Productivity Growth in the Advanced Economies:
The Past, the Present, and Lessons for the Future

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It is great to be here with my close colleagues to discuss productivity growth—among the more vexing challenges that economists and policymakers face today. Indeed, productivity poses perhaps the largest disparity between its substantive importance and how much we understand it. Productivity growth is central to a range of economic questions from the slowdown in middle-class incomes in recent decades to the outperformance of employment over output in the current recovery. Looking forward, productivity growth is essential to understanding how quickly wages can grow, how fast the economy can grow, and the magnitude—and potentially even the existence—of a long-term fiscal gap.

Our understanding has often been clouded, not just by the inherent difficulties of the subject, but also by the smoke thrown up by the often heated debates about its future. The steps we take toward a fuller understanding of productivity growth will necessarily be incremental and will require as much patience as analysis. The OECD's recent work on "The Future of Productivity" is an important step. It is one entry to the recent debate that sheds more light than heat. With a study of firm-level data that permits analysis of productivity differences within industries, the OECD has moved us closer toward understanding the path forward.

Today, I will reflect on the evolution of productivity in the United States and globally—focusing on its volatility through the postwar era and its recent slowdown. Both time periods are relevant to productivity's importance to aggregate output, middle-class incomes, and the trajectory of our fiscal position. While projecting the future of productivity is too ambitious for a twenty minute speech—or even a twenty hour speech—I am encouraged by a number of lessons we might draw from the past and present.

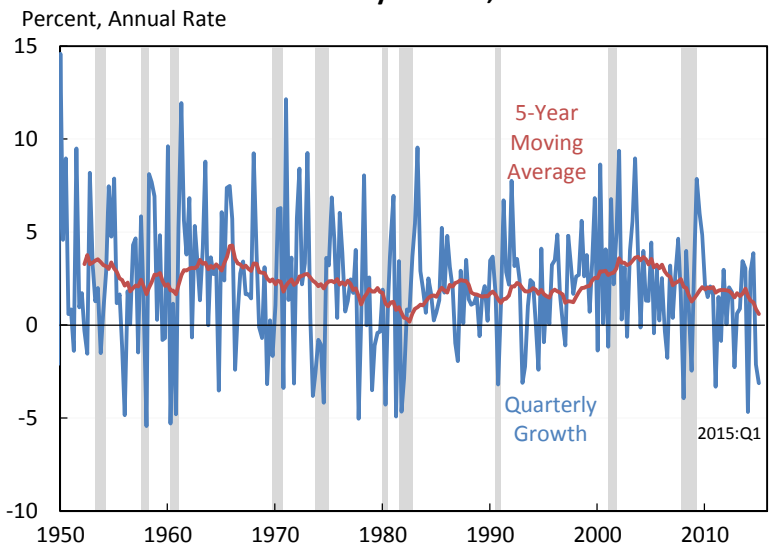
First, the slowdown in productivity growth across the advanced economies in the wake of the crisis offers very little predictive information about the future. Second, the slowdown has been driven by reduced post-crisis investment, a less persistent factor than the sort of actual innovation shifts that have affected productivity in the past. And third, evidence from the technology sector suggests some reasons for optimism about innovation in the United States and around the world—although I would caution anyone against too much confidence with respect to how quickly we will develop new ideas in the future. Finally, I will review aspects of the President's agenda most relevant to productivity growth. Much of my discussion will emphasize the United States, but I will try to put it in a broader global context because, as the OECD has emphasized, the challenges of productivity are in large part common to the advanced economies.

The Mysteries of Productivity

Productivity is important, but it is also mysterious—on three levels. In the first place, labor productivity data are notoriously volatile, as shown in Figure 1. This is intuitive and is to be expected, in part because of the compounding of measurement error in both the numerator and the denominator.

But it means that very little information is contained in each quarterly productivity release—denying economists like us our usual pleasure of analyzing high-frequency data. Indeed, it takes years for clear long-term trends in productivity growth to emerge. Even though the longer-term trends do not suffer from the same volatility as quarterly data, they too can be affected by more systematic measurement error over time as statisticians struggle to keep up with the innovations associated with quality improvements, new products, and goods with low or zero marginal cost.

Figure 1
U.S. Labor Productivity Growth, 1950-Present



A second level of mystery is that total factor productivity (TFP)—an important contributor to labor productivity, which I will discuss more in a moment—cannot be directly observed. It is measured as the residual between output and the weighted growth of inputs, and is subject to considerable measurement error.

The third level of mystery is explaining the conceptual drivers of productivity growth. Even if we agreed on the facts of historical productivity growth, explaining those facts is more difficult still. Moses Abramovitz famously called TFP a "measure of our ignorance," the unexplained gap between input and output.[1] And a rigorous conceptual understanding of that gap continues to elude economists. Intuitively, TFP tells us how efficiently and intensely inputs are used. This is easily mapped to innovation of the technological and managerial sorts. But periods of outsized

[1] Moses Abramovitz. 1956. "Resource and Output Trends in the United States Since 1870." NBER Occasional Paper 52. Available at http://www.nber.org/chapters/c5650.pdf.

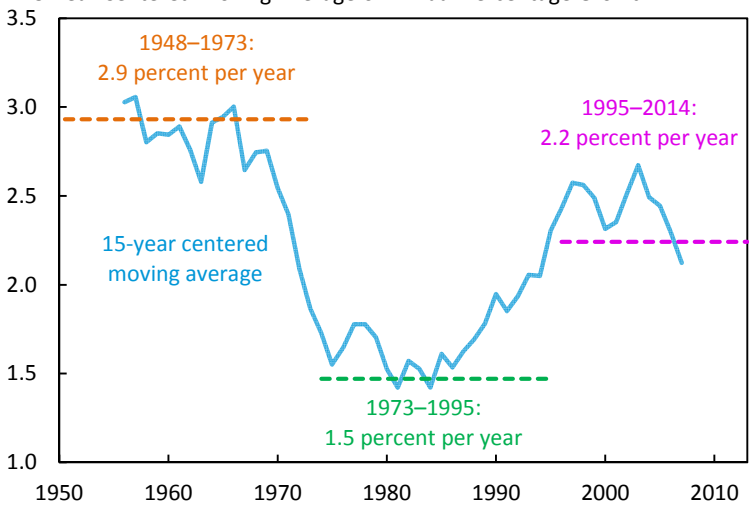
productivity growth do not necessarily align with periods normally associated with technological innovation.

And if understanding productivity's past or present were not challenge enough, understanding its likely future path poses a staggering challenge for researchers and policymakers, a challenge that sometimes exceeds the degree of humility that some have brought to question. Personally, I find the more I think about productivity growth the more questions I have.

Productivity in the Past: A Driver of Middle-Class Incomes

As shown in Figure 2, the evolution of labor productivity growth in the United States since World War II can be partitioned into three regimes.

Figure 2
U.S. Labor Productivity Growth
15-Year Centered Moving Average of Annual Percentage Growth



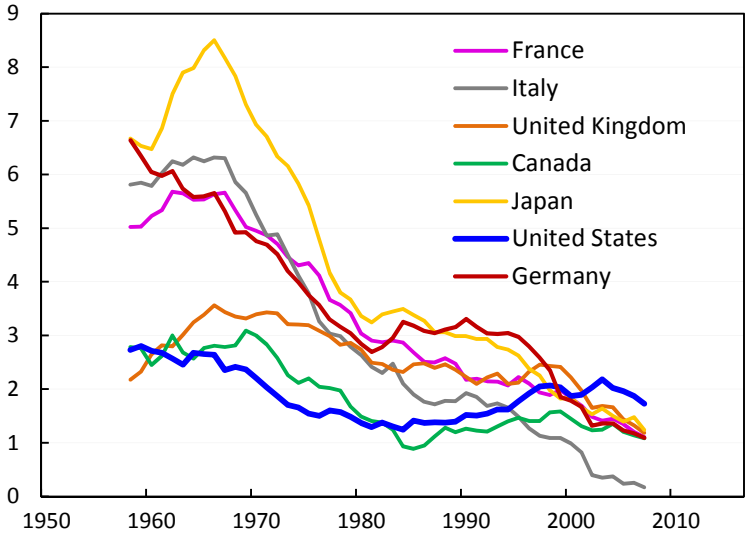
Labor productivity in the private nonfarm business sector rose by an average of 2.9 percent per year between 1948 and 1973.[2] Beginning in the earlier 1970s, though, productivity slowed sharply, averaging only 1.5 percent growth between 1973 and 1995. Several factors can help explain the downshift. First, growth in the immediate post-war era benefited from the commercialization of numerous innovations made during World War II, including the jet engine. The early 1970s marked the point at which the wartime innovations became exhausted. Public investment also slowed, and the 1970s oil shocks and collapse of the Bretton Woods system caused dislocations that weighed on growth.

[2] Figure 2—and all subsequent references to annual U.S. labor productivity in these remarks—references real output per hour worked in the private nonfarm business sector (excluding government enterprises) as reported by the Bureau of Labor Statistics (BLS). In other contexts, I have referenced the BLS' labor productivity series for the nonfarm business sector (including government enterprises). The two series are closely correlated and exhibit the same trends, but excluding government enterprises permits the analysis of total factor productivity (TFP) that follows.

Productivity growth did not rebound meaningfully until the mid-1990s, when the new economy improved the production and use of information technology at a startling rate. Productivity growth surged, rising 2.2 percent at an annual rate between 1995 and 2014. I will return to the question of whether the recent period should be considered part of the post-1995 resurgence or a new regime of slower productivity growth.

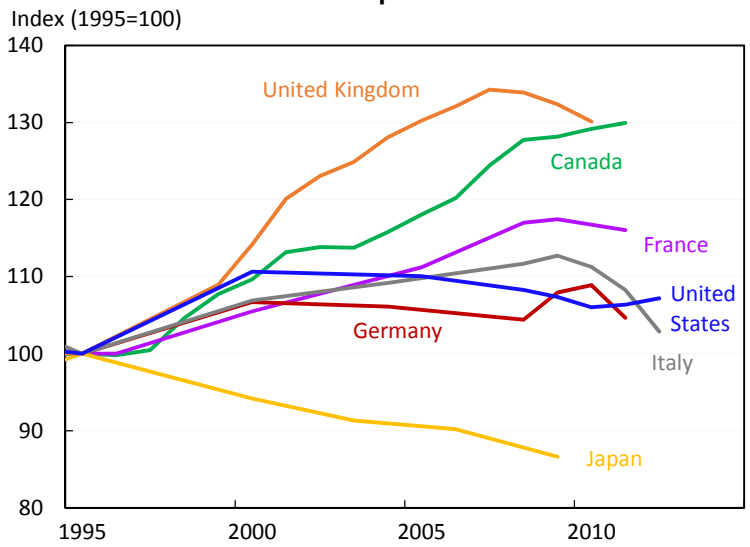
The international story is somewhat different. In the immediate postwar period, our G7 partners generally experienced much faster productivity growth than the United States as they rebuilt from the devastation of the war and moved closer to the American-led technological frontier. While all of our G7 partners experienced the productivity slowdown that began in the 1970s, most did not see the 1990s rebound. As shown in Figure 3, the largest European nations have seen a relatively consistent decline since the 1970s. The somewhat more positive situation in the United States likely reflected the U.S. concentration of high-tech innovation over the past twenty years.

Figure 3
Labor Productivity Growth, 1950-2014
15-Year Centered Moving Average of Annual Percentage Growth



Productivity is also central to a much longer-term challenge facing our economy and many of yours in the OECD: the multi-decade stagnation in middle-class incomes. As shown in Figure 4, real median disposable income in the United States was lower in 2012 than it was in 2000, suffering from a longer-term trend of slow growth compounded by the huge recession. The story varies across the G7 but the U.S. experience is broadly in the middle of the range.

Figure 4
Real Median Disposable Income



In fact, a simple thought experiment provides a sense of how important productivity is to incomes: what if productivity growth from 1973 to 2013 had continued at its pace from the previous 25 years? In this scenario, incomes would have been 58 percent higher in 2013. If these gains were distributed proportionately in 2013, the median household would have had an additional $30,000 in income. Had income inequality and labor force participation not worsened markedly, middle-class incomes would be nearly twice as high.[3]

Productivity in the Present: An Investment-Driven Slowdown

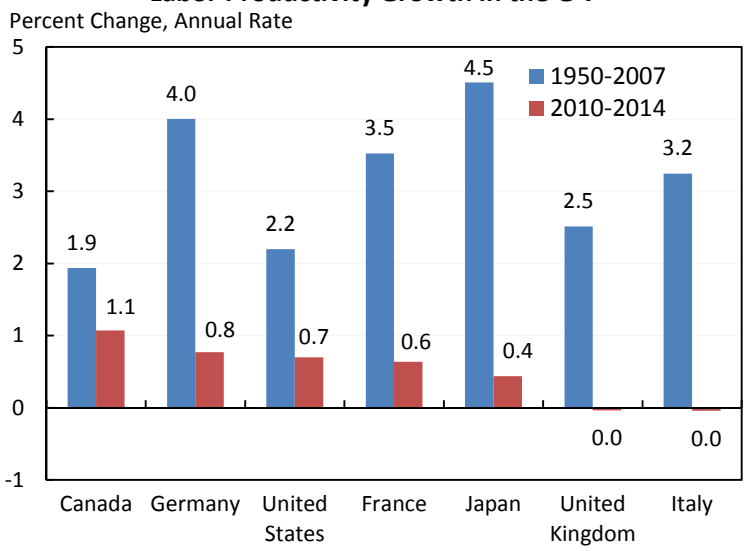
I will now turn to the present and toward the global concerns over productivity growth in the wake of the global financial crisis. Many economists have noted the appearance of a disconnect between labor market performance and economic output in 2015 so far, as employment growth in the first quarter remained at its 2014 pace while GDP was markedly lower. If output consistently rises more slowly than aggregate hours worked, productivity is falling by definition. No one is suggesting that we face an environment of persistently negative productivity growth, of course, and the well-known volatility of productivity in the short-term thankfully insulates economists from having to contend with that question on a regular basis.

But the recent disconnect between employment and output is only a more extreme version of the disconnect we have seen in recent years. Since mid-2010, output has increased at a 2.1 percent annual rate, which is below what most economic forecasters expected, while the unemployment rate has fallen by an average of 0.8 percentage point at an annual rate, which is faster than most forecasters expected. These two facts are reconciled by the fact that labor productivity has grown only 0.7 percent per year since 2010, well below the 2.3 percent average from 1948 to 2007.

[3] For more detail on these thought experiments, see Chapter 1 of the 2015 *Economic Report of the President*.

Moreover, this is not just an American phenomenon—in fact it has been even more extreme in a number of other OECD countries. For example, the United Kingdom has had comparable employment growth combined with slower output growth than the United States—a fact that is manifested in the negative productivity growth experienced by the United Kingdom since 2011. As shown in Figure 5, other G7 economies have also experienced similarly low productivity growth recently—in fact, the United States is in the middle of the pack.

Figure 5
Labor Productivity Growth in the G-7



Some have suggested that the disconnect between output growth and employment growth is an artifact of the data, claiming that the official statistics reliably record employment growth but miss much of the output growth that is accounted for by quality improvements, new goods, and goods with low marginal cost but high consumer surplus.[4] This is an important issue that merits considerable additional work. There is certainly reason to believe that the true growth rate exceeds what is shown in the official statistics. But there is also reason to believe this was true in the past as well so that it is implausible that any bias in the measurement of GDP has grown so quickly that it can fully account for the slowdown in reported productivity growth, although it may explain part of the slowdown.

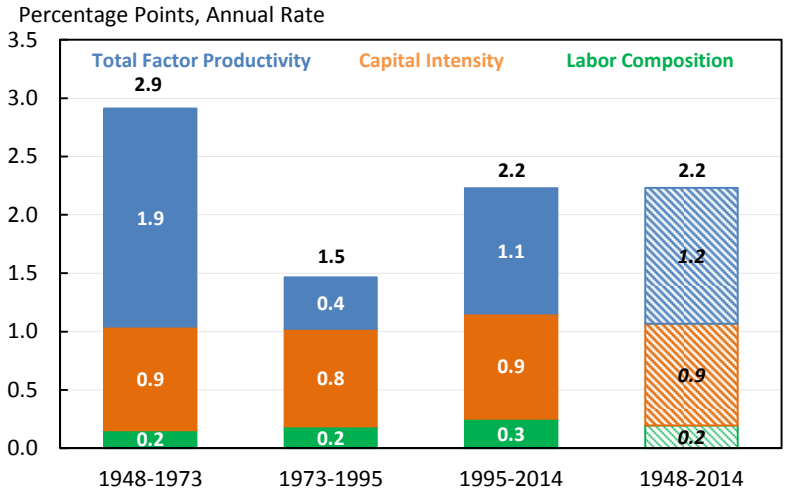
Explaining the post-crisis productivity slowdown can be informed by a bottom-up decomposition of the factors contributing to productivity growth. Because labor productivity reflects the amount of output generated per unit of only one input to production, it is positively related to increased quantities of other inputs. So when the capital stock rises, output and therefore labor productivity also tend to rise. Accordingly, one can decompose growth in labor productivity into three components: growth in investment per hour worked (or "capital deepening"), the quality of labor writ large, and total factor productivity (TFP).

[4] See, for example, Martin Feldstein. 2015. "The U.S. Underestimates Growth. *Wall Street Journal*. (May 18); Goldman Sachs. 2015. "U.S. Economics Analyst: 15/21 – Productivity Paradox v2.0." (May 23); David M. Byrne, Stephen D. Oliver, & Daniel E. Sichel. 2015. "How Fast are Semiconductor Prices Falling?" NBER Working Paper 21074 (April).

Figure 6 shows this decomposition for the United States applied to labor productivity growth in each of the three historical periods I considered earlier. Notably, increases in capital intensity and in labor quality have been roughly constant, on average, across the three periods. Virtually all the variation in labor productivity growth is accounted for by variation in TFP.

Figure 6

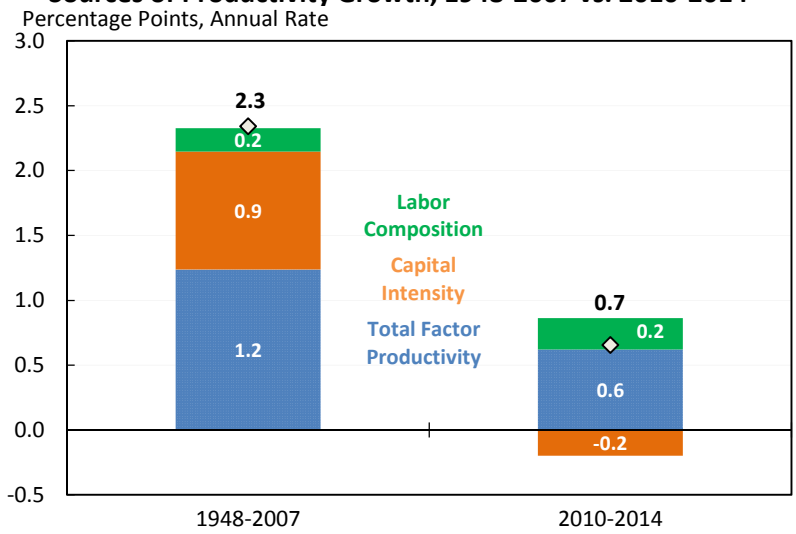
Sources of Productivity Growth Over Selected Periods



Since the crisis, the story has been quite different. Total factor productivity growth has been lower since the recovery began, rising 0.6 percent per year since 2010 compared with an average of 1.2 percent per year between 1948 and 2007. But that difference only accounts for a fraction of the lower post-crisis growth in labor productivity, as shown in Figure 7, with most of the slowdown explained by a reduction in the contribution of capital deepening. Capital intensity actually declined between 2010 and 2014, despite growing at a consistently positive rate since the crisis.

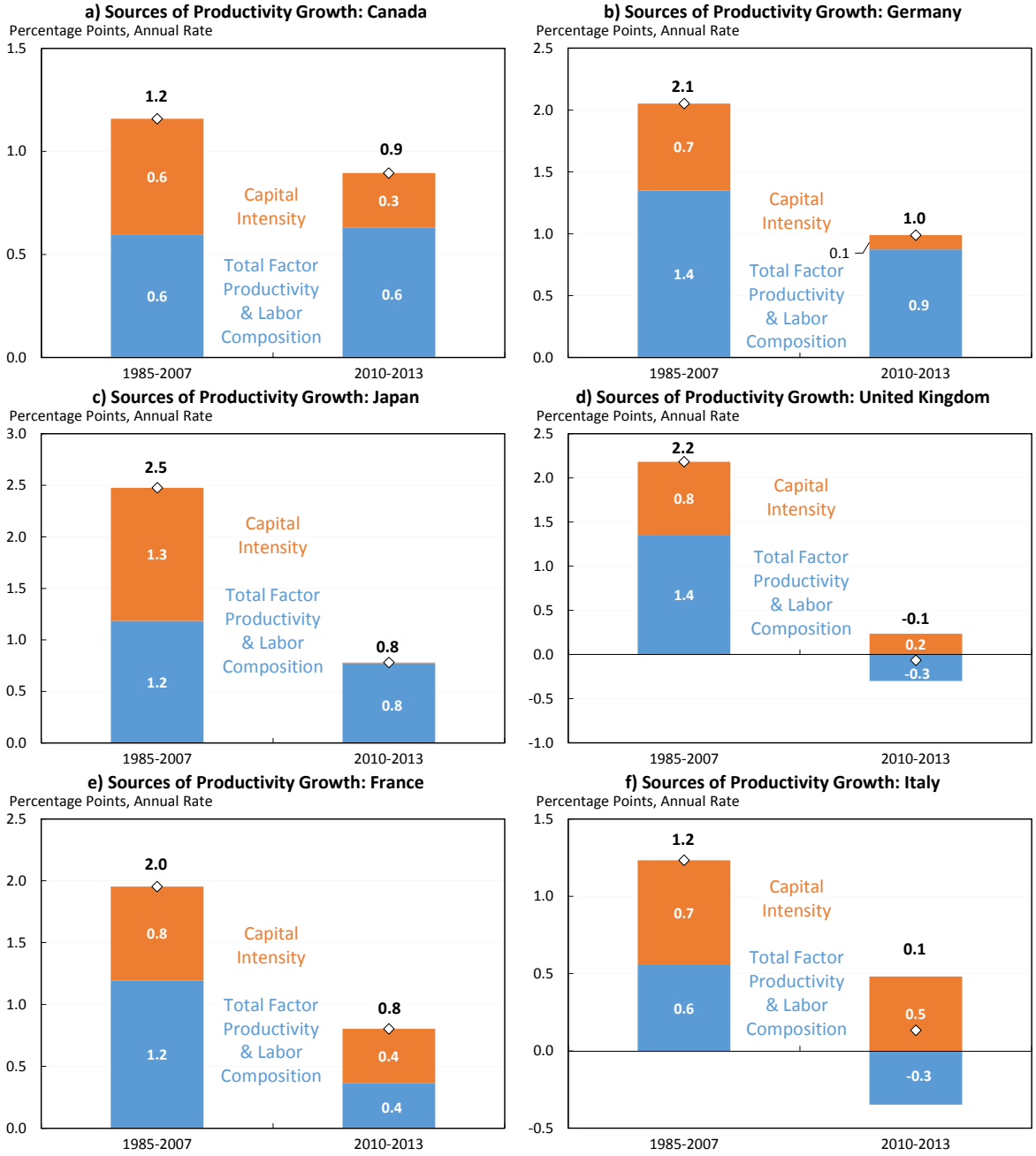
Figure 7

Sources of Productivity Growth, 1948-2007 vs. 2010-2014



The story is similar across some—but not all—of the other G-7 economies. In the United States, Canada, Germany, and Japan, more than half the slowdown in productivity growth between the pre-crisis period and the recovery is accounted for by reduced capital deepening, as shown in Figure 8a-c. But in the United Kingdom, France, and Italy, most of the decline is attributable to lower TFP, as shown in Figure 8d-f.

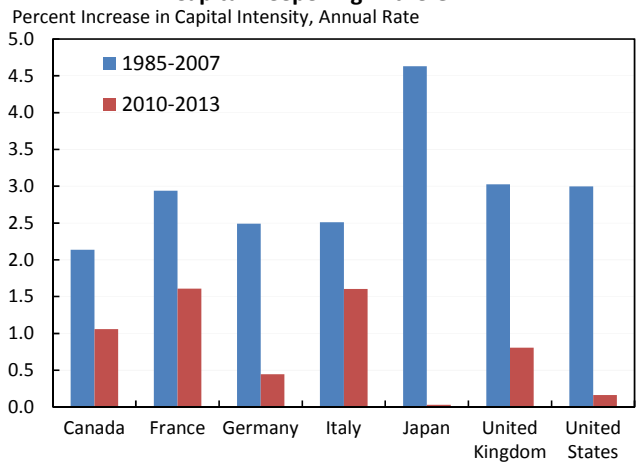
Figure 8



Productivity variation in the sixty years following the end of World War II was almost entirely attributable to TFP variation. But, since the global financial crisis, U.S. labor productivity has been driven down by negative capital deepening, the principal source of the shortfall. This has

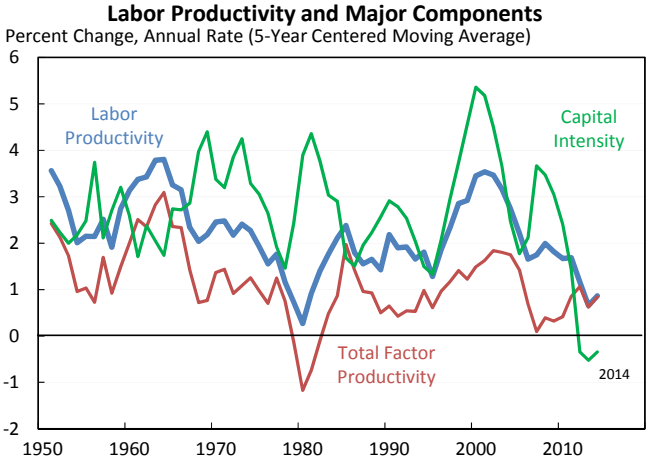
been generally true across advanced OECD economies where investment growth in the wake of the crisis has been slower relative to previous business cycles, as shown in Figure 9. The OECD and the IMF have argued that this can largely be explained by a classic accelerator model where aggregate demand growth was not sufficiently strong to justify strong investment. This effect was likely compounded by a combination of capital overhang going into the crisis and widespread deleveraging in the wake of the financial crisis.[5]

Figure 9
Capital Deepening in the G-7



A different way to visualize this pattern is to look at the historical evolution of labor productivity along with its two most influential components—TFP and capital intensity—as shown in Figure 10. Labor productivity and TFP have generally moved together throughout most of the post-war era, but diverged around the financial crisis.

Figure 10
Labor Productivity and Major Components



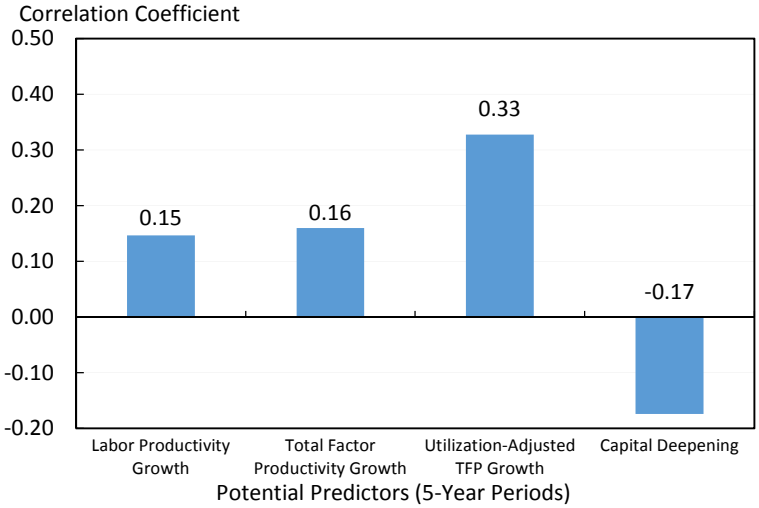
[5] Organisation for Economic Co-operation and Development. 2015. "OECD Economic Outlook, Chapter 3: Lifting Investment for Higher Sustainable Growth." (May 2015); International Monetary Fund. 2015. "World Economic Outlook: Uneven Growth, Short- and Long-Term Factors, Chapter 4. Private Investment: What's the Hold-up?" (April 2015).

So the post-crisis productivity slowdown has been no normal shift by historical terms. I personally find this encouraging in thinking about the future of productivity growth. It suggests to me that much of the recent weakness in productivity growth across the advanced economies is attributable to the macroeconomic circumstances coming out of the crisis—a consequence of a unique cyclical moment rather than some new structural omen. Therefore, it is not the sort of shift that one would extrapolate forward over the next decade or two. Indeed, TFP—the principal source of historical variations in labor productivity—has slowed much less than labor productivity.

Looking forward, the evidence shows that TFP growth is more inertial than capital deepening. The story is confirmed and strengthened somewhat by looking at "utilization-adjusted total factor productivity" (UATFP) developed by the economists at the Federal Reserve Bank of San Francisco.[6] UATFP models and removes changes in labor effort and capital workweek in an attempt to isolate the "innovative" elements of productivity growth, rather than capturing changes in the intensity of capital and labor usage that show up in TFP.

Recently, UATFP has been growing at roughly the same rate as TFP (0.5 percent per year between 2010 and 2014, compared with 0.6 percent per year TFP growth). This is relevant because the historical data suggest that the correlation of productivity growth over the next five years against the past five years is strongest for UATFP and is in fact negative for capital deepening, as shown in Figure 11, suggesting that measured "innovation" has some inertial tendencies while capital investment tends to be mean reverting.

Figure 11
Correlation of Five-Year Productivity Growth with Prior Five Years' Growth in Potential Predictors



Of course, a correlation coefficient of 0.33 explains only about 10 percent of the variance in productivity growth, so I do not claim to have unlocked the mysteries of productivity by observing this relationship. But the *comparative* correlation of lagged UATFP versus broader measures suggests that the "pure innovation" measured by TFP is a core, persistent component

[6] Susanto Basu, John Fernald, and Miles Kimball. 2006. "Are Technology Improvements Contractionary?" American Economic Review.

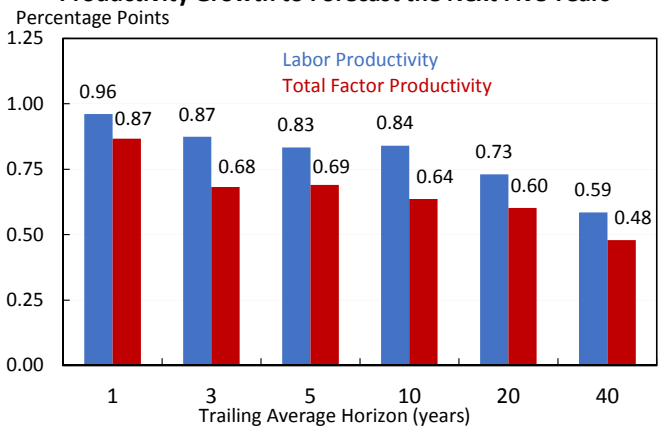
of productivity growth. It is conceptually akin to the relationship between private domestic final purchases (the sum of personal consumption and fixed investment) and gross domestic product, which I have discussed in other contexts.

Productivity in the Future

Some economists have argued that the slower productivity growth across the advanced economies in recent years is evidence of a shift towards sustained sluggish productivity growth in the future. John Fernald, for example, has argued that total factor productivity growth slowed prior to the Great Recession and that potential GDP is lower than commonly estimated.[7] Robert Gordon has argued that faster productivity growth in the 1950s, 1960s, and 1995-2005 was the result of special, one-time factors and we are unlikely to be able to continue to innovate at that pace going forward.[8] Some commentators have seized on the last few years of productivity growth to argue that potential growth rates will be much lower going forward.

But, as I have discussed, there is evidence that the post-crisis slowdown was a special, one-time result that is more akin to a cyclical feature of the economy than a structural one. Moreover, forecasting productivity based on just the past few years is an unproductive exercise as a general matter. In Figure 11, I showed that the labor productivity growth over five-year periods is a virtually useless predictor of labor productivity growth over the subsequent five. Goldman Sachs[9] has argued that if one is going to forecast productivity only by looking at its historical average, the forecast error is smallest when the historical window is largest, as shown in Figure 12.

Figure 12
Average Absolute Forecast Error from Using Trailing Average Productivity Growth to Forecast the Next Five Years



[7] John G. Fernald. 2014. "Productivity and Potential Output Before, During, and After the Great Recession." NBER Working Paper. June.
[8] Robert J. Gordon. 2012. "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds." Centre for Economic Policy Research. September.
[9] Goldman Sachs Research. 2014. "US Daily: Trend Productivity Growth: 2% Still Seems About Right (Mericle)." November.

But the choice of a long historical window is only a way to optimize a less-than-ideal forecasting methodology: assuming mean reversion in the rate of productivity growth. To truly understand productivity mechanics, we will need some model that can identify regime changes and respond to macroeconomic fundamentals.

But as I pointed out when I began my talk, this is quite difficult. The OECD's recent innovation—using firm-level data to identify productivity differences within industries—takes a step in the right direction.[10] The OECD has identified that despite the slowdown in average productivity growth in recent years, the most productive firms—those at the "global frontier"—have actually seen continued robust productivity growth, as shown in Figure 13a-b. To the extent that economic policies do not stand in the way, diffusion of productivity from the frontier can provide some upside potential for aggregate productivity.

Figure 13a
Labor Productivity: Manufacturing Sector

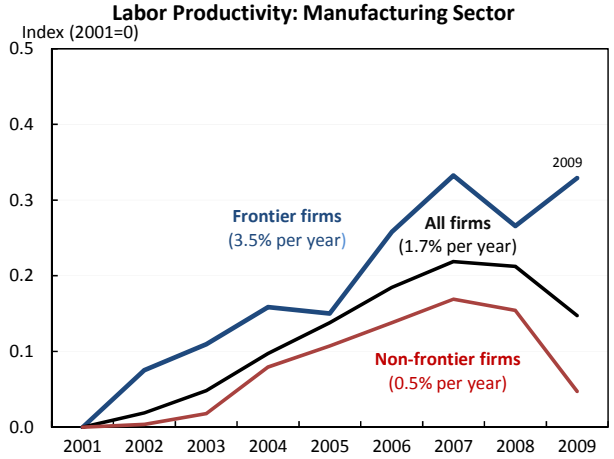
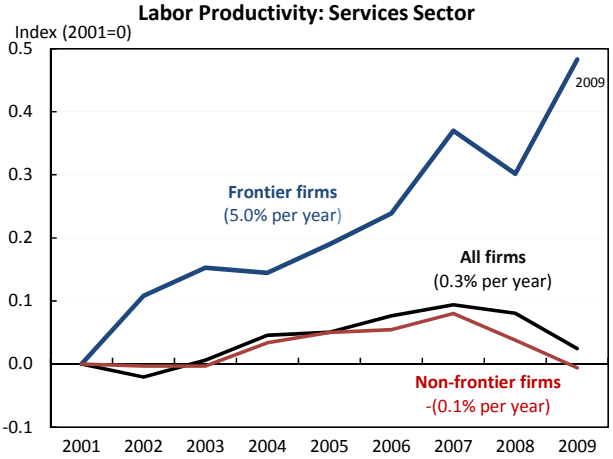


Figure 13b
Labor Productivity: Services Sector



The productivity frontier thesis embedded in the OECD's work ties in well with the observation that the post-crisis slowdown is mostly a product of reduced investment rather than reduced innovation. To the extent that more productive firms have prospered in this recovery, they are also likely to have suffered the least from reduced investment.

While the data do not support a strong presumption of slowing productivity growth in the future, there is certainly substantial reason to be uncertain about the future of productivity growth which, unlike demographic factors, can be very difficult to predict. There are, however, some reasons to be optimistic—including the potential in a variety of areas including cloud computing combined with mobile devices, biotechnology and personalized medicine, advanced materials, and clean energy research—some of which may not be fully reflected in the productivity data.[11] But the degree to which we make advances in these areas—and productivity growth more broadly—will depend on the policy choices we make.

[10] Organisation for Economic Co-operation and Development. 2015. *The Future of Productivity.*
[11] Erik Brynjolfsson & Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.*

The Productivity Policy Agenda

Encouraging productivity growth is critical to boosting middle-class incomes. The President's economic agenda recognizes that we must not only improve the transmission of productivity to typical households, but we also must increase the pace at which productivity grows. Today, I will outline four major elements of the President's agenda designed to do just that.

Expanding International Trade

I will begin with the importance of expanding free trade for boosting both the level and the growth rate of productivity. The traditional economic understanding of trade rests on the argument that it raises the level of output and incomes. But recently, economists have developed a greater appreciation of the ways in which trade can increase innovation and therefore economic growth. As Nobel Prize-winning economist Robert Solow wrote, "[r]elatively free trade has the advantage that the possibility of increasing market share in world markets is a constant incentive for innovative activity."

Trade can increase growth in a number of ways. First, trade fosters greater specialization in research and development—which in turn can increase innovation. For example, if engineers at one firm focus on improving memory chips, and engineers at another firm focus on improving microprocessors, the R&D productivity of each firm may be higher, leading to better and cheaper computers than if each company had to improve both components simultaneously.

Trade also helps firms become more productive by accelerating the global flow of ideas. Both exporters and importers are frequently exposed to new ideas and novel tools, materials, or techniques that make them more productive. For example, many multinational companies have systems and standards to promote the diffusion of "best practices" within their global supply chains. Learning also occurs when a firm adapts novel ideas to suit its own operating environment, leading to both new goods and greater productivity.

Moreover, a larger market can increase the incentives for innovation. International trade allows companies to access a larger market, which yields more profit for a given level of innovation, boosting the incentives to innovate. For example, the global reach of the "App Stores" managed by Apple and Google provides a larger market—and greater reward—for developers seeking to market their software.

Finally, even holding market size constant, increased trade can promote innovation by strengthening competition. More than fifty years ago, the Nobel Prize-winning economist Kenneth Arrow pointed out that a monopolist may have relatively weak incentives to innovate, because its innovations do not allow it to "steal" business from competitors. A similar idea appears in more recent "Schumpeterian" models of innovation and economic growth, where competition can promote growth by increasing the expected payoffs of successful innovation. When combined with smart intellectual property laws, our trade policies can promote harmonization around a set of rules that strike the appropriate balance for promoting long-run growth and job creation.

Public Investment in Infrastructure

Investments in infrastructure—such as those the President proposed in his FY2016 budget—can have a substantial positive impact on productivity and long-run economic performance. Strong infrastructure facilitates the more efficient exchange of goods, labor and ideas. Investments by previous generations of Americans—from the Erie Canal in 1807, to the Transcontinental Railroad in 1869, to the Interstate Highway System in the 1950s and 1960s—were instrumental in putting the country on a path for sustained economic growth. Continued investment in infrastructure is essential to supporting productivity and economic growth in the future.

For example, strong transportation and communication infrastructure reduces commuting times, making it easier for workers to move between jobs and expanding the labor force. Businesses are also able to manage their inventories more efficiently and transport goods faster and more cheaply, helping them access new suppliers and markets. Faster information flows and increased access to knowledge also facilitates greater innovation. Concentrated investment in infrastructure may even draw market participants together and build new cooperative efficiencies, multiplying the productivity gains.

The benefits of investing in infrastructure are especially high when there are underutilized resources in the economy. In addition to the long-run effects on economic growth and productivity, investments in infrastructure can have short-run benefits by supporting employment in construction and in the production of materials. Moreover, increased spending by the workers hired in these sectors can have positive ripple effects throughout the economy.

Business Tax Reform

Reforming our nation's broken business tax code has important implications for productivity growth. In particular, business tax reform has the potential to increase productivity growth by improving the *quality* rather than the *quantity* of overall investment. By the "quality" of capital, I do not mean more expensive or higher-end equipment, which, after all, would show up in the dollar value of investment. Instead, I mean better choices about what to invest in, where to make those investments, how to finance them, and so on.

To be a bit more concrete, let me offer three examples of ways in which business tax reform has the potential to improve the quality of investment. One is by shifting capital from less productive areas of the economy to more productive areas of the economy. The tax code has numerous benefits for particular industries as well as a complex set of rules around depreciation that do not match the actual economic depreciation of assets. As a result, there is wide variation in effective tax rates by industry, ranging from 14 percent for utilities to 31 percent for construction and wholesale and retail trade, as shown in the Treasury Department estimates in Figure 7. These differences can potentially lead to too much capital in industries that are tax preferred and too little capital in industries that are tax-disadvantaged. This misallocation of capital reduces productivity. To the extent that reform can remove these distortionary incentives—ensuring that business decisions are made for business reasons and not tax reasons—we can help resolve the problem.

A second way in which tax reform can improve the quality of capital is by ensuring that capital is distributed in a globally efficient manner, including not over-allocating capital overseas and having more economically productive global sales and supply chains. Differences in international taxation can encourage locating profits abroad even when it is not otherwise productive to do so. For example, the fact that in 2010, U.S. controlled foreign corporation profits represented 1,578 percent of Bermuda's GDP and even 15 percent of the Netherlands' GDP does not simply reflect business decisions made for purely business reasons. The President's framework for business tax reform would establish a hybrid international system with a minimum tax on the earnings of foreign subsidiaries. This system could effectively deter some tax-based decisions on the location of production, while also having the potential to improve the global competitiveness of U.S. corporations.

A third example is encouraging investment in projects with externalities, like research and development in general, or clean energy in particular. Such tax-encouraged investments in innovation can help boost aggregate productivity. The key test for any incentive is whether it is motivated by a positive externality such that the underlying good or service will be underprovided by the private economy. The framework singles out three incentives as passing this test: the research and experimentation tax credit because the social returns to R&D are roughly twice the private returns, the Production Tax Credit because of the negative externalities associated with carbon emissions, and the manufacturing deduction because of the broader spillovers in the manufacturing sector. While one can and should debate what provisions should be added to or subtracted from this list, the key is orienting the argument around the principle of economy-wide spillovers.

Continued Investment in Technology

Innovation is the core driver of productivity growth in advanced economics. The U.S. government has a long tradition of supporting the research and development driving technical change, and the President's economic agenda advocates expanding these important investments. The long-term benefits of this investment are evident in the way technology is creating new industries and transforming old ones throughout the United Sates.

Some of the most visible changes are occurring in the information and communications sector, where a combination of smaller, more powerful computing and communications devices as well as improvements in mobile broadband connectivity have unleashed a new wave of invention.

While most of us feel the impact of the computing revolution every day, many scientists say that we are also on the cusp of a revolution in life sciences. The first complete human genome was sequenced in 2003 at a cost of roughly $3 billion—today it can be done for as little as $1,000 per person.

Transformations like these are occurring throughout the rest of the economy as well. Progress in nanotechnology has the potential to tremendously improve the efficiency of energy consumption and production through the use of new materials for light bulbs, wire insulation, combustion engines, and photovoltaic cells, to name just a few.

The President's technology policies are contributing in all of these areas. We are working to nearly double the amount of spectrum available for mobile broadband. We have made openness and interoperability the new defaults for government data. And we are working to ensure that our patent and copyright laws are well-suited to the modern age.

While economists debate the extent to which innovation has shown up in productivity statistics, the idea that the next twenty years will look more like the late 1990s because of continued innovation seems entirely plausible to me.

Conclusion

The combination of productivity's importance and its murkiness ensures that it will remain a focus of macroeconomic research for decades to come. As I have emphasized today, the past is rarely prologue when it comes to productivity—but despite the difficulty of prediction, we should resist the pessimistic case that the recent slowdown is persistent. Indeed, it looks more like yet another result of post-crisis deleveraging than a regime change in the pace of innovation. Going forward, it will remain important for the United States and its partners to ensure that economic policies promote private innovation while targeting public investments toward high-return projects—helping to foster productivity growth in a shared and sustainable manner.

Notes to Figures

Figure 1
Note: Data reflect quarterly releases of labor productivity for the nonfarm business sector. Shading denotes recession.
Source: Bureau of Labor Statistics.

Figure 2
Note: This figure—and all subsequent references to U.S. labor productivity reported by the Bureau of Labor Statistics in these remarks—references real output per hour worked in the private nonfarm business sector (excluding government enterprises). The dotted lines divide the last 60 years into three periods that broadly reflect three "episodes" in productivity growth for the private nonfarm business sector.
Source: Bureau of Labor Statistics.

Figure 3
Source: Conference Board; CEA calculations.

Figure 4
Note: Median disposable incomes in local currencies at current prices are reported by the OECD, and are then deflated by each country's consumer price index. All series are indexed to 1995, except Italy (indexed to 1996) and the United Kingdom (indexed to 1994) due to data availability.
Source: Organisation for Economic Co-operation and Development; national sources via Haver Analytics; CEA calculations.

Figure 5
Note: For all nations except the United States, productivity growth rates are those reported in the Conference Board Total Economy database; for the United States, the Bureau of Labor Statistics' productivity series for the private nonfarm business sector is used.
Source: Conference Board; CEA calculations.

Figure 6
Note: Displayed series are the contributions to labor productivity growth in the private nonfarm business sector.
Source: Bureau of Labor Statistics; CEA calculations.

Figure 7
Note: Displayed series are the contributions to labor productivity growth in the private nonfarm business sector.
Source: Bureau of Labor Statistics; CEA calculations.

Figure 8a-f
Note: Total labor productivity growth and total multifactor productivity growth (including labor composition changes) for the displayed nations are reported by the OECD. The contribution of capital deepening is inferred as the difference between the two.

Source: Organisation for Economic Co-operation and Development.

Figure 9
Note: Capital intensity is defined as capital services per hours worked of all persons. Capital deepening is the percent increase in capital intensity.
Source: Organisation for Economic Co-operation and Development; CEA calculations.

Figure 10
Note: Capital intensity is defined as capital services per hour worked.
Source: Bureau of Labor Statistics; CEA calculations.

Figure 11
Note: The displayed correlation coefficients result from the comparison of a five-year moving average of labor productivity growth with a five-year lag of five-year moving averages of the potential predictors. Accordingly, they reflect the ability of the predictors averaged from years t to $t+4$ to predict labor productivity growth from years $t+5$ to $t+9$.
Source: Bureau of Labor Statistics; Federal Reserve Bank of San Francisco; CEA calculations.

Figure 12
Note: This analysis follows the general methodology adopted in Goldman Sachs Research. 2014. "US Daily: Trend Productivity Growth: 2% Still Seems About Right (Mericle)." The displayed values are the average absolute difference between trailing averages of growth in the given productivity series (for the given horizon) and averages of the next five years' growth in the given series, from 1988 to 2008. This is the longest period over which the calculation can be performed for a forty-year time horizon.
Source: Bureau of Labor Statistics; CEA calculations following Goldman Sachs (2014).

Figure 13a-b
Note: These figures are adapted from the OECD's 2015 work *The Future of Productivity.* "Frontier firms" corresponds to the average labor productivity of the 100 globally most productive firms in each 2-digit sector. "Non-frontier firms" is the average of all other firms. "All firms" is the sector total.
Source: Organisation for Economic Co-operation and Development. 2015. *The Future of Productivity.* Andrews, D., C. Criscuolo and P. Gal (2015). "Frontier firms, technology diffusion and public policy: micro evidence from OECD countries," OECD Mimeo.