. productivity doubles, people would spend more than double on these kinds of goods and services, and employment would grow in these

industries. Even if productivity were miraculously to increase by a factor of five or even ten, then the vast majority of U.S. households would likely have no problem spending all their added income (either as personal consumption or through higher taxes for public goods, such as a cleaner environment, better cities, or more infrastructure). This is even more true in developing nations where median per-capita income is just $6,000. Productivity in these nations could increase by a factor of 50 and still come nowhere near exhausting people's desires for goods and services.

As a recent Deloitte study notes, technological innovation creates jobs in four ways.[30] First, in some sectors where demand is responsive to price changes, automation reduces prices but also spurs more demands, leading to at least compensating job creation. For example, as TV prices have fallen and quality increased, people have bought many more TVs. Second, jobs are created making the automation equipment. Workers are employed in factories making robots. Third, in some industries technology complements workers, making output more valuable, leading to increased demand. For example, as doctors have gained better technology, the demand for health care has increased. Finally, as discussed, reduced prices from automation increases consumer purchasing power, which in turn creates jobs at the industries they spend their new additional income on.

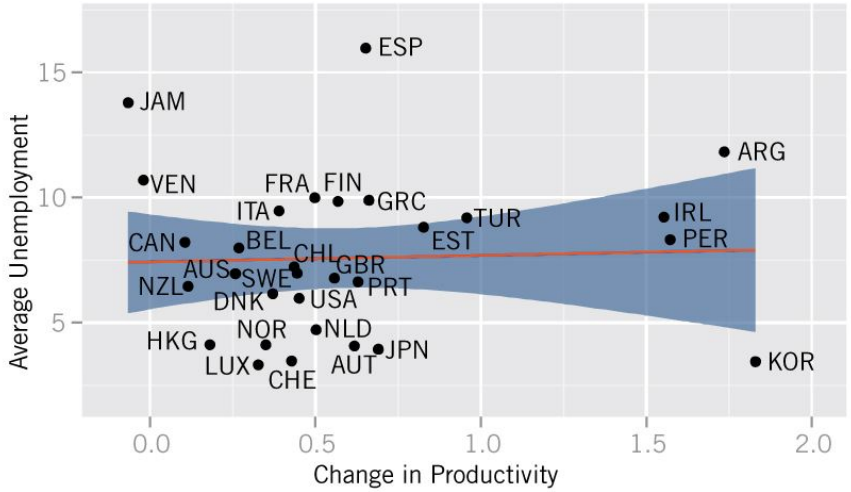
Historically, the relationship between productivity growth and unemployment rates has actually been negative. In other words, higher productivity meant lower unemployment.

The productivity kills jobs argument is refuted not only by logic, but also by data and econometric studies. Historically, the relationship between productivity growth and unemployment rates has actually been negative. In other words, higher productivity meant lower unemployment. This correlation is shown in the 2011 McKinsey Global Institute report, "Growth and Renewal in the United States: Retooling America's Economic Engine."[31] MGI looks at annual employment and productivity change from 1929 to 2009 and finds that increases in productivity are correlated with increases in subsequent employment growth, and that the majority of years since 1929 feature concurrent employment and productivity gains. In looking at 71 10-year slices, only 1 percent had declining employment and increasing productivity. The rest showed increasing productivity and employment. In looking at 76 five-year periods, just 8 percent had declining employment and increasing productivity.

In the 1960s, U.S. productivity grew 3.1 percent per year and unemployment averaged 4.9 percent. However, during the 1980s, productivity grew just 1.5 percent and unemployment rates averaged 7.3 percent. Between 2000 and 2007, productivity was growing at a healthy 2.7 percent per year and the unemployment rate was under 5 percent. But from 2008 to 2015, productivity growth was only 1.2 percent yet the unemployment rate averaged over 7.5 percent.

Internationally, we see similar patterns. A cross-national sample of productivity growth and average unemployment rates between 1990 and 2011 shows essentially no relationship (see figure 3).[32]

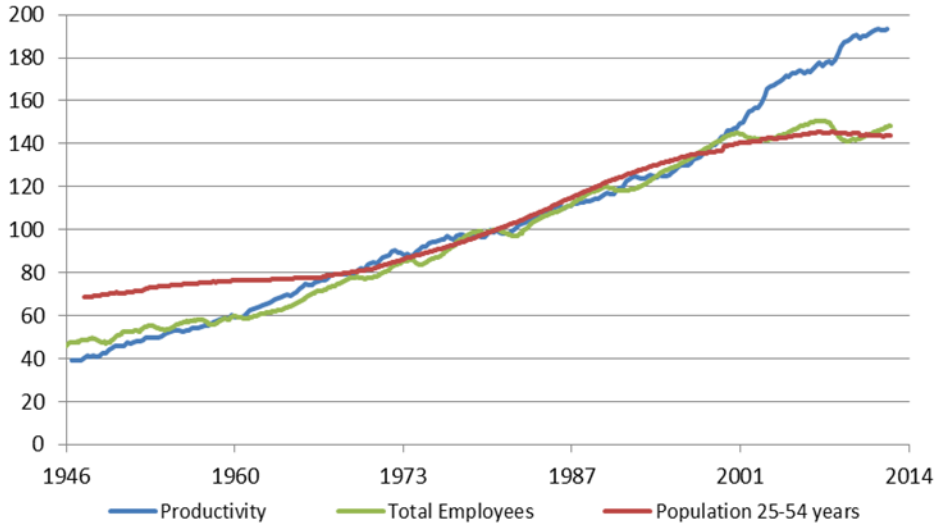
Figure 3: Average Unemployment Rate and Annual Change in Total Factor Productivity in Select Nations, 1990–2011 (Percent)



Despite this historical evidence, many pundits still opine that productivity kills jobs. McAfee and Brynjolfsson, for example, argue that "productivity and employment have become decoupled," given that before 2000 jobs and productivity grew more or less together, but after 2000 productivity continued to grow but employment did not. This misleading interpretation is now repeated endlessly around the world, from Boston's *Harvard Business Review*, to Geneva, to Delhi.[33] For example, in an op-ed for *The Hindu Business Line*, Ashoak Upadhyay argues that "more [productivity] growth equals less jobs," and he cites McAfee and Brynjolfsson, to claim that "what studies in America and India have discovered is a decoupling of employment from the causal chain of rising productivity and economic growth."[34]

But it is important to realize that the relationship McAfee and Brynjolfsson examine merely shows two variables that happen to be increasing together from 1970 to 2000. There is no reason why one trend should impact the other, for in reality these two variables were never coupled, any more than the divorce rate in Maine and the consumption of margarine (two variables that have moved together) are coupled. The real reason productivity gains and employment rates became "decoupled" after 2000 is that while productivity continued to grow (albeit at a much slower rate than before), the growth of the working-age population slowed. The number of 25- to 54-year-old Americans entering the workforce declined, as did the entry of women into the labor market, as the 30-year long expansion peaked. In other words, the slowdown in labor force growth had absolutely nothing to do with productivity growth and everything to do with changing demographics. Employment cannot increase if the population of potential workers does not increase. Looking at the data in figure 4, it is equally plausible to argue that productivity kills people, since population growth and productivity growth have also become uncoupled.[35] In short, the so-called great decoupling is nothing more than a great charade.

Figure 4: Productivity, Civilian Labor Force Participation, and Working-Age Population (Index, 1981=100)



Not only is the notion that productivity kills jobs rebutted by logic and history, virtually all academic studies on the topic have found that productivity increases do not decrease the number of people working or raise the unemployment rate. If anything, the opposite is true. Trehan found that "The empirical evidence shows that a positive technology shock leads to a reduction in the unemployment rate that persists for several years."[36] The OECD finds that "Historically, the income generating effects of new technologies have proved more powerful than the labor-displacing effects: technological progress has been accompanied not only by higher output and productivity, but also by higher overall employment."[37] In its 2004 *World Employment Report,* the International Labor Organization found strong support for simultaneous growth in productivity and employment in the medium term.[38] In a paper for the International Labour Organization's *2004 World Employment Report*, Van Ark, Frankema, and Duteweerd find strong support for simultaneous growth in per-capita income, productivity, and employment in the medium term.[39] A study by Industry Canada's Jianmin Tang find that for 24 OECD nations, "at the aggregate level there is no evidence of a negative relationship between employment growth and labour productivity growth…. This finding was robust for rich or poor countries, small or large, and over the pre- or post-1995 period."[40] The United Nations Industrial Development Organization finds that in fact, "productivity is the key to employment growth."[41] It goes on to note that:

> The link between productivity and the creation of jobs is strong but somewhat complex. In a static formulation, employment and productivity are in an inverse relationship: A given quantity of work to be done will require fewer and fewer jobs as productivity increases. In dynamics, though, the relationship is altogether different. Real wages divided by labour productivity is what defines the share of the wage bill in value added. Thanks to this relationship, the share of the wage bill can be reduced without affecting the

> income of the workers. The larger capital residual stimulates investment and, finally, jobs.[42]

To be sure, this is not to say that in economic recessions productivity might not be accompanied by consumer demand from lower prices and job growth from increased demand, because by definition in these periods, demand is below supply. The evidence and logic suggest, however, that once demand returns (e.g., when the recession ends) productivity once again leads to compensating job growth. Nor is this to suggest that if productivity is higher than average in some industries—particularly industries with low elasticity of demand, where lower prices do not lead to accordingly higher sales—that it cannot lead to fewer jobs in those particular industries. But this is very different than the aggregate, economy-wide effects many doomsayers are forecasting.

In summary, even in the face of history, logic and overwhelming scholarly evidence, the "tech kills jobs" true believers remain unconvinced. Like perennial Marxists who hold on to the hope that the proletariat revolution is just around the corner, today's tech-kills-jobs advocates are stubbornly confident that the destruction of jobs is just around the corner. Even if they acknowledge that productivity has not yet killed jobs, for them the future will be different. This argument is seductive, of course, because there is no way to prove or disprove it.

Like perennial Marxists who held out hope that the proletariat revolution was just around the corner, today's "tech kills jobs" advocates are ever confident that the destruction of jobs is just around the corner.

The doomsayers tell a story about technological change accelerating so much that soon there will be nowhere left to run: After the super-intelligent robots take our jobs, there will be no new jobs left to create. The narrative is as follows: As automation reduced agricultural jobs, people moved to manufacturing jobs. After manufacturing jobs were automated, they moved to service-sector jobs. But as robots automate these jobs, too, there will be no new sectors to move people into. This argument is not new. Economist Wasily Leontif warned in 1983 that:

> We are beginning a gradual process whereby over the next 30-40 years many people will be displaced, creating massive problems of unemployment and dislocation. In the last century, there was an analogous problem with horses. They became unnecessary with the advent of tractors, automobiles, and trucks.... So what happened to horses will happen to people, unless the government can redistribute the fruits of the new technology.[43]

A decade ago, Brian Arthur wrote, "when farm jobs disappeared, we still had manufacturing jobs, and when these disappeared we migrated to service jobs. With this digital transformation, this last repository of jobs is shrinking—fewer of us in the future."[44] Ray Kurzweil argues in *The Singularity Is Near* that because of Moore's Law, IT will remain on a path of rapidly declining prices and rapidly increasing processing power, leading to developments we can only barely imagine, such as smart robots and bio-IT interfaces.[45] Kurzweil claims that "gains in productivity are actually approaching the steep part of the exponential curve."[46] (In fact, productivity growth rates fell by half after he wrote this.) Stuart Elliott, in a paper for the National Research Council, extrapolates Moore's Law and argues that in 23 years computers are likely to displace 60 percent of all jobs.[47] McAfee and Brynjolfsson suggest that we are "reaching the second half of the chessboard," where

exponential gains in computing power lead to drastic changes after an initial gestation period.[48]

Some even go so far as to claim that artificial intelligence will lead to superintelligence, where intelligent machines do all jobs and more, which will spell the end of jobs, and maybe even the end of the human race if the smart machines decide it is in their best interest to kill us.[49] For these pessimists, computers and robots will eclipse the full range of human ability—not only in routine manual or cognitive tasks, but also in more complex actions or decision-making. The logic is as follows: For there to be labor demand, there must be things that humans can do better or more cheaply than machines, but machines are becoming more useful than (a large majority of) workers in almost every conceivable way. The gloomy conclusion is we will all be living in George Jetson land (from the 1960s U.S. TV show *The Jetsons*), but, unlike George, we will not be working at Spacely Sprockets, we will be at home on the dole, and only Mr. Spacely will be employed, because he owns the robots.

Far from being doomed by an excess of technology and productivity, the real risk is being held back by too little technology.

But techno-utopians make three crucial mistakes. First, they wrongly assume that current technological trends will continue or even accelerate. Second, they overstate the extent to which digital innovation is transforming occupations. For some of the them, virtually all jobs will be disrupted by smart machines. One of the most widely cited studies on this matter, from Osborne and Frey, finds that 47 percent of U.S. jobs *could* be eliminated by technology over the next twenty years.[50] But they appear to overstate this number by including occupations that have little chance of automation, such as fashion models. Osborne and Frey also rank industries by the risk that their workers would be automated. They find that in accommodation and food services, "as many as 87 percent of workers are at risk of automation, while only 10 percent of workers in information are at risk."[51] Although this is a speculation about the future, one would expect some positive correlation between recent productivity growth and risk of automation. In other words, industries they expect to be most at risk of being automated (by definition, through productivity growth) should have enjoyed higher-productivity growth in the last few years, given that many of the technologies Osborne and Frey expect to drive automation are already here, albeit not at the same levels of deployment. But, in fact, the correlation was negative between the risk of automation in an industry and the industry productivity growth of 0.26.

Moreover, even Osborne and Frey admit that "could be eliminated" is not the same as "will be eliminated." A more likely estimate is that only about 20 percent of U.S. jobs are likely to be easily automated over the next decade or two, about 50 percent being difficult to automate and the remaining 30 percent extremely difficult.[52] One reason for this difference is that, for many occupations, automation does not affect the occupation as much as the tasks performed in an occupation. For example, the McKinsey Global Institute concludes that "Very few occupations will be automated in their entirety in the near or medium term. Rather, certain activities are more likely to be automated, requiring entire business processes to be transformed, and jobs performed by people to be redefined."[53] In other words, technology will lead much more to job redefinitions and opportunities to add more value, not to outright job destruction. If 20 percent of an administrative assistant's time is

spent on tasks that can be automated, that does not mean we lose 20 percent of administrative assistants—it means they can spend that time doing more meaningful things than routine tasks such as weekly scheduling.

But even if Osborne and Frey are right and 47 percent of jobs are eliminated by technology over the next 20 years, this would be equivalent to an annual labor productivity rate of 3 percent a year, barely higher than the productivity rate of the U.S. economy in the 1960s, when unemployment was at extremely low levels and job creation was high.[54] Similarly, a Citibank report on the future of work ominously predicts that new developments in computer "algorithms could displace around 140 million knowledge workers globally."[55] This indeed might sound ominous until one realizes that this sector accounts for just 4.6 percent of global employment and any process is likely to take at least a decade or two to work its way through the labor market.

The evidence is quite strong that technology has not been the cause of growing inequality.

The majority of those arguing that tech will eliminate jobs are technologists, not economists. Few technologists also have a background in economics. Case in point is computer scientist Jeremy Howard who, in speaking about improvements in machine learning, rightly points out that in developed nations more than 80 percent of jobs are services. He then says that computers have just learned how to do services (e.g., to recognize images, to speak, etc.). Therefore, he logically concludes that 80 percent of jobs in advanced economies will be eliminated.[56] However, to jump from the fact that machines can learn to speak Chinese, recognize patterns in X-rays, and write short descriptions of pictures to the statement that they will eliminate jobs such as barbers, trial lawyers, social workers, gardeners, policemen, and so on, is sloppy at best.

The techno-utopians third mistake is that this nowhere-left-to-run argument is absurd on its face because global productivity could increase by a factor of 50 without people running out of things to buy. Just look at what people with higher incomes spend their money on: nicer vacations, larger homes, more restaurant meals, more entertainment like concerts and plays. Moreover, if we ever get that rich, working fewer hours would evolve on its own.

In sum, the worries of machines overtaking humans are as old as machines themselves. Pitting man against machine only stokes antipathy toward technology and could have a chilling effect on the innovation and adoption of technology essential to boost productivity. For example, U.K. scholar Anthony Atkinson advocates that policymakers encourage "innovation in a form that increases the employability of workers." In other words, support innovation that does not boost productivity.[57] This is in fact the very last thing economies need. The reality is that, far from being doomed by an excess of technology and productivity, the real risk is being held back by too little. To be sure, productivity improvement generates both winners and losers. Some workers will lose their jobs, and it is appropriate for policymakers to put policies in place to help those workers quickly transition to new employment. But to say that we should worry about productivity growth reducing the overall number of jobs available and implement basic income supports to the anticipated large mass of nonworkers is simply without merit.

Productivity Still Lifts All Boats

In their campaign to advance a redistribution agenda over a productivity agenda, many on the Left argue that productivity not only kills jobs, it also does not even benefit workers with jobs. It has now become a widely held view that despite gains in U.S. productivity, average workers have benefited little. The liberal Economic Policy Institute (EPI) states that the vast majority of U.S. "workers have not benefited from productivity growth for four decades."[58] Economists Thomas Piketty and Emanuel Saez claim that "between 1979 and 2007 over 91 percent of income gains due to productivity growth have been captured by the wealthiest 10 percent of the population. This left just 9 percent of the economy's expanded output for the bottom 90 percent of the population, who only managed a meager real income growth of 5 percent while GDP per person for all Americans, including the top 10 percent, was rising 74 percent."[59]

Many argue that technological innovation will only exacerbate this situation. Krugman writes, "Smart machines may make higher G.D.P. possible, but also reduce the demand for people—including smart people. So we could be looking at a society that grows ever richer, but in which all the gains in wealth accrue to whoever owns the robots."[60] A Citibank report on jobs and technology makes a similar point: "Although technology can raise productivity and boost wages, it can also take the form of capital that substitutes for labour. In that case, productivity growth will simply enhance capital's share of income, and thus the concentration of wealth."[61] In other words, only a few will capture the gains.

Despite these claims, the evidence, at least in the United States, suggests that productivity has benefited the average worker. Liberal economist Dean Baker finds that from 1973 to 2006, median hourly compensation grew by 20.1 percent, and that "usable" productivity—"productivity growth that can be translated into higher wages and living standards"—rose 47.9 percent. [62] Thus, median wages actually did grow because of productivity gains. Likewise, data from the Congressional Budget Office also show that the bottom 90 percent got between 42 and 47 percent of the growth in after-tax income since 1980.[63] To be sure, average Americans would have gained more had income inequality not increased, but they would have gotten nothing had productivity stalled completely. Sustainable median real wage increases are simply not possible unless productivity grows as well.

Likewise, the evidence is quite strong that technology has not been the cause of growing inequality. EPI has shown that productivity has not been the cause of income inequality. They find that inequality did not increase because jobs in middle-wage occupations were eliminated by productivity gains.[64] Rather, inequality increased within occupations, some individuals making winner-take-all incomes at the expense of other workers in the same occupation. This had nothing to do with productivity and everything to do with socio-political factors. To take an example from pro basketball, income inequality did not grow because technology eliminated middle-skilled players, it grew because of political economy factors, such as the introduction of free agency. In addition, as Jonathan Rothwell shows, 6 percent of the top 1 percent of earners are in the financial services industry, 7 percent in law, 7 percent are doctors, 7 percent work in hospitals, and 4 percent are dentists.[65] In fact, 21 percent of dentists are in the top 1 percent of earners, and 31 percent of physicians and

surgeons are. Even 15 percent of college presidents are in the top 1 percent. In contrast, if you take workers in the software, Internet publishing, data processing, hosting, computer systems design, scientific R&D, and computer and electronics manufacturing, combined they represent just 5 percent of workers in the top 1 percent of income earners. Rothwell finds "five times as many top 1 percent workers in dental services as in software services." In other words, the notion that technology is the cause of income inequality is without merit. What is much more the cause is a financial services industry and professions able to extract extremely high rents.

Moreover, one reason why wage growth has been slow in the United States since the 1990s is that productivity growth has been slow, especially when considering that overall U.S. productivity growth in the 2000s has been overstated due to mismeasurement by approximately 25 percent.[66]

Historically, periods of high productivity have been associated with reduced income inequality, not more. During the 1960s, productivity grew at rates more than twice as fast as it has in the last 10 years. However, income inequality declined while median family wages increased by almost 30 percent.[67]

Historically, periods of high productivity have been associated with reduced income inequality, not more.

Finally, the scenario of a few "robot" owners making "trillions" while the rest of us are impoverished and on the dole strains credibility. The only way this could happen is if the laws of economics for competitive markets were repealed. If one robot "owner" jacked up prices and made massive profits, another robot owner would lower prices to get market share. This process would keep happening until profits were at a normal level, just as it has in the U.S. economy for the last 200 years. Moreover, evidence that robot markets lead to winner-take-all outcomes is scant because network effects do not appear to be the same as in some IT markets that naturally lead to a small number of firms with large market shares.[68] Moreover, the claim that when capital substitutes for labor (e.g., the average worker has more and better tools to work with) echoes back to Marx's prediction that capitalists would immiserate workers. But no evidence exists that as companies increase capital expenditures that they increase their profit rates. If that were the case, U.S. corporate profit rates would not be essentially the same as they were in the 1960s, even though total capital per work is much higher.

How Productivity Grows: Enterprise and Industry Shifts

Given the centrality of productivity growth to economic progress, it is important for policymakers to understand how productivity grows. Productivity can grow in two ways: the growth effect (when most industries increase their productivity) and the share effect (when more-productive industries gain share at the expense of less-productive ones). The growth effect is by far the most important driver of productivity.

The growth effect can drive productivity two ways. The first is when the productivity of all firms in an industry increases. For example, all retailers adopt point-of-sale (POS) terminals. This can be referred to as the industrywide effect. The second is when an industry's productivity increases because more-productive firms gain market share at the expense of less-productive ones. This can be referred to as the industry reallocation effect.

For example, smaller brick-and-mortar retailers may go out of business because more efficient big-box and online retailers gain market share. In this case, no firm had to increase productivity for industry productivity to go up. Instead, productivity increased as less-productive firms lost market share to more-productive firms.

Sometimes, technological innovation enables new, more-productive firms to replace less-productive ones. For example, as smartphones integrated cheap, high-quality cameras in them, production of stand-alone digital cameras dropped. The productivity of the stand-alone camera industry and the smartphone industries might not change, but as people bought more smartphones, the overall combined productivity of the two industries (smartphones and cameras) increased significantly because people received more value with fewer resources devoted to their production.

These two processes of productivity growth occur within all sectors but at different rates. The first effect appears to be more important in manufacturing than in retail. Foster, Haltiwanger, and Krizan find that reallocation, broadly defined to include firm entry and exit, accounted for around 25 percent of U.S. manufacturing productivity growth but about 90 percent of U.S. retail productivity growth as less efficient single-store firms were replaced with more efficient national chain store affiliates and e-commerce sellers.[69] It is not clear what the processes are within industries such as construction and health care, but it is likely that productivity growth occurs more through industrywide growth rather than reallocation, in part because, at least in the United States, these markets are localized and fragmented, making it difficult for productivity leaders to move into new markets and take market share away from laggards.

Numerous studies of other countries also find differences in the role of within-industry reallocation in explaining differences in productivity growth. Several studies find that variations in reallocation across countries play a major role in explaining differences in productivity growth.[70] Anderson finds that reallocation explains about 10 percent of Swedish productivity growth between 1997 and 2003.[71] In contrast, Dumont and his colleagues find that, in the United Kingdom and Belgium between 2002 and 2009, 125 percent of productivity growth was from within-firm effects and that reallocation actually decreased productivity growth by about 25 percent. For Finland, France, Germany, Italy, and Spain, reallocation contributes 2 percent to 32 percent to productivity.[72] Looking at manufacturing productivity growth, Criscuolo, Haskel, and Martin find that from 1980 to 1990, about 25 percent of manufacturing productivity growth stemmed from reallocation, but 50 percent from 1990 to 2000.[73] Ding and colleagues attribute up to 71 percent of total factor productivity growth between 1998 to 2007 in Chinese manufacturing to reallocation effects.[74]

Sources of growth can shift over time. For example, Harrison, Martin, and Nataraj find that after trade liberalization in the early 1990s in India, much of manufacturing productivity growth was due to reallocation as less productive firms lost market share, but after that this initial shock the lion's share of growth was due to most firms increasing their productivity.[75] In the United States, analysts estimate that America's economy today is getting 1 percentage point less productivity growth from reallocation than in the 1980s.[76]

Firm-level research in many nations has shown large, persistent productivity gaps between firms in the same industry, which means that large productivity gains are to be made from moving toward best practice production techniques—whether by laggard firms catching up or by leading firms gaining share.

The second driver—the shift effect—comes from high-productivity industries becoming a larger share of the economy. For example, as Chinese workers moved from the unmechanized farm to the more productive factory, Chinese productivity increased. In contrast, when the United States lost more than 3 million manufacturing jobs in the 2000s from declining global competitiveness, it slowed U.S. productivity growth as economic activity shifted out of relatively high-productivity manufacturing to lower-productivity services.[77] When nations gain global market share in higher-value industries, they can obtain higher relative prices on world markets (terms of trade) for what they produce, equivalent in type to raising domestic productivity.

To the extent that nations focus on productivity, most—especially developing nations—seek to do so by changing their industrial mix toward higher-productivity sectors. But this is short sighted.

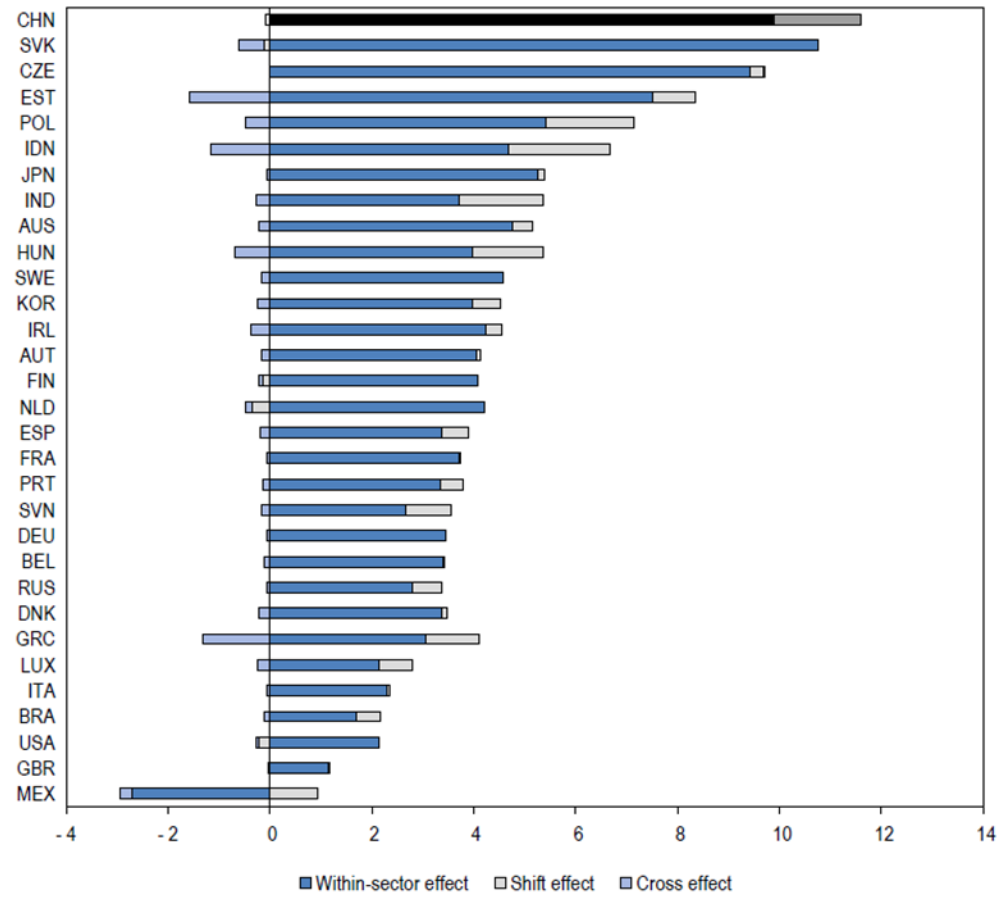
Which productivity strategy—growth or shift—is the better path to higher productivity? The answer depends in part on the size of the economy and to a lesser degree on the type of sector. The larger the economy the more important the growth effect since in larger economies the share of output in internationally traded sectors is lower than it is in small nations. This matters for two reasons. First, larger shifts between industries is more likely in traded sectors than domestic-serving sectors, because different traded sectors can lose or gain share based on global competitiveness. Second, the larger the economy is, the more it benefits from increases in productivity in traded-sector firms. To understand why, consider that if an automobile firm in a small city raises the plant's productivity (the growth effect), the lion's share of direct benefits will flow to the firm's customers outside the city in the form of lower prices. The city will benefit only to the extent that its residents buy cars from that factory (they will pay lower prices), if some of the increases in productivity go to higher wages, or if the factory is able to employ more workers because it gains global market share. In contrast, if a retail store in a city raises its productivity, virtually all of the benefits go to local residents in the form of lower prices.

To the extent that nations focus on productivity, most—especially developing nations—seek to do so by changing their industrial mix toward higher-productivity sectors. But this is short sighted because the lion's share of productivity growth in most nations comes not from changing the sectoral mix to higher-productivity industries, but from all industries, even low-productivity ones, boosting productivity.[78] This means that for most nations, except perhaps the smallest, the surer path to growth is raising productivity growth across the board rather than trying to shift to higher-value-added sectors.[79] This is what the OECD has found in a study of productivity growth in a number of nations, the within-sector (growth) effect much larger in most nations than the shift effect (see figure 5).[80]

Despite this, most nations persist in focusing on the shift strategy, seeking to build their economies around high-productivity, high-value-added, export-based sectors, such as high-tech or capital-intensive manufacturing. Nations such as China, India, and Indonesia are following this path, copying nations such as Japan and the Asian tigers of Hong Kong, Korea, Singapore, and Taiwan. Yet though these latter nations have robust and reasonably

productive export sectors, their domestic-serving sectors are characterized by relatively low productivity. For example, despite some extremely productive multinational firms, Japanese productivity is just 70 percent of U.S. levels and South Korean productivity is just 50 percent.[81] The gap is even greater in developing nations. Productivity in India is just 12 percent of U.S. levels and Chinese is 14 just percent.[82]

Figure 5: Decomposition of Labor Productivity Growth, 2000–2011[83]



Expanding the output of a few high-value-added export firms will normally not provide enough heft to drive overall productivity growth. Boosting productivity of all sectors is the key. For example, a decade ago, Indian retail banking was just 9 percent as productive as U.S. levels and the productivity of its retail goods sector just 6 percent.[84] If India could raise productivity in these two sectors to just 30 percent of U.S. levels, it would raise its standard of living by more than 10 percent.

Moreover, in the longer term, once the catching-up mechanism through shifting employment to higher-productivity sectors is complete, generating productivity gains within industries becomes the only sustainable source of productivity growth.[85] That so many developing nations have not done this, in part because of a lack of a growth-oriented productivity strategy, explains much of the phenomena of the middle-income trap whereby developing nations get to a certain income level and then get stuck. Thus the escape from the middle-income trap is not, as so many advocate, moving to higher-value-added or

creative industries; it is to raise productivity across the board in all industries. This is true not only because high-value-added industries make up a relatively modest share of even the most developed nations, but also because the share of high-value-added industries globally is relatively fixed, and if all nations seek to gain share, they will be fighting over a fixed pie.

How Productivity Grows: Technology

The previous section discusses how productivity grows in part through reallocation either at the industry- or economy-wide level and in part at the firm level. But what drives productivity within an enterprise? Why does one firm become more productive than another? Why do almost all firms in an industry become more productive over time? This is a critical question because correctly answering it can point policymakers in the right direction for making productivity policy.

The lion's share of productivity growth comes not from changing the sectoral mix to higher-productivity industries, but from all firms and organizations boosting productivity.

The subdiscipline of economics that focuses on growth accounting has long grappled with this question. Early growth accounting studies tried to allocate economy-wide growth among various factors, such as the supply of capital and labor, economies of scale, and other factors. These studies found that greater accumulation of traditional inputs, known as capital deepening, contributed surprisingly little to advances in productivity.[86]

In these models, the large residual—what was left over after accounting for capital and labor—was described by Nobel Prize-winning economist Robert Solow as "technical advances," which he defined as changes in how firms produce output. Technical advance thereby increased an economy's growth potential above its limit based on rates of simply accumulating more capital and labor. As Robert Gordon writes in his book *The Rise and Fall of American Growth*, "the rise in the American standard of living over the past 150 years rests heavily on the history of innovations, great and small."[87] In other words, it is better tools, made possible by technological innovation, that enables productivity growth.

An array of growth accounting studies has pointed to technical advances as the key driver of productivity. Robert Hall and Charles Jones studied 127 nations to determine why some grew so much faster and were so much richer than others. They find that "output per worker in the five countries in 1998 with the highest levels of output per worker was 31.7 times higher than output per worker in the five lowest countries." However, they also find that "relatively little of this difference was due to physical and human capital."[88] (Human capital refers to the level of education of workers.) They find instead that high productivity was determined not so much by how much capital (physical or human) an economy had, but by how new it was and how effectively it was used. How capital was used was 4.6 times more important in driving growth than how much capital a nation had. Another way to appreciate this is to note that, of 127 nations, the United States ranks first in output per worker and 13th in labor productivity per hour, but 39th in capital-output ratio.[89] As a result, they conclude that "differences in physical capital intensity and differences in educational attainment explain only a small fraction of the differences in output per worker."[90]

Other studies come to similar conclusions. Klenow and Rodriguez-Clare decompose the cross-country differences in income per worker into shares that could be attributed to

physical capital, human capital, and total factor productivity (total factor productivity represents output growth not accounted for by the growth in inputs like physical and human capital). They find that more than 90 percent of the variation in the growth of income per worker is a result of how effectively capital is used, differences in the actual amount of human and financial capital accounting for just 9 percent.[91] Not all studies have found such a large share, but almost all find that technical advances (e.g., innovation) and how capital is used are the main driver, and that the expansion of capital and skills account for a much smaller share.[92]

Before discussing what drives technological innovation, it is important to clarify the relationship between human capital (education) and physical capital (equipment) and growth. Much of growth accounting economics makes clear that it is not changes in the amount of capital that are key to increased productivity, but this is not to say that investment in equipment and education and skills is not important. Perhaps the best way to think about this is that it is not so much the quantity of capital (physical and human) that matters, but the quality and freshness. For example, it is not just the stock of capital, but how often it is refreshed and replaced with newer and more productive machinery, equipment, and software.

One way to understand this is to consider a machine. What would be better, an economy with 20 percent more fork lifts or an economy where existing fork lifts were replaced with new robotically controlled ones? Assuming that the new ones cost 20 percent more, the capital-to-GDP ratio would be the same but the economy would be significantly more productive with the robotic forklifts (assuming that they are more than 20 percent more productive). In other words, although adding more forklifts will show diminishing returns (each additional one would be less productive than the prior one), more technologically advanced forklifts will not, at least in the short run (given that each additional one would be more valuable than the one replaced). In other words, it is not how many machines an economy has, it is how advanced those machines are and how well they are used. That is where the importance of innovation comes in.

The same process is true for human capital. Which machinist would be better for an economy, one that obtained a college English degree 20 years ago, or one with a high school degree who regularly takes courses to keep his skills at the cutting edge to match the pace of change in machining technology? The answer is clear: The latter machinist engaged in lifelong learning would be more productive. Although he might have less human capital than the one who got a college degree (at least in terms of how economists measure human capital as years of schooling), his human capital is better matched to the needs of the economy because it is constantly being refreshed. More years of education will show diminishing returns. Economies would not be more productive if every worker had a Ph.D. in part because few jobs require such high levels of education. But continued lifelong learning (either on-the-job or in school) to keep up to date with changing technologies and work environments shows fewer diminishing returns. In other words, it is not how many years of schooling workers have that matters, it is how well matched their skills are to the technologically possible production process.

Organizational knowledge capital may be different, however. If organizations are not continually adapting their internal processes in response to adaptations in product and process technologies, they will fall behind. Here the learning is not so much key to driving productivity, but to ensuring that organizations effectively use the best available technology. Even within industries and firms, a learning curve is associated with technology investment—and firms that move faster up the curve, or embed the continuous learning discipline, are able to better capitalize on productivity gains. This may be a key reason some firms have been able to keep increasing their productivity in the digital era but others have lagged.

One key way to develop better tools is through research and development. Numerous studies find that R&D contributes to productivity. Charles Jones estimates that if the U.S. economy invested only the same amount on R&D as a share of GDP today that it did in 1950, productivity would be 17 to 32 percent lower.[93] He also finds that R&D accounts for around 1.38 percentage points of annual economic growth.

The key way productivity grows is through the adoption of new tools.

In other words, the key way productivity grows is by the adoption of new tools. Productivity can continue to grow until all establishments have adopted all available technologies and made any available changes in the production system to fully take advantage of the tools. At this point, further growth depends on the development of better tools—in other words, innovation. This is why developing nations should be able to grow more quickly than developed ones: They are much further from the frontier of using all available tools in the most efficient way.

But even in developed nations a gap normally separates the production-possibility frontier (what tools are available to maximize productivity) and their use. For example, the McKinsey Global Institute estimates that not all firms and industries in the United States have taken full advantage of ICT for productivity. In fact, it finds that "most sectors were only 12 percent as digitized as the leaders in 2005. Despite a massive rush of adoption and change since then, the rest of the economy was operating at only 14 percent of the leaders' digital capacity in 2013."[94]

At this point, productivity depends not on adoption of the best tools, but on development of better ones. This process of technological upgrading can be seen in a number of industries. In banking, for example, IBM invented an automatic check reading and sorting machine in the 1950s. Every few years, they and other producers would come out with a better and somewhat cheaper machine that would process checks just a little faster with a few fewer errors. But, by the early 1980s, the improvements slowed because it is physically possible to move paper only so fast. At that point, efficiency gains were more difficult, in part because virtually all banks had adopted the best technology and technological improvements had stalled. It was not until a fundamentally new technology system was developed that productivity could once again increase. Online banking and digital check imaging emerged in the late 1990s and both were much more productive than physical check processing.

This gets to the last part of technology-enabled productivity growth. At any particular time, not all technologies have the same impact on productivity growth per dollar invested.

Some provide a bigger productivity bang for the buck than others. For most economies today, the most effective tools in raising productivity are based on information and communications technology (ICT). These digital tools are more than simply the Internet, though that itself drives growth.[95] They include hardware, software, and telecommunications networks and, increasingly, tools that incorporate all three components, such as computer-aided design and manufacturing systems and self-service kiosks. In addition, many seemingly non-ICT products, such as sensors and actuators, are in fact ICT products now given that most have semiconductors and transistors.

These tools can be used in the internal operations of organizations (business, government, and nonprofit), transactions between organizations, and transactions between individuals and organizations. Indeed, ICT has enabled the creation of a host of tools to create, manipulate, organize, transmit, store, and act on information in digital form in new ways and through new organizational forms. Its impact is also pervasive because it is being used in virtually every sector, from farming to manufacturing to services to government. In the United States, 48 percent of non-structures capital investment is in ICT; the number would be even higher if all IT-enabled machines were classified as ICT.[96]

ICT is a key driver of productivity because it is what economists call a general purpose technology (GPT). GPTs have historically appeared about once every half century, and represent systems of fundamentally new technologies that change virtually everything, including what economies produce, how they produce it, how production is organized and managed, the location of production, the skills required, the infrastructure needed to enable and support it, and the laws and regulations needed to maintain it.[97] GPTs have certain shared characteristics. First, they typically start in relatively crude form for a few select purposes but increase in sophistication as they spread throughout an economy. As this happens, they engender extensive spillovers in the forms of externalities and technological complementarities, their evolution and diffusion spanning decades.[98] Second, GPTs undergo rapid price declines and performance improvements, as we have seen in the last 40 years with declines in the costs of ICTs. Finally, they become pervasive and an integral part of most industries, products, and functions, enabling downstream innovations in products, processes, business models, and business organization. By any of these measures, ICT ranks well against the most transformative technological breakthroughs in human history.[99]

This is why ICT is such an important enabler of better tools to drive productivity. The evidence that ICT led to the U.S. productivity rebound in the 1990s, and has remained a key driver of growth since then, is well established. In a conclusive review of more than 50 scholarly studies on ICT and productivity published between 1987 and 2002, Dedrick, Gurbaxani, and Kraemer find that "the productivity paradox as first formulated has been effectively refuted. At both the firm and the country level, greater investment in ICT is associated with greater productivity growth."[100] In fact, nearly all scholarly studies from the mid-1990s through 2014 find positive and significant effects of ICT on productivity.[101] These effects cross levels and sectors of economies, from firms to industries to entire economies, and both goods and services industries.[102]

Firm-level studies have also shown that "firms with high levels of ICT are more likely to grow (in terms of employment) and [are] less likely to [go out of business]."[103] The United States was the first country to show a large impact from ICT. Between 1995 and 2002, ICT was responsible for two-thirds of total factor productivity growth in the United States, and virtually all of the growth in labor productivity.[104] Although productivity growth slowed in the mid-2000s, ICT continued to be a primary source of growth: ICT-using and ICT-producing industries were the only source of value-added growth between 2005 and 2010 because low-IT-using industries lost productivity over that time.[105] Overall, more recent studies find that approximately one-third of U.S. growth over that period is attributable to the adoption of ICT by organizations.[106]

Why has the use of ICT tools been the key growth driver? A principal reason is that it has a greater impact on productivity and growth than non-ICT capital. Studies from the early 2000s find that investment in ICT capital increased productivity three to eight times more than investment in non-ICT capital.[107] Wilson finds that, of all types of capital, only computers, communications equipment, and software are positively associated with multifactor productivity.[108] Hitt and Tambe find that the spillovers from IT nearly double the impact of IT investments.[109] Rincon, Vecchi, and Venturini confirm the GPT nature of ICTs through an industry-level study of productivity benefits and spillovers.[110] These studies are corroborated with research on the benefits of ICT in a rich variety of contexts, including developing countries and public-sector organizations.[111]

Why has the use of ICT tools been the key growth driver? A principal reason is that it has a greater impact on productivity and growth than non-ICT capital.

ICT has strong effects on productivity for at least three reasons. First, ICT capital enables firms to pick the low-hanging fruit of relatively easy-to-improve efficiencies. Second, ICT does not just automate tasks; it also has widespread complementary effects, including allowing companies to reengineer processes. Third, ICT has network externalities, the spillovers from adding additional users to a network. Increasing the user size of a network makes all current users better off. When these three factors are combined, ICT can have a big impact.

Finally, most existing productivity research is too myopic in its focus on firms and organizations. The focus should not be on firms, but instead on output. In other words, if the focus is on the productivity of firms producing music CDs, it will underestimate music industry productivity as more consumers get music through downloads and streaming. In other words, music output is from CDs as well as (legal) Internet consumption, but most productivity analysis is confined to the firm, not to the system. We can see the same limitation with industries such as roofing. The focus of most analysis is on how roofing companies can increase productivity, perhaps through use of better technology (pneumatic nailers, for example). But if roofing shingle companies could develop longer-lasting shingles, then roofing hours per 100 years of roof tiles would go down. To be fair, effective national productivity measures would include the development of longer-lasting shingles as increased output in the roofing shingle industry, but it is not clear that they always do include this.

Productivity Performance

The development of an effective national productivity policy requires an understanding of past and present productivity performance. Several issues can make that difficult, however. First, for most developed nations, national productivity data exists but usually only goes back to the 1940s when most developed nations put in place a system of national income and product accounts. For developing nations, the data series are shorter in time and, for some nations, nonexistent.

Second are issues regarding the quality of the data. Even in the most advanced nations with their well-funded national economic measurement agencies, it can be hard to accurately measure productivity and, in particular, output.

For example, when a new version of a product is sold and it takes 3 percent more work hours to produce it, but the product sells for 6 percent more, has productivity increased or decreased? The answer depends on whether the quality of the product has increased by more than 3 percent. For example, a new car may come with a new feature like antilock brakes that takes more labor to produce.

After the Great Recession, U.S. productivity growth sagged to 1.2 percent per year, its lowest level since the government began reporting productivity statistics.

Output in some sectors, including government and health care, is usually poorly measured. Even within sectors where it is easier to measure output, such as manufacturing, doing so can be difficult. This is particularly problematic in the electronics and computers sector, where, according to U.S. government data, output increased by 420 percent during the 2000s, but for the rest of manufacturing decreased by more than 5 percent.[112] This is not because companies produced more computers in the United States; in fact, as they moved production to places like China they made fewer. Rather, it is because the quality of computers increased so rapidly, in particular processing speed and storage. But how quality in this sector is measured leads to significant overstatement of productivity.[113]

Third, productivity data measure only market output. This is in large part because the assignment of value for output is based on monetary values. If a person cooks a meal at home it is not counted as output in national accounts, but if he goes to a restaurant and someone cooks the meal for him it is included. As the sharing economy becomes larger, this discrepancy can be even more of a problem. If someone rents a house from someone on Airbnb while on vacation, that output does not get counted; if they rent a hotel room, however, it does.

Finally, national product accounts do not distinguish between the social value of different kinds of output. Given the increased concern over crime and terrorism, expenditures on security have increased significantly in the United States over the last two decades. But these expenditures do not provide value; they are instead defensive measures against loss of value. This omission has led some to call for new measures of national output that take into account differences in social value. For example, the French government created the Commission on the Measurement of Economic Performance and Social Progress.[114] Although this approach risks being hijacked by particular advocates advancing their specific goals, particularly sustainability (which is too often defined as ending economic growth and productivity),[115] overall it merits serious attention because it gets to the key issue that the

goal of any economic system is to advance the well-being of individuals. Not all output does that equally.

Despite these limitations in productivity measurement, value in analyzing the available data on productivity is nonetheless considerable. It can identify important trends and overall levels.

Global Productivity Performance

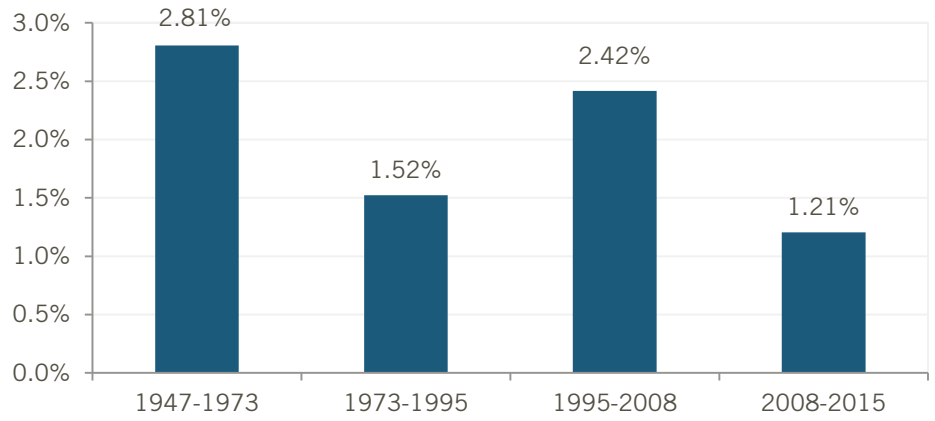
The Conference Board finds that global labor productivity growth, measured as the average change in output (GDP) per person employed, has slowed in recent years.[116] It grew 2.6 percent per year from 1999 to 2006. From 2007 to 2012, it grew 2.5 percent; in 2012 only 1.7 percent; in 2013, 2.1 percent; and in 2014, 2.1 percent. Moreover, most of this decline is in advanced nations, not developing nations. Compared with the 1999 to 2006 period, productivity growth in the EU, Japan, and the United States fell by over half after 2007. In contrast, Chinese productivity rates stayed more or less constant, while Indian rates doubled, and Latin American rates tripled. This suggests that any slowdown was at the leading edge, not the followers.

U.S. Productivity Performance

U.S. productivity has gone through periods of strong and weak growth. In the heyday of the old economy, from 1947 to 1973, U.S. labor productivity grew on average 2.8 percent per year. Overall, for the five-year periods between 1950 and 1975, it grew no slower than 12.4 percent, and as fast as 22 percent in the first five years of the 1960s. Real compensation (wages and benefits) per hour grew no slower than 13.7 percent per five-year period between 1950 and 1970. The engine of productivity was firing on all cylinders during this era.

However, in 1974, to the surprise of almost everyone, productivity growth all of a sudden fell off the cliff. From the mid-1970s until 1995, labor productivity growth fell by about half, to just 1.5 percent per year (see figure 6).[117] Three of the four five-year periods between 1975 and 1995 saw productivity growth under 8 percent and the peak only reached 10.3 percent.

Figure 6: Annual Labor Productivity Growth in the Private Business Sector

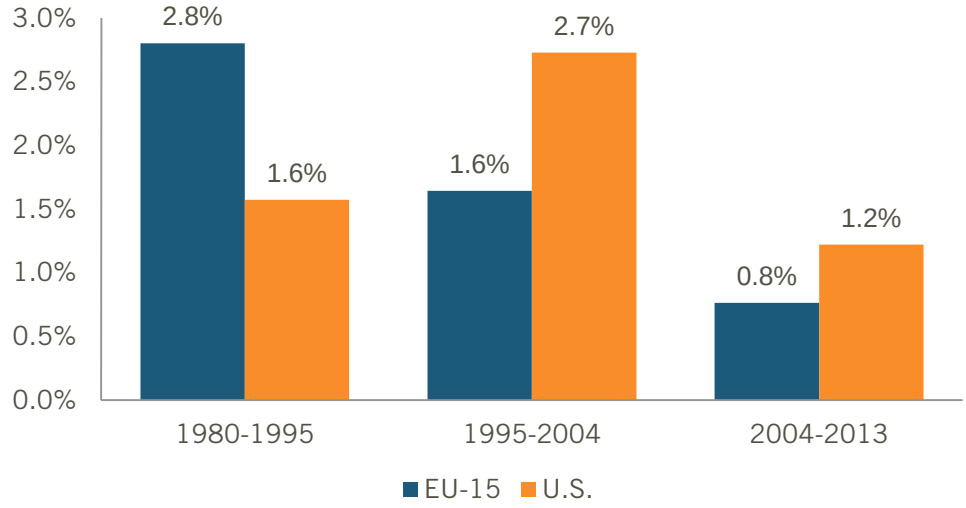


It turned around in 1995, however, as labor productivity grew by 2.4 percent between 1995 and 2008. However, as ITIF has shown this official measure appears to be overstated by at least 20 percent, in large part because of the way that output in the computer and electronics (NAICS 334) is measured.[118] After the Great Recession, productivity growth sagged to 1.2 percent per year, its lowest level since the government began reporting productivity statistics.

Developed-Nation Productivity Performance

Most European nations enjoyed strong productivity growth after World War II. Productivity in the United Kingdom grew by 2.1 percent annually from 1950 to 1995, and in France, Germany, Belgium, Italy, and the Netherlands by an annual average of 3.1 percent over the same period.[119] Indeed, for most of the postwar period, productivity was growing faster in Europe than in the United States, as figure 7 shows.[120]

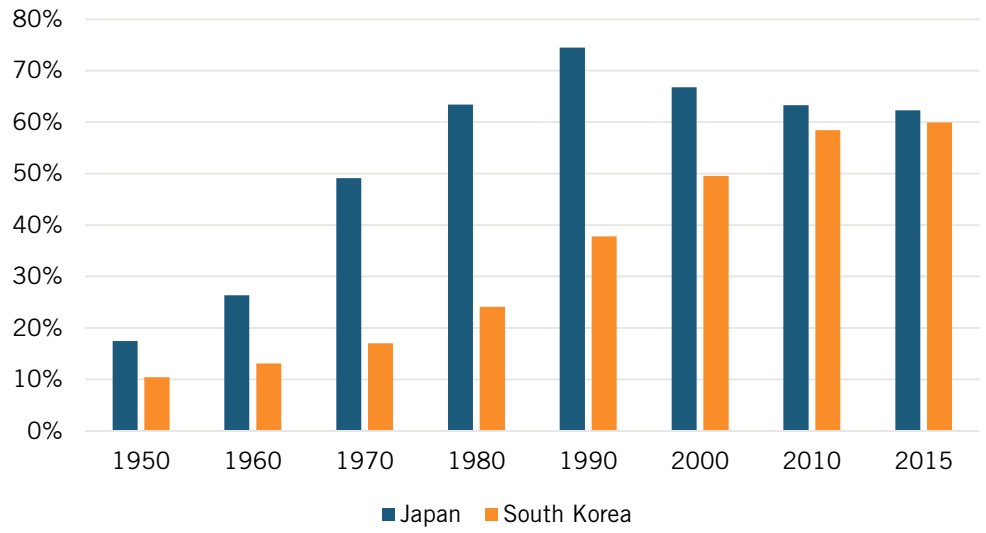
Figure 7: Annual Labor Productivity Growth in the EU-15 and the United States



Yet after 1995 the trend reversed. As U.S. productivity growth accelerated in the late 1990s into the mid-2000s, its European counterpart slowed. U.S. growth averaged 1.6 percent per year from 1980 to 1995, rose to 2.7 percent from 1995 through 2004, and then slowed to 1.2 percent between 2004 and 2013. In contrast, growth in the EU-15 has gone in the other direction, declining from an average of 2.8 percent per year before 1995, to 1.6 percent between 1995 and 2004, to an average of only 0.8 percent since then.[121] As a result, the labor productivity gap in the EU-15 relative to the United States widened by 10 percentage points between 1995 and 2013, from 89 percent to just 79 percent of U.S. levels. The gap between the EU-28 and the United States is even greater, at 74 percent of U.S. levels, because even though EU-13 productivity growth has been more robust than in the EU-15, productivity levels in the new EU countries are much lower. Since the end of the Great Recession, EU-28 labor productivity grew just 0.7 annually.

Similarly, in the postwar period, Japan and South Korea enjoyed strong productivity growth, which propelled them into developed-nation status. In 1950, Japanese and Korean labor productivity as a share of U.S. productivity was 17 percent and 10 percent, respectively. Today, Japanese productivity is 62 percent of U.S. levels and Korean 60 percent (see figure 8).[122]

Figure 8: East Asian Labor Productivity as a Share of U.S. Labor Productivity, 1950–2015



Developing-Nation Productivity Performance

As a group, developing countries, in large part because they started from a lower level of productivity and are much further from the productivity frontier, have generally enjoyed stronger productivity growth than developed nations. We see this in table 1, which examines annual average labor productivity from 2005 to 2015 for 117 nations categorized by income per capita.[123] The poorest nations saw productivity grow 3.1 percent per year, the next poorest at 2.9 percent. Middle-income nations saw their productivity grow 1.7 percent a year, the next richest 1.3 percent, and the richest just 0.6 percent. These data show considerable divergence, the nation with the fastest-growing productivity—Azerbaijan—rising almost 10 percent per year, and the worst performing nation—Yemen—saw its productivity fall 2.4 percent per year. Most nations were clumped more in the middle, 39 of them growing between 1.5 and 4.5 percent per year.

Over the last half century, some nations have made rapid progress. In the 1950s, South Korea had labor productivity rates on part with Afghanistan. Due to rapid growth (at least until recently), they are now as rich (on per-capita terms) as the United States was in the 1980s. Other nations have also made progress. In the 1950s, labor productivity in India was 6 percent of U.S. levels, and in China 4 percent. More than half a century later, in 2015, India had closed the gap to 12 percent of U.S. levels, and China was at 14 percent.[124]

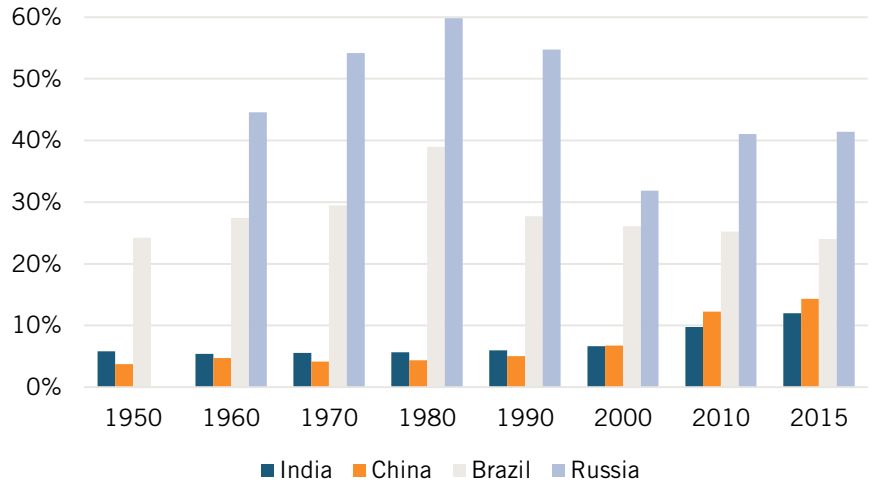
India and China are two cases where productivity levels are gradually increasing over time to enable higher living standards. This is illustrated by segmenting the past 65 years of productivity data. India's productivity relative to the United States was 5.8 percent in 1950, and increased by 0.2 percentage points over the next 40 years. However, in the 25 years from 1990 to 2015, India closed the gap by 6 percentage points. China's trajectory is similar, up by 9.3 percentage points in the same 25 years relative to the United States.[125] Yet, despite these important and much-needed improvements, both countries still have a long way to go.

Table 1: Annual Average Productivity Growth (2005-2015), by GNI per Capita (percent)

More than $28,000		$17,000 to $28,000		$9,000 to $17,000		$3,000 to $9,000		Less than $3,000	
Average	0.5	Average	1.3	Average	1.7	Average	3.0	Average	3.3
						Azerbaijan	9.9		
						Turkmenistan	8.6	Myanmar	8.1
						China	6.2	India	6.9
						Georgia	6.1		
						Sri Lanka	5.2	Zimbabwe	5.7
								Ethiopia	5.6
								Uzbekistan	5.6
								Cambodia	5.6
								Mozambique	5.4
				Kazakhstan	4.1	Armenia	4.8	Moldova	4.9
						Belarus	4.5	Tajikistan	4.8
						Serbia	4.1	Vietnam	4.0
						Indonesia	4.0		
				Latvia	3.9	Albania	3.8	DR Congo	3.5
				Lithuania	3.6	Peru	3.6	Burkina Faso	3.4
				Romania	3.5	Philippines	3.6	Ghana	3.2
				Uruguay	3.4	Dominican Republic	3.0	Nigeria	3.2
								Bangladesh	3.1
								Tanzania	3.1
								Zambia	3.0
								Kyrgyz Republic	2.8
		Slovak Republic	2.9	Poland	2.5	Bosnia & Herzegovina	2.5	Mali	2.5
		Taiwan	2.3	Russia	2.3	Thailand	2.4	Niger	2.4
		South Korea	2.3			Ecuador	2.4	Kenya	2.3
		Estonia	2.2			Bulgaria	2.3	Uganda	2.3
		Saudi Arabia	2.1					Bolivia	2.1
Singapore	1.4	Czech Republic	1.6	Malaysia	1.8	Colombia	1.8	Malawi	1.8
Ireland	1.2	Trinidad & Tobago	1.4	Chile	1.4	Guatemala	1.6	Côte d'Ivoire	1.5
Spain	1.0	Slovenia	1.3	Turkey	1.3	Tunisia	1.6	Sudan	1.1
U.S.	1.0			Costa Rica	1.3	Jordan	1.4		
Iceland	1.0			Barbados	1.3	Ukraine	1.4		
				Argentina	1.1	Morocco	1.3		
				Brazil	1.0	Iran	1.2		
						South Africa	1.1		
Kuwait	0.9	Portugal	0.9	Hungary	0.9	Macedonia	0.8	Pakistan	0.9
Sweden	0.9	Cyprus	0.7	Mexico	0.4	Iraq	0.5	Senegal	0.6
Australia	0.8	Malta	0.3			Egypt	0.2		
Canada	0.7								
Japan	0.6								
United Kingdom	0.5								
Germany	0.5								
Switzerland	0.5								
Netherlands	0.5								
France	0.5								
New Zealand	0.3								
Belgium	0.3								
Denmark	0.3								
Austria	0.2								
Finland	0.2								
Qatar	0.1								
Luxembourg	0.1					Algeria	-0.1	Cameroon	-0.3
Norway	-0.2	Greece	-0.2	Croatia	-0.2	St. Lucia	-0.4	Madagascar	-0.4
Italy	-0.4			Venezuela	-0.8				
UAE	-1.1	Bahrain	-1.1	Oman	-1.2				

Moreover, some developing nations have not closed the productivity gap, but regressed instead. For example, Brazil's and Russia's productivity levels in comparison with the United States are lower today than they were half a century ago. In 1950, Brazil's productivity was 24.3 percent that of the United States, today it is 24 percent; similarly, in 1960, Russia (USSR's) productivity was 44.6 percent that of the United States; today it is 41.4 percent (see figure 9).[126] Lackluster productivity growth can indeed be a bane for developing countries. Although Brazil and Russia demonstrated sizable advances in productivity, reaching highs of 39 percent and 60 percent relative to the United States in 1980, neither could maintain their productivity growth pace and both are worse off today than they were 50 years ago relative to the United States.[127]

Figure 9: Selected Developing Countries' Labor Productivity Relative to U.S. Productivity, 1950–2015[128]



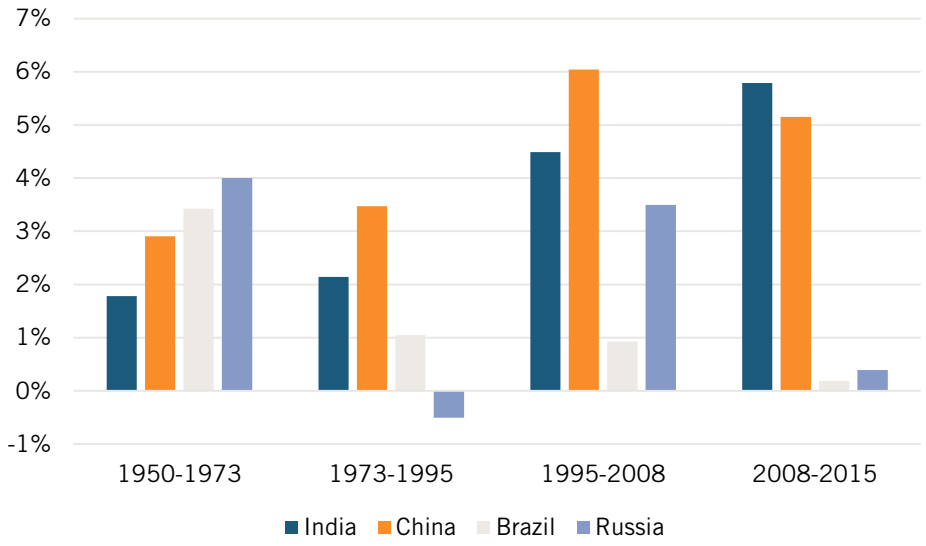
Tracing absolute labor productivity growth shows where the divergence occurred. China and India display similar trends, their average growth rates slowly but steadily rising over the past 65 years. As figure 10 shows, between 1950 and 1973, labor productivity in India and China increased at an annual average of 1.8 percent and 2.9 percent, respectively.[129] Since 2008, growth in India has been at its highest historically, 5.8 percent annually, or 4 percentage points more than four decades ago. On the other hand, China saw its highest growth between 1995 and 2008, growing yearly at 6 percent. Although China has slowed down to an annual average of 5.2 percent, that rate is still far better than it was 60 years ago.

In comparison, Brazil and Russia enjoyed moderately strong labor productivity growth between 1950 and 1973, annual rates of 3.4 percent and 4 percent, respectively. Since 1973, Brazil's productivity has retreated, hovering around 1 percent from 1973 through to 2008, dropping even further to an almost stagnant rate of 0.2 percent since the Great Recession. Russia's economy is slightly different, both spurting and stuttering since the 1960s. From 1960 to 1973, its labor productivity grew by 4 percent annually. Such gains were reversed slightly when the economy stuttered from 1973 to 1995 as labor productivity dropped by 0.5 percent each year. Between 1995 and 2008, however, it grew by 3.5 percent a year. Since then, however, it has essentially evaporated, growing by a miserly 0.4

percent annually. Put simply, robust and sustained productivity growth continues to remain a significant challenge for Brazil, China, India, and Russia, as it is for most developing nations.

Finally, overall Latin American productivity has performed well in the last decade. As noted, labor productivity growth rates tripled in the last decade over the previous one. This growth, though, as one study reveals, was not because of use of ICT. In fact, the relatively low use of ICT capital, especially when compared with the United States, has detracted from overall productivity growth.[130]

Figure 10: Selected Developing Countries' Labor Productivity Growth, 1950–2015



Why Has U.S. Productivity Growth Stagnated?

Whenever U.S. productivity shows a spurt or conversely stagnates, economists are usually puzzled, so it should be no surprise that most are scratching their heads to explain today's lagging U.S. productivity growth. As the *Wall Street Journal* notes, "It's difficult for economists to pin down why productivity gains have been historically weak."[131] In discussing the slowdown, Alan Blinder observes, "What's scary is that we don't know why."[132]

Economists are puzzled for two reasons. First, economics is poorly suited for understanding productivity, because productivity is largely an organizational and technological process, not a market one. Few economists or economic models focus on organizations or technology. In terms of "what is going on with technology," Paul Krugman says simply, "The answer is that I don't know—but neither does anyone else."[133] What he really means is that few economists know. A second reason is the lack of government data by which to understand productivity dynamics within organizations. For example, the U.S. national statistical system is not only underfunded, it is still grounded in its postwar mission of collecting data to manage the business cycle. It does a poor job of collecting data that would give researchers a better sense of what organizations are doing to raise productivity and how technology is enabling it or not.

That said, some hints and hypotheses explain the productivity slowdown. One hypothesis that does not appear to be true, in light of a recent Federal Reserve Bank of San Francisco study, is that it is a cyclical phenomenon.[134] However, a number of other explanations are plausible.

Unmeasured Output

One explanation is that the gains are occurring but that official government statistics do not measure them properly.[135] Many who advocate for this view talk about the output of things like Wikipedia and the consumer surplus from better web searches. To be sure, these are real and provide definitive value to consumers, but it is not clear that they are large enough to account for the measured slowdown. As Chad Severson writes in an analysis of the issue, "these complementary facets of evidence suggest that the reasonable prima facie case for the mismeasurement hypothesis faces real hurdles when confronted with the data."[136] A recent Brookings paper and another by Nakamura and Soloveichik also argue that mismeasurement is overstated.[137] However, like other work in this area, they focus on the consumer surplus from free online services and the increased choice from e-commerce, rather than on the substitution effects (less output at paper maps companies but more unmeasured output from Google maps). Moreover, as Gordon explains, mismeasurement and unmeasured consumer surplus are scarcely new.[138] When the flush toilet and electric lights emerged, considerable consumer surplus was included in the GDP. Finally, evidence is clear that the official productivity statistics for the United States have recently been overstated by approximately 25 percent because of overstatement of output in NAICS 334 sector (computer and electronic products).[139]

The U.S. national statistical system does a poor job of collecting data that would give researchers a better sense of what organizations are doing to raise productivity and how technology is enabling it or not.

Although the evidence suggests that unmeasured outputs cannot explain the slowdown, it does appear that this output is larger than the benefit from free Internet services and extends to more fundamental measurement questions. Take, for example, how the government measures the productivity of the printed map industry. The government does not collect data on printed maps, but the evidence indicates that production is down because so many people use the maps on their smartphones. For example, Pennsylvania printed 2 million maps in 2000 but only 750,00 in 2012. Assuming that the productivity of the map printing industry did not increase, it is clear that the productivity of the map industry defined more broadly to include paper and digital maps did increase, because people are able to consume more maps (paper and digital) with fewer inputs. We see the same dynamic with many other products (the shift from chemical-based film and paper photo printing to smartphone cameras; the shift from buying CDs to downloading music, etc.) For example, U.S. employment in NAICS 334600— Manufacturing and Reproducing Magnetic and Optical Media—fell by 75 percent from 2002 to 2014, from 55,700 to 17,200 workers, as output fell, presumably by that much as well.[140] But consumption of music did not fall as people shifted to digital downloads. This added value is generally not measured but it is quite real.

It Takes Time to Adapt and Learn

Many argue that we should just be patient, that we will learn to use the technologies and get a big productivity benefit. Barry Eichengreen writes that "it takes time for the productivity-enhancing effects of new technologies to show. Indeed, when radical

innovations are rolled out, their immediate effect is to reduce, not raise, productivity. Electricity, the new technology studied by Paul David, economics historian at Stanford University, is a case in point."[141] In his article "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," David argues that it took more than 30 years for electric motors to be fully used in factories after they were first developed in the early 1900s.[142] He analogizes with the computer by suggesting that it takes a long time for companies to figure out how to best use technologies.

This hypothesis has two key problems, though. The first is that it was not really true with electricity. David assumes that electric motors came onto the scene fully formed and that it took 30 or 40 years for recalcitrant companies to finally adopt them. The actual process was much different. Electric motor technology took more than 25 years to improve, to increase power output, functionality, versatility, and ease of use.[143] As it improved, more companies used it and its impact on productivity grew.

Some firms have continued to find ways to significantly boost productivity, but others in the same industry have not.

Second, evidence that information technologies are all that hard to learn is scant. Most of today's information technologies (computers, Windows operating systems, kiosks, and so on) have been around almost 20 years and have been getting easier, not harder, to adopt and use and organizations have had plenty of time to make internal changes needed to maximize the results from them. Many of the newer technologies, such as cloud computing and mobile platforms, are not particularly hard to master, either for individuals or organizations. It is true that the Internet of Things and data technologies are more difficult, but both are still nascent.

Inadequate Investment in New Tools

More and better tools, as reflected in rates of investment in equipment and software, is a key factor driving productivity growth. However, as ITIF has shown, quality adjusted nonresidential equipment and software investment peaked in 2001, fell, stabilized until 2007, and then fell again.[144] For the entire 15 years, overall investment levels were below previous levels. Some of this may be a reflection of the slowdown in tool improvement, but some may also be due to other factors: Companies are simply not investing enough to maximize productivity. Lack of growth in capital goods will reduce the capital-to-labor ratio and make it more difficult to increase productivity.

Difficulty Adopting New Tools

One reason companies may not be buying more tools is possible difficulty in getting the full benefit from them. This is likely true for platform technologies. Many promising ICT technologies are not likely to be adopted at robust rates unless the chicken-or-egg challenge can be solved. Why would a firm become capable of accepting digital signatures if no one has them, and why would users have them if they cannot use them anywhere? A number of promising technologies today seem stymied by such a dynamic: such as near-field communications (NFC)–enabled contactless mobile payments, intelligent transportation systems, health IT platforms, digital signatures and electronic IDs, and the smart electric grid.

Failure to Take Full Advantage of Tools

Even if organizations were investing enough in tools, other factors may be blocking the firms from the full productivity benefits. This often appears to be the case. Both the OECD and McKinsey Global Institute have found that the gap between productivity leaders and laggards has grown. In other words, some firms have continued to find ways to significantly boost productivity, but others in the same industry have not. At one level, this is a puzzle because in conventional economic theory one of two things should happen. First, all firms should be able to increase their productivity because they all have access to the same workers and technologies and face the same market conditions. Second, firms that are less efficient should lose market share and the large firms gain, thereby leading to increased productivity. With regard to the first point, it may be that something may be somewhat different about the ICT system that makes it more difficult for all firms to easily adopt it and reap the benefits from it. The research shows that unless a firm makes a wide array of internal changes at the same time it adopts ICT, it will get less bang for the buck. Erik Brynjolfsson and Adam Saunders find that corporations that gained the most productivity benefit from IT shared distinct organizational practices, including moving from paper-based to digital business processes, empowering front line service personnel, fostering open information access, linking incentives to performance, maintaining focus and communicating goals, hiring the best people, and investing in human capital.[145] The McKinsey Global Institute cites similar results, observing that when companies invested in ICT and changed management practices, they were the ones that had the largest increases in productivity.[146] Likewise, one study of European productivity growth from ICT finds that firms that combine ICT with intangible capital, especially R&D and organizational innovation get a larger productivity benefit than firms that only use ICT.[147]

The conventional economics view of innovation is that it is linear, something that just happens regularly. But in fact technological innovation appears to follow a pattern of repeating S-curves.

It Is Harder to Raise Productivity Now

Economists such as Robert Gordon of Northwestern University maintain that this slump in productivity growth reflects the stagnation of technology. He argues that all of the epochal advances, from running water and electricity to the internal combustion and jet engine, powered growth through the 1970s but that today's IT-based tools are inadequate.

Given that much of the narrative is that we are living in a revolutionary technological era, arguing that tools are inadequate may seem strange. Are we not inundated with breakthrough tech like self-driving cars, drones, and artificial intelligence?

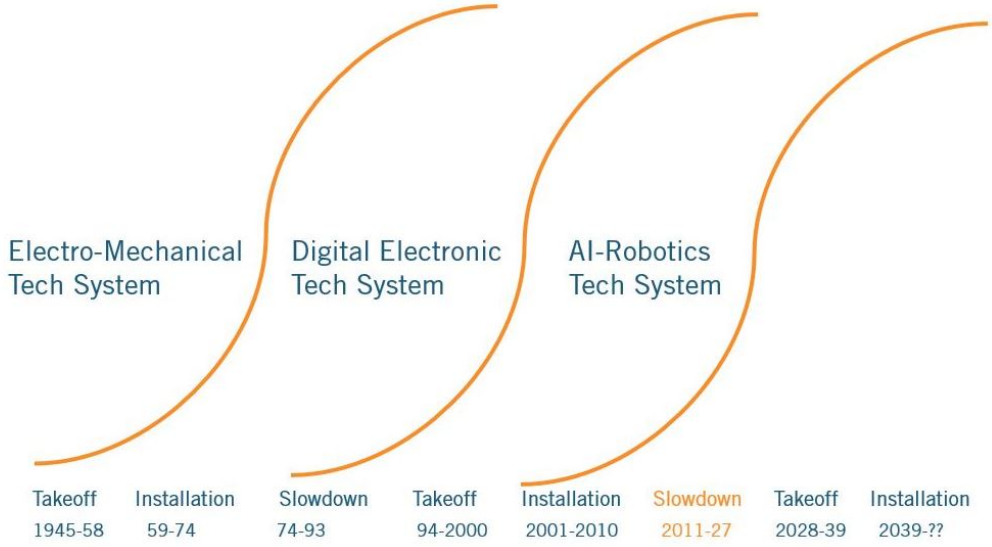
Before discussing this topic, it is first worth postulating on the nature of technological innovation. The conventional economics view of innovation, to the extent that economists have one, is that it is linear, something that just happens regularly. But in fact technological innovation appears to follow a pattern of repeating S-curves, waves of technology emerging and then stagnating before the next new wave. This is what Joseph Schumpeter argues in writing that "each of the long waves in economic activity consists of an 'industrial revolution' and the absorption of its effects."[148] He continues:

> These revolutions periodically reshape the existing structure of industry by introducing new methods of production–the mechanized factory, the electrified factory, chemical synthesis, and the like; new commodities, such as

> railroad service, motorcars, electrical appliances; new forms of organization–the merger movement; new sources of supply–La Plata wool, American cotton, Katanga copper; new trade routes and markets to sell in and so on. This process of industrial change provides the ground swell that gives the general tone to business; while these things are being initiated we have brisk expenditure and predominating prosperity–interrupted, no doubt, by the negative phases of the shorter [business] cycles that are superimposed on that groundswell.[149]

The key to Schumpeter's analysis is the insight that innovation is not a regular process bringing steady incremental improvements but rather a discontinuous process that leads to waves of technological innovations. He notes that "these revolutions are not strictly incessant; they occurred in discrete rushes which are separated from each other by spans of comparative quiet. The process as a whole works incessantly, however, in the sense that there is always either revolution or absorption of the results of revolution, both together forming what are known as business cycles."[150] One reason technology changes in these waves is because the prior technology system establishes firmly committed ways of doing things that are not easily disrupted. It takes the exhaustion of existing systems before institutions look to whole new approaches.

Figure 11: Evolution of Technology Systems



Perhaps the most important question to answer in understanding where we are vis-à-vis productivity is where we are on the technology S-curve. If we are in the middle of the current ICT-powered curve, then we could likely enjoy at least a decade or two of robust growth before the expected slow-growth intervening period before the next big technology wave. If we are at the end, we are likely in for slower growth, especially in leading nations without sophisticated national productivity policies.

As figure 11 illustrates, one can model the evolution of technology in the U.S. economy through S-curves. The post-war wave, powered by the electro-mechanical technology

system (e.g., TV, electric appliances, etc.), drove growth until the mid-1970s when the technology ran out of gas as improvements in performance and reductions in cost diminished. It was not until the emergence of the next wave—digital technologies grounded in computing and the Internet—that robust growth resumed.

One can make a reasonably strong argument that we are closer to the end than the middle of the current digital technology S-curve. This is true for two reasons. First, with regard to the existing ICT innovations, most are less transformative than those of a decade or two ago. Take broadband telecommunications. Moving from a 56K dial-up modem to a 2MB broadband connection in the late 1990s and early 2000s was a huge improvement. Not only did speed increase by a factor of 36 and users have an always-on model, the new speeds supported a wholly different set of applications than the old ones, including voice and video. Going from 2 MB to 11.7MB since then was less valuable, not only because it represented only a six-fold increase in speed, but because it did not really enable a whole suite of new applications and uses; it just made existing ones work better.[151] Likewise, going in the next decade from 11.7MB to 100MB or even a gigabit per second is likely to do even less, unless somehow new applications are developed that require super-fast speeds. So far, they are not here. We can see similar dynamics in operating systems (the shift from DOS to Windows was major, but the regular improvement in operating systems from Microsoft is helpful, but not transformational). The new systems provide added functionality but not the major breakthrough of moving to a graphical interface system did in the early 1990s. Similarly, moving from the x86 microprocessor series to the Pentium in the mid-1990s was a huge step. Going from Pentium to today's core processors, though certainly a major increase in performance, was less important. Today, many people talk about the emergence of cloud computing as a similar revolution to the Internet. But little evidence of this is apparent. As useful as the cloud is in reducing costs and improving functionality, it is a step-wise increase in the Internet system, compared with the emergence in 1995 of the Netscape browser and client-server computing.

Second, many of the gee-whiz applications tech enthusiasts point to as proof that they must be driving productivity—artificial intelligence (AI), autonomous vehicles, drones, and robots, are still quite nascent. Some, like AI, although improving and able to be used in a number of areas, such as medical diagnosis, still have a way to go before they affect a large share of knowledge work. Others, like autonomous vehicles, though closer to being ready for use, have a price-point that is still much too high to enable widespread adoption; it will likely still be decades rather than years before we see ubiquitous autonomous vehicle (AV) use. As discussed below and shown in figure 11, this suggests that growth may be slower until the emergence of the next wave, likely in another 10 to 20 years, powered by technologies like robotics and machine learning.

The Future of Productivity: Stagnation, Revolution, or More of the Same

In the last several years, a great debate has emerged between stagnationists and techno-optimists. Much like the story of the blind men and the elephant, proponents in this debate look at the same evidence but see different things. For stagnationists, such as Robert Gordon and Tyler Cowen, the U.S. economy has "picked all the low-hanging fruit" for productivity advancement and is in for a long period of stagnation.[152] The techno-

utopians, in contrast, see an array of emerging technologies with enormous potential to drive productivity. In fact, the truth is likely in the middle.

Stagnationists

Stagnationists make four main errors. First, because the Internet and associated ICT technologies are so central to most economists' view of sources of productivity growth, a core of the stagnationists' argument is that the Internet is a minor technology with few benefits. Cowen calls it an "entertainment medium," writing that "the Internet made the downturn more bearable because people can still have fun."[153] He goes on to write that it "is especially beneficial for those who are intellectually curious, those who wish to manage large networks of loose acquaintances, and those who wish to absorb lots of information fast." Robert Gordon is equally dismissive: "Invention since 2000 has centered on entertainment and communication devices that are smaller, smarter, and more capable, but do not fundamentally change labor productivity or the standard of living in the way that electric light, motor cars, or indoor plumbing changed it."[154] To note, although indoor plumbing and electric lighting (two technologies Gordon cites) certainly improved people's lives, it is not clear they were all that important in boosting productivity. Moreover, it is striking that in Gordon's 784-page book he does not mention business-to-business (B2B) e-commerce, but instead confines himself to discussing the Internet as a communications medium only. Yet the evidence is clear that the impact of B2B e-commerce on productivity is significantly greater than business-to-consumer (B2C) and even greater than Internet use related to communications.[155] For example, Amazon's impact on productivity growth may be higher in the B2B space, where it is rapidly growing through its Amazon Business offering, than in the B2C space.

In the last several years a great debate has emerged between stagnationists and techno-optimists. Much like the story of the blind men and the elephant, proponents in this debate look at the same evidence but see different things.

Second, stagnationists apply an atom-based standard to technological change. In other words, only if an innovation is in physical form and changes the actual atom structure of the world (for example, steel skyscrapers, plumbing, cars) is it real innovation. Cowen writes, "We still drive cars, use refrigerators."[156] Gordon looks at air travel to make his atom claim, writing that there is "no better illustration than transport speed. Until 1830 the speed of passenger and freight traffic was limited by that of 'the hoof and the sail' and increased steadily until the introduction of the Boeing 707 in 1958. Since then there has been no change in speed at all and in fact airplanes fly slower now than in 1958 because of the need to conserve fuel."[157] Others note that the loss of supersonic commercial air travel due to the retirement of the Concorde has contributed to the decrease in air travel speeds. However, new innovations may allow for the emergence of new supersonic jets.[158]

But this misses the fundamental point that most of today's most important innovations are not based on changes in atoms (physical discoveries like steel bridges and cars) but in bits (digital *systems* that allow for current economic activities to be conducted much more productively). In other words, it is highly likely that the world of 50 years in America will *look* pretty much like the world of today, not like the world of the Jetsons—cars will still drive the streets, buildings will be similar, we will be wearing the same kind of clothes. But the cars will be more autonomous, buildings will be smart, and clothing will be connected to the Internet. Smart cities will look the same as "dumb" cities, but they will function much more efficiently. Smart factories will look the same as dumb ones, but again they will

function more efficiently and smartly. Air travel will also continue to improve, not necessarily because it gets faster but because it gets smarter and more efficient. Technology will let people check into flights without ever stopping. GPS-based NextGen air traffic control systems will mean fewer flight delays, more direct as-the-crow-flies flights, and more flexibility to get around weather problems.[159] To be sure, atom-based technologies will also likely increase in importance because some of these technologies that are now at an earlier phase in their technology life cycle, such as nanotechnology and biotechnology, will likely increase in capabilities and reduce in cost.

Gordon is equally dismissive of the promise of autonomous vehicle technology, writing about AVs that this "category of future progress is demoted to last places because it offers benefits that are minor."[160] He goes on to say that the "consumer surplus of being able to commute without driving are relatively minor." Yet studies find that the benefits of autonomous vehicles will be quite large, on the order of over $1 trillion a year in savings, most of the benefits coming from a reduction in accidents.[161] Because AVs will dramatically cut the costs of accidents, the auto body repair business will radically shrink, and associated benefits will carry over to productivity. Moreover, the savings in medical costs from reduced accidents are quite large.

Technology Cassandras have a long history of proclaiming the end of innovation during economic downturns.

Third, stagnationists have a long history of proclaiming the end of innovation during economic downturns. In 1899, at the end of an awful economic decade, Charles H. Duell, commissioner of the U.S. Office of Patents, stated that "Everything that can be invented has been invented." A few years later, the American Physical Society worried that there would be a surplus of physicists because all the important scientific questions had been answered. Forty years later, toward the end of the Great Depression, when Alvin Hansen made his presidential address before the American Economics Association, he argued that, unlike in the past when the railroad and electricity and the automobile had propelled growth, "we cannot take for granted the rapid emergence of new industries as rich in investment opportunities."[162] But such pessimists were wrong in the past and are wrong now. As Joseph Schumpeter stated, "There is no reason to expect slackening of the rate of output through exhaustion of technological possibilities."[163]

Finally, if technology possibilities have been exhausted, as the stagnationists assert, then we should expect to see productivity slowdown across all firms, including those at the productivity frontier. In fact, the opposite appears to be happening. The OECD reports that the recent global productivity slowdown has not been because the possibilities of productivity growth have diminished, because the most globally advanced firms have continued robust productivity growth. Rather, a growing gap has emerged between the least and most productive firms in the same industry.[164] According to the OECD report, "a striking fact to emerge is that the productivity growth of the globally most productive firms remained robust in the 21st century but the gap between those high productivity firms and the rest has risen."[165] The McKinsey Global Institute finds a similar phenomenon.[166] If there were no more "low-hanging fruit" and if the technologies of the day are frivolous, why are the best firms in the world still seeing high productivity growth?

Techno-Utopians

In contrast to the stagnationists, techno-utopians proclaim breathlessly that we are poised on the edge of a new industrial revolution, even greater in magnitude than the prior ones. Because of this, the techno-utopians argue that productivity growth rates will soon skyrocket. Jeremy Rifkin argues that "The Internet of Things is already boosting productivity to the point where the marginal cost of producing many goods and services is nearly zero, making them practically free."[167] For Ray Kurzweil, these innovations mean that "gains in productivity are actually approaching the steep part of the exponential curve."[168] Klaus Schwab, head of the World Economic Forum, writes that that we are in the midst of a "Fourth Industrial Revolution" and that "major technological innovations are on the brink of fueling momentous change."[169] One government official at a recent closed-door meeting speculated that the impacts from the Fourth Industrial Revolution will be 100 times greater than the impacts of the Internet revolution. Diamandis and Kotler assert that "within a generation, we will be able to provide goods and services, once reserved for the wealthy few, to any and all who need them."[170] But such predictions stretch credulity. For to reach this goal, global productivity would have to rise at 25 percent each year, at least six times faster than the rate over the last 50 years.

If technology possibilities have been exhausted then we should expect to see productivity slowdown among all firms, including firms at the productivity frontier.

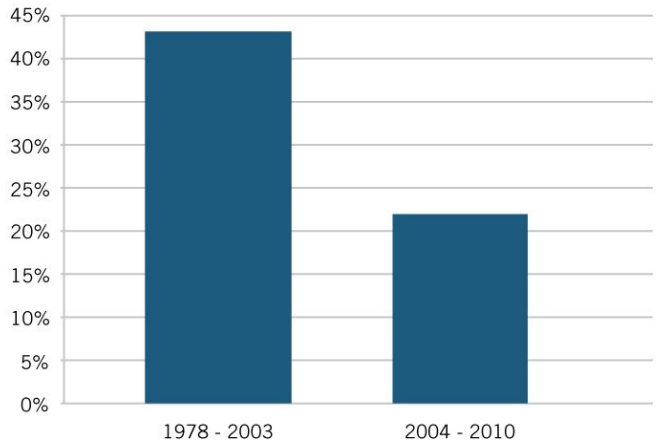
Techno-utopians make two key mistakes. First, they assume that the current pace of IT-based change will continue or even accelerate. Second, they assume that most of the economy is bit-based, rather than atom-based, and as such subject to such rapid transformation. Overenthusiastic predictions from techno-utopians are not new. In his 1967 book *The Year 2000*, futurist Herman Kahn relied on the new "science" of forecasting to write a book that had the tone of "you ain't seen nothing yet." Of the 100 innovations Kahn said were very likely to occur by the year 2000, only 30 had been developed by 2005 and 15 of these were IT-related. For example, Kahn predicted a range of things that have yet to come about, including new airborne vehicles; more reliable and longer-term weather forecasting; widespread use of nuclear power; extensive centralization of computer power; control of weather; lunar settlements; and automated grocery stores. (He did correctly predict things like use of lasers, more transplants of human organs, direct broadcasts from satellites, and personal pagers.)[171]

With regard to the former mistake, techno-utopians cite Moore's Law for their optimism. Moore's Law is named after one of the founders of Intel, Gordon Moore, who famously predicted the speed of computer processing would double every 18 to 24 months even as the price of that computing power halved. Moore's Law, however, has actually slowed down by half over the last 12 years compared with the prior three decades, hardly evidence of the so-called exponential acceleration of the rate of growth (see figure 12).[172] Moreover, for the first time since their invention, the number of transistors able to be purchased per dollar is decreasing.

Moreover, the pace of IT advancement could slow even more. Silicon-based IT systems are likely nearing their limits—even Gordon Moore said Moore's Law is dead.[173] Intel recently announced that it was moving away from its past development process and that this shift will "lengthen the amount of time [available to] utilize... process technologies."[174] And possibly as soon as 2020, the dominant silicon-based complementary metal-oxide

semiconductor (CMOS) architecture will likely hit physical limits (particularly pertaining to heat dissipation) that threaten to compromise Moore's Law unless a leap can be made to radically new chip architectures. That is not to say that at some point a radically different technology will not replace the current silicon-based IT system, perhaps quantum computing.[175] But it is unlikely that this replacement system will be ready for commercialization just as the miniaturization constraints of silicon reach their limits. An intervening period of a least a couple of decades of slow innovation and slow growth until the next technology system fully emerges is likely.[176]

Figure 12: Annual Percentage Change in Computer Processor Speed



Some argue that because of machine learning the pace of innovation will continue to be exponential, even if semiconductor innovation is not. For example, computer scientist Jeremy Howard states that capabilities of machine learning grow exponentially.[177] The better computers get at intellectual activities, he asserts, the better they can build better computers to have better capabilities. But though machine learning systems get better at their particular task the more practice they have (e.g., identifying images of cars), no evidence indicates that the machine learning process is improving exponentially, much less that computer programs are improving the performance of computers exponentially.

Moreover, despite the constant refrain that the growth rate of innovation itself is exponential, absolutely no evidence backs up the assertion. It is now standard fare to proclaim that the pace of technological change is now exponential. John Kotter writes in *Forbes* that the rate of change is "not just going up. It's increasingly going up not just in a linear slant, but almost exponentially."[178] Peter Diamandis and Steve Kotler write in *Abundance* that we are entering into an era in which the pace of innovation is growing exponentially.[179] Brynjolfsson and McAfee tout that "technical progress is improving exponentially." Ray Kurzweil writes that "an analysis of the history of technology shows that technological change is exponential, contrary to the common-sense 'intuitive linear' view. So we won't experience 100 years of progress in the 21st century—it will be more like 20,000 years of progress (at today's rate)."[180] Popular speakers on technology reinforce the view. Jack Uldrich explores exponential trends in technology. Daniel Burrus reminds us

"that we're in a world of exponential transformational change." Eduardo Braun analyzes the "technology revolution and its exponential nature." Joseph Jaffe talks about "explosive and exponential" advances. Josh Linker explores "exponential complexity."[181]

This view is so widely repeated that almost no one recognizes its absurdity. Innovation improving exponentially every few years would suggest that, a decade from now, the U.S. Patent and Trademark Office should be issuing 4.4 million patents a year, up from the 542,000 it issued in 2013 (the exponential rate). Likewise, exponential innovation would mean that economic growth rates should be increasing exponentially. In fact, they are stagnant or falling.

Singularity University cofounder Peter Diamandis argues that we are entering an era in which the pace of innovation is growing exponentially, and are close to a world of global abundance in which most people will enjoy U.S. living standards within a generation. Such techno-utopians are making the same mistake that futurists of the 1960s did when they predicted that growth over the following 40 years would accelerate, completely missing the dramatic slowdown from 1974 to 1995.[182] The 1960s futurists underestimated how long the transition period would be from the old system to the new one, and it is likely Kurzweil, Diamandis, and others are making the same mistake now.

Some, if not many, techno-optimists are optimistic about technology being able to raise productivity, but pessimistic about those gains leading to economic growth.

As noted earlier, the second mistake techno-utopians make is to assume that much of the economy is based on bits rather than atoms. Despite Marc Andreessen's insight that "software is eating the world," so far it has only been the appetizer, not the main course. Moore's Law shows no sign of emerging in food production, haircut production, or even blog production. Despite IT advances that boost productivity in a wide array of information-based functions (e.g., check processing, information retrieval, etc.), a large part of the economy still involves functions where people interact with people (e.g., nursing homes, police and fire, psychologists) or perform physical tasks that are difficult to automate (e.g., construction, janitorial services, haircuts).

This is not to say that any slowdown in the rate of innovation and hence productivity growth will not be temporary. According to Schumpeterian long-wave theory, economic growth comes in long cycles of approximately 50 years.[183] These cycles are powered by the emergence of new and powerful technology systems. But when the major technology system of an era reaches the limits of its development and is fully adopted, an intervening period of stagnation always sets in until the next technology wave emerges and drives economic growth once again.

So the real question is where we are today in this cycle. Despite the considerable interest in emerging IT systems, such as the Internet of Things, cloud computing, drones, 3-D printing, and autonomous vehicles, it appears that in terms of position on the S-curve that we are closer to the top of it than the start of it (see figure 11). Some of the technologies touted as revolutionary, such as cloud computing and advanced broadband, are evolutionary extensions of existing technology rather than radical breakthroughs. As noted, going from a 56K dial-up modem to a 10MB always-on broadband connection was much more transformative than going from a 10MB connection to a 1 gigabit connection. Other technologies, such as drones and the Internet of Things, represent real advances but are not

likely to be transformative to most industries. Still others, particularly robotics, artificial intelligence, nanotechnology and biotechnology, which truly are powerful and transformative technologies, are likely at least two decades away from being to the point where the PC and Internet were in 1995—reasonably powerful, easy to use, and affordable. This is not to say that when these and other technologies that make up the next major technology wave are ready that they will not be powerful engines of growth. They will be, but that power will be on the order of the past technology revolutions, at best boosting annual productivity growth rates 2 to 4 percentage points about annual historical average rates.

Finally, a strain of techno-utopianism embraces the stagnationists in a paradoxical way. Some, if not many, techno-optimists are optimistic about technology being able to raise productivity, but pessimistic about those gains leading to economic growth. A Citibank report on how the new tech wave will be revolutionary asserts that:

> The digital economy may cause secular stagnation is a real risk. The simple reason is that businesses of the digital revolution require less capital investment and thus fewer workers to build the new capital, relative to the investment opportunities brought by technological revolutions of the past. As economies are becoming increasingly digitized, investment opportunities will continue tapering off. Accompanied with a rising share of profits, the savings glut is likely to persist.[184]

The authors, though, seem to believe that the digital economy repeals fundamental laws of economics, such as supply and demand. If the next digital economy requires less capital, then by definition the price of capital will fall, leading to less saving and more spending as people decide that low interest rates mean saving is not as worthwhile. The higher spending will in turn spur job growth and some additional investment, allowing robust productivity gains to translate into robust output gains and no secular stagnation.

Opportunities for Productivity Growth by Sector

To understand the potential for future productivity growth, it is important to not just assess potential technological innovations but also to assess the challenges and opportunities for productivity by industry. In his new book, *The Rise and Fall of American Growth*, Robert Gordon reviews a number of U.S. industries, concluding that the future for productivity growth is dim for all. This section provides an alternative view.

Agriculture

U.S. agriculture has experienced a century of robust productivity growth. Therefore, it would appear that future improvements are unlikely. However, three main technologies—robotics, biotechnology, and data science—offer promise. Continued improvement in automation in both planting and harvesting certainly seems possible. Precision tractors and planters that run themselves are certainly technologically feasible, as are robotic pickers. Biotechnology, and in particularly genetic engineering, holds significant promise for improving food, fiber, and fish yields while reducing fertilizer use.[185] Big data can also help farmers make better decisions, thereby improving efficiency.[186]

Manufacturing

Manufacturing is similar to agriculture, a sector that has made large productivity gains. Can any more gains be squeezed out? Again, three main technologies—robotics, new materials, and data science and the Internet of Things—all offer promise. Many jobs in factories are still done by hand that more adept robots could do instead.[187] Breakthroughs in materials science, some of them fueled by the Materials Genome Initiative, and technologies like nanotechnology are enabling stronger, lighter, and more durable materials, all of which would boost goods-sector productivity.[188] Finally, what many term the Industrial Internet—a set of technologies to embed fine-grain intelligence into machines and products in the supply chain—promises to improve manufacturing efficiency.[189] For example, the Internet of Things can help with predictive maintenance, performance optimization, and better scheduling.

Construction

Construction productivity growth has been largely stagnant in the United States over the last decade. But a host of technological opportunities are primed to boost productivity, such as integrated building information modeling (BIM), 3D printing, IT to better integrate participants in the construction supply chain, more pre-fab parts, and some robotization.

Higher education has long suffered from Baumol's disease, meaning that it has been hard to raise productivity. But technologies exist that could increase productivity.

Retail Trade

Retail trade has enjoyed productivity growth in part because of reallocation from small retailers to large ones and in part because of the integration of IT systems. But further improvements are possible. Self-service technologies continue to improve and increase in their utilization rates. As e-commerce grows, the potential for automated drone delivery will grow. Data analytics will continue to allow turnover maximization, and the Internet of Things will likely continue to boost productivity along the supply chain.[190]

Transportation and Warehousing

Gordon is dismissive of the promise of technology for transportation. Although affordable, fully autonomous vehicles are still years away, they promise significant gains in productivity, particularly in long-haul trucking and taxi services. ITIF estimates that AVs could replace half of all truck drivers and most cab drivers.[191]

Higher Education

Higher education has long suffered from Baumol's disease, meaning that it has been hard to raise productivity. But technologies exist that could increase productivity, particularly massive open online courses (MOOCs) where one professor teaches thousands if not hundreds of thousands of students. It is not likely that MOOCs will replace all face-to-face courses, but if they displaced even one-third of courses, the productivity increase would be significant.

Health Care

In most developed economies, health care continues to account for a growing share of GDP. Gordon dismisses the possibility of health-care productivity. However, more widespread use of IT, including electronic patient records and remote health care, would spur increased efficiencies.[192] Moreover, the potential for biopharma innovation to cut

costs from diseases and maladies such as diabetes, cancer, obesity, and Alzheimer's is very real. Whether we develop these cures depends on many factors, including the willingness of governments to pay for drugs, but the potential is real.[193]

Financial Services

Financial services have been growing as a share of output, at least in the United States. Two paths are key to raising productivity in the sector. One is *fintech* (financial technology), or the application of radical and disruptive technological innovation to the financial sector. Although still early in its development, the technology could significantly disrupt the industry and boost productivity. Second, policy changes could shrink the components of industry that add little real value, such as excessive trading, and this would in fact likely add value.

Government

Much of what government does involves information transactions, yet relative to the private sector, U.S. government entities (at local, state, and federal levels) have lagged substantially in using ICT to drive growth.[194] But there is no reason the government could not use ICT to more effectively automate the hundreds of millions of information-based transactions that still involve government workers.

PART II: A FRAMEWORK FOR NATIONAL PRODUCTIVITY POLICIES

Productivity is the wellspring of prosperity. But why do nations need an explicit productivity policy? Given that most organizations benefit from increased productivity, why won't market forces alone maximize productivity? The reality is that not only do a host of market failures abound when it comes to productivity growth, the entire frame of market failures is also faulty when it comes to conceiving of productivity policy. Rather than think of an economy as a large market with self-interested actors transacting on the basis of price and seeking to maximize productivity, it is more accurate to conceive of an economy as a large, integrated enterprise that requires coordination of activities that individual enterprises will not effectively undertake on their own. Unfortunately, conventional economics conceives of economies not as evolving enterprises, but as either self-adjusting markets or machines with too much or too little pressure that fiscal policy moderates.

Productivity and Economic Doctrines

One key reason almost no countries have a national productivity policy is that most economists counsel against it. This is not because they have marshaled studies finding productivity policies to be welfare detracting. Rather it is because most economists subscribe to an economic doctrine or ideological worldview that simply holds such policies to be wrong. Economics prides itself on being a science, but is in fact based on doctrines. In the United States (and other Anglo-Saxon nations), two major competing doctrines vie for influence: neoclassical and neo-Keynesian economics, neither of which support a national productivity policy. The result of this doctrinal dominance is that many economies are hamstrung by an ideological rigidity that puts productivity policies, especially ones going beyond the standard remedies of getting rid of government

distortions and supporting factor inputs, outside the bounds of acceptable economic discourse.

In most Anglo-Saxon nations, including the United States, the neoclassical economic doctrine is focused on limiting government's role in the economy, even as neo-Keynesians see the government's main role as managing the business cycle and supporting a fairer distribution of income. For the former, government just gets in the way. For the latter, it is the role of business to drive productivity; government's job is to help the little guy. As a result, both camps leave questions of productivity to the market and provide policymakers in search of an effective productivity strategy with little usable advice, other than do not develop a national productivity policy.

Let us start with neoclassical economics. For neoclassical economists, maximizing allocative efficiency is the principal goal. Allocative efficiency refers to managing scarce resources in such a way that maximizes the net benefit from their use, and that produces the quantity and mix of goods and services most beneficial to society. A market economy characterized by allocative efficiency is one in which scarce goods and services are consumed on the basis of the prices consumers are willing to pay, and produced on the basis of equality between marginal costs and price. Neoclassical economists believe that economic welfare is almost always maximized if actors in competitive markets set prices that are not distorted by policy. They spend much of their professional lives defending this utopian balance, believing that any violation of allocative efficiency leads to *deadweight loss*—a loss of economic efficiency as people buy too much of a product that is priced lower than it costs to produce (due to preferential tax incentives or subsidies, for example) or buy too little of a product priced higher than cost (from regulations or taxes, for example). Reflecting this conventional view, the Committee for Economic Development reports that a system that allocates "accurately and efficiently" will "cause productivity growth."[195] Yet, as Nobel Prize–winner Edmund Phelps writes, "standard economics offers no inkling of what policy initiatives might solve the stagnation of productivity and wages.… Their models were conceived to show how short-term fiscal interventions could shave off peaks and troughs of a short cycle around a rising trend path—not to address a sea change in dynamism bringing stagnation."[196]

When it comes to productivity policy, the major failure of neoclassical economics is that its practitioners ignore it, or more accurately believe that it is maximized by enabling price-mediated transactions to take place in a marketplace unfettered by government action. Indeed, page one of the most economics textbooks defines economics as "the study of how to allocate scarce resources among competing ends." As Harvard's Clay Christensen writes, "Most theories of growth are developed at the macroeconomic level—at 30,000 feet. That perspective is good for spotting correlations between innovation and growth. To understand what causes growth, however, you have to crawl inside companies—and inside the minds of the people who invest in and manage them."[197] In other words, economists do not study how societies create new forms of production, products, and business models to expand productivity; rather, they study markets to see how commodities are exchanged. But progress does not come from allocating widgets more efficiently, it comes from making widgets more efficiently and, even more so, by inventing the next new widget.

In contrast, neo-Keynesian economics is grounded in the core belief that demand for goods and services from business investment, government spending, and consumer spending drives growth. Because of their focus on aggregate demand, many neo-Keynesian economic policy prescriptions revolve around increasing government spending to keep the economy at full employment and ensuring economic fairness and redistribution, because the propensity to spend, rather than save, is higher for low-income people. But their goal is not productivity growth, it is full employment.

Although neoclassical economists support productivity, but do not think government can do little about it, many neo-Keynesians are in fact skeptical of productivity. Because full employment and worker welfare are so critical to neo-Keynesians, many have a decidedly schizophrenic view of productivity: grudgingly recognizing its role for growth, but disparaging its purported negative effect on workers and potentially on output if it creates unemployment. For example, a recent economic growth plan from the liberal Center for Economic Progress holds that a "fundamental challenge" that advanced economies face is "the profound technological changes that … are also replacing traditional middle-income jobs."[198] The report goes on to assert that "The rapid pace of innovation in computer automation of routine tasks has rightfully worried policymakers, as this scale of automation has little precedent in industrialized economies."[199] It then notes the "disruptive technological change in the form of information and computer technology that is rapidly allowing machines to replace even complex forms of human work."[200] Despite a slowdown in productivity, not the speed-up such disruption would suggest, this is now a common framing by many U.S. neo-Keynesians.[201] Indeed, for many of them, economic change has become "red in tooth and claw," leading to more destruction than creation and more pain than gain, especially for workers swept up or swept aside by change.

Although neoclassical economists support productivity, but don't think there is much government can do about it, many neo-Keynesians are skeptical of productivity.

Both doctrines thus provide a poor foundation on which to build and justify a national productivity policy. One reason is that both doctrines focus largely on how economies fall into recessions and how policy can avoid them. Understanding and responding to business cycle downturns is certainly important, but it ignores the more important issue: how to expand productivity and long-term growth. This obsessive view on the business cycle is a key reason the media relentlessly covers updates to employment, GDP, and interest rates as if they are Delphic indicators of future economic growth or recession, but meets announcements of quarterly productivity numbers with collective indifference.

Holders of both doctrines also believe that productivity growth is fixed and that policy can do little to change it. Neoclassical economist Alan Blinder explains that "Nothing— repeat, nothing—that economists know about growth gives us a recipe for adding a percentage point or more to the nation's growth rate on a sustained basis. Much as we might wish otherwise, it just isn't so."[202] Paul Krugman writes, "Productivity growth is the single most important factor affecting our economic well-being. But it is not a policy issue, because we are not going to do anything about it."[203] Likewise, Greg Mankiw, former director of the Council of Economic Advisors in the Bush administration, states, "Policy makers don't have a lot of policy measures they can use to change pretax incomes."[204] Neo-Keynesians agree. Frank Levy states, "We cannot legislate the rate of productivity growth.... That is why equalizing institutions are so important." Former Clinton administration economist

Brad Delong says that "The challenges we face are now those of abundance."[205] As a result, he writes that the number one priority for economic policy is finding ways to reduce income inequality. Even Robert Gordon admits that his proposed productivity policies would have little effect on growth, but that they would "create a more equal, better-educated society, together with new sources of tax revenue to resolve the fiscal headwind and pay for high-priority government programs."[206] In other words, the best we can do is a miniscule bit more growth and a lot more fairness.

This is why conventional economists from either doctrinaire camp provide little usable counsel to policymakers seeking to formulate a productivity policy. Neoclassical economists not only contend that little can be done about productivity, many actually counsel policymakers to do nothing, because for them government intervention only distorts the workings of the free market, producing allocation inefficiency. If you are a policymaker and seek to put in place policies that will lead to a 40 percent increase in productivity in 10 years, you will not only get little guidance from the conventional economics community, you will also be scolded for being on a fool's errand. You will be told that the government can do little to grow the economy in the long term, and the best you can hope for is to not take steps that would reduce the natural fixed rate of growth that the market will bring on its own.

To the extent the neoclassical doctrine has any anything to say about a proactive role for the government in spurring productivity, it advises supporting factor conditions that all firms can benefit from (e.g., free trade, better education, reduced regulations, basic scientific research, etc.). For example, in Robert Gordon's 784-page treatise on American productivity, his policy agenda for raising productivity consists of a grab bag of just seven measures: raising the earned income tax credit, legalizing drugs, more preschool education, more money for public schools, free college education, more immigration, and reducing copyright and patent protection. Most of these measures would have little or no effect on productivity (e.g., free college tuition, earned income tax credit) and some (reduced intellectual property protection) would worsen it. A recent report on productivity based on a joint workshop between the French think tank France Stratégie and the U.S. Council of Economic Advisors speculates on a wide range of possible factors leading to the productivity slowdown and could only conclude that "some policy measures [were] worth exploring."[207] They think that "a workforce with less skills, less competitive product markets, less access to risk financing, less R&D investment, and less R&D cooperation between firms and universities all lead to national frontier firms lagging way behind global frontier firms" in productivity.[208]

Overall, these broad market and factor input improvements are woefully inadequate as a comprehensive strategy, but they are the best the neoclassical economists can offer, not only because they fail to understand technology and organizations, but also because actual technology-based and sector-focused productivity policies violate their views of what is acceptable economic policy. Given the constraints neoclassical economics imposes on its practitioners (Commandment I: "Thou shalt not distort allocation efficiency"), however, this usual potpourri of broad market-enhancing recommendations is the best they can do.

The conventional doctrines lead policymakers seeking to increase productivity astray in other ways. First, neoclassical economics sees the accumulation of more capital as the central driver of growth. The belief that capital drives economic growth leads neoclassical economists to recommend a set of policies designed to spur private savings (for conservative neoclassical economists) or public savings (for liberal neoclassicalists). The policy implication that flows naturally from the neoclassical model is clear and unambiguous: Focus public policy on ensuring high levels of saving because the supply of capital mechanically leads to investment, which in turn drives economic growth. This can mean anything from cutting spending on productivity-enhancing infrastructure to eliminating tax incentives for investing in new machines. Anything that gets saving rates up. But, as described, the newer innovation economics literature has clearly shown the supply of savings is not the driver of growth but the result of growth.

If neoclassicalists privilege savings and the supply of capital, neo-Keynesians privilege the demand for goods and services. According to this logic, spending—not investment—drives growth. This means that, because higher-income people save more, the compelling argument for funneling a greater share of economic output to the "middle class" is compelling. But this demand-side formulation fails on two counts. First, to the extent that companies respond to growing demand, it is usually by investing in more of the same machines used by workers doing similar jobs to produce the same goods and services for more customers, none of which boosts productivity. To be sure, boosting demand when an economy is not at full employment would increase output and GDP, but it would do little to increase long-term productivity. If the economy is at full employment, stimulating more spending will only increase inflation and interest rates, reducing investment.

The first step for any policymaker seeking to maximize the economy's productivity is to reject the conventional neoclassical and neo-Keynesian economic advice and embrace an alternative economic doctrine grounded in an understanding of the economy as a complex enterprise.

Second, this framing does not explain the long-term per-capita growth patterns of the last half century, which have been driven more by the development of and investment in productive technologies than by increasing demand. In fact, over the last half century, years with high consumption growth are actually associated with lower productivity growth three to five years later.[209] Productivity growth slowed considerably in the 1970s despite continued increases in workforce size and the growing demand that followed. In the late 1980s and early 1990s, employment growth moderated but productivity increased in the following decade. This pattern might be expected given that higher consumption is likely to mean less investment. As noted, new growth theory shows that most growth in productivity and per-capita income stems not from more spending but from innovation (the development and adoption of new technologies).[210]

Thus, the first step for any policymaker seeking to maximize the economy's productivity is to reject the conventional neoclassical and neo-Keynesian economic advice and embrace an alternative economic doctrine grounded in an understanding of the economy as an integrated, complex enterprise. Known by a variety of labels (including innovation economics, endogenous growth theory, evolutionary economics, and neo-Schumpeterian economics), this approach is grounded in understanding that productivity is less about markets and more about organizations and systems, in particular about how technology is developed and deployed to drive productivity. Few conventional economists bother, as Nathan Rosenberg wrote, to "look inside the black box" of actual innovation in actual

organizations or industries and cross-industry systems. Yet it is there that the keys to raising productivity and the keys to the right productivity policy will be found. In this sense, the innovation economics literature is clear: Allocation efficiency, capital accumulation, and aggregate demand are not the key drivers of growth.

It also means understanding that markets alone will not maximize productivity, nor will simply ensuring an adequate supply of factor inputs (infrastructure, education and skills, and scientific research). Unfortunately, the productivity policy discussion, to the extent nations have one, usually stops there. Usually the only accepted role for government is to supply factor inputs, leaving all other matters up to firms. But, as Drummond argues, it is clear that this is an inadequate framing, "necessary but not sufficient."[211] He goes on to note in reference to Canadian government policy that "Canada is not alone in having shifted gears on framework policies quite radically without reaping all the expected benefits. Something seemed to be missing from the policy paradigm."[212] Drummond argues that a "research agenda with a focus on firm behavior from a micro approach is needed to obtain a deeper understanding of Canada's terrible productivity record and to develop actions to boost productivity growth."[213]

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As the limits of the conventional approach become more obvious, it is becoming clearer that two things are missing from the productivity policy paradigm: technology and the firm. With regard to technology, most neoclassical economists assume it away, believing it to be exogenous (outside the model), or, as Nobel Prize–winning economist Robert Solow once said, "manna from heaven." Innovation is assumed to be a natural market function that simply cannot be improved upon. Rather than mention any of the myriad proposals students of U.S. innovation policy have made, Robert Gordon in his proposals to raise U.S. productivity writes, "The fostering of innovation is not a promising avenue for government policy intervention, as the American innovation machine operates healthily on its own."[214] This is despite ample evidence that companies underinvest in research and that the performance of U.S. universities and federal laboratories could be improved.[215]

Many conventional economists assume, absent some government distortion, that companies are efficient and take steps to maximize productivity. But empirical work shows that this is not the case. The OECD finds that firms at the global productivity frontier are on average four to five times more productive than nonfrontier firms in terms of multifactor productivity, and that with respect to labor productivity this difference is more than 10 times. The lagging firms have the same access to the factor inputs (e.g., talent, capital, infrastructure, and technology) as the leading firms, but for some reason do not take advantage of it. In other words, many firms do not maximize productivity. As Schmitz writes in a study of U.S. and Canadian iron ore processers, "Work practices clearly led to money being flushed down the toilet. I can't say this loud enough."[216] Conventional economists simply deny this reality because they have no explanation. After all, firms should be rational profit maximizers and maximizing productivity is a key way to maximize profits.

Fortunately, at least a few economists involved in thinking about productivity go a step further and, while acknowledging the first two areas for government action (eliminating

market distortions and providing factor inputs), argue that an array of market failures facing individual firms lead many to fail to take the needed action to maximize productivity growth. These failures include positive externalities from certain investments (such as investing in research or capital equipment) and risk aversion for certain investments.

Finally, far fewer economists argue that a fourth premise accompanies the three mentioned: Because national economies are best understood as large, complex enterprises, gaps between organizations, if filled, could maximize productivity. These gaps involve issues such as chicken-or-egg challenges in the face of which organizations will not implement a technology unless users already do; system interdependencies where advancement of a system (e.g., the construction system, transportation system, etc.), requires coordinating action and gap-filling investments that no individual firm or even industry will make; and, finally, market failures that work on the industry as well as the organization level. In this sense, the task is for economists to move beyond what Peter Schmidt calls the "fallacy of failure thinking," meaning looking at the economy through the lens of market failures, rather than the lens of complex, dynamic systems.[217]

A final reason conventional economics is a poor guide to productivity policy is that it seeks to identify theories and test hypothesis that apply for all time across all kinds of economies. In its goal to be a science akin to physics, economics overlooks the fact that any effective productivity policy will change over time and differ between nations. Indeed, any effective productive policy must be constantly evolving to respond to changes in the environment.

If short, it nations are serious about maximizing productivity growth they will reject the market fundamentalism and demand-driven paradigms in favor of a national production systems approach.

Why Do Nations Need a Productivity Policy?

To develop the most effective productivity policies, nations need to embrace a coherent conceptual and analytic framework that includes an analysis of why market forces alone will not maximize productivity. As noted, neither neoclassical nor neo-Keynesian economists believe that nations need a national productivity policy and some even argue that a productivity policy is harmful. But they are wrong. Markets alone lead to less productivity than is possible for three main reasons: public goods and public functions, externalities and enterprise failures, and system interdependency challenges.

Public Goods Help Firms Boost Productivity

In all but the least-developed economies, organizations (for-profit, nonprofit, and governmental organizations) account for the vast majority of output (in some developing economies with relatively large informal sectors, individuals account for a not insubstantial share). And organizations rely on an array of public goods—a good or service provided without profit to all members of a society—to increase their productivity.

An array of public goods can make organizations more productive. High-quality, innovative physical infrastructure can boost productivity in a variety of ways. For example, good transportation infrastructure lowers transportation costs for the shipment of goods,

raising productivity both directly in shipping functions but also allowing greater economies of scale. Similarly, when firms innovate they often rely directly or indirectly on knowledge developed from government funding. Governments also play a key role in human capital development, in large part by funding K–12 and higher education. In addition, governments play a role in technical infrastructures, including measurement and test methods, science and engineering data, and the technical specifications for the physical and especially the functional interfaces between components of modern technology systems.[218] In all of these cases, the market could provide these goods, but for an array of reasons that include transaction costs and externalities, in most cases they do not. Governments play a key supporting role in their provision instead.

As suggested, some conservatives want to significantly shrink the role of government, believing that the private sector will use the resources more efficiently. Market forces can and should be harnessed in many areas (for example, greater use by governments of road pricing and private-sector broadband provision), but evidence that markets acting alone will produce adequate quantities of public goods (for example, broadband deployment in higher-cost areas) is scant. And, in many of the cases that conservatives want to shrink government and empower markets, government still has a role. For example, even if society shifted to private schools, government would still provide school vouchers.

The neoclassical economics notion that just getting factor inputs right is clearly rebutted by studies of sectoral differences in productivity in nations.

Most conventional economists stop at the provision of public goods and reject a role for government to affect firm decisions or industry structure. But though public goods are necessary, they are not sufficient. The neoclassical notion that just getting factor inputs right is clearly rebutted by studies of sectoral differences in productivity in nations. As former head of McKinsey Global Institute Bill Lewis shows in *The Power of Productivity*, if factor conditions were the key, then differences in productivity would not be dramatic across sectors (relative to global best practice), in particular nations, because all firms have access to the same factor inputs.[219] But differences are dramatic, and account for the lion's share of productivity differences between nations. As a recent report from the McKinsey Global Institute notes, "The global competitiveness of industry sectors in countries such as Japan, Korea, and Finland vary immensely, despite the fact they all exist under the same macroeconomic policy rubric."[220] Only policies grounded in both the notion of market failures and having a deep sectoral understanding can effectively drive productivity.

Externalities and Enterprise Failures

Most economists assume that if provided with the right public goods and a free market, firms competing with each other will maximize productivity. This simplistic assumption is not true. Firms may not maximize productivity for an array of reasons.

The first is that firms cannot capture all the benefits of their productive activity, meaning they will produce less productivity than is societally optimal. One problem with neoclassical economic theory is its insistence that firms should keep investing only until their net present value rate of return equals their cost of capital. But if the actual rate of return to society is greater than to the firm, firms will stop investing before the societal rate of return equals the cost of capital. In other words, the inability of firms to capture all the benefits of its activity means that, left on their own, they will invest less in productivity-

spurring activities than is optimal. This is the key rationale for policies such as R&D tax incentives, which are designed to stimulate additional private R&D activity by increasing the private rate of return from R&D closer to the public rate of return.

Many neoclassical economists will argue that patents, copyright, and other ways in which companies can protect their discoveries from being used by others solve the appropriability problem and obviate the need for government policies like R&D tax incentives, but the reality is that not everything can be protected, and even if it could be, spillovers that keep firms from appropriating all the benefits from their innovations are significant. This is because the knowledge needed to create new products, processes, and organizational forms cannot be wholly contained within an individual firm, even when the firm patents its discoveries. It inevitably spills over to other firms and individuals, who can use it without paying the costs of creating it. For example, an entrepreneur like Michael Dell develops a new business model for building and selling computers that others copy; a university transfers discoveries from the lab to the marketplace; or a company makes a breakthrough that forms the basis of innovations that other companies can use. Such spillovers are rampant in innovation, arising from product R&D, process R&D, technology adoption, and the development of new business and organizational models.

This is why a plethora of studies have found that the rate of return to society from corporate R&D and innovation activities is at least twice the estimated returns that the company itself receives.[221] For example, Tewksbury, Crandall, and Crane examine the rate of return from twenty prominent innovations and found a median private rate of return of 27 percent but a median social rate of return of 99 percent, almost four times higher.[222] Yale economist William Nordhaus estimates that inventors capture just 4 percent of the total social gains from their innovations; the rest spill over to other companies and to society as a whole.[223]

Although some economists accept the reality of spillovers from R&D investments, few accept that of spillovers from investing in physical assets, especially capital equipment and software. However, new research suggests that companies capture only about half of the total societal return from their investment in new capital equipment. One of the earliest studies finding this was by Lawrence Summers and Brad DeLong.[224] Later studies offer similar results. Jonathan Temple finds externalities from capital investment.[225] Van Ark finds that the spillovers from investment in new capital equipment are larger than the benefits accrued by the investing firm.[226] Hitt and Tambe finds that the spillovers from firms' investments in IT are "significant and almost as large in size as the effects of their own IT investment."[227] In other words, firms capture on average only about half the total societal benefits from their investments in IT, suggesting that the current level of IT investment is significantly less than societally optimal. Xavier Sala-i Martin finds that both equipment and non-equipment investment (e.g., buildings) are strongly and positively related to growth, but that equipment investment has about four times the effect on growth as non-equipment investment.[228] Ornaghi also finds "statistically significant knowledge spillover associations for process and product innovation."[229] He asserts that these "knowledge spillovers play an important role in improving the quality of products, and to a lesser extent, in increasing the productivity of the firm."[230] At least one study finds

that firms invest more in product R&D when they invest more in process R&D, meaning that spurring process R&D also stimulates product R&D.[231] Cefis, Rosenkranz, and Weitzel observe that positive externalities in process R&D indicate relatively high technological spillovers in this type of innovation.[232]

Firms are not able to capture all the benefits from their investments in capital equipment for a number of reasons. One is that investments in new machinery give workers knowledge about these new investments and in turn transmit this information to their next employer, leading them to also invest in new machinery. Indeed, users of new equipment learn what modifications need to be made and then transfer this experience to other firms a host of ways, including interfirm labor movement, trade shows, and professional association meetings. In addition, some equipment, especially information technology, has network effects where the benefits to other firms from a firm adopting the technology are significant. As Hitt and Tambe note, "firm-level investments in communications technologies can create benefits for business partners. Alternatively, investments in information technologies can produce knowledge that can spill over between firms."[233] This is not to say that all kinds of corporate capital investment have all of these characteristics. When a company buys office furniture or a car or builds a new building, the suppliers (the makers of the furniture, car, or the building) benefit, but these do not create spillovers because the equivalent number of jobs would have been created elsewhere in the economy from other spending. But when a firm buys new equipment or software, it is not likely to capture all the benefits because other firms are able to boost their own productivity because of it.

There are a number of reasons why firms are not able to capture all the benefits from their investments in capital equipment.

Other market failures relate to the fact that many of the social and economic benefits from large-scale deployment of technology accrue not to those buying or selling products and services, but to competitors through the expansion of network benefits. One of these comes from the use of data. For example, with the Internet of Things, an application that can analyze billions of data points is more valuable to society and to an individual company than one that can tap only millions of data points. This phenomenon occurs for many networked technologies, because the value of a network rises as the number of users grows.[234] Moreover, for many connected technologies, a higher number of users will bring down prices due to economies of scale in production, but individual buyers will receive only a tiny portion of the resulting benefit.

Another firm-level market failure relates to uncertainty. Because increasing productivity often depends on adoption of an emerging but not yet fully proven technology, many potential users will disregard the benefits it promises and delay adoption until the technology is proven. Economists refer to this challenge as excess inertia or, more commonly, the *penguin effect*—in a group of hungry penguins, no individual penguin is willing to be the first to enter the water to search for food due to the risk of encountering a predator. Yet if no penguin is willing to test the waters, then the entire group risks starvation.

Another firm-level market failure relates to time. Rational firms maximize net present value profits. In other words, if a firm can earn $1 in profits this year, but $1.20 next year, the

rational firm will choose the latter because the annual return would be 20 percent. But evidence is considerable that firms increasingly, at least in the United States, invest to maximize short-term returns at the expense of higher productivity.[235] One manifestation of this is that private financing of R&D in the United States has shifted away from early stage and higher-risk research efforts.[236] Generic technology developed from earlier-stage research can produce robust returns, but it can take considerable time to show payoffs for the bottom line. In contrast, development can show quicker, albeit usually lower, returns.

Before the 1980s, many U.S. corporations made investment decisions on the basis of expectations of long-term returns. But changes in the institutional system of U.S. investing and management beginning in the 1980s under the rubric of the shareholder value movement changed that. Changes in how investment funds are structured and corporate managers rewarded has altered investment strategies. Because managers themselves became key short-term stockholders (through the significant growth of stock options), they made even more efforts to boost the welfare of short-term stockholders, including by boosting dividends and stock buybacks rather than reinvesting in plant and equipment. As the Business Roundtable reports, "The obsession with short-term results by investors, asset management firms, and corporate managers collectively leads to the unintended consequences of destroying long-term value, decreasing market efficiency, reducing investment returns, and impeding efforts to strengthen corporate governance."[237] One result is that, starting in the 1980s, companies began paying out more in dividends and engaging in stock buybacks as a way to boost stock prices for short-term investors, even though this meant relatively less investment in activities that would boost long-term innovation and productivity. As William Lazonick notes, today "a combination of innovation, redistribution, and speculation drives the stock market," and maximizing innovation often plays second fiddle.[238]

Some industries do not have strong incentives for driving productivity because of the principal-agent problem.

Another challenge for firms to maximizing productivity is that they can maximize profits from increasing revenues or reducing costs. Many companies focus less on boosting productivity and more on increasing revenues, either by getting more customers or increasing revenue per customer by selling products or services with higher margins. This can mean that for some firms and industries a large share of capital investment spend is toward activities to gain market share, rather than to cut costs. In an early 2000s study, the McKinsey Global Institute finds that a significant share of discretionary spending on technology went to customer interfaces (e.g., developing systems that keep customer data in real time, or developing customer information files) or improved decisionmaking, much of it focused on upselling to customers.[239] It finds a similar pattern in hotels where, despite increased investment in IT in the last half of the 1990s, increase in productivity was minimal. A large part of the reason, according to McKinsey, is that "hotels were focused on improving their top-line revenue and made IT investments primarily to achieve this goal."[240] And of course it is hard to see how most of the billions spent by companies on advertising boosts productivity. Rather, most, though not all, simply shifts purchases from one product to another. This focus on top-line revenues can make sense from the perspective of an individual company, but from the perspective of the economy as a whole, it is mostly a zero-sum game, companies investing solely to gain market share from their

competitors. If they all accepted their current market share and instead invested all that capital in raising productivity, economies would be more productive.

Another challenge is that some industries do not have strong incentives for driving productivity because of the principal-agent problem. This issue arises when productivity increases hurt its implementers. In such industries, workers "control the means of production" and therefore productivity is a direct threat to their jobs. Although companies such as Ford and Toyota managers might be loath to adopt managerial automation, they have strong incentives to adopt production automation because the workers do not control production. Production automation means lower prices for vehicle consumers. In many industries, however, such as legal, accounting, health care, real estate, optometry, and higher education, the same workers affected by automation are often those making decisions about automation. In these cases, increased productivity often means cannibalizing their own jobs. Why, for example, would real estate agents embrace more efficient e-realty systems that would put many of them out of work and reduce commissions for the rest due to increased agent productivity? Why should the legal industry embrace more efficient online provision of legal services when it would result in fewer lawyers practicing law? Why would professors embrace open online courses when it will mean fewer professors teaching?

Only when looking at economies as large, interrelated enterprises is it possible to get a clearer sense of these gaps that firms acting alone in markets are unlikely to fill.

Finally, in most economies, for-profit firms account for no more than two-thirds of output and even among many of these industries, such as health care and education, they are heavily influenced by government policy. Clearly, any productivity strategy has to include a strategy for improving productivity in government organizations, nonprofit organizations, and for-profit industries deeply influenced by government.

System Interdependencies and Productivity

Finally, a full set of issues relate to productivity being limited by firms acting only on their own, even if firms always acted rationally to maximize economy-wide productivity. Conventional economics is focused on firms acting in marketplaces, but this framing overlooks interdependencies that are only observable and actionable at the industry or economy level. Only when looking at economies as large, interrelated enterprises is it possible to get a clearer sense of these gaps that firms acting alone in markets are unlikely to fill.

If innovation involved nothing more than a company or entrepreneur inventing and selling something, it would be a lot easier and much more prevalent. But, all too often, successful innovation depends on others. When Apple developed the iPod, it needed customers with broadband Internet access and it needed music to be available for purchase online. Without either, the iPod would have gone the way of the Newton (an earlier, failed Apple attempt at creating a PDA). Luckily, Apple was able to coordinate music licensing and broadband Internet had been deployed to most households in the prior few years. Moreover, broadband demand increased after this, in part because of applications like the Apple iTunes store, and music firms put even more content online because people had devices like iPods.

Coordination worked in this instance, but in plenty of cases it is much more difficult. Another market failure stems from markets tending to be poor at coordinating action when multiple parties need to act together synergistically and simultaneously. These chicken-or-egg challenges must be overcome for productivity-enhancing innovation to occur in many technology platforms, such as NFC-enabled contactless mobile payments, intelligent transportation systems, health IT platforms, digital signatures and electronic IDs, and the smart electric grid. Unless government plays a facilitating role, relying on markets alone can mean significantly delayed implementation.

Take NFC-enabled mobile phones. NFC enables consumers to use their smartphones as electronic wallets, allowing individuals to make payments at subway stations, vending machines, taxis, retailers' point-of-sale devices, and many other venues simply by passing their cell phone near an NFC terminal. But mobile payments are significantly different from the classic widget industry in which a company need only to acquire the requisite inputs to manufacture its products and sell them. Contactless mobile payments are stymied by a classic chicken-or-egg problem, which is why few if any are to be found in the United States. For consumers to demand mobile phones with embedded electronic wallets—and thus, critically, for mobile network operators to require this feature from the handset manufacturers—they must be certain that a mobile payments infrastructure is in place at merchant POS terminals, at fare readers in metro subways and buses, at airports, in parking garages, in automated devices such as vending machines and parking meters, and in other venues they can use the device. Merchants, for their part, are not likely to deploy NFC-enabled payment terminals until a critical mass of users gives them confidence that their investments in such technology will be repaid. Thus, the market is stillborn unless and until, as happened in Japan and South Korea, a wide range of actors, including the mobile network operators, handset manufacturers, financial institutions including major banks and credit card issuers, commercial retailers, merchant stores, public transit authorities, and government agencies act simultaneously to develop the market.[241]

Chicken-or-egg challenges must be overcome for productivity-enhancing innovation to occur in many technology platforms.

A second problem limiting adoption of proven technologies afflicts industries with fragmented structures, such as construction and health care. The fragmentation of these industries, including many smaller firms and firms in a variety of sectors involved, hinders productivity growth and technology adoption. For example, the average building construction firms in the United States employs just six employees. These small firms often lack the incentives and capabilities to adopt new technology. And firms acting on their own in a variety of different but related industries do not necessarily engage in the coordination needed to adopt shared technology systems.

Why does the market not address these challenges? In the case of the construction industry Barry LePatner explains that the buyers are not particularly sophisticated, usually buying construction services only occasionally.[242] As a result, they have limited ability to demand quality and price efficiency. And so firms remain small. Similarly, in health care, fragmentation arises because an underdeveloped and not fully competitive marketplace results in inadequate price and quality signals for buyers. In both cases, the natural forces of innovation—market pressures leading to consolidation and scale, with more sophisticated firms adopting more technology—are underdeveloped.

Another problem relates to coordination challenges in these fragmented industries. Many technology solutions require mutual adoption and coordination for them to be effectively deployed. For example, in construction, building information modeling can help design, build, and manage buildings, but it is much less effective when only one part of the ecosystem—such as designers—adopts it. To be fully effective, all players have to adopt it because many of the benefits come from sharing functionality and information. In fragmented industries with no natural coordinator, adoption of such systems can lag significantly behind what is economically rational. This is different in other industries in which one or more very large firms (such as Wal-Mart and Amazon in retail) can use their size to go first to overcome coordination problems.

Since the rise of industrialization, this kind of system coordination has been a challenge. For example, when automobiles were first developed few paved roads had been built. Only after a certain number of autos were sold was demand strong enough that the government needed to build roads. But initially cars could be driven on dirt roads that horses used, so adoption could grow gradually in the absence of government construction. Today such coordination challenges appear to be a particular challenge because IT systems are the main drivers of productivity. They are because many of these systems exhibit network effects, where cost-effective adoption by one party depends on others adopting it as well; agreement on standards, interoperability, and information sharing is also required by all parties if widespread adoption is to be achieved.

PART III: PRODUCTIVITY POLICIES

For neoclassical economists, few market failures or other factors constrain productivity. Government's role is therefore limited to establishing the right market framework conditions, such as the rule of law, respect for property rights, creation of competitive markets, and other measures. Some go a step further and support a government role to provide inputs—such as infrastructure, education, and basic research—that organizations can take advantage of to become more productive. But virtually all the productivity policy literature stops at this point, with recommendations limited to market conditions and factor inputs. This explains why virtually all reports on productivity policy differ only in the extent to which they stress these different factors and why they provide such poor guidance to policymakers.

To be sure, the right market conditions and factor inputs are necessary conditions for productivity growth, but they are woefully inadequate for maximizing productivity. If nations are to effectively drive productivity growth, they need to go beyond conventional advice and embrace an array of policies focused on driving productivity by all organizations (large and small; business, nonprofit, and governmental), particularly polices focused on remedying market failures at the firm level and establishing the right industry and economic systems to maximize productivity. Even though few studies embrace these last two policy areas, they are the best opportunity for most nations to raise productivity. This section lays out policy steps governments need to take in five areas: framework conditions, factor inputs, organizational incentives, R&D and system productivity policies, sectoral policies, and government institutional changes.

Framework Conditions

Framework conditions refer to the overall economic system in which organizations operate. One condition includes stable fiscal and monetary policies that get the balance right between controlling inflation and supporting full employment. Nations should work to get to a place where these functions become like plumbing: They work well and are not seen. Instead, in many nations, central banks have assumed the status of wise oracle. Most policymakers and pundits are far more concerned with the latest interest rate announcements from the Fed than they are with BLS productivity data. This obsession with monetary policy explains why what passes for economic growth policy in the United States is in fact little more than business cycle stabilization policy. The United States, at least, has fallen into an unfortunate pattern of waiting with bated breath to see whether the chairperson of the Fed will tighten or loosen the money supply like an economic valve. This practice just reinforces the impression that our economic health hinges solely on demand indicators such as whether consumers binge on Black Friday. It is certainly true that providing a more stable economic environment can have a positive effect on short-term investment and consumption, but monetary policy does not change productivity growth.

Other conditions include a rule of law that market participants can trust, including the ability to enforce contracts and protect tangible and intellectual property, and regulations and processes that make it easy to start and close a business. These policies constitute the rules of the road for organizations and affect several stages in the lifecycle of an organization. As Daron Acemoglu and James Robinson write in *Why Nations Fail,* if nations cannot get factors like the rule of law and property rights correct, they will have less growth, regardless of other policies.[243]

Moreover, less-than-adequate framework conditions can lead to lower productivity because resources are poorly allocated. As an OECD report explains, "in the case of employment protection legislation, product market regulations (including barriers to entry and bankruptcy legislation) and restrictions on foreign direct investment, this is largely traceable to the worsening of allocative efficiency (i.e., a lower correspondence between a firm's size and its productivity level)."[244] These market conditions are important so that capital is not misallocated. For example, despite strong labor productivity growth in China, total factor productivity has been lower because of market conditions that lead to the inefficient use of capital. This is why Hsieh and Klenow find that Chinese aggregate TFP could increase by 30 to 50 percent and Indian TFP by 40 to 60 percent by achieving the U.S. level of allocative efficiency with their existing resources.[245] In a study of Chinese productivity, Wu writes that "China's traditional labour-intensive industries may not be as efficient as the theory of comparative advantage would imply. The explanation may be heavy involvement by local government in these industries for job creation and taxation purposes. Local protectionism and subsidies may thus have played a major role in affecting the efficiency performance in these industries."[246] At the same time, the massive subsidies have led to overcapacity, which by definition leads to lower productivity.[247]

Labor Market Regulations

Economies need not only mechanisms to enable failing or unsuccessful businesses to close so that capital can be reallocated to other opportunities, but also labor flexibility so that talent can be deployed to the most productive pursuits. As the *2013 World Development Report* explains, interindustry and intra-industry reallocation happens to a large extent through labor reallocation. As workers move from jobs in low-productivity firms to jobs in more productive firms, output increases and the economy moves closer to the efficiency frontier. Differences in productivity across organizations underlie this creative destruction process. Market imperfections and government failures may hinder labor reallocation, however, resulting in a wider dispersion of productivity and many missed opportunities for growth.[248]

The challenges that excessive labor market regulations introduce for enterprises' efforts to achieve productivity gains can be especially acute in developing nations. For example, India's 51 central and 170 state labor statutes—many of which predate independence—make it hard for firms to fire underperforming workers. As the *2013 World Development Report* states, "In India, complex and cumbersome labor market institutions have unambiguously negative effects on economic efficiency but these institutions have remained largely untouched for 60 years."[249] Other studies of India's economy show that excessive labor market regulations (e.g., India has had laws stating that manufacturing firms with more than 100 employees must technically receive approval from a government agency to affect layoffs), means that many firms remain artificially small, which hinders the overall productivity potential of Indian industry.[250]

All too often nations enact regulations to respond to a current crisis or uproar only to later realize that the regulations do little to protect the public, but do consume societal resources.

In many nations, labor market regulations limit productivity in part because they have a large negative impact on ICT investment. Van Reenen and colleagues find that labor market regulations can reduce productivity gains from ICT investment by as much as 45 percent.[251] The authors attribute one-third of this effect to how labor market regulations can slow down the entry and exit of firms: Stricter regulations can protect and preserve less productive, less technologically advanced firms.[252] Antonelli similarly finds that rigid labor markets make firms less likely to adopt new technologies.[253] Labor market regulations also reduce the flexibility of managers, preventing them from reorganizing production in more efficient ways.[254] Why buy IT to reorganize production and cut costs when regulations make it difficult to redeploy or reduce the size of the workforce?

Product Market Regulations

Poorly designed or overreaching product market regulations can also limit productivity. As an OECD report notes, "Excessive regulation of product markets is a barrier to the diffusion of technology and lowers the speed at which labour productivity catches up to the level of the best performing economies."[255] Aghion and colleagues find that liberalizing product markets is key to enhancing productivity growth in developed economies.[256] Van Reenen and his coauthors find that both product market and labor market regulations "may be significant determinants of cross-country differences in the impact of ICT," because "high levels of labour and product market regulation are associated with a lower productivity impact of ICT."[257] They also find that European product market regulations act as a productivity drag on ICT, lowering its impact by 16 percent for each dollar

invested.[258] That companies in Europe can get less bang for their buck from their ICT investment means not only that productivity is lower, but also that fewer projects meet investment hurdles, explaining in part why firms in Europe invest less in ICT than firms in the United States. These regulations include product subsidies. For example, Bridgman, Qi, and Schmitz show how regulations in place for decades in the U.S. sugar market destroyed incentives to raise productivity. The U.S. Sugar Act, passed in 1934 as part of the Depression-era restructuring of agricultural law, funded a subsidy to sugar beet farmers with a tax on downstream sugar refining.[259] Likewise, Wolfram examines the effect of electricity market reforms that occurred in many regions in the United States during the 1990s and finds that plants experienced efficiency gains after the shift in the regulatory environment.

Social Policy Regulations

Regulations designed to protect consumers can reduce productivity, even when output is properly defined to include societal outputs, such as improved health from a cleaner environment. The point is not to reduce regulation per se, but to work toward a regulatory system that better takes costs and benefits into account and focuses on optimal regulatory design.

One key area is for nations to review all major regulations to assess their costs and benefits. All too often nations enact regulations to respond to a current crisis or uproar only to later realize that the regulations do little to protect the public, but do consume societal resources. In other words, they lower productivity by consuming resources to produce outputs that have no or little value. One reason is that governments do not have to bear the cost through their budget functions. It is easier to force the private sector to pay. Moreover, many advocates for regulations believe (usually incorrectly) that corporations pay the cost of regulatory compliance, not consumers. For example, in the United States, the Gramm-Leach-Bliley privacy notices banks are required to send out every year cost $700 million annually and generate 171 million pounds of greenhouse gases.[260] Yet very few people actually read the notices before tossing them in the trash. Financial institutions could provide the same level of privacy information at a much lower cost by allowing banks to send these notices to customers only who register their email address.[261] Similarly, the European Union's regulation of Internet cookies— small text files sent from a website and stored in a user's web browser while the user is browsing that website—as part of its e-Privacy directive, costs Europeans $2.3 billion annually in both compliance costs for European website operators and productivity costs.[262] The U.S. Federal Trade Commission has expressed support for requiring the practice of data minimization for data generated by the Internet of Things—limiting the collection and retention of data so it can only fulfill specific, predefined purposes. If implemented, this would likely limit the deployment of productivity-enabling connected devices by raising the costs of providing service and limiting the value to companies selling services that rely on the Internet of Things. Governments need to carefully balance social goals, such as privacy, against negative impacts on productivity and innovation.

Competitive Markets

Another important factor is competitive domestic markets. As former McKinsey Global Institute head William Lewis argues, competitive markets provide a powerful incentive to spur firms to be productive: "Differences in competition in product markets are much more important [than differences in labor and capital markets]. Policies governing competition in product markets are as important as macroeconomic policies."[263]

For example, in a study of Great Lakes iron ore producers, James Schmitz finds that once they began to face competition from foreign iron ore producers, U.S. and Canadian iron ore industries faced a major crisis. He writes, "In response to the crisis, these industries dramatically increased productivity. Labor productivity doubled in a few years (whereas it had changed little in the preceding decade). Materials productivity increased by more than half. Capital productivity increased as well."[264] Likewise, Kalaitzandonakes and Taylor find that growers of Florida crops which faced considerable competitive pressure exhibited significant productivity growth while growers of crops that faced minimal competitive pressure generally exhibited little growth in productivity.[265]

Countries that protect entrenched, incumbent, or politically favored industries from market-based competition only damage their own country's productivity and economic growth potential.

This suggests that countries that support competitive domestic markets create the conditions for new ventures to flourish, at the same time providing established firms the incentive to continue to innovate and to boost productivity. But countries that protect entrenched, incumbent, or politically favored industries from market-based competition only damage their own productivity and economic growth potential. For competitive domestic markets to thrive, governments must resist vested interests that can organize to limit competition, whether from foreign or domestic firms, large or small.

One framework condition shaping domestic competition is a nation's openness to market-based inward direct investment (as opposed to foreign direct investment (FDI) by state-backed enterprises which is often distortionary and harmful to productivity). For example, a World Bank study of 77 developing countries over 20 years found that a country's productivity grew faster the more open the country is to trade with industrial countries.[266] Moreover, a number of studies find that firms involved in trade and investment are more productive and innovative than their purely domestic counterparts.[267] But many nations limit inward FDI, in part because of the desire to protect national champions.[268] This limits the ability of firms at the productivity frontier to take market share away from firms with lower productivity.

Domestic markets are also shaped by the extent of government involvement in the economy, particularly in the form of state-owned enterprises or state-supported enterprises (SSEs). In countries in which SSEs account for a disproportionate share of economic activity, private market-based economic activity is usually substantially distorted, particularly because SSEs enjoy advantages such as monopoly access to markets through sharply constrained (foreign and domestic) competition; public subsidies, including preferential access to free or discounted land, capital, and even labor; and exemptions from certain laws and regulations. This brings an important caveat to the point about inward FDI. Inward FDI based on market-based competition can be an important motivator for

raising productivity. But when it is backed unfairly by the state through subsidies or other favors, then the competition becomes destructive, not constructive.

In addition, governments often impose regulations that only protect incumbent industries from competition, even if the purported intent of these protections is consumer protection. For example, in the United States, states have passed laws at the behest of car dealers making it illegal for car producers to sell directly to consumers.[269] Other industries that face protection from more efficient e-commerce competition include real estate brokerage and settlement and small business benefits management.[270] Optometrists have worked with contact lens manufacturers to prevent online lens sellers from getting products. Gas station owners in Oregon and New Jersey have resisted the move to self-service gas stations. Wine wholesalers have opposed direct online sales from wineries and out-of-state retailers.[271] In California, grocery store unions and their allies have pressed for legislation to restrict self-service checkout at grocery stores.

A productivity-focused view of competition policy would recognize the importance of larger firms in driving productivity, in part through their ability to marshal resources, gain scale, and help coordinate systems.

It is also important to get competition and antitrust policy right. In some nations, especially Anglo-Saxon ones, competition policy privileges consumer welfare (e.g., lower prices) over productivity (e.g., lower costs).[272] In other nations, including many in Europe, competition policy privileges producer welfare (stable market share) over productivity. In the former case, antitrust policy sees any higher prices stemming from market power as pernicious even if the result is higher productivity. Thus, if a merger or other economic activity gives a firm market power and pricing power, competition authorities will often oppose it, even if the benefits to society from increased productivity or innovation are greater than the losses to consumers. In the latter case, competition policy is often focused on protecting firms from competition, especially foreign competitors who are often more productive. Neither approach to competition policy is likely to maximize productivity.

An approach to antitrust focused on productivity would place more weight on the impacts of actions in the marketplace on productivity and relatively less on short-term price effects, even if they distort market allocation or harm incumbent firms. As Harvard's Michael Porter argues, "Since the role of competition is to increase a nation's standard of living and long-term consumer welfare via rising productivity growth, the new standard for antitrust should be productivity growth, rather than price/cost margins or profitability."[273] This is true because, as Xavier Vives points out, under certain conditions, heightened competition (at least for a market of fixed size) can actually diminish a firm's incentive to make productivity-enhancing investments because it is starved of the revenues needed to make investments in productivity-enhancing technology.[274] Thus, a productivity-focused view of competition policy would recognize the importance of larger firms in driving productivity, in part through their ability to marshal resources, gain scale and help coordinate systems. This issue is particularly important in industries with low marginal costs and high fixed costs. In these industries, a greater market share means lower overall production costs.

In fact, many studies have shown that the relationship between productivity and competition can be modeled according to an inverted U relation, either too much or too little competition producing less innovation and productivity. One study of U.K. manufacturing firms finds this relationship.[275] Others, including Scherer and Mukoyama,

finds similar patterns.[276] In a study of U.S. manufacturing firms, Hashmi finds that too much competition led to reduced innovation in a slightly negative relationship.[277] Firms need to be able to obtain Schumpeterian profits to reinvest in innovation and productivity that is both expensive and uncertain. As University of California Berkeley economist Carl Shapiro explains, "Innovation incentives are low if ex-post competition is so intense that even successful innovators cannot earn profits sufficient to allow a reasonable risk-adjusted rate of return on their R&D cost."[278] Aghion finds that when firms are further below the technological frontier in their sector worldwide than the median, more intense competition leads to lower productivity growth. The closer a country is to the world-leading productivity level, the higher the number of above median firms, and therefore the more productivity-enhancing product market competition.[279]

Moreover, it is possible that an overemphasis on competition may limit productivity by limiting the ability of global productivity leaders to gain market share, thus boosting global productivity. An OECD study on the future of productivity points out that the gap is growing between firms at the global productivity frontier and lagging firms. [280] But the report's main focus is on how the laggards can catch up by raising their productivity. That is important, but it is also important to ensure conditions under which the leaders can acquire lagging firms and transform them into leaders or simply continue to expand and take market share from laggards. In this sense, given the growing differences between high-productivity leaders and laggards, competition policies that limit mergers or are more aggressive against large firms may hurt productivity.

Finally, a key component of competitive markets is to ensure that less-efficient firms are not artificially supported by government and hindered from downsizing or even going out of business. Many nations prop up weak firms because they do not want the economic disruption from job loss. But this approach simply keeps more productive firms from gaining market share. South Korea is a classic case in point. Because of deep societal aversion to employment disruption, the Korean government perpetuates an array of policies to limit firms from going out of business. The *2012 Global Innovation Index* ranks South Korea 120th in the cost of redundancy of dismissal of employees. Moreover, Seoul subsidizes national champions, even those that likely should have gone out of business because of a lack of productivity and competitiveness. For example, the South Korean government targeted the dynamic random access memory (DRAM) chip industry as a key industrial target, and propped up the DRAM chip producer Hynix. The firm went bankrupt and was saved twice by its creditor banks, which the government majority-owned. By not allowing a less productive firm to go out of business, South Korea's actions lowered global productivity.

Firm Size Agnosticism

One key productivity policy is firm size agnosticism. In other words, nations should eliminate policies favoring small firms over larger firms because as a class small businesses are less productive than their larger counterparts. In most nations, small firms are significantly less productive than large ones in the same industry, in part because they have fewer economies of scale when they invest in capital stock, including ICT.[281]

In the United States, workers in large firms earn 57 percent more than workers in companies with fewer than 100 workers, and large firms also injure and lay off their workers less, are more innovative, and export more. In Canada, one study reported "a positive relationship between firm size and both labour productivity and TFP is found in both the manufacturing and non-manufacturing sectors. Given this relationship, the difference in the employment distribution over firm sizes between Canada and the United States can account for half of the Canada-U.S. labour productivity gap in manufacturing."[282] In South Korea, the productivity of small and medium-sized enterprises is less than one-third that of large companies.[283]

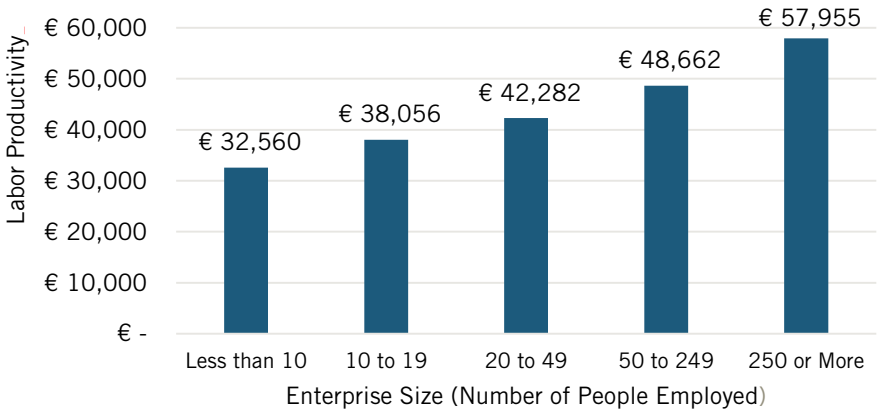
In Europe, the economies with the highest productivity—Germany, Switzerland, and the United Kingdom—have the smallest proportion of workers in small firms.[284] On the other hand, those with the lowest productivity, such as Greece, have the highest percentage of small firms in Europe. As figure 13 shows, the relationship between enterprise size and productivity in Europe is clear.[285]

In many developing nations with a large informal sector, the productivity gap is even larger between large incorporated firms and small, informal ones. As a World Bank report explains, informality provides "unfair advantage to noncompliant firms, thereby distorting the allocation of resources."[286] The development organization Women in Informal Employment: Globalizing and Organizing notes that the "informal workforce reduces productivity and thereby diminishes economic growth."[287] The McKinsey Global Institute finds that "One reason for Mexico's weak productivity growth overall is that more than half of non-agricultural workers are employed in the informal sector; indeed, informality is growing due to the high regulatory cost of establishing a formal business and lax enforcement."[288] Likewise, McKinsey finds that in Mexico just 0.5 percent of employees in the banking sector work for large firms that generate half of the industry's value added.[289] Employees in Mexico's traditional neighborhood bakeries and small-scale tortilla factories have at best one-50th the productivity of the best-in-class large bakeries and one-20th the productivity of the average industrial bakery. Lagakos finds that modern retailing accounts for 67 percent of total employment in the retail sector in the United States, but just 23 percent in Mexico, 21 percent for Brazil, 19 percent in Thailand, and 15 percent in El Salvador and the Philippines, and that the labor productivity of modern retailers is three times higher than that of informal retailers in Brazil, four times higher in El Salvador, three and a half times higher in Mexico, six times higher in the Philippines, and four times higher in Thailand.[290] Reducing informality in developing nations would be a key driver of productivity.

Many nations have a widespread belief that small businesses deserve special treatment because they purportedly create more jobs (they do not) or are the foundation of a democratic system (they are not). For example, economic policy in India has been heavily influenced by this thinking, and particularly by the work of development economists such as E.F. Schumacher, the author of the influential book *Small Is Beautiful: Economics as if Peopled Mattered*. As Schumacher explains, "The task in every case is to find an intermediate technology (which will be labor-intensive and will lend itself to use in small-scale establishments) which obtains to a fair level of productivity without having to resort

to the purchase of expensive or sophisticated equipment."[291] Embracing this small is beautiful mentality, India's government passed laws limiting the size of certain enterprises, largely in the quixotic goal of creating jobs.[292] Thus, in the 1970s, Indira Gandhi reserved approximately 800 industries for the small-scale sector. In these 800 industries, only small firms were allowed to compete. Investment in plant and machinery in any individual unit producing these items could not exceed $250,000. For example, pencil makers could grow no larger than 50 employees, which resulted in India having one of the world's most inefficient pencil industries, meaning that few Indians could even afford to buy a pencil. India did not succeed in creating jobs; they did succeed in perpetuating poverty.

Figure 13: EU Labor Productivity by Size of Enterprise (2012)



Many nations have a widespread belief that small businesses deserve special treatment because they purportedly create more jobs (they do not) or are the foundation of a democratic system (they are not).

Not all countries have taken the small as beautiful message to heart as much as India has, but virtually all at least believe that small is pretty attractive. It is common in Europe for policymakers to defend preferential policies for small business, arguing in a circular way that because such a large share of workers is employed in small business that Europe has no option but to protect and promote small business. In the United States, ever since the work of researcher David Birch, who found in the early 1980s that small establishments (but not small enterprises) created more jobs than their share in economy, small business has been in vogue, elected officials of both parties singing its praises.

The reality is that, for most nations, shifting more output to larger firms away from small or micro ones would boost productivity. The problem is that most nations have policies that protect and favor small businesses that result in their producing a larger share of output than would otherwise be the case. For example, Hsieh and Klenow find that in India and China, small manufacturers have a significantly larger share of the market than they should if the goal was to maximize productivity.[293] They argue, "it is harder for a more productive firm to grow but also easier for a less productive firm to survive in India than in the United States. Thus, the creative destruction process operates more efficiently in the United States."[294] The OECD finds something similar when it states, "Unfortunately, in some economies, even though the most advanced firms can have productivity levels close to the global frontier, their aggregate impact is muted to the extent that they are under-sized. This suggests that there is much to be gained by reforms that make it easier for productive firms to attract the resources required to underpin their growth."[295]

Small Business Cronyism: Policies Favoring Small Business

Two areas of policy need to be rolled back in this context: special benefits to small business and discriminatory policies that place tax and regulatory burdens only on large businesses. The former policies, unless carefully targeted to potential high-growth *gazelle firms*, simply keep the share of the economy produced by small businesses larger than it otherwise would be.[296] The latter policies not only slow the growth of larger firms, they also slow the growth of smaller firms that do not want to lose their special protections that come from being small if they get bigger than the threshold.

Most nations have policies to make it easier for small firms to secure capital. For example, South Korea requires banks to funnel large amounts of investment into small firms, resulting in an overabundance of debt among small firms. In addition, public financial institutions—such as the U.S. Small Business Administration and the Korea Finance Corporation and the Small and Medium Business Corporation—provide loans or loan guarantees directly to small firms. The international development community has placed significant emphasis on financing for microbusinesses, which has the result of slowing productivity growth by perpetuating small firm size structure.[297]

Most governments also have special small business set-asides for government procurement. For example, the Obama administration has even set a goal of giving 23 percent of prime federal contracts to small businesses. The U.S. federal government favors small broadband carriers in programs such as the Broadband Technology Opportunities Program grant program and in the Federal Communications Commission's Office of Communications Business Opportunities. South Korea goes even further, having not only government set-asides, but also a National Commission on Corporate Partnership (NCCP) charged with "leveling the playing field" between large businesses and small and medium enterprises (SMEs). It annually issues a "win-win scorecard" on how large businesses can "co-exist" with SMEs designed to shame large corporations that fail "to promote shared growth with small partner firms."[298]

In many countries, small businesses pay lower fees for government services than large companies, even though it costs the same to provide them. For example, in the United States, small businesses pay a lower application fee applying for a patent. In South Korea, the NCCP reached an agreement with the Small and Medium Business Administration to get TV Home Shopping networks to agree to not only sell more products from SMEs but also to not charge them commissions and for the government to subsidize the costs for improving design and packaging for the selected small companies.

Most governments exempt small businesses from many regulations. France, for example, has a number of laws that apply only to businesses with 50 or more employees, and this provides an incentive for firms to stay under the 50-worker threshold.[299] Garicano, Le Large, and Van Reenen find that this labor law keeps French firms from getting bigger and the negative effect on total factor productivity can be as large as 5 percent of GDP.[300] In the United States, the Small Business Administration's Office of Advocacy is dedicated to ensuring that the Regulatory Flexibility Act—which is designed to exempt small businesses from many of the regulatory requirements large ones face—is enforced.

Many countries protect small-scale enterprises through barriers to competitive entry, zoning laws, and restrictions on the size of stores. For example, Argentina has put in place an array of policies to favor small, less productive grocery stores.[301] For instance, small stores can sell products whose void date has expired, but larger firms are forced to donate food to grassroots neighborhood associations. It can take four years to obtain a permit for a large grocery store, and regulations limit the size of stores and the maximum number of stores any one firm can operate in an area. Buenos Aires even has zoning laws that ban larger stores. Furthermore, only in the larger stores does the government impose price controls on food and limit imports of certain items. Sunday work must be paid overtime in many large stores and some regions even require hardship pay increases for working in large stores. The same dynamic is in Brazil.[302] In Japan, laws limiting the entry of large supermarkets and providing incentives for small retailers to stay in business explain the country's high share of family retailers, and their low productivity. France, India, Korea, and even some U.S. localities have likewise handicapped the most effective companies in their retail sectors.

To boost productivity, governments should embrace firm-size agnosticism in all policies.

Many nations tax small businesses at lower rates and provide greater tax incentives. In most nations, corporate income is taxed twice (at the corporate level and again at the individual level when capital gains and dividends are paid). In addition, many have lower corporate tax rates for small corporations. In the United States, the corporate tax rate on the first $50,000 of income is 15 percent, and on revenue above $18,333,333 it is 35 percent. Small corporations with less than $5 million in receipts are exempt from the corporate alternative minimum tax. In South Korea, small companies pay a 10 percent corporate tax and large ones 22 percent. It is routine for the U.S. Congress when passing special bonus depreciation rules to limit them to small business. Likewise, in South Korea only small firms are eligible for a 5 percent tax credit for "industrial equipment or advanced office equipment."

Some countries even pass rules that protect small businesses from competition from larger firms. South Korea passed a ruling that medium-sized restaurant companies cannot open new stores within 150 meters from small eateries that earn less than 48 million *won* ($42,800) in annual revenue. The NCCP even goes so far as to "designate suitable industries for SMEs" when large business participation is limited. In the United States, some local governments have passed rules making it hard for more productive big-box retail stores from opening.

In some nations, competition authorities include a mandate to create a "competitive environment" for small and medium-sized enterprises. Some governments simply tell large retailers they may not sell at a discount, as France has done for Amazon.com. India prohibited Wal-Mart from selling directly to consumers; they could only sell to retailers who then resold their items. The Korea Fair Trade Commission uses competition policy to protect small and medium-sized enterprises.

Although well intentioned, these programs and policies prop up small firms that would otherwise lose market share to more efficient and innovative medium-size or larger businesses or even fast-growing small firms. They also provide a perverse incentive for firms

to not grow, for getting bigger means an end to the special treatment. France, for example, has a number of laws that apply only to businesses with 50 or more employees, which as noted provides an incentive for firms to stay under the 50-worker threshold.[303]

To boost productivity, governments should embrace firm-size agnosticism in all policies. To be clear, size agnosticism is different from age agnosticism. To the extent that a focus is on small firms, it should be on not just new ones, but also new ones that can scale to become larger firms. In other words, policy should support the creation and growth of innovative opportunity-seeking startups. This is important because new, high-growth firms are a key driver of economic evolution and productivity, much more so than new firms in general.[304] For example, Guzman and Stern find in the United States no relationship between regional GDP growth and number of new firms, but a strong one between GDP and the number of high-growth entrepreneurial startups.[305]

Being size agnostic means dramatically scaling back programs, including lending programs, targeted at small business and eliminating the regulatory and tax exceptions provided to small business. Governments should end small business set-asides for procurement. To be sure, procurement processes should be streamlined and easy for all firms to comply with, but they should not favor small businesses. If governments impose regulations, such as mandatory health-care coverage or required notice to workers being laid off, they should require that all firms, not just large ones, comply.

Those working in the development field need to recognize that informality is a drag on productivity growth, not a progressive force.

In developing nations, governments should work to reduce the size of the informal sector. They could start by replacing the term *informal* with the accurate term the *illegal economy*, for in these nations individuals are breaking the law by not registering their businesses and paying taxes. As a World Bank report explains, "this type of activity allows employers, paid employees, and the self-employed to increase their take-home earnings or reduce their costs by evading taxation and social contributions."[306] In addition, those working in the development field need to recognize that informality is a drag on productivity growth, not a progressive force.[307]

In addition, nations should undertake to reduce informality by making it easier for informal businesses to comply with regulations while increasing efforts to enforce existing laws. As the OECD finds, "there is a highly statistically significant correlation between a country's overall performance on the [World Bank] Doing Business indicators and the size of its informal economy; a worse environment for doing business correlates with a larger informal economy."[308] Moreover, it is not enough to make it easy for businesses to be legal; nations must also strengthen enforcement against individuals operating unlicensed businesses. This means cracking down on the informal economy and requiring all "firms" to pay taxes and comply with the same rules and regulations facing the formal economy. Many informal companies could easily become formal but choose not to. For example, the McKinsey Global Institute estimates that an informal player in Brazil that underreports sales and employee costs by 30 percent thereby improves net margins more than twofold.[309] Moreover, McKinsey finds that it is not just traditional corner stores that evade taxes and put larger, more productive players at a competitive disadvantage. A number of informal

regional retail chains, in some cases, run very sophisticated software that enables them to keep double accounts to facilitate tax evasion.

Small business defenders will protest that a level playing field is unfair because small firms do not have the resources large corporations have. But this is precisely the point. One reason they do not have resources is that they are less productive. Markets, not governments, should determine firm size structure. Defenders will also complain that ending small business protection will kill jobs. It will, at least in some small firms that cannot compete without government help. But it will not result in fewer jobs overall because larger, more productive firms will take their place, creating jobs and also lowering prices so consumers have more money to spend, creating jobs in other sectors.

A Pro-Productivity Culture

A final component of supportive framework conditions is culture and a set of attitudes supportive of productivity. Economies where support for raising productivity is widespread will be able to be more successful than societies where productivity is viewed with skepticism or fear.

Some nations that do not go as far as to actively support featherbedding still have a negative view of productivity, seeing it as too disruptive to existing jobs or simply not worth the trouble.

Although most economies grow in productivity, the pace and nature differs. As Daron Acemoglu and James Robinson write in *Why Nations Fail*, some economies are organized to limit growth.[310] Sometimes this is because incumbent interests are committed to rent-seeking, extractionist behavior and want to limit any evolutionary threats to that. One artisan guild in 18th-century Prussia went so far as to issue an ordinance laying down that no artisan "shall conceive, invent, or use anything new."[311] In other cases, the underlying culture is inimical to experimentation and freedom, on which evolution depends. As technology historian Joel Mokyr argues, "in every society there are stabilizing forces that protect the status quo. Some of these forces protect entrenched vested interests that might incur losses if innovations were introduced, others are simply do not-rock-the-boat kinds of forces. Technological creativity needs to overcome these forces."[312] Schumpeter agrees: "The resistance which comes from interests threatened by an innovation in the productive process is not likely to die out as long as the capitalist order persists."[313]

Specifically, with respect to productivity, in some nations suspicion of productivity is widespread and support is active for *featherbedding*, the practice of intentionally employing more workers than are needed to do the job. In the United States, featherbedding was once a serious problem, one well supported by many public intellectuals as not only good for workers but also not damaging to productivity.[314] For example, a 1966 *Challenge* article asserted, "For the marvel of genuine featherbedding is that it actually creates nothing except a job."[315] By and large, elite support for featherbedding in America is no longer common. However, support remains widespread in many developing nations, and is commonly justified on the grounds that nations need featherbedding because they need jobs.

This overmanning is rife in developing economies. After a trip to China I wrote,

> Everywhere I looked, what's done in the United States by one or two workers, was done in China by a multitude of workers. Our hotel's front desk

> was staffed with 7 or 8 clerks, although I never saw more than 2 or 3 guests there. At the pool, 3 workers staffed the cabana, although this being December I only saw one hearty guest braving the unheated pool. At a nearby park, 7 government workers were huddled together to weld one chain. At a local deli, 3 people handled paying for the sandwiches. One to put your sandwich in a bag, another to take your money, and a third to put money in the register and hand your change back to the second person. The examples could go on and on. All this is why, despite industrialization, output per Chinese worker is just 14 percent of U.S. levels.[316]

Some nations that do not go as far as to actively support featherbedding still have a negative view of productivity, seeing it as too disruptive to existing jobs or simply not worth the trouble. For example, the government of Kenya's national productivity strategy acknowledges that:

> Across the work force, in both the private and public sector, productivity culture is characterized by poor work ethics as manifested by lack of time management as well as waste of other resources. In this regard, the majority of the Kenyan population including public and private sector organizations is hardly conscious of the need to understand and appreciate the norms of productivity parameters. Efforts towards inculcating a productivity mindset have been initiated through the performance contracting initiatives albeit with resistance widely encountered. In many organizations, the concept is being equated with contemporary exploitive management practices which is untrue.[317]

Still other nations are neutral toward productivity, neither embracing nor exercising active policies against it. Finally, a very few nations, such as Scandinavian countries, are generally characterized by active support for higher productivity and the policies to support it. In these nations, innovations to boost productivity are generally welcome and organizations that increase productivity are praised, not criticized.

Labor unions also influence attitudes in behaviors toward productivity. Some research suggests that in unionized industries unions can play a role in helping boost productivity, especially by supporting skill upgrades. But numerous other examples cite unions as being able to pressure employers or others into reducing efforts to automate. As Crafts writes, union "bargaining practices in the United Kingdom tended in the 1970s to retard and dilute the gains from the introduction of new technology."[318] In the United States, many industrial unions have seen new technology as a threat. In the early part of the 2000s, for example, the United Auto Workers special bargaining convention set an agenda that called for income protections, including from layoffs associated with new technology or productivity improvements. Unions successfully pressured the U.S. Agriculture Department to cut funding for research at the University of California Davis for tomato-harvest automation.[319] The United Food and Commercial Workers has fought against stores installing automation, because, as one union official explains, "We don't like self-checkout scanners because they put cashiers out of work."[320]

To be sure, some of this union opposition to productivity depends on the overall social support systems in nations. For example, in Sweden, which has a strong employment safety net, unions are more supportive, as a Swedish labor union leader recently said, "Swedish unions don't fear new technology; we fear old technology."[321] For they know that if the companies they work for do not continually modernize, union members may lose their jobs because of reduced global competitiveness. So they are willing to risk having their companies restructure work through new technology because they know that the loss of any particular job is not catastrophic.

Cultural attitudes to productivity can also change over time. The U.S culture has likely devolved, moving from one in the first half of the 20th century that enthusiastically embraced productivity, seeing it as a force for progress not only because it saved people from backbreaking work but because it was seen as the future, to one now that is at best neutral toward it, with a large share of elites viewing productivity as a negative force for its purported impact on jobs. In 1964, only about 20 percent of Americans thought that automation was a major part of the reason for unemployment. By 2013, that number had increased to 30 percent.[322] A 2015 Monmouth poll about artificial intelligence finds that "72% of the public believe having machines with the ability to think for themselves would hurt jobs and the economy, among the most negative responses in the history of polling on the effect of technology on employment."[323] This is not just at the mass level, it is reflected in the views of elites. For example, a recent open letter on technology signed by various academics and business leaders argues that it is important to "identifying business models in which technology is a complement to—not a substitute for—labor and creating a taxonomy of their common characteristics."[324] Likewise, productivity may be becoming less popular over time in Canada. One study notes that "Environic's quarterly Focus Canada poll of 2,000 Canadians found that the number of Canadians who agreed that increasing productivity is 'very important' decreased by 18.4 percentage points between 1985 and 2005."[325]

One result of this is that many public officials are now loath to even mention the word productivity for fear that they will be accused of not being sensitive to the workers who might lose their jobs. As Don Drummond argues:

> Public aversion to the concept of productivity is so intense that government officials dare not refer to it by name: ... Canadian governments react to the public's misunderstanding, even fear of productivity, by borrowing a concept from Harry Potter. Just as Lord Voldemort must be referred to as "He-Who-Must-Not-Be-Named" or the "Dark Lord" so must "productivity" be globally replaced by "innovation" or "competitiveness."[326]

Those terms are now seen as politically safer than the more charged word *productivity*. Likewise, a U.K. CEO writes, "policy has been preoccupied with maximizing employment, often at the expense of productive investment."[327] To support productivity advance and productivity policies, it will be critical for elites and elected officials to embrace productivity growth while telling a more accurate and optimistic story about productivity:

how it is central to increasing living standards and how it does not increase unemployment rates.

Supporting Factor Inputs

Organizations not only need the right market framework conditions to enable them and provide the incentive to increase productivity, they also need the right external factor inputs, including physical and digital infrastructures, a skilled workforce, and scientific research output.

Infrastructure

Well-developed infrastructure reduces the effect of distance between regions, integrating markets both domestically and globally. In addition, the quality and extensiveness of infrastructure networks significantly impact productivity.[328] In developing nations, a well-developed transport and communications infrastructure network is a prerequisite for less-developed communities to be able to access core economic activities and services. Broadband telecommunications infrastructure is also important, but in lower-income nations where most people cannot afford Internet access, the focus should be on business connectivity and use in order to boost productivity. Only after businesses raise productivity and incomes rise will larger numbers of people be able to afford to use the Internet. In more-developed nations with more widely built out infrastructures, the challenges are threefold: ensuring that infrastructure expands to meet expanded demands, ensuring that as infrastructure ages it is adequately maintained, and ensuring as we develop advanced information technologies that physical infrastructure incorporates digital technologies to become hybrid infrastructure.

As a general principle, nations should embrace public–private partnerships and user-pricing to build and pay for infrastructure. Information technology has dramatically reduced payment transaction costs, allowing for user fees to be more easily applied to transportation infrastructure, including roads, ports, and airports. In addition, pricing should be used to better allocate use of infrastructure, whether it is congestion pricing on roads or auctioning of gate slots at airports. At the same time, governments should ensure that they are investing enough in public infrastructure and modernizing government-related infrastructures, like air traffic control systems. For utility infrastructure often provided by the private sector (e.g., gas and oil pipelines, electricity, broadband, and others), the key is to ensure that the regulatory system encourages upgrading infrastructure when necessary. For example, public utility commissions should allow electric utilities to build into the rate base the costs of moving to a smart electric grid. For broadband, the role of government is to not reduce incentives for investment through overly rigid regulations while providing funding for the deployment of broadband to moderately high-cost regions and ensuring adequate availability of radio spectrum.[329]

An Educated and Skilled Workforce

Although technology (both development and deployment) is a much more important driver of productivity, a workforce with strong general education and specific skills that fit existing and emerging needs of organizations is important.[330] Skill deficiencies create a vicious circle whereby firms are unable to hire the workers they need with higher-level

vocational and university skills to innovate, and individuals are resistant to investing in their own skills development because the market has too little demand for higher skills. This dilemma is known as the *low-skill equilibrium*.[331]

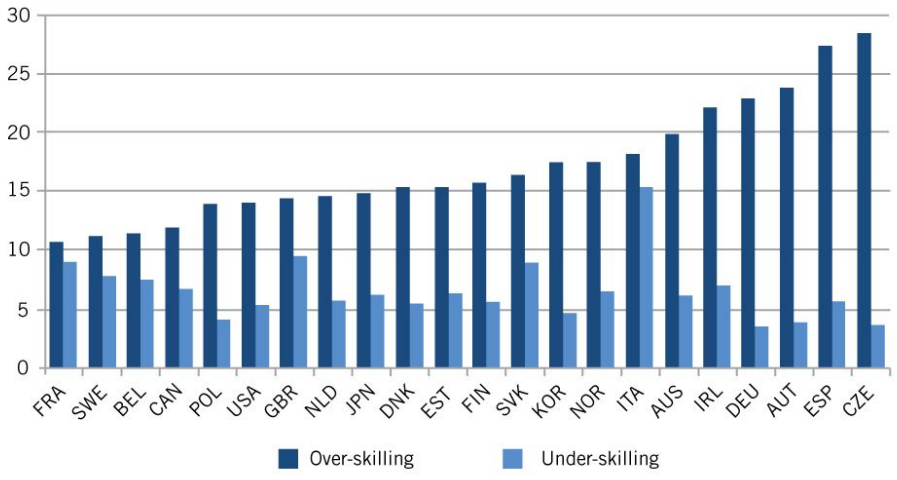
However, more education is not necessarily a panacea. Overskilling, where individuals obtain more education than they actually need to perform a job, can be a problem. As an OECD report notes, the correlation between overskilling and productivity is strongly negative, and overskilling is on average roughly two and a half times more widespread than underskilling.[332] According to the European Commission, the number of adult employees who report that they are overskilled (have higher skills than are required to perform their current job) is quite high, particularly in some nations. In fact, almost 40 percent of European adults are overskilled, with even higher shares in service and sales occupations (see figure 14).[333]

This all has several implications. The first is that any skills and education policy needs to be carefully tailored not just to the needs of the national economy but also to sectors. Some evidence indicates that the impact of education and training on productivity differs by how advanced the economy is and how close to the global technological frontier. Aghion and Cette find that higher education, especially graduate education, enhances productivity growth more in countries with higher per-capita GDP and that technical training plays a stronger role in middle- and lower-income nations.[334]

To support productivity advance and productivity policies, it will be critical for elites and elected officials to tell a more accurate and optimistic story about productivity.

Second, any skills upgrade program is not enough on its own. Skills and technology upgrades need to be done concurrently in order to overcome the low-skill equilibrium trap. The German economy appears to do this successfully with its well-developed apprenticeship system, coupled with industry-technology support systems, such as the Fraunhofer Institutes.

Figure 14: Percentage of Workers Overskilled or Underskilled



Third, employers should be deeply engaged in any technical skills efforts, including through workforce apprenticeship programs, industry-led regional skills alliances,[335] and incentives for private-sector investment in skills such as workforce training tax credits.

Fourth, nations, particularly more-developed ones, need to develop science and engineering-based skills, in part through expanding specialty math and science high schools, supporting new ways of structuring science, technology, engineering, and mathematics (STEM) programs in colleges and expanding STEM graduate fellowships.[336]

Fifth, much of the focus on education policy is on expanding access, but more needs to be placed on quality. At least in the United States evidence is disturbing that the quality of higher education is inadequate. For example, one study finds that among college seniors in their last semester just 34, 38, and 40 percent were proficient in prose, document, and quantitative literacy, respectively.[337] As the report from the Secretary of Education's Commission on the Future of Higher Education, better known as the Spellings Commission, noted in 2006, "There are ... disturbing signs that many students who do earn degrees have not actually mastered the reading, writing, and thinking skills we expect of college graduates. Over the past decade, literacy among college graduates has actually declined."[338] Because it has, nations need to ensure that policies provide incentives to improve educational quality.

Finally, nations need to focus not just on education for innovation, but innovation in education, including encouraging alternative forms of K–12 pedagogy such as project-based learning, increased use of big data to improve and customize education, and a new business model of higher education to separate education from credentialing so that new forms of education like massively open online courses can gain market share.[339] The increased use of electronic learning, whether through innovations like the Khan Academy or free MOOCs from institutions such as MIT could play a breakthrough role in developing nations. As David Weil writes,

> In the case of educational technology, those of us living in countries with plenty of highly trained teachers and a well-functioning system for traditional education delivery can view technology as a marginally useful addition to the teaching toolkit. Our children can use the Khan Academy website to supplement instruction from their well-qualified math teacher. Once again, we might not think that people in poor countries will have the money for such a fun convenience. But in developing countries, where such service delivery is absent, and where the human capital of teachers is exceedingly scarce, technology may well represent a way to leapfrog the old form of delivery almost entirely.[340]

Management Capabilities

One component of a skilled workforce is a cadre of high-quality managers. Bloom and Van Reenen find that higher-quality management practices are correlated with several measures of productivity, including labor productivity and total factor productivity.[341] They also find that managerial quality differs considerably by nation—that American management

quality is better overall than that of many other nations across a range of management quality indicators.[342]

Better management skills and practices are one reason U.S. firms appear to have gained more from ICT than firms in many other nations, where managers have been less willing or able to reengineer business processes around the use of ICT. Such restructuring is crucial in getting the full productivity benefits from ICT. This theory is strongly supported by recent evidence by Bloom, Sadun, and Van Reenen, who examine differences in management techniques between U.S. and European firms both operating in Europe.[343] U.S. firms are considerably more likely to have management practices that enable organizational changes that harness the benefits of ICT, and the authors attribute nearly half of the U.S.-EU productivity differential between 1995 and 2005 to this organizational capital. Such differences are obviously more difficult to influence through public policy than regulation and taxes, but governments can work to ensure that university MBA programs are high quality and that students are able to attend the best MBA programs in the world.

Nations need to focus not just on education for innovation, but innovation in education.

Scientific and Engineering Research Funding

Economists have long found that R&D spending, including government support, drives productivity growth.[344] Indeed, the 21st-century economy grows not because we do more of the same, but because we do things differently and better, and this requires generating and applying knowledge. Scholarly research clearly shows that government support for scientific research is a complement rather than a substitute for private-sector research.[345] That is why a recent ITIF study notes that federal government funding for research supported 22 major innovations.[346] A recent study of 15 OECD nations finds that that a 1 percent increase in R&D spending expands economic growth by 0.61 percent. An OECD study finds that investment in knowledge-based capital, including R&D, drives productivity.[347] This means that governments should adequately support scientific and engineering research, including at research universities, as well as support policies to help transfer discoveries from the lab to the market.[348]

Organizational Incentives

Productivity grows when organizations and the systems they are embedded in produce more with fewer inputs. Having the right market conditions and factor inputs is important, but because of a number of market failures discussed earlier, absent specific incentives for organizations to invest in the factors driving productivity increase, productivity growth will trail what is possible.

Productivity increases stem from a variety of factors, but the principal one is producers and consumers using better tools. In most economies today, the tools that are most effective in raising productivity are ICT-based, including computer hardware, software, high-speed data networks, and tools that incorporate all three of those components, such as computer-aided manufacturing systems and self-service kiosks. Businesses, nonprofit organizations, and governments use these tools to improve their internal operations and to conduct transactions with other organizations. This is happening in every sector in every economy, from farming to manufacturing to services to government.

Therefore, an effective productivity policy focuses on increasing capital investment by organizations, particularly in machinery, equipment, and software. As a general rule, anything that lowers the cost of capital equipment relative to the cost of labor will increase the substitution of technology for labor and as such will increase productivity. Thus policies that increase the price of labor and reduce the cost of capital equipment will spur investment in new tools.

Increased Labor Costs

When the price of labor is high, the return on investment from investing in labor-saving technology is higher. Often referred to as the Webb effect, the theory is that a higher wage floor leads to higher levels of efficiency.[349] It explains, not surprisingly, why countries with higher wages are generally more likely to adopt labor-saving technology. Indeed, one study on the effects of the minimum wage on employment concludes that "if the federal government raises the minimum wage, employers in some sectors may expedite the adoption of automated equipment and new technology to increase labor productivity."[350] Daron Acemoglu finds that in the absence of minimum wage legislation, the labor market in the United States is inefficiently biased toward low-wage jobs.[351] Therefore, a reasonably set minimum wage indexed to inflation helps make it more economical for organizations to substitute capital for labor. This effect is likely with other policies that do not exempt employers from costs, such as providing health insurance.

Absent specific incentives for organizations to invest in the factors driving productivity increase, productivity growth will lag what is possible.

Some will argue that this will lead to fewer jobs, but as described this stance is fallacious. The feedback effects from the higher wages for the remaining workers and lower prices mean job creation in other sectors. Most economists argue that a higher minimum wage reduces employment, but in asserting so make the same mistake they accuse others of in regard to robots killing jobs: They fall prey to the lump of labor fallacy. It may very well be that a minimum wage priced so high that it is a significant jump in wages would have negative employment impacts. But most minimum wage proposals, at least in the United States, represent modest increases (less than 50 percent). At this level, fewer jobs may be available in occupations that see a wage increase, in part because of productivity effects and in part because of demand effects, but the higher income of the remaining workers is not buried under a mattress. They spend it and in so doing create other jobs in other industries and occupations.

The same is true with respect to low-wage immigration. Greater numbers of low-wage workers reduce capital intensity as it becomes easier for employers to substitute workers for machines. As a report by the Migration Policy Institute asserts, "production techniques shift in response to less-educated immigrant labor, with employers less likely to substitute capital and/or technology for less-educated labor when more immigrants are available."[352] Likewise, economist Harry Holzer acknowledges with regard to low-skill immigration that "While this might reduce productivity growth within industries, it also means that many more low-skilled jobs are now available to immigrants as would likely exist in their absence, as they would be replaced by capital and technology."[353] Napasintuwong and Emerson estimate that limits on low-wage immigration to the United States would stimulate the adoption of additional available labor-saving technology with an increased substitution of capital for labor.[354] Assuming less low-skill immigration leading to a hypothetical 10

percent increase in the wage rate, their estimates suggest an 18 percent increase in the capital-to-labor ratio. By contrast, an even less restrictive policy in the United States toward lower-skill foreign workers would reduce the incentives for adopting new technology, in turn reducing the extent of substitution of capital for labor.[355] As ITIF has shown, high skilled immigration, particularly STEM-based immigration, boosts productivity and innovation.[356]

Reduced Capital Equipment and Software Costs

Investment in new capital equipment (machinery, equipment, software, computers, etc.) is a major path by which productivity grows. For this reason, public policies should focus on spurring additional investment in capital equipment by minimizing government-imposed costs while using the tax code to reduce the after-tax cost of capital equipment.

Reduce Taxes and Tariffs on Capital Equipment

Policies that raise costs of capital equipment, especially ICT capital, lead to reduced capital equipment adoption, in turn reducing productivity growth. For every 1 percent increase in the costs of ICT goods and services, investment falls by between 0.2 to 1.4 percent, depending on the nation.[357] Unfortunately, of 125 nations ITIF examined, 46 impose an additional cost on business purchases of ICT goods and services of more than 5 percent through tariffs or discriminatory taxes. Nations should minimize, if not eliminate, taxes and tariffs on capital goods, including ICT broadband telecommunications, computers, and related equipment. In addition, a range of other policies raise the price of—or compel the use of inferior—capital goods, such as ICTs. These can include mandatory domestic consumption rules (e.g., requirements to include domestic software in smartphones sold), forced offsets for selling to a country, and local production as a condition of market access. When these restrictive policies are applied to capital goods, they artificially raise the price of those goods.

Policies that reduce the after-tax cost of capital goods, such as accelerated depreciation or investment tax credits, will increase the number of investable projects.

Provide Tax Incentives for Capital Equipment Purchases

Although eliminating policies that artificially raise the price of capital goods is important, so are policies that reduce their after-tax cost. Policies that reduce the after-tax cost of capital goods, such as accelerated depreciation or investment tax credits, will increase the number of investable projects.

Many nations have put in place or expanded tax incentives designed to spur investment, including in plant and equipment. For example, Taiwan's Statute for Upgrading Industries provides a package of corporate tax incentives including accelerated depreciation and tax credits for investments in R&D, automation, worker training, pollution controls, and investments in newly emerging important and strategic industries. Companies can also take a credit of up to 20 percent of funds invested in hardware, software, or technology that can promote an enterprise's "digital information efficiency." The tax credit for investing in automation cost the government NT$7.8 billion (US$268 million), but it also spurred growth that led to an increase in overall tax revenues of NT$13.3 billion (US$458 million).[358] Many other nations also have business tax incentives for investment, including Austria, where firms can receive a tax credit of 6 percent on the costs of educating and training their workforce; Malaysia, where companies can depreciate general plant and equipment over six years, with heavy machinery over four years, and computer and IT

equipment even faster; and Canada, where purchases of computers are eligible for a 55 percent declining-balance capital cost allocation rate in the first year.[359] Singapore is particularly noteworthy because firms there can expense in the first year all computers and prescribed automation equipment, including robots.[360] Japan introduced a "tax reform outline to stimulate private-sector investment" that included tax incentives to promote capital expenditure on productivity-enhancing equipment.

Some conventional economists argue that tax incentives are justified only for investments in areas, such as R&D, where companies seldom capture all the benefits. However, as noted, evidence is considerable that because ICT transforms organizations and leads to innovations within other organizations, it operates in the same way as research, characterized by high spillovers that other organizations may take advantage of. The socially optimal amount of investment will therefore lag behind actual investment.

This is why research has shown that an investment tax credit does spur more investment in new machinery, equipment, and software. As noted, Summers and Auerbach find that an investment tax "credit will spur investment in equipment."[361] Likewise, in the article "The Determinants of Investment," former U.S. Federal Reserve Bank Chair Ben Bernanke observes that "a one percentage point increase in the investment tax credit raises net equipment investment 1.9 percent… in the first year."[362]

Reform Equity Markets and Corporate Governance

Another factor affecting investment in productivity-improving machinery and equipment is corporate governance. At least in the United States, evidence suggests that equity market pressures and other distortions lead firms to invest less in capital expenditures in an effort to boost short-term equity values. For example, in a 2004 survey of more than 400 U.S. executives, more than 50 percent said they would delay new investment projects in order to meet short-term earnings targets, even if it meant sacrifices in value creation.[363] A McKinsey Quarterly survey of more than 1,000 board members and C-suite executives around the world finds that 63 percent of respondents said the pressure to demonstrate short-term financial performance had increased over the previous five years, but 86 percent believed that using a longer time horizon to make business decisions would positively affect corporate performance.[364] A 2013 study by Asker, Farre-Mensa, and Ljungqvist finds that public firms invested substantially less than privately held firms in terms of capital expenditures and mergers and acquisitions.[365] A study by Ladika and Sautner shows "that executives with more short-term incentives spend less on long-term investment."[366] Likewise, a study by the UK Investment Association on how productivity depends on long-term investment finds "evidence that the post-crisis system is not well structured to facilitate long-term investment approaches and the provision of growth capital."[367] As Andrew Smithers writes,

> Modern incentive structures encourage managements to push up profits in the short-term at the expense of exposing their companies to greater long-term risks. This has led them to push up profit margins and reduce investment. But the fall in the cost of capital has not, as would previously have been expected, stimulated investment. This is because the perceived cost of capital to management has risen not fallen, because it is in the interests of

> management to spend on buy-backs rather than on new investment. As analysts' attention to RoE has increased, the speed with which equipment has been scrapped is thus likely to have risen.[368]

MIT's Clay Christenson writes that one way to increase return on net assets (a common financial reporting measure) is to reduce net assets.[369] Therefore, any national productivity policy needs to include measures to counter corporate short-termism. Policymakers should seriously consider a proposal from the Institute of Corporate Directors to replace quarterly financial reports with a less frequent update, such as half-year results.[370]

R&D and System Productivity Policies

If nations are to maximize productivity, governments need national productivity policies that go beyond market conditions, factor conditions, and firm incentives for tool adoption. They need to focus on policies to support innovations that boost productivity (e.g., R&D on robotics) and widespread deployment of system tools (e.g., technology platforms).

If nations are to maximize productivity, governments need national productivity policies that go beyond market conditions, factor conditions, and firm incentives for tool adoption.

Productivity-Focused Platform Policies

So far this analysis has focused on market conditions and firm actions, largely the focus of most economists. But any effective national productivity policy needs wider horizons grounded in a vision of the economy as a complex enterprise that underperforms without a national productivity policy. When viewed this way, it is clear that firms acting alone, even if supported by factor inputs and incentives to buy better tools, will fail to capitalize on and overlook some opportunities to be found in the gaps between firms and industries.

A key gap relates to platforms. If the only productivity tools were individual tools that each organization could buy or not buy, the productivity challenge would be much easier: Help organizations invest in and use tools effectively. But the problem is that many tools are shared by multiple organizations and cannot be effectively used without interfirm and interindustry coordination. These tools are platforms that many organizations, sometimes in multiple industries, rely on for productivity. Platforms can be powerful drivers of productivity because they represent shared tools that both buyers and sellers can use to increase efficiency.

A good example is the credit card system. Credit cards are a key tool for enabling commerce. Yet, for credit cards to work, three things need to happen. First, organizations have to agree to accept a credit card transaction in lieu of cash. Second, consumers need to use them. Third, a process by which the merchant is paid and the consumer pays needs to be in place. And for these to be truly effective they need to be able to be used nationally, and even globally. The first credit card was developed in New York in the mid-1940s, but purchases could only be made locally and the customer had to have an account at the bank issuing the card. Even with the emergence of the Diners Club card in the early 1950s, the full credit card platform was still not developed because these were still *closed loop* systems that limited their scope of use. It was not until the mid-1960s when the Bank of America franchised the BankAmericard brand (later to be known as Visa) to banks nationwide that the new open loop system took off, many more merchants accepting the card and many more customers carrying it.

Today most platforms are ICT-based and include things like smart grids, mobile payments, digital signatures, the Internet of Things, health IT systems, and others. Most of these platforms rely on underlying IT infrastructure systems, including computers and smartphones, the Internet, and wired and wireless broadband networks. Once these underlying infrastructures are in place, platforms can emerge on top and play a key role in enabling productivity.

But to work, platforms need the three things just described: Buyers to acquire the tool. Sellers need to acquire it. And a third-party intermediary to manage or coordinate the system. These factors can cause all sorts of market failures because success often depends on chicken-or-egg dynamics under which both users and sellers act concurrently.

A good example is electronic IDs. Electronic IDs are a system of technologies and policies that enable individuals to electronically prove their identity or an attribute about their identity to an information system. One key part of the electronic ID system are digital signatures. Digital signatures use a technique known as asymmetric cryptography that requires two components: a private key for the sender to use to sign a document and a public key for the receiver to use to verify the signature. The keys are generated by a certificate authority, a trusted third party as a private company or the government. Certificate authorities issue digital certificates that contain these public keys, along with information about owners and the cryptographic protocols used. The certificate is signed by the issuing certificate authority and is valid only for a specified date range. The public key of a certificate authority is typically distributed in software packages, such as web browsers. A public key infrastructure defines the set of certificate authorities for digital signatures and the trust relationships between the various certificate authorities.

Digital signatures can be a valuable tool to increase efficiency as people can prove their identity without having to appear in person or submit notarized documents. A nationwide system of electronic IDs would support applications such as age verification for retailers at kiosks and help prevent fraudulent transactions. Electronic IDs would also enable more secure e-commerce and give consumers more control over sensitive information, such as their online electronic health records

But, like so many platform technologies, electronic IDs suffer a chicken-or-egg problem. Few people will use them if no counterparties will accept them. Few organizations requiring identification will switch to them if few of their customers have them. Finally, to work effectively a single technology needs to be in place, not multiple ones. Few people will want to have to get four or five digital signatures to deal with all the standards from the organizations accepting digital signatures.

We see similar dynamics with regard to many other platform technologies, such as the Internet of Things, health IT, intelligent transportation systems, mobile payments, and deep learning systems.[371] In some advanced countries, for example, consumers use their phones as multifunctional electronic wallets to pay public transit or taxi fares; to make purchases from merchants, restaurants, convenience stores, and automated devices; and to check in at airports, hotels, and schools, as well as a host of other functions.

Government roles regarding platforms must be based first on pragmatic analysis. Each case needs to be examined afresh. But often good platform policy involves government being a lead adopter. For example, the U.S. government could provide digital signature capabilities for individuals getting a passport. It can adopt mobile payment systems for their own payment processes. It can take the lead on electronic medical records for the Defense Department and the Veterans Affairs. It can fund smart cities and intelligent transportation projects.

Scientific and Engineering Research Policy for Productivity

In the medium to long term, the most important factor in driving productivity will be technological innovation that makes it easier to replace workers with machines, that increases the lifetimes of products while reducing waste, and that reduces social and human dysfunction so that more people are able to work and society spends less on coping with dysfunction.

The greatest driver of economic progress since the industrial revolution has been the development of technology to either replace or augment workers. This will be true for the next century as well. The possibilities are endless: robots that could replace janitors and restaurant waiters; artificial-intelligence systems that could replace knowledge jobs such as insurance agents and accountants; and autonomous vehicles to replace taxi drivers and truck drivers.

Few governments have designed their scientific research programs explicitly around advancing technologies to drive productivity.

The challenge is that few governments have designed their scientific research programs explicitly around advancing technologies to drive productivity. Instead, they follow the advice of neoclassical economists that governments should not pick particular technology areas and should focus on curiosity-directed basic science. Moreover, governments often shy away from productivity-focused R&D for fear of public opposition to automation. This is one reason the U.S. National Robotics Initiative, run by the National Science Foundation, focuses only on robotic technology that complements rather than replaces workers. By limiting their research funding in this way, they slow the development of robotic technologies that can significantly boost productivity.

In summary, if economies are to maximize productivity growth, they need to craft technology research agendas specifically around productivity. This should involve conducting a formal assessment of the scientific research areas most likely to support productivity and then significantly increasing funding in these areas so researchers can apply for funds to develop technologies that could make major improvements in productivity.

One area that probably does not deserve extensive focus is green technology, or clean energy. Many argue that green technology is the next major general purpose technology that will power the next wave of growth.[372] But they usually make this claim with little evidence or logical argument. By definition, a GPT is a major driver of productivity growth across a wide array of industries and functions. The biggest impact of the clean energy transformation, though, if humanity can achieve it, is to substitute one form or energy for another. At best this might result in modest reduction in energy costs, but because energy costs are small share of total costs in an economy, the productivity benefits are likely to be

minimal at best. This is not to say that societies should not seek deep decarbonization of the global economy through clean energy to address climate change. They should simply not be under any illusion that it is an important driver of productivity growth.

More Productive Tools

Rather, nations should develop national research roadmaps for key automation technologies and the technologies underlying those technologies, such as semiconductors, and invest significant funds for their advancement.

One key technology will be robotics. Improving productivity in many functions and industries involving the movement of atoms will not be possible without much better robotic technology. To be sure, robots are already driving productivity.[373] Their potential is still limited, however, by functionality constraints and cost considerations. Robots could be developed to pick up litter and clean streets and parks, however. Robots could deliver food in restaurants and room service in hotels. Robots could operate fork lifts in warehouses. Given this potential, nations should commit to significantly increase funding going to robotics research. Related to robotics is artificial intelligence, which also will be critical to future productivity improvements, especially in knowledge-based work. AI is already helping doctors diagnose diseases using tools such as IBM's Watson. In the future, AI could replace at least some of the work of personal assistants (e.g., scheduling) and automate a range of tasks, such as insurance underwriting.

A related technology that will reduce the need for services is AVs. ITIF estimates that if the United States vehicle fleet were autonomous, savings would total $1 trillion annually, in large part from the reduction in accidents (less medical care, less car repair, and so on).[374] Although the private sector will do much of the development work here, governments can and should provide funding for earlier-stage research on AV technology.

A host of other technologies could also boost productivity. For example, one university recently developed low-cost electric snow-melting concrete that could significantly reduce the costs involved in cities of plowing streets, airports, and other facilities.[375] A Japanese firm has developed a fully automated lettuce farm that will reduce labor costs by 50 percent, cut energy use by 30 percent, and recycle 98 percent of water needed to grow the crop.[376] Governments need to focus on identifying and funding many more research and engineering projects that are specifically targeted to developing technology that can replace human labor.

Better Materials and Drugs

A second area of needed research is into areas where the application of the technology would reduce the need for expenditures, in part by improving the functional life of materials. For example, it is hard to imagine how technology could significantly improve the productivity of house painters or barbers, despite the automated haircut machines envisioned in the 1960s TV show *The Jetsons*. But it is possible to imagine innovations that would reduce the need for these services. If scientific research could develop paint that lasted not 10 or 15 years, but 50 or 100 years, housepainters' productivity would stay the same, but the labor society needs to allocate to house painting would fall dramatically. The same is true for materials such as road surfaces, roofing shingles, and other materials that

wear out and must be replaced. Likewise, rust has been estimated to cost the U.S. economy $400 billion per year.[377] Innovations that enabled significantly slower metal corrosion would boost productivity. Likewise, self-healing concrete could save billions of dollars in road repair costs.[378] Much of this innovation will come from advances in nanotechnology, including nanomaterials such as graphene.

Biological innovations also hold great promise for reducing the need for services or preventing wasted goods. Imagine a biotechnology compound that could be developed that would radically slow the growth of hair follicles. People would be able to go to the barber perhaps once a decade, instead of once every 6 weeks. Applications to teeth that would dramatically reduce tooth decay would significantly reduce the need for dentistry services. Slow-growing grass would reduce the need for lawn mowing services. Gene-editing techniques such as the CRISPR method, which has been approved to prevent mushrooms from browning, will help reduce food waste.

Governments need to focus on identifying and funding many more research and engineering projects that are specifically targeted to developing technology that can replace human labor.

In addition, a growing share of output in most developed societies is for health care, in part as societies age, but also as health-care productivity grows more slowly than overall productivity. For example, the financial impact of Alzheimer's disease is expected to soar to $1 trillion per year by 2050 in the United States.[379] According to the Milken Institute, the most common chronic diseases are costing the U.S. economy more than $1 trillion annually, and potentially $6 trillion by 2050. A report by the World Economic Forum and the Harvard School of Public Health concludes that in 2030 cancer will cost the world $458 billion, cardiovascular disease $1.04 trillion, chronic obstructive pulmonary disease $4.8 trillion, and diabetes $745 billion.[380] One study points out that seven chronic health conditions led to lost economic output of $1 trillion per year, including lost work days and lower output while working.[381]

Therefore, health-care innovations that reduce the need for medical care will boost productivity, save on costs from disease, and improve labor force participation rates. Some of these will be in nonbiological areas, such as health IT, that will reduce information processing costs; robotics, which could reduce the cost of caring for the elderly in nursing homes; or the emergence of autonomous vehicles, which could enable the elderly to live more independently. Continued innovation in drug therapies will likely play a critical role.[382]

Other innovations could boost productivity by reducing the need for health expenditures. For example, significant reductions in health-care spending depend on improvements in people's lifestyles. Half of U.S. deaths are estimated to arise from lifestyle choices, including smoking, drug use, alcohol use, unhealthy diets, and limited physical activity.[383] This means that health policy that changes people's behaviors in favor of healthier lifestyles will need to be a major part of a national productivity policy. For example, taxes on sugar content of foods and elimination of subsidies for sugar production could reduce consumption of foods leading to obesity.

Social Policy to Support Productivity

Although many of the advancements in productivity will be driven by better technology, a growing part of most economies—social services—is less likely to be affected positively This does not mean, though, that productivity policy should not focus on it.

Mental illness is one part of the social services economy that imposes large costs on the economy. Indeed, a significant share of spending on social services, education, and criminal justice is related to treating (or incarcerating) individuals with mental health problems. The social costs from this are massive, and include reduced workplace productivity, increased security and public safety costs (e.g., police, courts, prisons, private security workers, home and building security systems, etc.) and direct expenditures on the individuals (e.g., social workers, welfare, etc.).[384] A report by the World Economic Forum and the Harvard School of Public Health concludes that mental illness will cost societies $6.0 trillion by 2030.[385] These figures do not include all the secondary costs from mental illness, including those for the criminal justice system and private security. Some mental illnesses and more broadly social dysfunction is biological, and increased innovation to address and treat the causes (e.g., autism, psychosis, bipolarity, etc.) could yield significant direct and indirect cost reductions.

Most social services spending is spent on addressing the problems after they occur (e.g., drug treatment, community mental health facilities, etc.) and much less on prevention. Indeed, a very large share of individual dysfunction appears to stem from inadequate or damaging parenting (e.g., emotional and physical abuse and neglect).[386] These impacts include not just mental illness per se, but psychological problems and social disorders stemming from individuals having grown up with inadequate parenting. Perhaps biomedical innovations could help treat people after such damage is done, akin to how bad memories are erased in the movie *Eternal Sunshine of the Spotless Mind*. Regardless of whether such innovations emerge, any national productivity strategy needs to have a core component focused on improving the quality of parenting. Many nations, especially the United States, have long had an ethic that child rearing is largely a private matter as long as the parents do not engage in sexual abuse or overt and sustained physical abuse or neglect. This is coupled with an ethos that children have few rights and are not innately deserving of respect. That a number of U.S. states still legally allow corporal punishment in public schools is evidence of this attitude. Advanced societies no longer condone violence against women, but most have a different view when it comes to children.

The result is that for many families, especially those beset by other difficulties, providing quality parenting can be a challenge. All too often, children without good, nurturing parenting end up with problems and needs that later require societal resources to address, even if the resources are prisons. This situation suggests that any national productivity policy needs to focus on reducing bad or inadequate parenting, including providing paid parental leave; more generous tax credits for stay-at-home parents of preschoolers so that parents can spend more time taking care of their preschool children instead of placing them in long hours of nonfamily care; significant investments in parenting education including mandatory parenting classes if parents want to avail themselves of the child tax credit; making it illegal to hit children, including in schools; and providing more active

intervention to help at-risk families.[387] The United Kingdom is leading the way here, Prime Minister Cameron calling on all new parents to enroll in government-backed parenting classes that would help parents learn to be more effective parents.[388]

Sectoral Policies for Productivity

Neoclassical economics assumes that all industries are alike in that they all seek to and can effectively maximize productivity, arguing that sectoral productivity policies are not needed because all industries respond adequately to market forces. In fact, productivity policy cannot be fully effective unless it is grounded in a sophisticated understanding that industries differ significantly with regard to their productivity dynamics. To counter the immediate howls of "picking winners," and "industrial policy," it should be clear that sectoral productivity strategies are about analyzing how opportunities and constraints regarding productivity differ by industry and understanding what policy can do to improve the productivity of all industries.

Industry Typologies

Productivity policy cannot be fully effective unless it is grounded in a sophisticated understanding that industries differ significantly with regard to their productivity dynamics.

Any sectoral productivity policy needs to start with an industry typology. Three key factors differentiate industries when it comes to considering productivity policy.

Scale

Industries differ in terms of average firm size. For example, the average U.S. automobile manufacturing firm employs 450 workers, and the average construction firm just 8.[389] This matters because industries with larger firm size are generally more productive. Thus, as noted, policy should not favor small business and competition policy should not ignore the benefits of scale.

Competition

Industries differ in the extent to which they face competition. This has less to do with industry concentration ratios and more to do with the ability of consumers to make informed and demanding choices and with the actual structure of the industry. For example, health care and higher education appear to have less motivation to increase productivity in part because consumers cannot accurately assess quality and seldom pay full costs. In some industries, competitive forces from new entrants and new business models is blunted because incumbent industries are able to limit competition. New car dealers, for example, have succeeded in getting laws passed in the United States prohibiting car makers from selling directly to consumers. Likewise, taxi companies in a number of cities and nations have fought to leverage government to protect them from competition from companies such as Uber.[390] All else equal, policymakers should attempt to provide consumers with more information to make better choices, and to limit the ability of incumbents to stifle entry.

Incentives

The third factor is intensity of incentives for an industry to increase productivity. For-profit industries where the firm is controlled by a professional manager (or owner) have considerable incentives to raise productivity. Managers are rewarded for boosting productivity. But in some industries where the workers have more control over production decisions, such as law, medicine, real estate, and higher education, managers have less

incentive to boost productivity. In these industries, higher productivity means fewer professionals. The same can be true in some unionized sectors, such as ports, where unionized workers have fought automation.

It is difficult for policymakers to change the structure of industries, but they can limit the ability of these industries to use their market or political power to limit the entry of new, more efficient players. For example, pushing back against efforts by the real estate industry to limit online real estate companies to emerge will help boost real estate productivity. Moving to a world where it is easier for students to take massively open online courses as a substitute for in-person courses in college will boost higher education productivity. Allowing online provision of a wide array of goods and services, including law, contact lens sales, and others will boost industry productivity.

Table 2: Industry Structure Framework With Example Industries

		Atomized Industry Structure	Industries with Scale
Robust Competitive Forces	Managerial Control	Dry Cleaning	Computers
	"Worker" Control	Used car dealers	Motor Vehicles
Weak Competitive Forces	Managerial Control	Construction	Government
	Worker Control	Real Estate	Legal Services

Sectoral Analysis and Sectoral Policies

An effective national productivity policy needs to be based on an analysis of individual industries and when appropriate broader production systems. Industries include firms in the same industry. Systems are broader and go beyond any particular industry. For example, the construction industry involves firms that actually build things. But the construction system is broader, including providers of materials inputs (e.g., sawmills), designers (e.g., architects), and builders (e.g., carpenters, welders, etc.) and even building owners. Economies are composed of a wide array of systems, including transportation systems, information systems, transaction systems, health systems, and others.

To understand how such an analysis might work, consider the construction system. The U.S. construction industry accounts for about 4.5 percent of GDP, but the construction system (lumber and wood products, architecture services, real estate sales, etc.) is much larger.

Over the last 40 years, U.S. construction industry productivity actually declined.[391] Many aspects of the industry limit productivity improvement. First, the industry lacks scale. According to the National Academy of Sciences, in 2009, 98 percent of U.S. construction firms had fewer than 100 workers and employed 79 percent of construction workers. In part because

of that lack of scale, the industry invests little in research and development, about 1/25th the rate of the broader manufacturing sector.[392] Not only are firms small, they are also generally not horizontally integrated: different firms deal with different aspects of the system (design, planning, development, engineering, construction management, construction operations, and within construction even more subspecialization). This makes developing and deploying shared tools difficult. For example, much of the industry involves communication among designers, contractors, suppliers, and construction workers. Often costs and delays are added as construction managers wait for crews or for materials or supplies that are sometimes stored in the wrong place. A National Academy of Sciences report cites "25 to 50 percent waste in coordinating labor and in managing, moving, and installing materials."[393] Another study finds that "interoperability, the goal of which is to seamlessly integrate systems capable of exchanging and interpreting data among members of the design and construction teams, causes losses of between $15.6 and $36 billion per year."[394] However, emerging technologies such as the Internet of Things could play a key role by enabling everyone in the industry to know where everything is at any time.

An effective national productivity policy needs to be based on an analysis of individual industries and when appropriate broader production systems.

Because these inefficiencies occur at the industry and system level, as opposed to just the firm level, however, the market is at best a weak mechanism to address these issues. As one study notes, "Once the industry begins to recognize how everyone in the process pays a price for permitting incomplete and uncoordinated design documents, we can start to address the imminence of how new technology will bring greater efficiency and profitability to the entire industry."[395] Taking full advantage of these technologies, though, would require interoperable standards and overcoming chicken-or-egg issues. Why, for example, would construction managers and workers have devices like wireless tablets if no materials can be kept track of electronically?

Second, the industry has relatively weak incentives to improve productivity, in part because customers tend to be relatively unsophisticated, buying buildings only infrequently. As Barry LaPatner writes in *Broken Buildings, Busted Budgets*,

> Contractors have every incentive to bid low on a project to get the job. Because the business is highly competitive at the bid stage, most firms know that their low bid will not return an adequate profit. But after a contractor is awarded a contract, the situation changes radically. The contractor then becomes a monopolist, who will attempt to recoup through change orders the profits denied it by the bid process. This explains the pervasiveness of mutable-cost (open-ended) contracts. Owners realize that, even with a seemingly straightforward fixed-price contract, once they are embroiled in construction, they have few good options but to pay up in order to keep the project moving ahead so as not to incur even greater delays and costs. The industry is caught in this unvirtuous cycle.[396]

Finally, there is significant variation in building codes, permitting processes, and construction-related regulations, usually at the state and local level. This variation makes it difficult to develop products and solutions that can gain national scale, including more use of prefabrication.

But this is not Baumol's string quartet industry where productivity gains are difficult. In fact, opportunities for productivity improvements that firms are not now taking advantage of appear to be ample. The National Academies of Sciences identifies five key areas for improvement, including widespread deployment and use of interoperable technology applications; improved job-site efficiency through more effective interfacing of people, processes, materials, equipment, and information; greater use of prefabrication, preassembly, modularization, and off-site fabrication techniques and processes; innovative, widespread use of demonstration installations; and effective performance measurement to drive efficiency and support innovation.[397] Indeed, given advances in IT, the industry is ripe for transformation. It is easy to imagine a system whereby architectural plans are prepared on computer-aided design software, sent to various factories where the parts are made with automated machines and partially assembled, shipped to site in a just in time basis, and assembled with workers using highly automated equipment.

Without a construction system productivity agenda, however, system productivity will lag potential productivity. Government can play a key role in helping construction system productivity to increase with three main policy approaches: public procurement to drive competition and change, supporting precompetitive industry R&D, and streamlining and aligning regulation.

In the United States, no national government entity has the mission to examine and to work to improve construction system productivity.

Any construction productivity effort should start with a national construction productivity strategy. For example, in response to anemic productivity growth in the industry, the United Kingdom established its Government Construction Strategy in May 2011.[398] In the United States, no national government entity has the mission to examine and work to improve construction system productivity. If the National Institute of Standards and Technology were given a new, more proactive mission, as well as funding to support it, it could play this role.

Public Procurement

In many nations, government is the largest purchaser of construction services. Because it is, how government buys services can help move the industry in particular directions. For example, the United Kingdom and the European Union have developed a public procurement directive that requires the use of building information management software. Among other things, the U.K. construction strategy report announced the government's intention to require: collaborative 3D BIM (with all project and asset information, documentation, and data being electronic) on its projects by 2016. BIM has been shown to help integrate operations and boost efficiency. About two-thirds of surveyed contractors stated that BIM had improved labor productivity, one-third of those saying that productivity increased by 25 percent.[399]

But procurement can also help in another way—to help drive more competition, and, by extension, scale. As LePatner notes:

> The industry relies so heavily on change orders and cost overruns it has little incentive to boost productivity. If governments engaged in contracts that had strong fixed price bids, it would not only provide stronger incentives for firms to boost productivity in order to meet bid requirements, it would likely lead

to consolidations as smaller firms would face too much risk of going over price and having to bear the costs themselves.[400]

Even large corporate construction buyers are generally not sophisticated buyers, one of the key drivers of industry competitiveness in Michael Porter's famous diamond. However, national governments have tremendous power to shape the future of the industry by being demanding buyers. Earthquake resilience is a good example. The U.S. National Institute of Standards and Technology came up with earthquake standards for buildings but few contractors used them until the federal government required it in its procurement policies. It then became a de facto industry standard. At the same time, cross-sectoral business organizations, such as the Business Roundtable in the United States, could organize a coalition of large corporate purchasers of construction services and have them commit to using standardized procurement policies to drive change.

Supporting Precompetitive R&D

In part because of the small average firm size, the construction industry engages in little R&D. Yet an array of R&D areas, if pursued, could significantly boost productivity. One solution is to support industry-cooperative research institutes. For example, South Korea established the Institute of Construction Technology, which employs more than 600 people. This may be one reason that, South Korean construction industry productivity growth in the 2000s was 10 times higher than its U.S. counterpart. Europe has funded its construction technology platform that includes more than 600 partners from industry (including IT) and government.[401] The Research Council of Norway has implemented a construction productivity and technology program.[402] Governments can also support construction research more directly. For example, in the United States, the National Science Foundation could establish a construction-oriented Engineering Research Center. Likewise, the National Institute of Standards and Technology could be given increased funding to expand its construction laboratory efforts.

In the United States, the issue of precompetitive R&D in the construction industry has been recognized and discussed for more than half a century. In the 1960s, the Johnson administration proposed a civilian technology program, in which one focus was construction, but Congress never provided adequate funds. In 1986, the National Research Council study on construction productivity proposed federal government actions to promote increased efficiency in construction, but nothing happened. In 1995, a White House National Science and Technology Council study proposed targeted funding for research into construction and building, but again nothing happened. In 2009, the National Academies of Science issued the report "Advancing Competitiveness and Efficiency of the U.S. Construction Industry," and yet again nothing happened. The industry did form Fiatech as a cooperative research organization (modeled in part after the late 1980s government-industry consortium Sematech for the semiconductor industry) and developed an industry roadmap that sets out a goal: "The future environment is one where information is available on demand, wherever and whenever it is needed to all interested stakeholders. Such an integrated environment could enable all project partners and project functions to interconnect—instantly and securely—all operations and systems."[403] The lack of a recognized need for a national productivity strategy, much less one with a sectoral focus, has meant that none of these construction R&D efforts has really come to fruition,

and why, without federal government funding, Fiatech has worked on a shoestring. The U.S. federal government should expand its National Network of Manufacturing Innovation program to include construction and let firms support and cofund an institute.

Aligning Regulation

One challenge for improving construction productivity is standardization to enable more scale economies. One barrier in many nations is the lack of national construction standards. National governments could make funding for construction projects (e.g., housing and infrastructure) contingent on states and localities adopting nationally uniform building codes and related regulations.

The construction system is not the only one burdened with significant structural flaws that limit productivity improvement. Health care, transportation, higher education, and financial services are just a few of the others that face similar challenges and where national sector-based productivity strategies could play important roles.

An array of opportunities exist, many through the application of IT, for governments to boost productivity.

Finally, it is worth spending a moment on financial services. For many years, the consensus view was that a large financial services industry was a driver of growth, even when the evidence showed the opposite. An OECD report on the sources of economic growth, written before the Great Recession, indicates that "The link between private credit provided to the private sector and growth has the wrong sign, but the banking credit indicator is not independent from other monetary variables, being strongly related to money supply and demand conditions."[404] A more recent study from the Bank of International Settlements explains that financial sector growth comes at the expense of productivity growth. The authors suggest that this is "a consequence of the fact that financial sector growth benefits disproportionately high collateral/low productivity projects. This mechanism reflects the fact that periods of high financial sector growth often coincide with the strong development in sectors like construction, where returns on projects are relatively easy to pledge as collateral but productivity (growth) is relatively low."[405] Another reason is that an overly large financial sector attracts skilled workers who could be more productively employed in technology-based sectors. In essence, an oversized financial sector can drain resources (financial and talent) from the real economy, lowering productivity. A national productivity policy needs to not leave the size of the financial sector up to market forces but should intervene strategically to limit excess, rent-seeking activity. One useful step, for example, would be to end the mortgage interest deduction, which creates a perverse incentive to put money into 401(k) accounts rather than to pay off mortgages early.

Productivity Policy for Government

In most economies, governments themselves account for a significant share of output. In the United States, federal, state and local governments together make up 13 percent of national output.[406] In most other developed nations, the share is even higher. Despite issues regarding data availability, it appears that governments lag in productivity growth for at least four main reasons. First, few governments adequately measure productivity benefits and therefore underappreciate its value. Second, the budgeting process in many governments cannot adequately support investments with longer-term productivity payoffs. Third, governments often resist downsizing. Top managers are often unwilling to discuss

replacing those in the state labor force with technology alternatives for fear that it will generate opposition. This is why few governments explicitly target headcount reduction through e-government or reward their employees or agencies for cutting costs and increasing their productivity. Finally, agencies often lack incentives to boost productivity. Unlike the private sector, which can keep its entire bottom-line savings, public-sector agencies that cut costs and save money are usually rewarded with smaller budgets. If employees believe that they will receive no reward or acknowledgment for improving the efficiency in their daily work, why would they bother to change anything?

But an array of opportunities exist, many through the application of IT, for governments to boost productivity. For example, ITIF estimated that U.S. state governments could save as much as $11 billion over the next five years if they aggressively used IT to cut costs.[407] One way is to boost IT-enabled self-service options. Government offers many opportunities to use self-service technology to improve efficiency, cut costs, and provide better service to its citizens. Fewer than 50 percent of citizens who apply for benefits from the Social Security Administration do so online, for example. Likewise, not all post offices have installed self-serve kiosks and the U.S. Postal Service has not done enough to encourage customers to use them. State motor vehicle departments could install kiosks that let customers do much of the work, avoiding the chronically long waits that plague most DMVs.

The single most important step governments can take to boost productivity is to make higher productivity the principal goal of economic policy, more important than managing the business cycle, defending liberty, or promoting equality.

To that end, governments should adopt IT-enabled productivity strategies with the explicit goal of being able to cut headcount while producing the same or higher level of services. Some cities have already done this, but more need to do so.[408] Governments should also reward citizens who use low-cost self-service options. For example, a parking ticket that is paid online should be priced lower than one paid in person.

Governments simply are slow to adopt more productive technologies in an array of other potential opportunities. Case in point is automated trash collection. Technology has existed for more than a decade that allow a single driver to drive a waste collection truck and have the truck automatically empty curbside trash cans, not only saving considerably on labor but also significantly improving the safety of sanitation workers. Despite these benefits, though, few U.S. municipalities have adopted the technology.[409]

As part of this approach, federal governments should adopt a productivity services challenge program to fund pilot programs by lower levels of government to boost productivity. For example, the strategic plan developed by the Danish Agency for Digitization provides funding focused on automation of public administrative procedures. National governments should also establish subnational government productivity institutes that examine key functions for solutions to boosting productivity and identify best practices from around the world and then support them for deployment nationally. Local waste collection productivity differs dramatically between best practice and average practice, for example. Fully automated collection is demonstrated as three times more efficient than average collection, but few places use it.[410] Absent national government leadership and incentives, subnational governments will lag in adopting productivity advancing technologies.

Governments could take a number of steps to reduce services in ways that would do little to reduce quality. For example, in 2016 a penny is worth what a dime was in 1950, but the U.S. Mint still produces pennies.[411] The federal government loses money from minting pennies and nickels; it will cost about $1.1 billion over the next decade to continue to provide them. This figure does not include the costs to the private sector of handling coins. Simply stopping minting pennies and gradually pulling them out circulation would boost productivity.

Likewise, in most nations, the mail is delivered six days a week, even though with the widespread use of email, most residential mail is advertising mail. Cutting back to delivery three days a week would cut costs with little effect on value, but would reduce inputs. The same is true with many areas of regulation where government rules require excess output. In the United States, most states require citizens to renew driver's licenses every five years, and the costs involve not just the money drivers pay but the time they must spend at overcrowded motor vehicle departments. The term could be extended to every 10 or even 15 years for people younger than 50 given that the odds of their driving skills deteriorating is quite low. Similarly, most states require annual renewal of auto registrations. Again, doing so every three or four years is another potential avenue for efficiency. Similarly, requiring air emissions inspections every two years for relatively new vehicles produces little benefit relative to the costs involved.

Government Institutional Changes

It is one thing to identify the kinds of policies nations can adopt to drive productivity growth. It is another to build the institutional competence and political will to develop and implement the right policies. To that end, the single most important step governments can take to boost productivity is to make higher productivity the principal goal of economic policy, more important than managing the business cycle, defending liberty, or promoting equality. This may become more challenging because there is a growing movement to reject GDP as a measure or goal and replace it with vague goals such as happiness, inequality, and sustainable development.[412] This would be a grave mistake, because productivity is the key driver of income growth.

In the United States this would be an important step, for productivity is largely absent from the missions of the major economic policy institutions. The mission of the U.S. Department of Commerce does not include productivity, instead focusing on promoting "job creation, economic growth, sustainable development, and improved standards of living for Americans."[413] The department comprises "12 bureaus that work together to drive progress in four business facing key goal areas," none of which mention productivity. Likewise, the Federal Reserve Board lists as its mission conducting the nation's monetary policy, supervising and regulating banking institutions, maintaining the stability of the financial system, and providing financial services to depository institutions. But no mention of productivity. The White House National Economic Policy Council makes no mention of productivity in its description. The President's Council of Economic Advisers only occasionally writes about productivity and when it does it is from a clearly neoclassical orientation:

> When private actors face incentives that lead them to optimal investments in growth-enhancing technologies, government policy should be to not interfere. But at other times, a light touch from government is needed to align incentives or to act in place of incentives that are missing: in the form of conducting of its own research; or of subsidization of private research; or through appropriate intellectual property rights laws, regulation, and enforcement.[414]

Legislatures should require that their nation's major economic policy bodies have as a core part of their mission advancing productivity.

This is not enough, however. To effectively drive productivity-enhancing policies, nations need a dedicated productivity agency or commission. Europe used to have a European Productivity Commission after World War II, but it was eliminated in the early 1960s and its functions moved to other agencies.[415] A number of nations, including Australia, Cyprus, and New Zealand, have established productivity commissions.[416] These organizations provide important analysis and advice to their respective governments, but they largely focus on the first two factors of productivity policy—market conditions and factor inputs—and devote much less attention to firm incentives and productivity-specific policies for R&D, platforms, and sectors.[417] This is in part because they are largely informed by the conventional neoclassical economics framing of productivity, which sees getting market conditions right as the principal or even sole goal.

Many nations, such as Tanzania, have quasi-public national productivity promotion organizations.[418] These are either established as corporations such as in Malaysia, authorities as in Australia and New Zealand, councils as in India and Mauritius, centers as in Japan and the United Kingdom, institutes as in South Africa, boards as in Singapore, or development academies as in Philippines. Regional productivity organizations have also been established, such as the Asian Productivity Organization, membership being national productivity organizations.[419] In Europe, the European National Association of Productivity Centers coordinates national centers in a number of EU nations.[420] But most of these organizations, such as Ghana's Management Development and Productivity Institute, are quasi-consultancies that focus principally on improving measurement of productivity and helping individual organizations boost productivity, and they tend to focus on agricultural and manufacturing sectors, not on the larger services sector.[421] In other words, they are more operational organizations to help business increase productivity, and not productivity strategy organizations.

A few nations have developed national productivity strategies. One is the Cameron government in the United Kingdom, though by and large it too is focused on market conditions (openness to global markets, more competitive markets, lower business taxes) and factor inputs (more funding for science, support for education), rather than on firm incentives and sectoral strategies.[422] Other nations develop productivity strategies but avoid politically controversial yet important issues. Case in point is Kenya's national productivity strategy, which is strangely silent on Kenya's limitations on the use of genetically modified

seeds for its agricultural sector, something that if changed would have a significant beneficial impact on agricultural productivity.[423]

In recent years, U.S. policymakers have shown little interest in productivity policy. Given the low productivity growth of recent years, however, that may begin to change. In the 1970s, when productivity growth rates had fallen dramatically, interest in establishing a national productivity policy was renewed. President Nixon appointed a National Commission on Productivity that, in 1974, became the National Commission on Productivity and Work Quality; in 1975, Congress established the National Center for Productivity and Quality of Working of Life. Because of the dominance of the neoclassical economics framework, the bodies focused mostly on business climate and factor conditions, not on the more effective productivity policies described here. A few exceptions are worth noting, such as when the commission conducted a study on productivity in the perishable food industry.[424]

However, because few economists expressed support for this kind of work legislative authority and it expired in 1978. A few years later, the director of the General Accounting Office testified before Congress commenting on the lack of sustained bipartisan support for the efforts. In frustration, he stated that "there is an urgent need for Federal involvement through a national productivity program that will foster greater awareness of the productivity problem and create the proper framework for productivity improvement."[425] He then called for the creation of a national productivity plan and a federal interagency productivity council. His entreaties were ignored.

The U.S. Department of Agriculture should support a comprehensive program to support agricultural mechanization with the goal being to mechanize as much agricultural work to reduce the need for low-wage workers.

Government agencies need to develop explicit productivity policies, not only for internal productivity, but also externally in the areas of the economies they influence. Part of this would include support for R&D-driven automation. The U.S. Department of Agriculture should support a comprehensive program to support agricultural mechanization with a goal of mechanizing as much agricultural work as possible to reduce the need for workers, particularly low-skill workers. Currently, funding for such efforts is limited.[426] The European Union has taken a step in this direction with its CROPS program (Clever Robots for Crops) which supports R&D for automation and robotics for crop and forest management.[427]

National governments should also identify or establish one agency or laboratory whose main mission is to support development and adoption of productivity technology as well as of platform and sectoral productivity strategies. In the United States, this might be the National Institute of Standards and Technology.

In addition, given the increase in income inequality in most nations, national productivity policies should focus on how productivity could reduce inequality. The focus should not be how to redistribute money from higher-income earners to lower or on how to increase skills of low-wage workers (though both can help). Rather, the focus should be on how to raise the productivity of low-wage jobs so that not only are they fewer in number, but also that the remaining jobs can support higher wages.[428] For example, the United States has more than 12.1 million food preparation and serving related workers, all with an annual mean wage of less than $21,000. Likewise, it has more than 3.1 million building cleaning

workers who make on average less than $25,000 per year. And according to the U.S. Bureau of Labor Statistics, more than 54 percent of jobs expected to be created between 2014 and 2025 will be in the one-third of occupations that currently have the lowest wages. If a national R&D program focused on improving robotic technology for these kinds of occupations, a not insignificant number of these jobs could possibly be automated.

Most economists would argue that such automation would not increase wages for low-wage workers because supply would increase and demand for them decrease. But if productivity grew twice as fast in the lowest-paid one-third of occupations in an economy than in the others, the result would be a shift in the occupational mix to more middle- and higher-wage occupations, and some workers now working in low-wage occupations who are likely overqualified would find jobs in middle-wage occupations. Clearly, their incomes would increase, but so would the incomes of the remaining workers in low-wage occupations. This is true for two reasons. First, the cost of goods and services made by low-wage workers would be less because of higher productivity, and thus their real consumption would be higher. Second, because the remaining jobs would have higher output, employers would be able to pay more, especially if a robust minimum wage policy were in place.

If nations want to maximize productivity growth they will need national productivity strategies that address all five key factors, and they need the political will and bureaucratic means to effectively implement the strategies.

Other sectors also need be more active in supporting a productivity agenda. The philanthropic sector does virtually no work in this area, largely buying into the view that the private sector acting on its own maximizes productivity or that public policy can do nothing to boost productivity. Foundations therefore focus their efforts on supporting a redistribution agenda. But without robust productivity growth, a redistribution agenda is not only more needed, but more difficult.

Finally, global organizations need to focus more on productivity. Of international organizations, the OECD has done the most and the best on productivity. More can and should be done, however. The United Nations, the International Monetary Fund, the World Bank, and other organizations should be benchmarking best practice productivity practices, especially in less than fully market-based industries, such as health care, government services, and so on. Moreover, these organizations should focus less on the dominant strategy of spurring national competitiveness (the shift strategy) and more on spurring national productivity (the growth strategy).[429] Also, by and large, their work on productivity is minimal, reflecting at best a lack of interest, at worst a belief that productivity growth may imperil developing-country job creation.[430]

CONCLUSION

Without productivity growth, sustained income growth is impossible. The best way for a nation to improve productivity is not to spur the growth of a few high-tech industries, but to ensure that all economic activities are done in ways that maximize outputs, relative to inputs. To do so effectively, nations will have to go beyond the conventional counsel from economists that getting market conditions and factor inputs right is enough. It is not. Acting in response to market forces alone, most firms will underinvest in productivity-enhancing activities. Moreover, many industries are simply structured in ways that will lead to productivity underperformance absent sectoral-based productivity policies. In addition, maximizing productivity in economies requires economy-wide technology platforms, and

adoption of these platforms often lags in the absence of supportive government policies. Finally, expecting the optimal array of policies and public programs and actions to emerge on their own in an organic, trial and error way is wishful thinking. If nations want to maximize productivity growth, they will need smart, analysis-based, ongoing national productivity strategies that address all five key factors; they also need the political will and bureaucratic means to effectively implement the strategies and tactics emerging from the strategic process. Nations that do this effectively should be able to enjoy the benefits of significantly higher-productivity growth.

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ERRATA

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ABOUT THE AUTHOR

Robert D. Atkinson is the founder and president of ITIF. Atkinson's books include *Innovation Economics: The Race for Global Advantage* (Yale, 2012), *Supply-Side Follies: Why Conservative Economics Fails, Liberal Economics Falters, and Innovation Economics is the Answer* (Rowman & Littlefield, 2006), and *The Past And Future Of America's Economy: Long Waves Of Innovation That Power Cycles Of Growth* (Edward Elgar, 2005). Atkinson holds a Ph.D. in city and regional planning from the University of North Carolina, Chapel Hill, and a master's degree in urban and regional planning from the University of Oregon.

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