Are Robots Taking Our Jobs, or Making Them?

BY BEN MILLER AND ROBERT D. ATKINSON | SEPTEMBER 2013

The view that machines are a problem saps the American spirit of its relentless and aggressive support for innovation and progress. It is time to consign neo-Luddism and its particular refrain that technology costs jobs once and for all to the dustbin of history.

INTRODUCTION

With U.S. unemployment remaining stubbornly above seven percent and job growth anemic, many have latched on to a compelling explanation: "the robots are taking our jobs." In other words, a "neo-Luddite" narrative has taken hold. According to this line of thinking, high productivity driven by increasingly powerful IT-enabled machines is the cause of U.S. labor market problems, and accelerating technological change will only make those problems worse. There's only one flaw in this narrative: it is completely wrong and not supported by data, scholarly evidence or logic.

This report analyzes the "robots are killing our jobs" arguments, shows how they are constructed on faulty analysis, examines the extensive economic literature on the relationship between employment and productivity, and explains the logic of how higher productivity leads to more jobs. We show that more technology benefits not just the economy overall, but also workers: more and better technology is essential to U.S. competitiveness and higher living standards. The claim that increased productivity eliminates jobs is misguided speculation.

These neo-Luddites make a rough and fallacious correlation between today's high unemployment and the cool technology they see all around them (e.g., their smart phones, the kiosks at airports, Watson on Jeopardy). Clearly, in their minds, there must be a connection. For them, technology is enabling the same amount of work to be done with fewer people and doesn't lead to a dynamic where these people become reemployed doing other work. In other words, they believe that the jobs are gone and the workers are added to the unemployment rolls.

This is what economists call the "Lump of Labor" fallacy, the idea that there is a limited amount of labor to be done. The implication is that technology can create unemployment by displacing workers, because the more efficiently we work (using machines or otherwise), the less work there is for workers to do. As we discuss below, this is a false reading of the process of technological change because it doesn't include critical second order effects whereby the savings from increased productivity are recycled back into the economy to create the demand that in turn creates jobs.

Even many of those who acknowledge that new jobs will be created worry that there will not be enough of them to replace the lost ones, even in the long run. They warn that a time will come, sooner than we think, when even new "jobs" will be better done by machines, and unemployment will skyrocket. For them, our consumption demand may be unlimited, but in practice it is dependent on the rate of change of technology and automation. There are jobs being created and destroyed in the economy all the time, but what happens if technology increases the rate of job destruction? How do we know that humans will always be better at some work—or more importantly, enough work—than machines? One reason is that our economy is complex, with a broad range of industries and occupations, some amenable at a particular time to automation, most others that are not. Another is that technological change, no matter how advanced, does not happen overnight—and current productivity increases are actually trending down. But the main reason is that human wants are close to infinite—we need look no further than the fact that most people would love to win the Powerball lottery. And as long as that is true, those wants will require labor to fill them (even if that labor is eventually supplemented by 22nd century robots).

We can also look to history: in many ways these arguments are not new. Over the last century whenever unemployment rates have risen there have always been some who blame the machines. Some even argued we were heading toward mass permanent unemployment. But what is different today is how widespread the neo-Luddite view has become and how well-received it is in Western society. (When the leading proponents of this view get an amiable hearing on the TV show "60 Minutes," you know that something has changed.)[1] This is what is different and most troubling. In the past, neo-Luddite anti-progress views were episodic, emerging occasionally when joblessness spiked but then receding into the background, and they were always going against the grain of the uniquely American faith in the desirability and inevitability of progress. Today that faith is waning, which points to the real threat that neo-Ludditism presents: the view that machines are a problem and not the solution saps the American spirit of its relentless and aggressive support for innovation and progress. It is time to consign neo-Ludditism and its particular refrain that technology costs jobs once and for all to the dustbin of history. Robots, automation, machines, productivity: these are key enablers of human progress and absolutely no threat to overall employment. As such, economic policy should at every possible opportunity not give in to neo-Luddite exhortations, but instead put the "pedal to the metal" for higher productivity and more "machines."

THE RISE OF THE NEW LUDDITISM

Many define the term "Luddite" as someone who resists adopting new technology. In fact, the term refers to a person who actively opposes technology and wants to literally or figuratively "smash the machine." It has its origins in English industrial history when Englishman Ned Ludd encouraged his followers to destroy textile machines at the beginning of the Industrial Revolution, for the machines were enabling more textile production with fewer workers. Ludd and his followers couldn't stop progress, but they could and did slow it down.

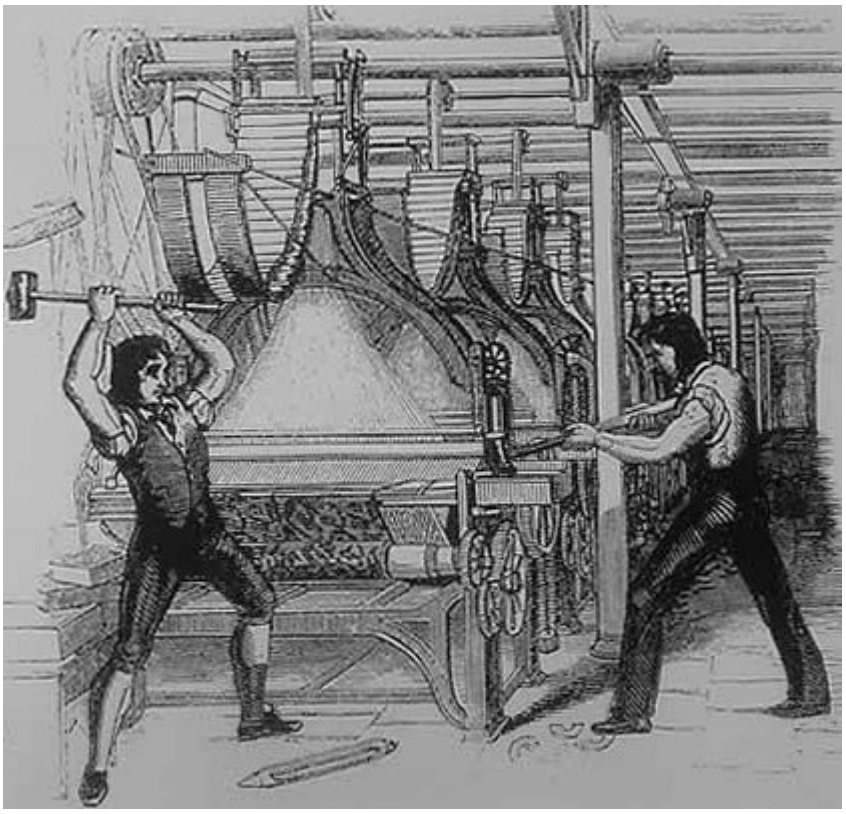

Figure 1: Newspaper illustration of British weavers destroying textile machines in the early nineteenth century (Unknown illustrator [c. 1840s]. Courtesy of Wikimedia Commons.)[2]

Many economists, journalists, and policymakers now routinely claim that technology, instead of being a key driver of increased standards of living, is to blame for our economic doldrums.

There has long been a small number of anti-technology zealots making the case that technology is hurting jobs. To wit, Jeremy Rifkin's 1995 book, *The End of Work*, laments that "[technological change] is now leading to unprecedented levels of technological unemployment."[3] But in the last few years these few divergent voices have been joined by a broad chorus of more mainstream voices claiming that technological change (referred to interchangeably with "innovation," "automation," and "increasing productivity") is leading to fewer jobs. Many economists, journalists, and policymakers now routinely claim that technology, instead of being a key driver of increased standards of living, is to blame for our economic doldrums. In the last few years there has been an outpouring of books, articles, op-eds, and blogs warning that it is technology that is behind today's high unemployment rates and that the destructive effect of technology on jobs will only increase going forward.

The following is a sampling of the wide range of commentators, from academics to journalists to technologists, who have picked up this notion:

- In perhaps the most widely cited tract making this case, MIT professors Erik Byrnsolfson and Andrew McAfee state in *Race against the Machine* that "it may seem paradoxical that faster progress can hurt wages and jobs for millions of people, but we argue that's what's been happening."[4]

- In a *New York Times* op-ed entitled "Sympathy for Luddites," columnist and Nobel-Prize-winner Paul Krugman warns that "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 and devalued, and pushing for more education may create as many problems as it solves."[5]

- Noted legal scholar and economist Richard Posner writes that "there is nothing inevitable about the virtuous process whereby automation and related negative effects on particular jobs merely shift workers to other jobs that are equally or more desirable. Workers may be highly compensated for possessing human capital that is specialized to a labor market that is shrinking...If technological advance is very rapid, causing in turn a large and very rapid drop in demand in a large labor market, the economy may not be able to absorb the sudden surplus of labor in a short period of time."[6]

- Nobel Prize winning economist Joe 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."[7]

- Tyler Cowen, blogger at Marginal Revolution and author of The Great Stagnation, writes: "Self-driving vehicles threaten to send truck drivers to the unemployment office. Computer programs can now write journalistic accounts of sporting events and stock price movements. There are even computers that can grade essay exams with reasonable accuracy, which could revolutionize my own job, teaching. Increasingly, machines are providing not only the brawn but the brains, too, and that raises the question of where humans fit into this picture — who will prosper and who won't in this new kind of machine economy?"[8]

- James B. Huntington's book, Work's New Age, warns that due to technological change, "No longer will the number of American jobs approximate the number of those who can work them."[9]

- Stuart Elliot of the National Research Council writes, "As long as computer abilities continue to improve, we should expect that the skill requirements for the human workforce will continue to shift up. With this steadily moving target, there will come a time when we are simply unable to move human skills up quickly enough to keep the full workforce employed."[10]

- In *Who Owns the Future*, Jaron Lanier writes, "We're setting up a situation where better technology in the long term means more unemployment" that may lead to "political and social chaos."[11]

- A *60 Minutes* program entitled "Are Robots Hurting Job Growth?" notes that "technology…is putting new categories of jobs in the sites [sic] of automation—the 60 percent of the workforce that makes its living gathering and analyzing information."[12]

- Bernard Condon and Paul Wiseman write in a widely distributed multi-part *AP* story entitled "Recession, tech kill middle-class jobs" that "overall…technology is eliminating far more jobs than it is creating," and that jobs are "being obliterated by technology."[13]

- *Financial Times* blogger Izabella Kaminska blogs regularly about possible negative effects of technology, arguing: "The natural unemployment [rate] may be changing on a permanent basis in the US, but… much of this is down not to global forces, but technology and the reboot of our economy, which in many cases is making those with jobs hugely over-productive."[14]

- At *The Atlantic*, Tim Fernholz's piece, "What Bankrupted Detroit—China or robots?" notes that "the problem of adapting social and economic institutions to a world where mechanization enhances productivity but costs jobs is one that all wealthy countries face, regardless of trade competition."[15]

- A recent article on *The Economist's* Schumpeter blog warns: "Brain work may be going the way of manual work."[16]

- Gary Marcus in a *New Yorker* article titled "Will a Robot Take Your Job?" argues that "there is no causal mechanism, physical, economic, sociological, or legal, that guarantees that new jobs will always come into existence."[17]

- Martin Ford, author of *The Lights in the Tunnel: Automation, Accelerating Technology and the Economy of the Future*, writes, "As jobs and incomes are relentlessly automated away, the bulk of consumers will lack the income necessary to drive the demand that is critical to economic growth."[18]

- Marshall Brain, founder of the website *How Stuff Works* and host of "Factory Floor" on the National Geographic channel, writes, "I firmly believe that the rapid evolution of computer technology will bring us smart robots starting in a 2030 time frame. These robots will take over approximately 50% of the jobs in the U.S. economy over the course of just a decade or two. Something on the order of 50 million people will be unemployed."[19]

- Anonymous investment banker "Wufnik," in an article for the blog *Scholars & Rogues* entitled "Where will the new jobs come from?" writes that "it's true that technology can create more jobs—and in the past this has often been the case. Whether we're at some sort of inflection point on this in the US (and eventually elsewhere as well) remains to be seen."[20]

- Frederico Pistono, author of *Robots will Steal Your Job but that's OK*, writes that "the total number of jobs required by industry will be gradually reduced over time, and each time we will have to reinvent ourselves, finding new occupations for the newly

displaced people by automation. …This becomes very tiring after some time. It is a game you cannot win."[21]

- Kevin Drum, in an article for *Mother Jones* entitled "Welcome, Robot Overlords. Please Don't Fire Us?" asserts that "smart machines probably won't kill us all—but they'll definitely take our jobs, and sooner than you think." He concludes: "The Luddites weren't wrong. They were just 200 years too early."[22]

- Gavin Mueller's "The Rise of the Machines" argues that "in the short term, the new machines benefit capitalists, who can lay off their expensive, unnecessary workers to fend for themselves in the labor market. But, in the longer view, automation also raises the specter of a world without work, or one with a lot less of it, where there isn't much for human workers to do."[23]

- Blogger at *Boing Boing* and science fiction author Cory Doctorow writes in "Will robots take all the jobs?" that "if market economies can't figure out how to equitably distribute the fruits of automation, [they] might end up with an even bigger, even more hopeless underclass"[24]

- Even President Obama has joined the chorus, arguing, "There are some structural issues with our economy where a lot of businesses have learned to become much more efficient with a lot fewer workers… You see it when you go to a bank and you use an ATM, you don't go to a bank teller, or you go to the airport and you're using a kiosk instead of checking in at the gate."[25]

What is different today is that our economy, and our job creation engine more specifically, has serious problems.

HAVEN'T WE BEEN HERE BEFORE? WHY IS THIS AN ISSUE NOW?

Why has neo-Luddism suddenly gained so many adherents? After all, technology has been advancing for centuries. People have always worried about the employment effects of new technologies but generally accepted technological change as inevitable and positive. What is different today that has sparked such widespread fears?

What is different today is that our economy, and our job creation engine more specifically, has serious problems. Since the Great Recession, unemployment has barely dropped below 8 percent, and much of the drop has been due to workers leaving the workforce. Broader measures of unemployment, including involuntary part-time workers and others who would prefer more work but are not included in the headline numbers, are even more discouraging (see Figure 2).

Our recently rediscovered fear of technology is a predictable reaction to employment problems. Indeed, throughout history as macroeconomic factors have led to recessions and periods of high unemployment, the same worries about technology and automation have resurfaced. Almost as far back as the original 19th-century Luddites themselves, David Ricardo expressed his reservations about technology at the tail end of the Post-Napoleonic Depression, arguing that "the opinion entertained by the labouring class, that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy"—

although he followed this quotation by acknowledging that nations still need to encourage the use of machinery.[26]

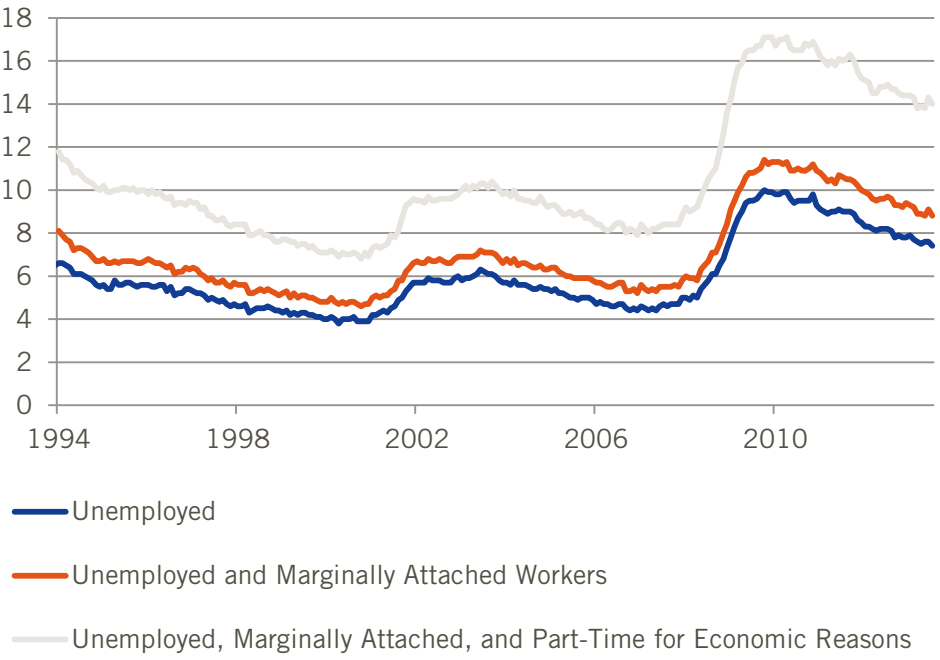

Figure 2: Percent of unemployed workers in U.S. labor force[27]

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In the 20th century, the Great Depression led to a general concern that labor was too productive. Prominent publications from the National Bureau of Economic Research and The Brookings Institution cited productivity increases, and associated dysfunction in the economy, as causes of the malaise.[28] "Economic Possibilities for our Grandchildren" by John Maynard Keynes popularized the phrase "technological unemployment" in the 1930s, which Keynes defined as "unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour."[29] Betrand Russell wrote his famous essay "In Praise of Idleness" in 1932, similarly arguing that after technology reduces the amount of work, the leftovers should be divided up evenly for more equal distribution of wealth and leisure time.[30] Labor unions advocated for more straightforwardly anti-technology policies. One local union leader wrote a letter to President Roosevelt proposing the following: "Remove the loading machines from the coal mines, complete all public work with man power, take the tractor off the farms, go into the various industries and remove enough labor-displacing machines to make employment for labor."[31] And to a limited extent, the New Deal brought some of these ideas to fruition through overtime laws, child labor laws, and other important restrictions on the labor force. Today we see most of these issues as fundamental human rights, and they are, but Luddite concerns were nevertheless instrumental in their legal implementation.

After the Second World War, factory automation began to increase rapidly, and in fact the term "automation" was not coined until the late 1940s. It was originally used to refer to new machine-based production processes put in place by the automaker Ford, and a Gallup poll from 1957 shows that more than half of those surveyed had not yet heard of the

word.[32] But the spreading technological changes soon focused national attention on the employment effects of automation and productivity. Such fears entered the popular consciousness, with one particularly telling episode of "The Twilight Zone" depicting a dystopian world in which a manager replaces all his workers with robots, and in the final scene, is replaced himself by a robot.[33] Kurt Vonnegut's novel *Player Piano* similarly envisions a world where labor has been automated away and workers rendered powerless.[34]

The concern with automation led to a number of official and scholarly inquiries on the matter. Congress's Joint Economic Committee held extended hearings on automation and push-button factories in 1955. Walter Buckingham's 1961 book, *Automation: Its Impact on Business and People*, argued that despite job displacement, technological progress holds important benefits for the economy and for workers.[35] This did not stop John F. Kennedy from creating an Office of Automation and Manpower in the Department of Labor in 1961, identifying "the major domestic challenge of the Sixties: to maintain full employment at a time when automation, of course, is replacing men."[36] But by 1966, when unemployment had fallen to new record lows, a major commission report found that although greater social protections were needed, technology did not pose a threat to employment.[37] Nearly 20 years later, in a report commissioned by the National Science Foundation, Nobel Lauriat Wassily Leontief and Faye Duchin found similar conclusions about technological progress: it affected industries in different ways and could be managed with proper training and educational efforts.[38] But these reports did little to quiet the popular imagination, as Gallup polling in the 1970s and 1980s found that workers were perennially worried about automation and held a negative view of it.[39]

Despite the episodic worries about technology destroying jobs, in each of these periods the number of jobs always recovered and continued to grow. And as they did, fears of machines destroying jobs receded and support for technology rebounded. Now, as we stumble through the Great Recession, our confidence in innovation is fading exactly when we need it most. Understanding productivity—a fruit of innovation—is key to understanding why we should not be afraid of innovative technology.

WHAT IS PRODUCTIVITY AND WHY IS IT IMPORTANT?

Before examining arguments further, we need to be explicit about what we mean by "productivity." Productivity is economic output per unit of input. The unit of input can be labor hours (labor productivity) or all production factors including labor, machines and energy (total factor of productivity).[40] Producing more output with less input can take several forms. The traditional notion of productivity is a firm reorganizing production and/or using better or more technology to produce more output per worker hour. This kind of productivity is seen by some, especially some on the left, as problematic because it can lead to layoffs. But whether or not this leads to fewer, the same, or more workers at the firm depends in part on the elasticity of demand for the product or service. If modest price declines lead to large increases in demand, then productivity improvements in a firm may result in more workers.

But there is a second kind of productivity that is more universally supported and that comes from higher-value-added production. Imagine a firm that is producing a widget that

costs $10, with $5 spent for inputs (a value added of $5). Now, thanks to previous R&D, the firm is able to produce a better widget and sell it for $15 with the same amount of work hours involved. By definition, productivity doubled because value added doubled from $5 to $10. No workers were laid off. And in fact, the workers might have even been able to get a raise. But to say that this is good productivity while the former is bad is to miss the real driving force for increased standards of living. For while the latter "top-line" productivity is certainly valuable, it cannot play the sole, or even dominant role in growth, for no other reason than much of what we consume are not products from "Nordstrom" but from "Wal-Mart." In other words, while high-value-added products and services are useful, people will still need to buy t-shirts, get haircuts, get banking services, and travel on low-cost airlines. Boosting the actual "bottom-line" productivity—enabling more of these goods and services to be produced with less labor—is the key to sustained per-capita income growth.

A region or nation may increase its productivity in two ways: the "growth effect" and the "shift effect." In the first, some or all sectors in an economy become more productive, usually by investing in new technologies or by improving workers' skills. For example, a country's retail, banking, transportation, and automobile manufacturing sectors might all increase their productivity at the same time. This can happen by all firms in an industry boosting their productivity or by low-productivity firms losing market share to high-productivity firms. The second method, the "shift effect," does not involve actual productivity increases within industries. Instead, it involves shifting production from less productive to more productive industries—for example, if unproductive farmers move to the city and start working for high-tech manufacturers. The shift effect can be more dynamic and disruptive as low-productivity industries lose out in the marketplace to high-productivity industries and the compositional mix of the economy changes.

Both within-industry productivity growth (the growth effect) and shifts in the mix of industries toward more productive ones (the shift effect) will contribute to an increase in an economy's productivity. But which strategy is best? The answer depends in large part on the size of the economy, and in part on the type of industry. The larger the economy, the more important the growth effect is, while the smaller the economy, the more important the shift effect is. Moreover, the more local-serving the sector, the more important the growth effect is. To understand why, consider an automobile factory in a small city. If its managers install a new computer-aided manufacturing system and raise the plant's productivity (the growth effect), a large share of the benefits will flow to the factory's customers around the nation and even around the world in the form of lower prices. Because the economy (the city) is small and the factory less local-serving, the city will benefit only to the extent that its residents buy cars from that factory or if some of the increases in productivity go to higher wages instead of only to lower prices.[41] In contrast, if the city attracts another auto plant where the wages average $18 per hour to replace a textile firm with average wages of only $12 per hour that moved overseas to a low-wage economy (the shift effect), most of the benefits will accrue to residents in the form of higher wages for the workers who moved from the textile plant to the car factory (and in the form of more spending at local-serving businesses like restaurants, dry cleaners, furniture stores, etc.). This implies that across-the-board productivity growth, rather than a

shift to higher-value-added sectors, will be more important for larger areas (including virtually all national economies), because their consumers will capture a greater share of the productivity gains.

Yet, even for small economies, within-industry productivity gains are still a vitally important way to become richer, especially through productivity gains in local-serving industries. To see why, consider a small nation in which average productivity across the board among existing industries increases two percent per year for five years. After five years, the nation's productivity is up by almost 11 percent. To achieve a similar increase in total productivity through an industry mix strategy, the nation would have to replace 20 percent of its existing jobs with new jobs having more than 50 percent higher output—an unlikely transformation.

Regardless of how productivity gains are achieved, productivity is important because it is the only way to improve per capita GDP outside of workers working more hours or more people working. Moreover, because they increase tax revenue, increases in per capita GDP will be a key factor in dealing with the federal debt and growing government benefit obligations.

Indirect effects occur when technological improvements increase demand and lower the prices consumers pay their for goods and services, thereby giving them more purchasing power and stimulating growth in other sectors, which leads to a self-reinforcing economic expansion.

Productivity growth, especially in internationally traded industries, is also essential to maintaining economic competitiveness.[42] As ITIF has shown previously, the United States has lost competitive advantage to other nations.[43] Other countries are making large strides in competitiveness and several economies have already surpassed the United States. If America continues to lose competitiveness it will lose high-valued-added production and the accompanying high-wage work. This is in fact the real story behind our employment problems and it will be explained below. First, however, we need to be clear and precise about why the neo-Luddites are wrong.

WHY THE NEO-LUDDITES ARE WRONG: WHY PRODUCTIVITY DOESN'T LEAD TO FEWER JOBS

Both history and scholarly analysis have clearly and consistently refuted the notion that increased productivity leads in the moderate to long term to higher unemployment. This is because rising productivity increases overall wealth, and in a competitive economy that increased wealth gets reallocated to create additional demand that requires new workers.

Most of the neo-Luddite critics, when pressed, will be willing to acknowledge this, but they argue that things are different now: technology is now replacing all possible activities a human could do better than machines. In other words, while in the past jobs moved from agriculture to manufacturing, and then from manufacturing to services, after service sector workers become obsolete there will be no sectors generating jobs. For example, author Jeremy Rifkin argues that when millions of retail jobs are displaced by e-commerce and a host of other service sector jobs undergo digital automation, there will be no new jobs to replace them. "If we boosted productivity in the retail, banking, insurance, and other service sectors that were job generators up until now, where in the world will people find work?"[44]

This view fails to recognize that the savings from new productivity gains must flow back to the economy in one or more of the following three ways: lower prices, higher wages for the fewer remaining employers, or higher profits. First, it's important to recognize that productivity increases produce savings, even if firms have to buy machines or software to generate them. Why else would firms seek higher productivity? And these savings are not stuffed under the proverbial mattress.

In a competitive insurance market, for example, most of the savings from higher productivity would flow back to consumers in the form of relatively lower prices for policyholders. Consumers might use the savings on lower premiums to go out to dinner a few times, buy books, or purchase any number of other things. This economic activity in turn creates demand that other companies (e.g., restaurants, bookstores, movie theaters, and hotels) respond to by hiring more workers. In other words, raising the productivity of one industry increases demand, either in that industry or all the other industries in aggregate.

We can call these direct and indirect ("second order") effects. Direct effects occur when companies or industries change their productivity and employment simultaneously because the change in their production processes directly changes their need for workers. Indirect effects occur when technological improvements increase demand and lower the prices consumers pay their for goods and services, thereby giving them more purchasing power and stimulating growth in other sectors, which leads to a self-reinforcing economic expansion.

It is possible that some or all of the savings go to the workers in the firm in the form of higher wages. And in this case, they would spend the money, creating demand that will be met by more employment. Some of the savings might go to higher profits, although in competitive markets, little of it will. But even if all of it were to, the higher profits are distributed to shareholders and are spent, likewise creating demand. Even if the savings from productivity don't get spent by consumers and for some reason are saved, this will still create jobs, assuming that the economy is not in recession. The reason is that increased savings lead to lower interest rates which in turn lead to increased investment.

Automation will also produce some new jobs in firms that sell the new "robots" or other labor-saving technology. This means that, in general, there will be an overall shift in the economy in the direction of higher-skill and higher-wage jobs. Moreover, if the United States becomes a leader in producing productivity-enhancing technology, it will experience a growth in jobs serving foreign markets.

Despite these benefits of second-order employment effects, it is important not to get too carried away. It is sometimes argued that *all* our employment problems will be solved by jobs making the robots that take other jobs. This view is unrealistic for the simple reason that by definition firms will not substitute 10 workers for technology if it takes 10 workers to produce the machine. In other words, firms adopt technology to save money. And if all society does is move workers from insurance firms, restaurants, and car factories to robot factories, productivity will have remained the same.

WHY THE NEO-LUDDITES ARE WRONG: PAST TRENDS

Amidst all the talk of robots stealing our jobs it is easy to overlook important trends in the data. Since 2007 unemployment has risen sharply and job growth has fallen—two trends the neo-Luddites are rightfully concerned about. However, they blame the wrong cause: productivity.

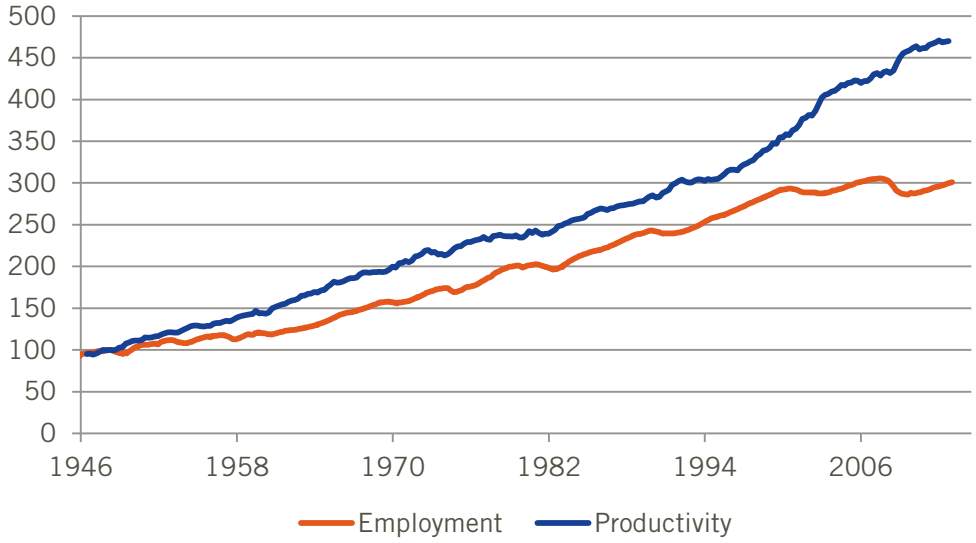

Figure 3: U.S. productivity and employment (index, 1947 = 100)[45]

There has never been any causal link between productivity and total employment growth.

The neo-Luddites make two related claims: that increasing productivity limits total employment growth, and that it causes unemployment. As an example of the first claim, Brynjolfsson and McAfee argue that the historic relation between total employment and productivity is broken. A recent *MIT Technology Review* article describes their presentation of a chart (see Figure 3):

> The pattern is clear: as businesses generated more value from their workers, the country as a whole became richer, which fuelled more economic activity and created even more jobs. Then, beginning in 2000, the lines diverge—productivity continues to rise robustly, but employment suddenly wilts. By 2011, a significant gap appears between the two lines, showing economic growth with no parallel increase in job creation.

Brynjolfsson and McAfee call it the "great decoupling," attributing the lack of employment growth to weak labor demand and claiming that it causes unemployment.[46] Jared Bernstein has posted a similar argument, with a similar graph, on his blog.[47]

The problem with this claim is that there has never been any causal link between productivity and total employment growth. The size of a national workforce is based primarily on demographic and cultural factors and exhibits no relation to productivity. The historical evidence is clear on this point: productivity growth was low in the 1970s and early 1980s but the United States nevertheless experienced high job growth. A big reason why job growth slowed in the United States in the 2000s was simply because the 30-year-long expansion of women into the labor market peaked (see Figure 4 and Figure 5).

Moreover, while employment peaked, job creation did not: Figure 6 shows that both gross and net job creation were consistently strong through 2007, after which they plummeted to 1980s Volker-era levels.

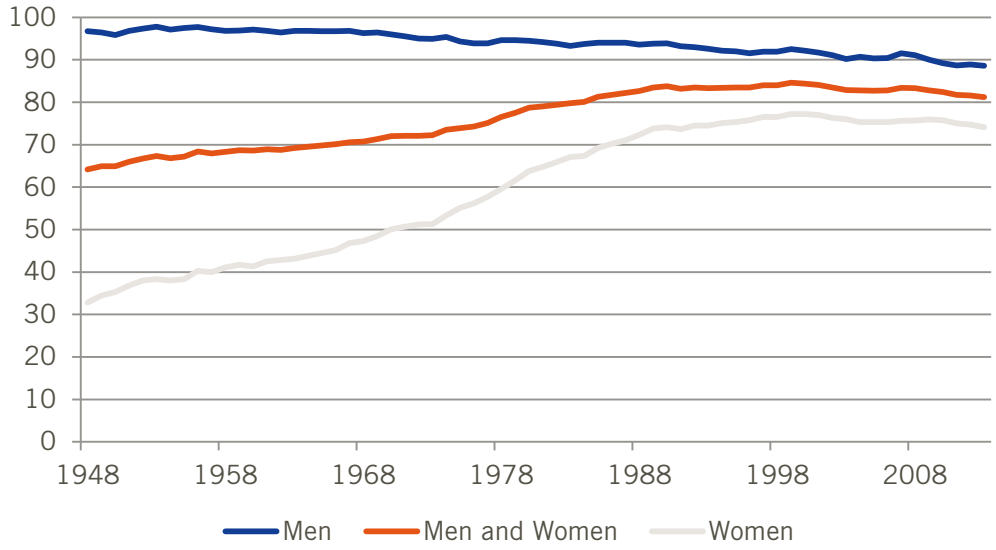

Figure 4: U.S. civilian labor force participation (ages 25-54; percent)[48]

The real question is not whether productivity affects the number of people in the workforce (the two are unrelated), but whether it affects the number of those people in the workforce who have or do not have jobs. This leads to the second neo-Luddite argument: that automation leads to higher unemployment.

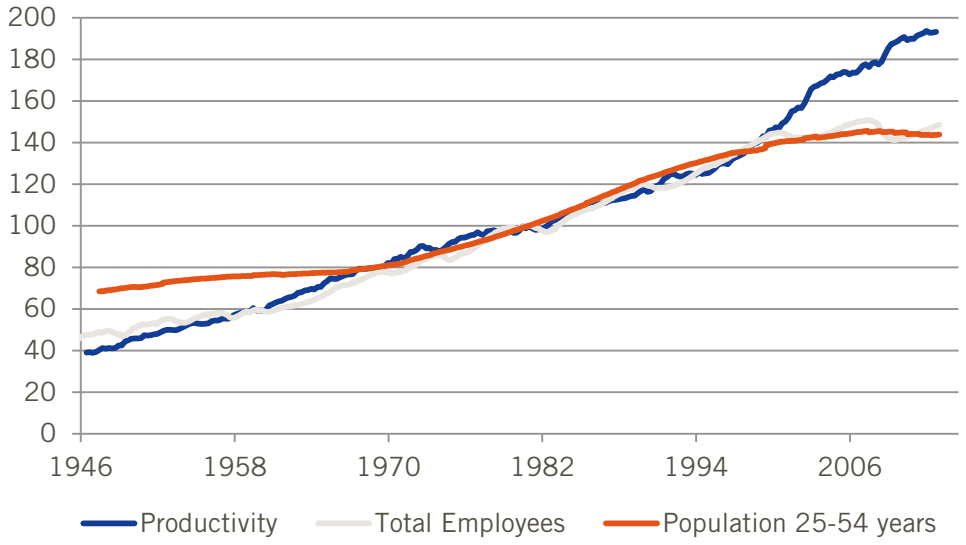

Figure 5: U.S. productivity, civilian labor force participation and working age population (index, 1981 = 100)[49]

In the past, productivity growth has gone hand-in-hand not with job losses but with growth in employment: our most productive years have been followed by our years of lowest unemployment. This correlation is shown in the 2011 McKinsey Global Institute

(MGI) report, "Growth and Renewal in the United States: Retooling America's Economic Engine."[50] MGI looked at annual employment and productivity change from 1929 to 2009 and found 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.[51] In looking at 71 ten-year slices, only one percent had declining employment and increasing productivity. The rest showed increasing productivity and employment. In looking at 76 five-year periods, just eight percent had declining employment and increasing productivity. And when looking at the 80 annual periods, 69 percent had increasing employment and increasing productivity. A simpler breakdown of change in productivity and change in total employment shown in Figure 7 makes it clear that higher productivity growth has not been associated with lower rates of employment increases.

If our strongest productivity growth and strongest employment growth often occur simultaneously, then it is difficult to make the argument that productivity growth causes unemployment.

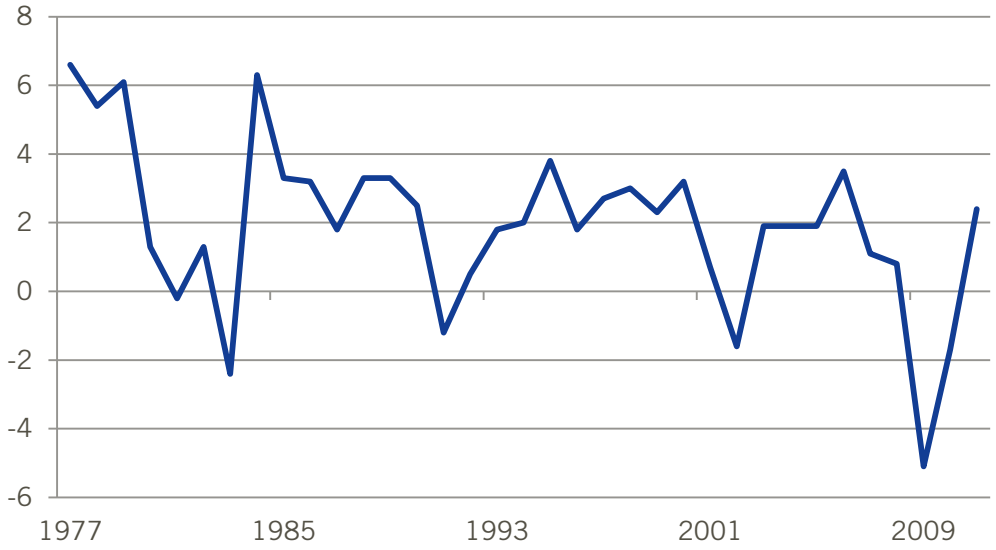

Figure 6: Percent of total jobs created (or destroyed) in the U.S.[52]

We can also see this in terms of the relationship between unemployment rates and productivity growth. During the 1990s, productivity was at near all-time high levels of growth, while unemployment was at all-time lows. This is usually attributed to the information technology revolution that came to fruition in the mid- 1990s. From 2000-2007, productivity fell somewhat and unemployment increased somewhat, again the opposite of what the neo-Luddite hypothesis would predict. And over the last few years since 2008, productivity fell even more and unemployment increased even more (see Figure 8). A cursory look at these data would seem to suggest that higher productivity leads to lower unemployment, not the other way around.

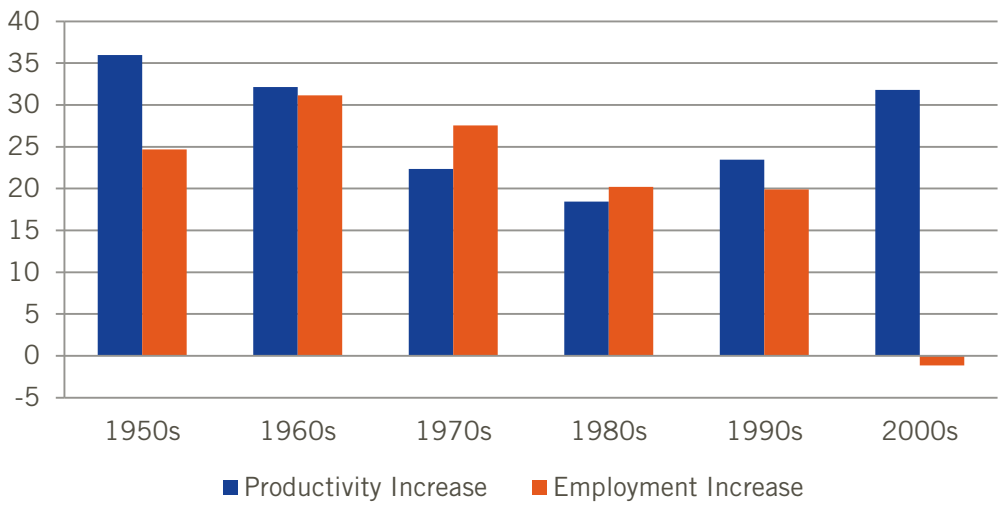

Figure 7: U.S. employment and productivity change by decade (percent)[53]

From 2000-2007, productivity fell somewhat and unemployment increased somewhat, again the opposite of what the neo-Luddite hypothesis would predict.

If our strongest productivity growth and strongest employment growth often occur simultaneously, then it is difficult to make the argument that productivity growth causes unemployment. Certainly productivity growth does cause some job destruction in the short run: the evidence (reviewed in the following section) is clear that some firms shed workers. But other firms hire them as prices fall in the high-productivity industries and consumers use these savings to buy other goods and services. In the medium run, and on a macroeconomic level, the effect of productivity in the vast majority of cases is toward more jobs, not less.

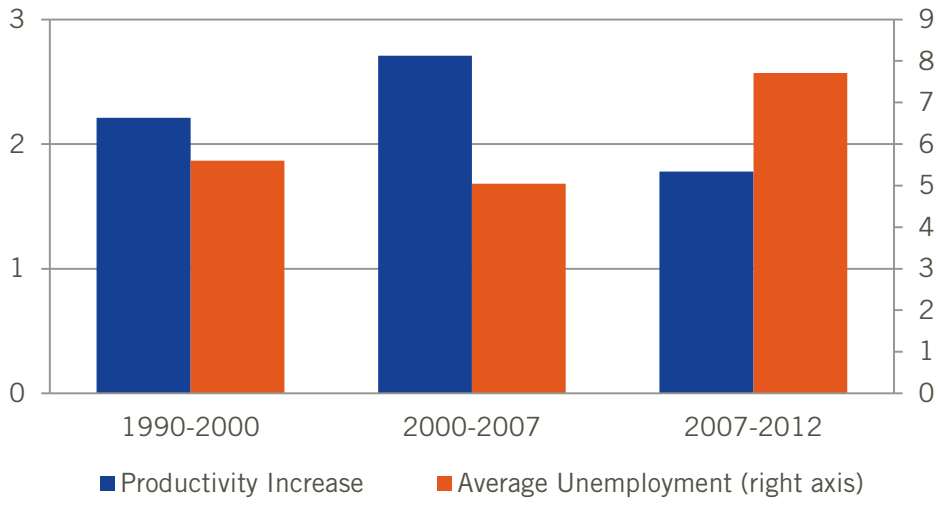

Figure 8: U.S. average productivity change and average unemployment (percent)[54]

The charts below show the relationship between productivity and unemployment in the United States. Using both period averages (Figure 9) as well as a five-year moving average (Figure 10), there appears to actually be an inverse relationship between productivity and unemployment—years with more productivity increases coincide with years of lower

unemployment. While a cross-national sample of productivity growth and average unemployment rates over the period from 1990 to 2011 does not show such an inverse relationship, it shows essentially no relationship (see Figure 11).

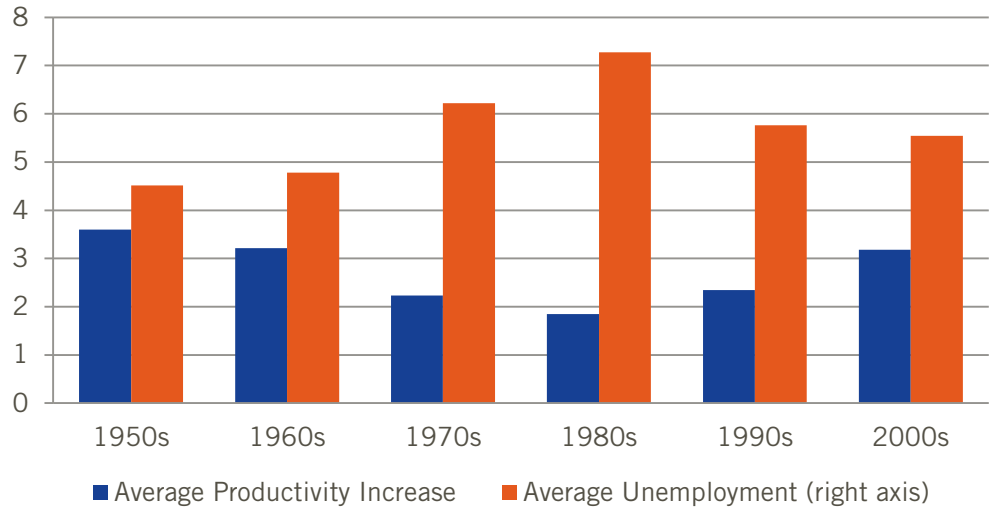

Figure 9: U.S. productivity change and average unemployment rate by decade (percent)[55]

While the data show several new trends in labor market numbers since the year 2000, the neo-Luddites have picked up on two of the trends (unemployment and a declining workforce) and combined them with speculation about future technological change. They have ignored the fact that productivity growth has been falling while unemployment has been rising. If robots were stealing our jobs, then productivity growth would be accelerating, not decelerating.

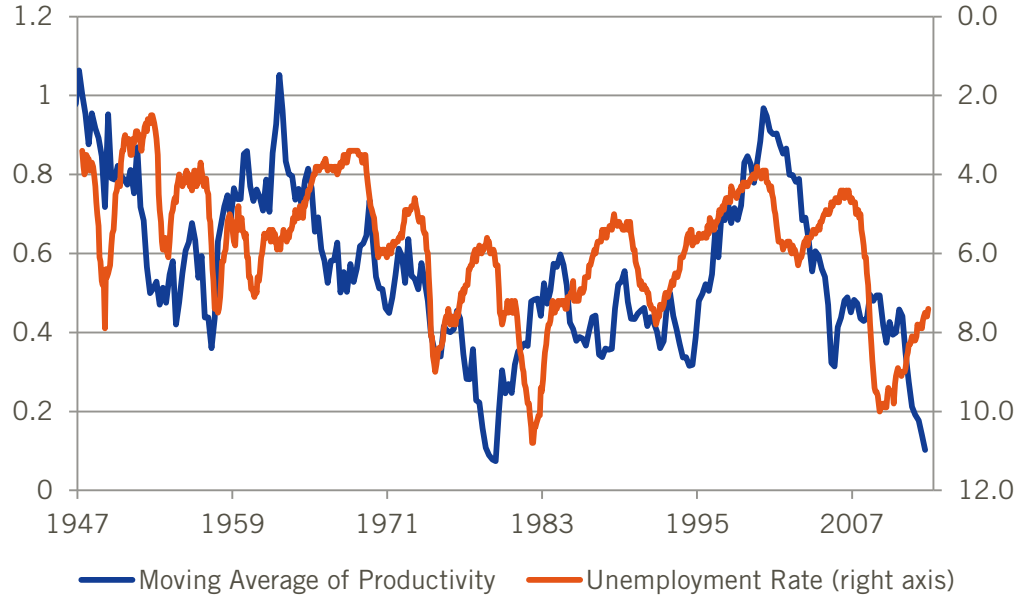

Figure 10: U.S. moving average of quarterly productivity change and unemployment rate (percent)[56]

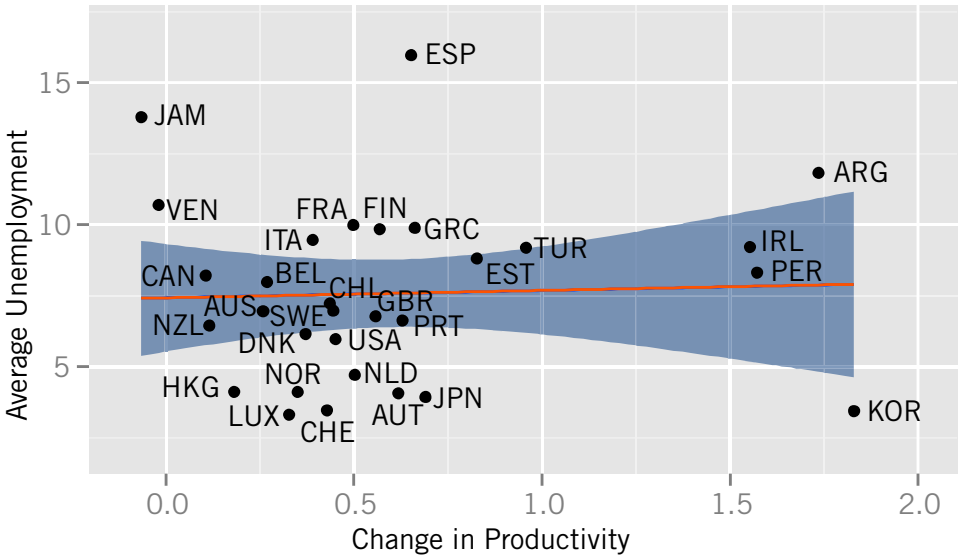

Figure 11: Average unemployment rate and total change in productivity in select nations, 1990-2011 (percent)[57]

The scholarly evidence, as shown by several overview studies, supports the idea that technological change does not lead to fewer jobs, and in some cases may increase employment.

WHY THE NEO-LUDDITES ARE WRONG: SCHOLARLY RESEARCH EVIDENCE

The link between technology and unemployment is far from the simplistic "robots replace workers" story. A more accurate simplification would be that "robots" help grow employment, but this too is not the full story. The relationship between productivity and employment can be studied at different levels of aggregation (firm, industry, region, country), and at different time scales (short term, medium term, and long term). Focusing primarily on medium- and long-term effects to industries and countries, this section analyzes the scholarly economic literature on the relationship between productivity and employment.

The scholarly evidence, as shown by several overview studies, supports the idea that technological change does not lead to fewer jobs, and in some cases may increase employment. For example, the 2004 *World Employment Report* examines productivity growth and employment growth over the long run, and finds little to no correlation depending on the region.[58] This is corroborated by the *World Development Report 2013: Jobs*, which states: "Over a long term (10-year period), changes in unemployment rates are small, in general, and employment in an economy is driven by the size of its labor force." That is, not by changes in technology.[59]

Some studies however have found a positive relationship, with increases in productivity leading to more, not fewer, jobs, at least in the medium and long term. An OECD study from 1994 found 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."[60] In a paper for the International Labour Organization's 2004 *World*

Employment Report, Van Ark, Frankema and Duteweerd surveyed empirical evidence and found strong support for simultaneous growth in per capita income, productivity, and employment in the medium term.[61] Likewise, Trehan finds that productivity-enhancing technology shocks reduce unemployment for several years going forward.[62] He writes:

> Productivity grew noticeably faster than usual in the late 1990s, while the unemployment rate fell to levels not seen for more than three decades. This inverse relationship between the two variables also can be seen on several other occasions in the postwar period and leads one to wonder whether there is a causal link between them. The empirical evidence presented here shows that a positive technology shock leads to a reduction in the unemployment rate that persists for several years.[63]

Some studies do find that employment decreases in the short run in response to a productivity shock, but that jobs grow in the medium to long term: Basu, Fernald and Kimball find this result, with labor (and investment) inputs falling immediately after productivity-enhancing technology shocks but quickly returning labor usage to normal with increased output.[64] Using evidence from Korea, Kim, Lin and Park also find support for a short-term negative and medium-term positive relationship between aggregate productivity and employment.[65] Chen, Rezai and Semmler examine unemployment and find evidence that in the short run, productivity and unemployment are weakly positively correlated. In the medium and longer term, however, they find that productivity growth is strongly *negatively* correlated with unemployment.[66]

Several new papers by IMF economists use other methods to examine the relationship between productivity and employment. DeMichelis, Estevao, and Wilson examine the relationship between long-run productivity growth averages and labor force growth for the OECD countries with available data.[67] They find that productivity growth and labor input growth are negatively related, but their further analysis finds the causation to run from higher labor force growth to lower productivity growth—i.e., presumably a large labor supply is driving down the costs of labor and making firms less likely to invest in labor-saving technology.[68] Ball, Leigh and Loungani take a shorter-term approach to look specifically at recent recessions, examining the "Okun's Law" relationship historically found between (peak-to-trough) declines in output during recessions and increases in unemployment.[69] Their findings show that during the recessions since 1990, job loss was due to output declines, not job destruction caused by technology—that is, due to short-term cyclical factors, not longer-term structural ones.[70]

This positive relationship between productivity and jobs appears to hold in developing nations as well, where many policymakers persist in believing that employment growth is dependent on ensuring low, not high productivity growth. The *World Development Report 2013: Jobs* examines productivity growth in 97 developed and developing countries over the past decade and finds that jobless growth has been quite rare and simultaneous employment and productivity growth is much more common.[71] In a study of the relationship between productivity and employment in developing nation economies, the

United National Industrial Development Organization finds that in fact, "productivity is the key to employment growth."[72] It goes on to note:

> 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.[73]

While the aggregate-level evidence is clear that higher productivity does not lead to fewer jobs, particularly in the medium term, what is the effect at the industry and firm level? As is to be expected, the evidence here is mixed. For example, in their examination of the U.S. manufacturing sector, Chang and Hong find that "some industries exhibit a temporary reduction in employment in response to a permanent increase in TFP [total factor productivity], whereas far more industries exhibit an employment increase in response to a permanent TFP shock."[74]

This positive relationship between productivity and jobs appears to hold in developing nations as well, where many policymakers persist in believing that employment growth is dependent on ensuring low, not high productivity growth.

Firm-level studies show many beneficial employment effects from productivity gains, but at the more granular level it is possible to observe the firms and workers that lose out as well. In response to technological change, many companies produce the same with fewer workers—these are the firms and industries where "robots are stealing jobs." But at the same time, some companies that increase productivity are able to sell more because their costs go down, and are able to maintain or even increase the number of workers they employ. Chang, Hornstein and Sarte examine reasons for industry-level differences in firms' reactions to technological change, showing that firms in industries with low inventory costs, elastic demand, and flexible prices are all more likely to increase employment after a productivity shock.[75] In other words, in industries where price declines are more likely to stimulate demand increases, productivity increases are more likely to not lead to job losses. Benavente and Lauterbach find mixed evidence along different lines: product innovations have a significant positive effect on firm employment, but there is no evidence to suggest that process innovations significantly affect employment.[76] Evangelista and Vezzani find that productivity increases lead to increased employment in European firms by increasing the size of the business overall, although they also find evidence of job displacement in manufacturing sectors.[77] Bartelsman, Haltiwanger, and Scarpetta find that while increased productivity causes firms to cut jobs in many cases, nearly half of the productivity gains come from firms that increase employment.[78] Baily, Bartelsman and Haltiwanger likewise find that almost half of aggregate productivity growth is due to firms that increase both employment and value added per worker, while the rest is linked to firms that decrease employment.[79]

Broader studies confirm these results for both developed and developing countries. In a large cross-country (OECD and non OECD) study of more than 26,000 manufacturing firms, Dutz et al. find that establishments with increasing productivity have higher

employment growth than non-increasing firms.[80] The strength of a firm's productivity-driven employment growth is significantly positively associated with the share of the firm's workforce that is unskilled, debunking the conventional wisdom that productivity-driven growth is not inclusive. Along the same lines but covering a broad array of industries, a study by the International Finance Corporation of firms in 106 developing countries found similar workforce growth in firms where productivity increases had occurred.[81]

There are also many examples of national markets in the developing world that reward productivity with the same level of medium-term employment growth seen in developed nations. Studying the effects of productivity in developing countries, Waheed finds strong support in Bangladesh and Pakistan for the idea that innovation (both process and product) increases aggregate employment.[82] In a policy paper looking specifically at agriculture in developing countries, Cheong, Jansen and Peters argue that "higher agricultural productivity can increase the quality of work and the wages of agricultural workers, reabsorb workers from the informal sector back into the formal agricultural sector, and leave manufacturing employment relatively unaffected."[83] Monge-Gonzalez et al. find that "product innovation and process innovation are positively related to employment growth…The findings suggest that overcoming challenges to the Costa Rican innovation system and strengthening it may contribute to improvements in the rate of employment generation."[84] Merikuell, in a 2010 study of Estonian firms, finds that "innovation positively affects employment growth, resulting from the strong effect of process innovation on employment in medium and low-tech industries. However, at the industry level, the effect on net employment vanishes."[85] Yang and Lin find that Taiwanese firms that undertook technological improvements in R&D-intensive industries experienced significant employment growth favoring skilled workers, while those in less R&D-intensive industries tended to shed workers.[86]

WILL THE FUTURE BE DIFFERENT? IS AUTOMATION SPEEDING UP?

The chorus of voices worrying about automation keeps growing louder, despite the lack of evidence linking productivity and unemployment. Their rationale for ignoring this evidence is that "this time is different": that despite whatever happened in the past, productivity growth destroys jobs and will only destroy more of them.

This new development—manifested, they say, by the slow recovery from the Great Recession—is explained through several lines of reasoning. The first line of reasoning is the "nowhere left to run" argument that is at the core of neo-Luddite logic: after the robots take our current jobs there will be no new ones to replace them. The historical narrative is as follows: as automation reduced agricultural jobs, people moved to manufacturing jobs, and after manufacturing jobs were automated, they moved to service sector and information-based jobs, but now as these jobs are automated there are no new sectors to move into.

This idea is pervades the worries of many neo-Luddites. Economist and complexity theory expert Brian Arthur argues in a McKinsey article that "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

may have white-collar business process jobs—and we face a problem."[87]In an article for *The Atlantic* entitled "The End of Labor: How to Protect Workers From the Rise of Robots," blogger Noah Smith puts it more bluntly: "Once human cognition is replaced, what else have we got?"[88]

This "nowhere left to run" argument is absurd on its face because there is no upward limit to our desire to consume. Clearly, U.S. median household incomes could quadruple to around $200,000 a year without these households running out of things to spend money on. Or for that matter they could increase 20 times to $1 million per year without exhausting consumption possibilities—and that consumption creates jobs.

Some neo-Luddites argue that even this would not be enough: computers and robots are finally eclipsing the full range of human ability—not only in routine manual or cognitive tasks but in more complex actions or decision-making as well. The logic is as follows: in order 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. We will all be living in George Jetson land, but unlike George, we won't be working at Spacely Sprockets, because the robots will do that job too.

As noted above, the "nowhere left to run" logic runs counter to historical evidence, but that does not necessarily disprove it for the future. Technology continues to progress, and there is plenty of recent talk about "inflection points" on the horizon, where automation reaches levels of competency that allow it to replace large amounts of the workforce in one fell swoop. In the words of McAfee and Brynjolfsson, this is "reaching the second half of the chessboard," where exponential gains in computing power lead to drastic changes after an initial gestation period.[89] In some sci-fi future these gains could lead to technology that surpasses human ability not only in terms of current work but possible future work as well, cutting off any potential areas of labor demand. In practice, as we will explain below, this will not occur (and if it does we should welcome it with open arms).

The second view is that even if we never run out of jobs, the rate of job obsolescence is getting too fast for job creation to catch up because disruptive new industries are destroying jobs faster than new ones can be created. While the fact that we are not creating enough jobs is self-evidently true in our current state of high unemployment, this explanation makes the additional leap of logic that technology is playing an important (at least on the margins) role in the job creation and destruction process.

This idea has become quite popular with commentators. Jared Bernstein, former chief economist and advisor to Vice President Joe Biden, writes, "I fear that the path back to full employment is looking very steep, and I suspect accelerated labor-saving technology is one reason for that."[90] James B. Huntington warns that "major future inventions will have nowhere near the employment-boosting effect as cars, electricity, or television did in the past, as their work processes will be far too automated."[91] Martin Ford claims in *The Lights in the Tunnel* that the newer the technology, the faster it becomes obsolete.[92]

It should be noted that, in aggregate terms, there is a substantial degree of labor market turnover every year. In other words, there are always lots of jobs destroyed by firms going out of business or downsizing, while new firms are being created and others are growing. The commonly cited statistic for the "number of new jobs created" is a net number; in reality, many more jobs than that were added, but others were also lost. For example, in 2011, 15.7 million jobs were created, but net job creation was only 2.6 million because 13.1 million jobs were destroyed (Figure 12). On average around 15 percent of jobs are newly created every year in developed countries.[93] Thus, when we talk about technology destroying jobs, what we are really talking about is technology increasing the job destruction rate relative to the rate of job creation.

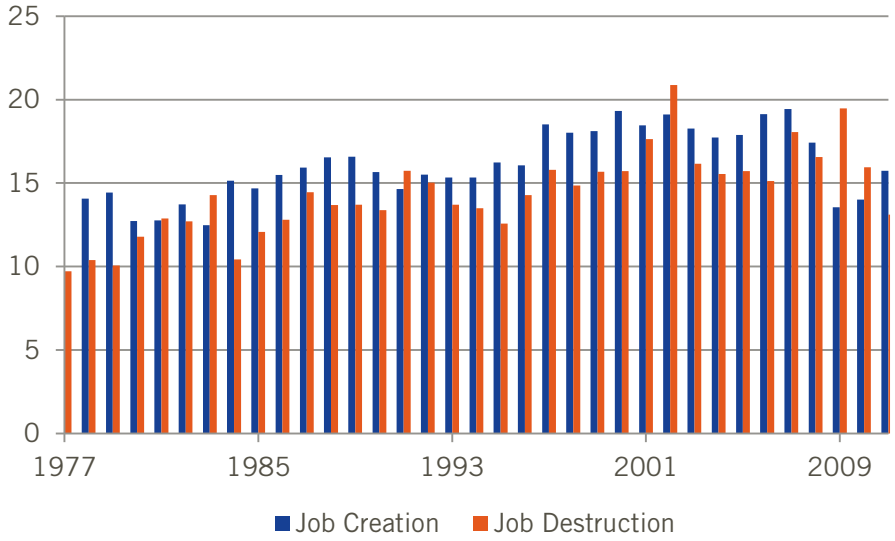

Figure 12: U.S. job creation and job destruction (millions of jobs)[94]

Despite the growing popularity of these arguments—people will not have any scarce labor they can sell on the market and job destruction is growing much faster than job creation—both are incorrect and it is clear that "this time" is no different from before. How can we be sure?

First, we need to remember that the U.S. economy is a vast, complex system—the kind of system that blanket pronouncements rarely manage to do justice to. The type of work that is done in the economy varies enormously between sectors and occupations, and the impacts of technology will be accordingly dissimilar. We are unlikely to see sudden breakthrough progress on all fronts at once, even if technology does make massive strides.

However, there are similarities between parts of the economy that will affect their automation. These similarities can serve as a framework for our understanding of how technology will likely change the economy. The most common ways to divide up the work done in the economy are along either sector and industry lines or occupational lines. Sectors and industries are convenient because they allow for the calculation of productivity changes due to technological change or other factors. Throughout most of the years since World War II, most service sectors exhibited lower gains to productivity and most of the overall gains were driven by manufacturing (and a few sectors like railroads and

communications). Despite this, wages in all sectors increased significantly, leading to the idea of "Baumol's Cost Disease."[95] Baumol's Cost Disease occurs where sectors that do not increase productivity nevertheless increase wages because they must compete with other sectors for workers. However, in the latter half of the 1990s and the first half of the 2000s more service sectors did experience significant productivity gains, leading some to claim that "Baumol's Disease is cured."[96]

Despite this burst of optimism, many industries remain stuck with little or no productivity gain—Baumol's Disease remains a powerful force in the economy and it shows us that there are some sectors that have a great deal of productivity gain while others do not. Many sectors, such as construction, nursing homes, police and fire, and janitorial services, have been experiencing slow or even declining productivity, and it is unclear how technology will turn the situation around. We could eventually see fully automated construction systems or cleaning services, but if this ever comes about it will be a gradual process, dependent on innumerable technical challenges as well as economic ones like finding economies of scale. In other words, industries involved in human services and non-routine physical tasks are very hard to automate.

Clearly there have been important trends toward productivity increases in some sectors and it appears that there will be more. Manufacturing technology continues to improve, although productivity growth rates are lower than in past decades. The transportation sector is likely to see some upheaval a few decades from now as driverless vehicle technology moves into mainstream use, but it may be a long time before shipping or taxi industries are fully automated. Algorithms may slowly replace some knowledge-based jobs, but most of them are a long way from automation, because machines are not yet intelligent enough. As we do replace knowledge-based jobs we will find ourselves with even higher bang-for-our-buck gains, since all those who retain their jobs will see the price of services come down drastically.

Industries are a helpful unit of analysis because they give us a functional view of the economy, but occupations provide an even more revealing lens through which to view the impact of automation. Technology tends to replace human labor one type of task at a time, so breaking down employment into occupations and even into more granular individual tasks can show us exactly where productivity gains may occur. Robots so far have specific, limited skill-sets and often replace specific, limited tasks.

Much of the research in this area has been focused on the relationship between skills and automation. In a recent report, Levy and Murnane identify five different types of skills: routine manual tasks, non-routine manual tasks, routine cognitive tasks, dealing with new information, and solving unstructured problems.[97] They find that jobs involving routine manual and cognitive tasks (e.g., assembly line workers and travel agents) have declined as a share of the economy since the late 1960s while the other categories have grown or stayed about the same. Autor and Handel, and Michaels, Rauch, and Redding have conducted related analyses tracking the evolution of tasks over time.[98] The main conclusion of this literature is that jobs are not disappearing, just shifting. As automation reduces routine

jobs, non-routine jobs automatically take a bigger share of the employment pie as the overall employment pie grows.

Shifts between industries or between occupations are important aspects of economic growth, but they also reveal a fundamental flaw in the worries about technology disrupting the balance between job creation and job destruction: even if the economy never again created a new industry or occupation, there would still be plenty of jobs going forward, even with very high levels of productivity. The reason is simple: higher productivity means cheaper goods and services, which means higher per-capita incomes and more consumer demand—and more consumer demand means more workers producing goods to satisfy that demand. So while people might not be buying flying cars and taking trips to Mars, with higher productivity they will be buying larger houses, eating out at nice restaurants more often, hiring personal trainers, and paying more in taxes for collective goods like cleaner air and more livable cities. We have never run out of things to spend money on and clearly will not for the conceivable future. And even if at some point we are all multi-millionaires and decide that all our materials desires are met, people would start to substitute time for money, working fewer hours per year. In other words, productivity growth could easily be 10 times faster than today with no negative employment effects, at least in the moderate term (three to five years) and beyond.

While the body of work on changes in the task or industry composition of the economy seems to show a sizeable body of remaining jobs, the task literature does present the question of human obsolescence in stark terms: if this time is different and machines do get better at tasks that have so far been the exclusive domain of humans (non-routine manual tasks, dealing with new information, and solving unstructured problems, according to Levy and Murnane[99]), then it is hard to imagine why labor would be useful. No new types of tasks would be available for humans to move into.

Luckily these concerns are more appropriate for the realm of science fiction than reality. The wide variety of sectors and tasks in our economy, no matter how good our technology is, will still be difficult to automate, and their multitudinous existence is far from the only thing standing between us and a jobless robot apocalypse. The fast technological progress forecast by neo-Luddites has not materialized and may never do so. While we cannot know for sure what will happen in the future, the idea that technology will suddenly launch productivity (or is already launching it) into the stratosphere seems farfetched—almost as farfetched as the idea that this burst of technological progress would decrease jobs instead of creating more of them. A simple look at productivity statistics shows why. Productivity has rarely increased at a rate of more than four percent per year, and the five-year moving average of yearly increases has not broken four percent since 1952 when unemployment was quite low (see Figure 13).[100] Its current rate is well below the average. This slow progress is because, for all the industries where we see progress, many more industries are operating with the same or lower levels of productivity as they had years ago. All of this means that massive improvements of the likes of even eight percent a year are basically out of the question for the United States, because they would require faster technological progress across a much broader array of technologies, industries and occupations. Just because prototypes of driverless cars have been tested does not instantly mean all taxi

drivers lose their jobs; on the contrary, there are myriad legal, social, and additional technological hurdles that prevent these productivity increases from occurring. And the evidence so far bears this out: although job destruction was high during the great recession, it was not drastically above trend, and has actually declined in 2011 to the lowest level since 1995.

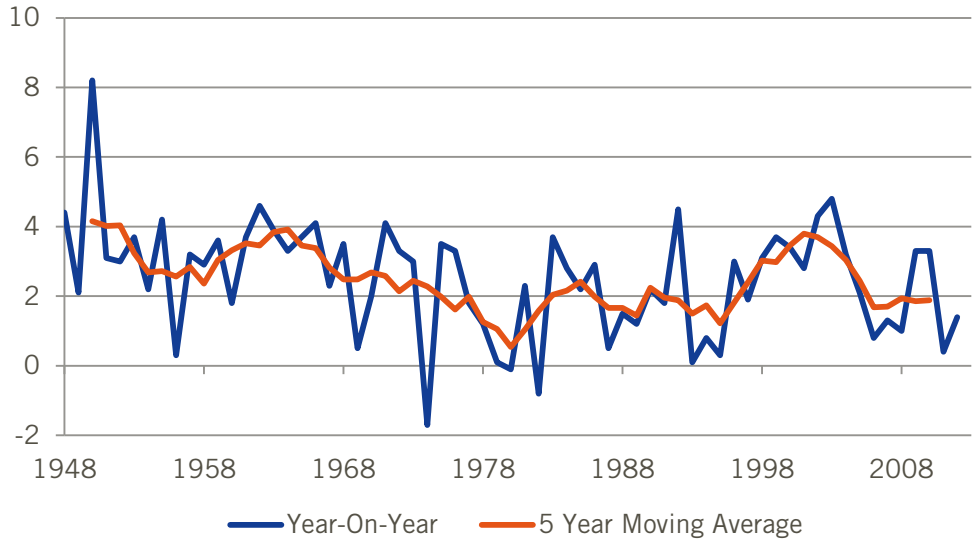

Figure 13: U.S. productivity percentage increase[101]

Kurzweil, Elliott, and other techno-utopians make two key mistakes. They overestimate the ability of computers to substitute for humans and they assume that current trends will continue or even accelerate.

As to the concerns about robots exceeding all human ability in the "nowhere left to run" argument, we can turn to the more speculative world of the techno-utopians. Perhaps the most noted techno-optimist is computer expert and futurist Ray Kurzweil. In *The Singularity Is Near*, Kurzweil argues 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.[102] Written a few years ago when productivity growth was much stronger, Kurzweil argues that "gains in productivity are actually approaching the steep part of the exponential curve."[103] In a similar vein, Stuart Elliott, in a paper for the National Research Council, extrapolates Moore's law and argues that in a short 23 years computers are likely to displace 60 percent of all jobs.[104] If this were likely to occur (which it is not), the impact on productivity would be remarkable.

But Kurzweil, Elliott, and other techno-utopians make two key mistakes. They overestimate the ability of computers to substitute for humans, and they assume that current trends will continue or even accelerate. The rate of innovation is not exponential, has never been exponential and never will be exponential. Yet some techno-utopians (and often neo-Luddites when it comes to jobs) persist in this view. For example, Singularity University co-founder Peter Diamandis argues that we are entering into an era in which the pace of innovation is growing exponentially and that we are close to a world of global abundance in which most people will enjoy U.S. living standards within a generation. But for this to happen, the global rate of productivity growth would have to increase to around 20 percent per year, almost six times faster than its rate of growth over the last two decades.

While Kurzweil, Diamandis, and others are clearly wrong that the rate of productivity growth is exponential, they are likely right that IT will continue to develop, leading to amazing innovations that we can barely imagine. They are also likely right that at some point IT will advance so much that machine intelligence will be quite sophisticated, enabling, for example, robots that can interact with humans in more natural-seeming ways. However, the techno-optimists are likely making the same mistake that futurists of the 1960s did when they predicted that growth over the next 40 years would accelerate, completely missing the dramatic slowdown that occurred from 1974 to 1995.[105] The 1960s futurists underestimated how long the transition period would be from the old system to the new one, and it is likely Kurzweil and others—including neo-Luddites like McAfee and Brynjolfsson—are making the same mistake now. Silicon-based IT systems are likely nearing their limits—even Gordon Moore says Moore's law is dead—and Kurzweil is almost surely right that we will at some time move to new IT technologies (e.g., optical, nano, biological computing, etc.). [106] But it is unlikely that this replacement system will be ready for commercialization just as the miniaturization constraints of silicon reach their limits. This means that there is likely to be an intervening period of slow innovation and slow growth until the next technology system fully emerges.[107]

Thus it is not at all clear—and indeed unlikely in the next decades—that machines will reach the level of intelligence required by Levy and Murnane's remaining three tasks (non-routine manual tasks, dealing with new information, and solving unstructured problems).[108] What is striking is that the "new stagnationists" such as Robert Gordon and Tyler Cowen argue that technological growth will in fact decrease significantly in the future. While we think that they are as wrong as the techno-optimists, the fact that they are making this argument suggests that the case for techno-utopianism is far from a slam dunk.

Clearly innovation is not over, and most certainly not exhausted due to past performance. As Schumpeter put it, "There is no reason to expect slackening of the rate of output through exhaustion of technological possibilities."[109] This is a good thing. We are still harvesting the fruits of past research and building on past knowledge, and if we plant the right seeds we will continue to do so. Productivity growth remains as critical for our economic health as it ever was, as we must never forget that the attendant creative destruction benefits the entire economy. We need *more* productivity increases—getting back to the healthy gains of four percent annually that we had in the 1990s and in postwar decades—not less. A return to healthy growth levels will maintain U.S. competitiveness and encourage domestic investment. Such an increase will keep net job growth strong as second-order effects spread the wealth throughout the economy.

WHY DON'T WE HAVE JOBS? WHAT IS REALLY GOING ON?

If technology is not the problem—if this time is really no different than before—then what is going on? Why is growth so sluggish and unemployment so high? While there are a number of important causes including inadequate demand and the problematic nature of recovery from financial crises, the most compelling diagnosis is that we are failing to achieve robust recovery because the overall U.S. economy has lost international competitiveness. This section will explain why competitiveness is important and how our loss of it has hurt job growth. For a complete overview of different explanations for the

poor job growth since the Great Recession, see ITIF's previous work, "Explaining Anemic U.S. Job Growth: The Role of Faltering U.S. Competitiveness."[110]

In a global economy, having a competitive traded sector is essential for economic growth. A nation's traded sector comprises those industries and establishments which compete in international marketplaces and whose output is sold at least in part to nonresidents of the nation. Traded sectors include almost all of a nation's manufacturing activity, some services (such as software, Internet, and engineering services, and entertainment content like music, movies, and video games), and some of the extraction sectors (e.g., farming or mining). Because these industries face market competition that is global in nature in a way that non-traded, local-serving industries (e.g., retail trade or personal services) do not, their success is by no means assured. For example, while we may not know whether Safeway, Giant, or Walmart are going to gain market share in the U.S. grocery store industry, we do know that the industry itself will be healthy, dependent only on the income and purchasing habits of American consumers. On the other hand, while we may not know whether Boeing or Airbus are going to gain market share in the global aircraft industry, we also do not know whether there will be aviation industry jobs in the United States, since this depends on the United States winning in global competition in this industry. Put differently, if a grocer goes out of business another will emerge to take its place to serve local demand, but if a traded sector enterprise such as a manufacturer or software company closes, the one that takes its place may well be located in another country.

Traded sector competitiveness is important because without it a nation's terms of trade decline—that is, a nation must give up more of its goods and services in exchange for what it needs to import. Usually, trade imbalances among countries are balanced through the adjustment mechanism of currency exchange rates. But if this cannot happen, the result is lost jobs. And indeed, this is what has happened to the United States over the last decade in particular as it has run up massive trade deficits. In this situation, the result is lost domestic output and lost jobs, which cascade throughout the economy, acting as a stiff "economic headwind" that overall economic growth must fight against.

The United States' loss of competitiveness can be seen most clearly in the manufacturing sector—a sector with important repercussions for the rest of the economy. In the 1980s, overall U.S. employment expanded by 19 percent and in the 1990s by 20 percent. During the same periods, manufacturing employment fell seven percent and one percent, respectively. But between 2000 and the peak of employment in January 2008, jobs grew just 5.4 percent, while manufacturing jobs fell 32 percent. Remarkably, few economists or pundits have made this connection between the anemic overall job performance in the last decade and largest percentage drop in manufacturing employment in American history, even greater than that of during the Great Depression. This is all the more troubling since manufacturing jobs have the highest employment multipliers of any sector, meaning that the loss of these manufacturing jobs led to significant job loss in the rest of the economy.[111]

Another way to look at the manufacturing sector's decline is by examining the changes in the contribution of manufacturing to changes in GDP. From 1980 to 1989 the sum of annual GDP changes was 30 percent, of which manufacturing added 5.8 percentage points

(about 20 percent of the sum of annual GDP growth). From 1990 to 1999, it was 32 percent, of which manufacturing added 5.2 percentage points (about 17 percent). But in the last decade the annual sum of GDP changes (gains or losses) was just 18 percent, with manufacturing changes subtracting 4.7 percentage points. If manufacturing had contributed its same share to GDP growth as it did in the 1980s and 1990s, overall GDP growth would have been 28 percent in this last decade, rather than 18 percent.[112]

The same signs of stagnation and decline can be seen in the United States' tradable sector more broadly: Spence and Hlatshwayo find that there has been almost no net employment growth in the tradable sector since 1990, despite across-the-board value added gains.[113] Trade statistics show this decline clearly. The previous year (August-June) deficit in non-petroleum products was $480 billion, roughly where it has remained the past three years after crashing and then rebounding. Current trends indicate that it may stay below pre-recession levels for the near future, although it remains deep in deficit territory (see Figure 14).

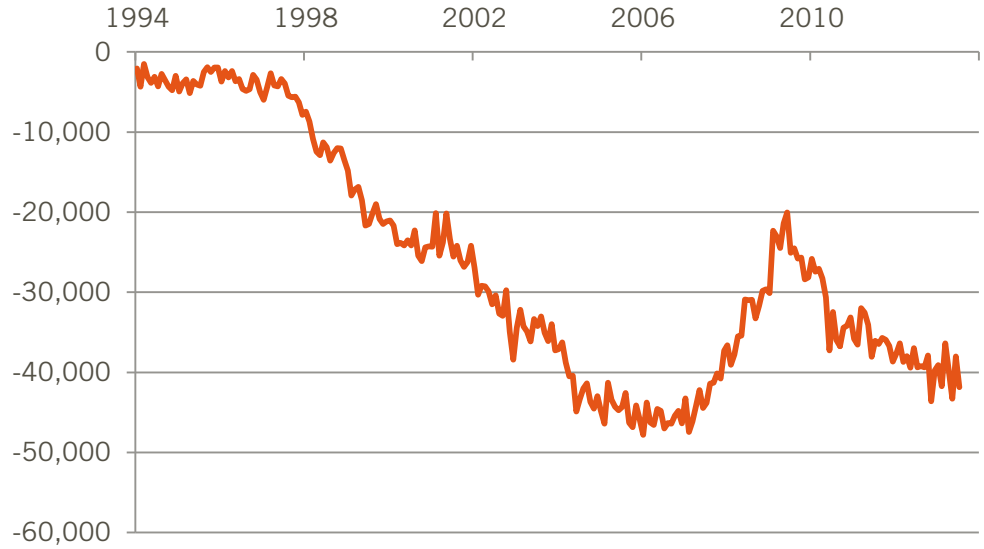

Figure 14: U.S. non-petroleum monthly trade balance (millions of chained 2009 Dollars)[114]

This loss of manufacturing and tradable competitiveness has turned the U.S. economy into a leaky boat with worn sails so it could not tack the headwinds that increased into a gale force in the last decade. For most of the 2000s, it meant slow growth, and contributed to the bubble dynamics that made the latest recession "The Great Recession."[115] And now it continues to put the brakes on our painfully slow economic recovery. For example, annual new orders for manufacturers and durable goods orders have only now reached their nominal pre-recession peak—almost six years later.[116]

This stiff headwind of robust foreign competition impacts recovery in a number of ways. First, just as reductions in corporate investment or consumer spending will exert a negative influence on GDP growth, so too do net increases in the trade deficit. Recall Macroeconomics 101 and the equation GDP= C+I+G+(X-M). When imports grow faster than exports in the short run, it exerts a contractionary effect on GDP and jobs. Conversely

if exports were growing faster than imports, it would exert an expansionary effect on the economy and jobs, precisely why President Obama declared a goal of doubling exports.

Manufacturing's decline, due to a large extent to foreign competition, turns out to have unexpected consequences as well. New research from Olney and Pacitte suggests that business cycle dynamics differ between manufacturing and service sectors.[117] This is because services must be produced on demand and cannot be inventoried: the implication is that *actual* demand instead of *expected* demand is the key driver of the recovery. Since actual demand comes after expected demand, economies are slower to recover.

But perhaps the most important impact on the economy of the loss of U.S. competitiveness is the way it erodes the confidence of businesses, workers and consumers. Ultimately, a strong and brisk recovery will depend on a faith that America will once again lead in the global innovation economy. Absent that faith—or in the presence of a sense of economic foreboding and decline—the rational exuberance needed to power investment and spending will be lacking, and recovery will continue to drag along. As Keynes noted, "Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as the result of animal spirits—a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities."[118]

Ultimately, a strong and brisk recovery will depend on a faith that America will once again lead in the global innovation economy.

If the United States is able to regain its lost ground in the race for competitiveness it will have a far better time attracting the investment and jobs necessary for a robust recovery.

CONCLUSION: THE CASE FOR A NATIONAL PRODUCTIVITY POLICY

Given that productivity growth is the most important factor in our nation's economy it is surprising that the United States does not have an explicit national productivity policy. There are at least two reasons for this.

First, there is no consensus that boosting productivity should be the central goal of economic policy. Many economists and policymakers believe that managing the business cycle trumps a concern with moderate to long-term growth issues. This is especially true since the onset of the Great Recession. Still others, including many on the left, increasingly believe that because of the growth in income inequality, redistribution should be the focus. For them, John Kennedy's famous statement that a "rising tide that lifts all boats" no longer applies. And of course, neo-luddites are increasingly arguing that we have too much productivity and cannot afford more, at least if we want people to have jobs.

Second, even among those who believe that productivity is important, many believe that government is powerless to do anything about to positively influence it. The best we can do, they claim, is to stand by, hoping that market forces and chance discoveries will eventually raise productivity. Indeed, most conventional neo-classical economists have little to say about productivity. For example, Alan Blinder believes government can do little to influence growth, except perhaps in the short-term on the consumer demand side as Keynesian economics suggests. Indeed, he argues that, "Although economists can tell the government much about how to influence aggregate demand, they can tell it precious little about how to influence aggregate supply. Let no supply-sider tell you differently." Blinder,

goes on to claim 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 ain't so."[119] Paul Krugman offers the same refrain, pronouncing, "Productivity growth is the single most important factor affecting our economic wellbeing. But it is not a policy issue, because we are not going to do anything about it."[120] Liberal economist Frank Levy agrees, stating, "We cannot legislate the rate of productivity growth...That is why equalizing institutions are so important."[121] These aren't outliers. The dominant economic thinking minimizes the role of policy in spurring productivity.

Despite what the neoclassical economists assert, we can't simply assume that productivity and automation is manna from heaven that will happen at the maximum rate without an explicit productivity policy. And despite what the Keynesian left says, we can't rely alone on redistribution to raise incomes of average Americans. We need higher productivity and to do that we need a national productivity policy.

We need higher productivity and to do that we need a national productivity policy.

Future ITIF work will lay out in detail what that productivity policy should look like, but for now suffice to say that first we need a coherent analytical strategy identifying productivity barriers and opportunities. Any strategy also needs to go beyond macroeconomic policy, factor inputs (e.g., education and skills) and framework conditions (e.g., competition policy). To be sure, getting these right is a part of any solution, but they are insufficient. Rather, any strategy has to focus on barriers and opportunities in particular industries (e.g., construction, health care, education, etc.) and occupations and functions (e.g., information processing, payments, etc.). In some cases, there may be little public policy can do to influence productivity in a sector, occupation, or function. But in others there may be quite a lot. In addition, a productivity policy should examine the role of technology platforms and tools for driving productivity. For example, platforms like health information systems and mobile wallets can be key drivers of productivity, but market forces alone can often not produce optimal platform development. Likewise, a coherent science and R&D policy focused on advancing key technologies can play in important role in advancing the technologies most important to driving productivity growth (such as robotics, expert systems, etc.). Finally, as ITIF discusses in a forthcoming report on trends in capital investment we need a tax code that provides explicit incentives for companies to invest in more and newer machinery, equipment and software.

In summary, if we want our children to enjoy the same improvements in standard of living we experienced vis-à-vis our parents, rather than be afraid of robots and automation technology generally, we should do everything we can, including developing a national productivity policy, to get more of it.

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