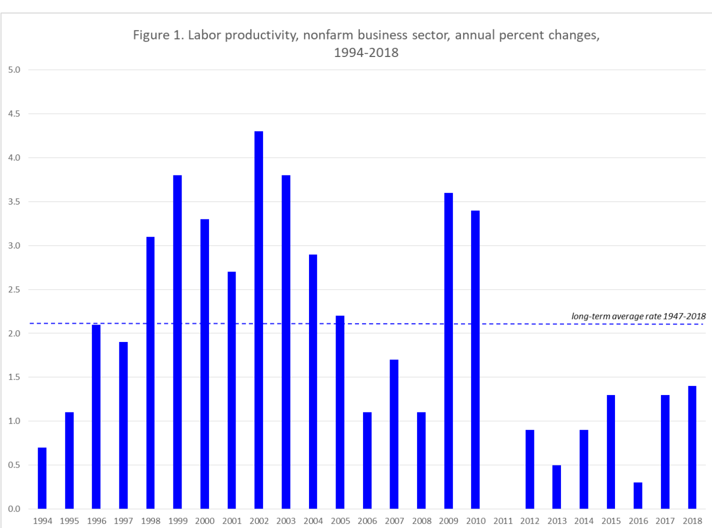
The U.S. Productivity Slowdown: An Economy-Wide and Industry-Level Analysis

Labor productivity—defined as output per labor hour—has grown at a below-average rate since 2005, representing a dramatic reversal of the above-average growth of the late-1990s and early-2000s. The productivity slowdown during these years has left many economic observers wondering why this situation has occurred, and what factors may have contributed. This article presents an analysis of labor productivity and its component series—multifactor productivity, contribution of capital intensity, and contribution of labor composition—at both the economy-wide and industry levels, complemented with a survey of the contemporary productivity literature, to shed light on potential sources of the productivity slowdown.

$10.9 trillion. This figure represents the cumulative loss in output in the U.S. Nonfarm Business sector due to the labor productivity slowdown since 2005, also corresponding to a loss of $95,000 in output per worker.[1]

These figures show that, when there is consistently below-average productivity growth, year after year, a substantial effect can result over an extended period. How could this situation have occurred, in a modern, technically-advanced economy such as in the United States? Well, not only has the productivity slowdown been one of the most consequential economic phenomena of the last two decades, but it also represents the most profound economic mystery during this time, and though many economists have grappled with the issue for over a decade and even created some innovative research approaches to address the question, we still cannot fully explain what brought this situation about.

One of the more perplexing aspects of the current slowdown is its genesis: that it came immediately following an historic productivity boom in the U.S., and represented a swift rebuke of the popular idea of that time that we had entered a new era of heightened technological progress; the suddenness and size of the reversal was difficult to comprehend. For some background: that much-cited productivity boom had begun in the late-1990s, when U.S. labor productivity growth had begun accelerating to rates of change not seen since the late-1960s and early-1970s. This late-1990s surge surprised many economic observers, who had become accustomed to the below-average productivity growth rates of the previous two decades. Additionally, the situation in the U.S. was even more startling due to the fact that the rest of the more-developed economies of the world were not similarly experiencing a speedup in growth rates. A debate ensued among economists: was the tremendous productivity growth of the late-1990s here to stay—a fundamental change brought on by the computing and internet-related innovations which we saw all around us—or was it a temporary phenomenon that would pass? The fact that the productivity speedup persisted through the recession of 2001, and then became even more pronounced in 2002, stunned



observers and convinced more that perhaps something had changed. The acceleration of U.S. productivity growth is shown in Figure 1, illustrated by the growth rates during the years 1998 through 2005 which rise above the long-term average rate since 1947, denoted by the dashed blue line. Over the course of these high-growth years, U.S. labor productivity grew at an average rate of 3.3 percent[2], which is markedly higher than the cumulative 2.1 percent average rate from 1947 to 2018.

This high-growth period came to an end during the mid-2000s, when U.S. labor productivity growth rates began to stumble, and in 2006 receded below the long-term average trend line for the first time in a decade. And, notwithstanding two years of high growth in 2009 and 2010 following the Great Recession, productivity growth rates have remained stubbornly low in subsequent years. Many economic observers were yet again surprised, in this case at just how drastically growth rates slowed down, given the recently observed high rates of growth and the continued technological innovations which were proliferating throughout the economy. Since 2005, labor productivity has grown at an average annual rate of just 1.3 percent; this is lower than the 2.1 percent long-term average rate from 1947 to 2018 shown in Figure 1. And, the low growth observed since 2010 has been especially noteworthy: labor productivity grew just 0.8 percent from 2010 to 2018, which is 1.3 percentage points below the long-term rate since 1947.

As the slowdown in labor productivity growth has steadily held on throughout the past decade, economic observers have been trying to make sense of this phenomenon, which has the effect of placing downward pressure on economic growth, worker compensation gains, profits growth, and gains in living standards of Americans. Many began to wonder: why has U.S. labor productivity growth been so consistently low in recent years, and why is it so markedly different from the strong growth observed relatively recently? Two approaches to addressing these questions are presented in this article, with each approach including an analysis of BLS productivity data along with a review of the contemporary productivity literature. Firstly, the economy-wide slowdown in labor productivity growth is analyzed by breaking out the series into its three component series: multifactor productivity growth, the contribution of capital intensity, and the contribution of labor composition. And, secondly, industry-level productivity data are used to identify the industries that made notable contributions to the economy-wide labor productivity slowdown.

I. Economy-wide analysis of the U.S. labor productivity slowdown

Decomposition of labor productivity growth

Labor productivity is a measure of economic performance that compares the amount of goods and services produced (output) with the number of labor hours used in producing those goods and services. It is defined mathematically as output per hour of work, and growth occurs when output increases faster than labor hours. For example, if output is rising by 3 percent and hours are rising by 2 percent, then labor productivity is growing by 1 percent.

Labor productivity growth is vitally important to present and future prospects for economic growth, as it represents the only way that economic growth can rise above what would be possible by simply working more hours. The economic gains brought about by labor productivity growth make it possible for an economy to achieve higher growth in labor income, profits and capital gains of businesses, and public sector revenue, and this has the potential to lead to improved living standards for those participating in an economy, in the form of higher income, greater leisure time, or a mixture of both. In addition, as labor productivity rises, it may be possible for all of these factors to increase simultaneously, without gains in one coming at the cost of one of the others.

Given the importance of labor productivity growth, it is worth delving into the measure in more detail to see what underlying factors are making this growth possible. As such, in addition to labor productivity growth being defined as a residual—the difference between output growth and hours growth—we can also analyze it at as a sum, built up from the contributions of its three component series.

Components of labor productivity growth

Labor productivity growth = multifactor productivity growth + contribution of capital intensity + contribution of labor composition

This equation provides us with a way to quantify the sources of labor productivity growth, and give us a deeper understanding of the measure by looking into its three component series.

Multifactor productivity (MFP) growth represents the portion of output growth that is not accounted for by the growth of capital and labor inputs, and that is due to contributions of other inputs such as technological advances in production, the introduction of a more streamlined industrial organization, relative shifts of inputs from low- to high-productivity industries, increased efforts of the workforce, and improvements in managerial efficiency.[3] Similarly to labor productivity growth, MFP growth can also be defined as a residual—output growth minus the growth of the combined inputs of labor and capital.

The contribution of capital intensity is defined as the capital-weighted change in the capital-labor ratio. The measure is computed as capital's share of current dollar costs multiplied by the growth in capital services per labor hour. The contribution of capital intensity—also often referred to as capital deepening—reflects businesses' decision-making process between hiring more workers and purchasing more or higher-quality equipment, or of substituting equipment for workers or vice versa.[4] In cases where firms increase their usage of capital relative to labor, or where capital costs rise relative to labor costs, there will be an increase in the contribution of capital intensity to labor productivity growth.

The contribution of labor composition is defined as the labor-weighted change in a measure—labor composition—which reflects shifts in the level of skills and experience of the workforce. It is computed as labor's share of current dollar costs multiplied by labor composition.[5] The contribution of labor composition provides us with a way to gauge the productive capacity of the workforce at a given point in time. When firms hire more workers with higher skills and more experience or lay off workers with lower skills or less experience, or when labor costs rise relative to capital costs, there is an increase in the contribution of labor composition to labor productivity growth.

The three components of labor productivity growth are displayed in Figure 2, for the slowdown period (2005-2018), the speedup period (1997-2005), as well as other selected post-WWII periods and the long-term historical average.[6] Labor productivity growth, corresponding to the purple dots, represents the sum of the three stacked bars of MFP growth, contribution of capital intensity, and contribution of labor composition. It is apparent that the labor productivity growth rate (1.3 percent) of the slowdown period has slackened dramatically relative to the speedup period and is also below the long-term historical average. Furthermore, we can see from the diminished red and dark blue stacked bars of the slowdown period relative to the speedup period that it is MFP growth and the contribution of capital intensity that are the two sources of the U.S. labor productivity slowdown (the contribution of labor composition was approximately the same as in the speedup period[7], and did not contribute to the slowdown). MFP grew 0.4 percent during the slowdown period, which is *less than one-fourth* the growth of the speedup period and is also well below the long-term historical average. And, the contribution of capital intensity in the slowdown period, 0.7 percent, is around half that of the speedup period and is also below the long-term historical average.

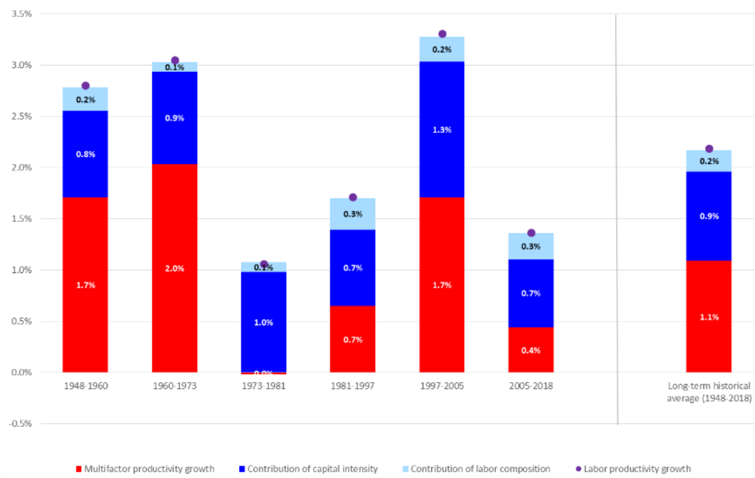


Figure 2. Contributions to labor productivity growth: MFP growth, contribution of capital intensity, contribution of labor composition, average annual growth rates for selected periods, private nonfarm business sector, 1948-2018

The deceleration in MFP growth—the largest contributor to the slowdown—explains 65 percent of the slowdown relative to the speedup period; it also explains 79 percent of the sluggishness relative to the long-term historical average rate. The massive deceleration in MFP growth is also emblematic of a broader phenomenon, shown in Figure 2. We can see that throughout the historical period since WWII, the majority of the variation in labor productivity growth from one period to the next was from underlying variation in MFP growth, rather than from the other two components. While the contribution of labor composition varied only between a range of 0.1 percent to 0.3 percent during the entire post-WWII era, and the contribution of capital intensity varied between 0.7 percent and 1.3 percent, MFP growth varied within a wider range, between 0.0 percent and 2.0 percent.

At the same time, in addition to the notable variation in MFP growth during the recent periods, something unprecedented about these recent periods was the additional contribution from variation in the contribution of capital intensity. The contribution of capital intensity had previously remained within a relatively small range (0.7 percent to 1.0 percent) during the first five decades of post-WWII periods, but then in the 1997-2005 period the measure nearly doubled, from 0.7 percent up to 1.3 percent, followed by nearly halving to 0.7 percent in the 2005-2018 period. This unprecedented variation in the contribution of capital intensity was the factor that combined with the variation in MFP growth to bring about such historically-large speedup and slowdown periods in recent years, increasing the size of the overall labor productivity slowdown to rival the widely-noted 1970s slowdown. The contribution of capital intensity accounts for 34 percent of the labor productivity slowdown relative to the speedup period; it also explains 25 percent of sluggishness relative to the long-term historical average rate.

The slowdown in MFP growth

Now let us take a deeper look into the two contributors to the labor productivity slowdown. For MFP growth, let us start out by noting the inherent difficulty in attempting to identify in numerical terms the sources or causes of MFP growth or a lack thereof. This difficulty arises due to the fact that MFP growth itself cannot be measured or identified on its own, and can only be ascertained as the leftover output growth that remains after all measurable inputs to production—in this case, labor and capital[8]—have already been taken into account. With MFP growth we are actually measuring what is unidentifiable, similar to how cosmologists can measure the extent of dark matter in the universe even as they cannot name the contents therein. This is the reason that this issue has puzzled so many economic observers in recent years and still remains incompletely explained following more than a decade of work on the issue.

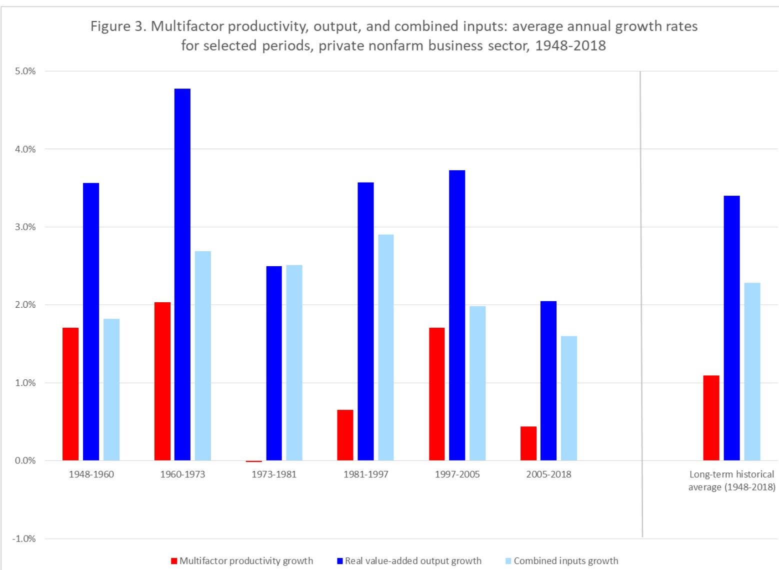


Figure 3. Multifactor productivity, output, and combined inputs: average annual growth rates for selected periods, private nonfarm business sector, 1948-2018

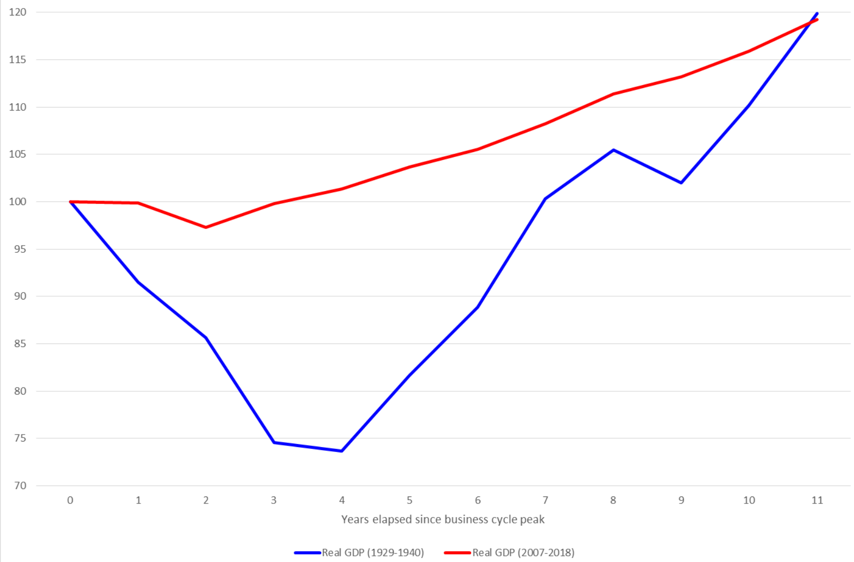
However, there are a few approaches that can be taken to help us gain a foothold on what might be happening to MFP growth, both by using BLS data as well as by looking at some clever approaches of the numerous researchers working on this issue. As a first step in our analysis, let us look at the BLS series which are used in calculating MFP growth, in order to provide some background and context on the economy in which the MFP slowdown took place. As noted above, MFP growth is a residual: output growth less the growth of the combined inputs of capital and labor. Figure 3 shows that, although output and combined inputs both slowed relative to the speedup period, output slowed by a much greater amount than combined inputs. While combined-input growth slowed by 0.4 percentage point, output growth slowed *four times as much*, by 1.6 percentage points. The fact that output growth receded so much further than combined inputs during the slowdown period is reflected in the notably low MFP growth rate of 0.4 percent during this period, and is a key fact connected with the productivity slowdown (for an in-depth look at the historically weak output growth during the slowdown period, and the state of the economy during these years, please see the box below).

Historically weak output growth of the post-2005 slowdown period

The rate of output growth during the 2005-2018 slowdown period (2.1 percent) is an historically weak growth rate. Not only does this rate pale in comparison to the 3.7 percent growth of the speedup period; it also represents an historically slow rate for the entire post-WWII period, being well below the historical average growth rate of 3.4 percent (see Figure

3). Of course, a major portion of the below-average output growth in the slowdown period reflects that this period encompasses the Global Financial Crisis and Great Recession of 2007-2009 and the subsequent recovery. It might surprise some to discover that the post-2007 business cycle, which includes this historic episode, not only had slower cyclical growth than all previous business cycles since WWII, but it even recorded a slower overall growth rate than the Great Depression of the 1930s (see Figure 4). In the case of the Great Depression, output plummeted by 26 percent, a much greater decline than the 3 percent decline during the Great Recession[9]. However, the recent cycle actually had a much weaker recovery than that of the Great Depression, with output growth from 2009 to 2018 being less than *one-third* of the 7.2 percent rate posted during the peace-time recovery from 1933 to 1940.[10] As a result, as of 2018, this cycle's growth rate actually came in at slightly below what had occurred during the 1930s—even more striking when one considers that the population growth rate was the same among these two periods.[11] Output growth during the post-2007 business cycle can be summarized as containing both the worst downturn since the Great Depression[12] and a rate of recovery that was slower than any recorded rate during or since that time. This historic episode, which occurred within the slightly broader productivity slowdown period from 2005 to 2018, has been the major contributor to the dramatic output slowdown of this period.

Figure 4. Output during declines and recoveries: Great Recession (2007-2018) and Great Depression (1929-1940)



The low output growth of the post-2007 business cycle—and in particular the weak recovery—was not wholly unexpected. Valerie Cerra and Sweta Chaman Saxena,[13] Carmen M. Reinhart and Kenneth S. Rogoff,[14] and Carmen M. Reinhart and Vincent R. Reinhart [15] show that a permanent loss of GDP and a lack of rebound to the long-term growth trend often follows financial crises such as the one the U.S. experienced in 2008. Similarly, the IMF asserts that output losses due to banking crises are usually substantial, stating that "typically, output does not recover to its precrisis trend. On average, output falls steadily below its precrisis trend until the third year after the crisis and does not rebound thereafter," though they also clarify that, following this permanent output loss, "medium-term growth rates tend to eventually return to the precrisis rate."[16] Daisuke Ikeda and Takushi Kurozumi offer a story which may underlie this phenomenon, suggesting that an "adverse financial shock tightens firms' financing and thereby dampens their activities, which in turn has a significant negative impact on the economy as a whole by decreasing activities not only on the demand side but also on the supply side of the economy. The effect on the supply side, such as the sectors of R&D and technology adoption, induces a persistent decline in [MFP][17] and thus can cause a permanent decline in output relative to a pre-shock balanced growth path."[18]

James H. Stock and Mark W. Watson look even further back in time, to before the financial crisis, claiming that greater than half of the weakness of the recovery is from slower long-term trend growth due to changing demographics that was already apparent before the Great Recession.[19] However, they also note that particularly slow government spending (specifically from the phase-out of the American Recovery and Reinvestment Act and the budget sequestration of 2013, as well as from slow state and local government hiring during the entire recovery) and weak international demand following the recession also played a role. Ray C. Fair also cites sluggish government spending following the Great Recession, asserting that it was the central factor underlying the weak recovery.[20] It should be noted here that J. Bradford DeLong and Lawrence H. Summers' work implied that the aftermath of the Great Recession had provided an opportune moment to accelerate government spending and utilize the Keynesian multiplier to increase potential future output, especially because "the absence of supply constraints in the short term, together with a binding zero lower bound on interest rates, means that the Keynesian multiplier is likely to be substantially greater than the relatively small value it is thought to have in normal times."[21]

In addition to citing weak fiscal stimulus, others have focused on monetary stimulus, with Robert E. Hall offering that the zero lower bound on interest rates placed a limitation on monetary stimulus following the financial crisis that had not been a limiting factor in prior U.S. recessions, and that despite the dramatic actions taken by the Federal Reserve in lowering rates to zero, "far from relieving the interest bound, the policy failed to prevent a decline in inflation."[22] Robert J. Barro also claims that monetary stimulus was insufficient to spur recovery, but not because of the zero lower bound itself, but because "the monetary changes seem mostly symptomatic of weak opportunities for private investment and growth."[23]

Now that we have an understanding of the recent trends in the measures which are used in computing MFP growth—in particular the unusually slow output growth of recent years—our first task at this point is to attempt to use this basic information to help us better understand the slowdown in MFP growth. Specifically, we may ask: could the state of the economy during the slowdown period, as indicated by the atypically low output growth—especially with it running below its potential and capacity during and following the Great Recession—have helped to *cause* the low MFP growth?

Yes, it is a possibility, according to several authors. As noted above, Ikeda and Kurozumi argue that when an economy is operating below it potential, firms may tend to pull back on investment in R&D and new technology.[24] David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel concur, noting that one possible explanation for the productivity slowdown is that "the economy has taken a long time to recover from the financial crisis and Great Recession, as the repair of balance sheets has proceeded slowly and as uncertainty about the pace of the recovery has held back investment."[25] Romain Duval, Gee Hee Hong, and Yannick Timmer agree, noting that "the combination of pre-existing firm-level financial fragilities and tightening credit conditions made an important contribution to the post-crisis productivity slowdown,"[26] and also that "while most forms of physical capital can be pledged as collateral to get a loan, intangible assets such as R&D or workforce training cannot. Furthermore, investments in intangible assets tend to translate more slowly into sales and to be riskier. Therefore, [their] hypothesis is that credit-constrained firms cut their investment in intangible assets[27], contributing in part to a sharper productivity slowdown after the crisis."[28]

At the same time, though the Great Recession and its aftermath has had a substantial impact on recent economic trends, it is clear from the data that the productivity slowdown started *prior* to the Global Financial Crisis and Great Recession.[29] Looking back at Figure 1, we can see that labor productivity grew at a successively lower rate in each consecutive year from 2002 through 2006, decelerating to well below the long-term average trend by 2006. So, a second question emerges: what might have led to this initial slowing and commencement of the slowdown period, and, more broadly, what factors might have contributed to the productivity slowdown of the 2005-2018 period, other than the Great Recession and its recovery?

The most fruitful source of answers to this question has come from a group of researchers who, over the past decade, have approached productivity measurement and analysis in a new way: by analyzing very detailed data on *individual businesses* to learn more about firm behavior and find out what it might offer as underlying reasons for economy-wide trends in productivity growth. This approach has become possible in recent years with increases in computing power, which has allowed researchers to work with massive datasets and glean insights about what is happening to the U.S. economy, firm-by-firm.

One major finding from this firm-level research is that innovation has actually continued to occur at the "productivity frontier" since the early 2000s, among the firms that are the productivity-leaders in their respective industries. Ryan A. Decker, John C. Haltiwanger, Ron S. Jarmin, and Javier Miranda show this indirectly, by observing that productivity dispersion in the U.S. has expanded in recent years, meaning that there is a wider gap between these leading firms and the laggards.[30] The authors claim that, within the framework of Michael Gort and Steven Klepper,[31] this increased productivity dispersion implies that there has not been a declining pace of innovation.

So then, why are innovations which have been sparking at these leading firms not translating into solid economy-wide productivity gains? The answer is that it has to do with how these firms *respond* to their productivity windfall. Namely, rather than there being a decline in "productivity shocks" from innovation at leading firms, Decker et al. observe *decreased responsiveness* to these shocks as a potential source of the aggregate productivity slowdown, as evidenced by falling rates of job reallocation. In other words, these businesses that have been creating innovations are having a difficult time expanding, and thus their innovations are failing to make a bigger impact on the economy-as-a-whole than would otherwise be the case.

Remarkably, the slump in firm-level reallocation coincides with the timeline of the aggregate productivity slowdown, with the authors finding that "reallocation has declined in all sectors—particularly the high-tech sector[32]—since the early 2000s."[33] In terms of quantifying the impact of this phenomenon, they observe that "counterfactual exercises imply that the decline in responsiveness yields a significant drag on aggregate (industry-level) productivity, as much as 2 log points in high-tech manufacturing and more than 5 log points economy-wide in recent years."[34] As for the sources of the lower rates of reallocation, the authors cite several potential factors, including rising adjustment costs, globalization, increased regulation, and declining competition.

In addition to the work of Decker et al., there has also been important firm-level work by Dan Andrews, Chiara Criscuolo, and Peter N. Gal, who investigate what is happening at the firm level globally, in OECD countries.[35] Similarly to Decker et al., Andrews et al. also observe that there has been widening within-industry dispersion of productivity growth, claiming that "slow productivity growth of the 'average' firm masks the fact that a small cadre of firms are experiencing robust gains."[36]

And, just as Decker et al. cite declining competition as a potential source of this dispersion, Andrews et al. point to these winner-take-all dynamics as well, noting that "global frontier firms have increased their market share and … within the global frontier, the productivity of the most elite firms (top 2%) has risen relative to that of other frontier firms (top 5%)."[37] Jan De Loecker, Jan Eeckhout, and Gabriel Unger echo this sentiment within the U.S., offering as evidence that average markup costs have risen from 21 percent as of 1980 to a current level of 61 percent, in addition to an increase in the rate of profits from 1 percent to 8 percent. The authors claim that "because passthrough [of cost savings from productivity growth to lower prices for consumers] is lower in the presence of higher market power, the rise in market power will give rise to [a] lower degree of adjustment of the variable inputs, including labor, for the same [productivity] shock process…. The rise in market power thus can rationalize the decrease in labor reallocation across firms, even if the observed shocks to firm productivity [have] remained constant."[38]

Supporting these findings on increased market power are findings of not only rising concentration across firms, but also of rising concentration in *ownership* across firms, with a few large shareholders in multiple companies in a given industry,[39] as well as findings of relaxed antitrust enforcement,[40] increased mergers and acquisitions,[41] and other restraints on competition such as increases in occupational licensing by states,[42] the growth of land use restrictions,[43] a greater scope of intellectual property law,[44] and increases in lobbying and political rent-seeking[45].[46]

Also, related to market power is the issue of income inequality, which Jason Furman and Peter Orszag hypothesize may be related to the productivity slowdown.[47] Namely, though low productivity growth may be leading to rising inequality, it may also be the case that rising inequality is reducing productivity growth, by stifling "the ability to harness the talents of potential innovators across the income spectrum," though the authors caution that "any plausible magnitude for such an effect would fall well short of explaining the 1 to 1.5 percentage point drop in productivity growth." [48] Furman and Orszag further qualify that rising income inequality and low productivity growth may both "have a common cause, namely that reduced competition and reduced dynamism—in part caused by specific policy changes—have contributed to both issues."

In addition to winner-take-all dynamics, Andrews et al. also cite "stalling technological diffusion" as a potential source of widening productivity dispersion of high-growth and low-growth firms, theorizing that low-growth firms may be having a difficult time integrating new technologies.[49] However, Decker et al. clarify that "while the diffusion hypothesis could play a role, [their] estimates of [MFP] persistence suggest that the group of 'frontier firms' is sufficiently fluid to somewhat limit the diffusion story's explanatory power. Increased adjustment frictions is an alternative, but not mutually exclusive, explanation. Both explanations allow for a decoupling of technological progress and aggregate productivity growth."[50]

Now, at this point it must be stated that there is a major qualifier to all of the foregoing material, based on a slightly different perspective on the recent data taken by several economists such as Robert J. Gordon [51] and John G. Fernald.[52] These authors have claimed that there was not actually a productivity slowdown per se in recent years. Rather, these researchers say, there was productivity *reversion* to the "new-normal" of lower productivity growth which had been established back in the early-1970s.

Even more, these economists assert that the innovations of recent decades simply cannot match the world-changing impacts of widespread electricity, the internal combustion engine, and indoor plumbing that had emerged in the late-1800s and early-1900s, and that it should not and could not be expected that productivity growth could sustainably continue on the same trend that had previously been seen as of the mid-20th Century. They regard the productivity speedup of the late-1990s and early-2000s as the true outlier, and the subsequent low productivity growth as just the expected case in this relatively lower-innovation era.

One underlying rationale for this potential story is made by Joseph A. Tainter, who notes that, in general, as complexity in a society increases following initial waves of innovation, further innovations become increasingly costly due to diminishing returns and thus productivity growth typically stumbles over the long-run and recedes below its once torrid pace: "as easier questions are resolved, science moves inevitably to more complex research areas and to larger, costlier organizations," clarifying that "*exponential* growth in the size and costliness of science, in fact, is necessary simply to maintain a *constant* rate of progress."[53] Nicholas Bloom, Charles I. Jones, John Van Reenen, and Michael Webb offer supporting evidence for this view with regard to the U.S., claiming that given that the number of researchers has increased by 23 times since 1930, it is apparent that producing new innovations has become significantly more costly during this period.[54]

However, at the same time, several other researchers have a few qualifiers of their own with regard to this hypothesis that we have long been in an essentially low-productivity era. Chad Syverson points out that productivity slowdowns did in fact occur between the early historic waves of innovation as seminal technologies such as electricity and the internal combustion engine emerged,[55] and Ana Paula Cusolito and William F. Maloney add that "while this prior diffusion hardly implies that a second IT wave is imminent, it does show that productivity accelerations from general-purpose technologies do not have to be one-off events. Just because their resultant productivity growth sped up in the late 1990s and early 2000s does not mean it cannot speed up again."[56]

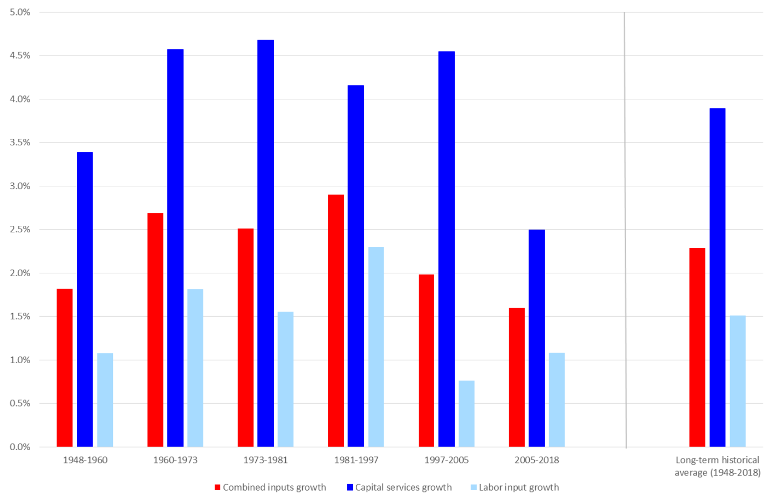
Cusolito and Maloney also contend that the now globally-connected research community, in addition to the ascendance of numerous developing economies with their own innovative research efforts, may help counteract the diminishing returns to innovation.[57] Furthermore, Joel Mokyr claims there are numerous powerful technologies that are just now emerging which may have substantial future impacts, such as genetic engineering, nanotechnology, and high-powered computers,[58] and Philippe Aghion, Benjamin F. Jones, and Charles I. Jones suggest that artificial intelligence (AI) may not only enhance production but may even accelerate the production of new *ideas*.[59] And, finally, it has been noted by Lucia Foster, Cheryl Grim, John Haltiwanger, and Zoltan Wolf that efforts are now underway by firm-level productivity researchers to improve the measurement of innovation, which will "integrate traditional measures such as patents, R&D

expenditures, and the indicators of firm and industry dynamics," so there may be new insights on the area of innovation in the near future.[60]

The slowdown in the contribution of capital intensity

Side by side with the slowdown in MFP growth is the other contributor to the labor productivity slowdown: the contribution of capital intensity, which exhibited an historically unprecedented variation and was reduced by nearly *half* relative to the speedup period. As noted above, the contribution of capital intensity grew just 0.7 percent during the 2005-2018 slowdown period, which is lower than the 1997-2005 speedup period (1.3 percent) and the historical average rate (0.9 percent). And, also as noted above, the measure accounts for 34 percent of the labor productivity slowdown relative to the speedup period; it also explains 25 percent of the sluggishness relative to the long-term average rate. Moreover, the contribution of capital intensity during the 2005-2018 slowdown period was the lowest among the selected post-WWII periods (see Figure 2).[61]

Figure 5. Combined inputs, capital services, and labor input: average annual growth rates for selected periods, private nonfarm business sector, 1948-2018



Given that the contribution of capital intensity is calculated as the difference in growth rates between capital and labor inputs, multiplied by the capital cost share, we can determine whether changes in capital services growth or labor input growth more greatly contributed to the slowdown in this measure, as well as the extent to which it was due to a change in the capital cost share. As shown in Figure 5, capital services grew during the slowdown period at a rate of 2.5 percent, which was well below both its rate for the speedup period (4.5 percent) and its long-term average (3.9 percent). Labor input grew at a rate of 1.1 percent, which lies between its rate for the speedup period (0.8 percent) and its long-term average (1.5 percent). Capital's cost share was 38 percent during the slowdown period, which was higher than during the speedup period (36 percent) and the long-term average rate (34 percent). So, we can say that, relative to the speedup period, it was the pairing of a large deceleration in capital services growth with a slight acceleration in labor input growth that drove down the change in the capital-labor ratio in the slowdown period. This combined effect outweighed an increase in the capital cost share and lowered the contribution of capital intensity to 0.6 percentage points below what it had been in the speedup period.

At the same time, relative to its long-term trend rate, the sluggishness in the contribution of capital intensity in the slowdown period was comparatively modest—just 0.2 percentage points below its long-term trend rate (see Figure 2). Furthermore, the contribution of capital intensity in the slowdown period was actually not as much of an outlier as it had been during the speedup period, in which it was 0.4 percentage point above the long-term trend during these high-growth years; nonetheless, both periods exhibited rates that were outside the norm. So, a question arises: what led to such a dramatic acceleration in the contribution of capital intensity and then an even more dramatic deceleration not just back to normal during the slowdown period, but to slightly below the norm?

To answer the first part of this question, we actually need to look back at the capital and labor components of the contribution of capital intensity during the 1981-1997 pre-speedup period (see Figure 5). What this reveals is that the vast majority of the acceleration in the contribution of capital intensity from the pre-speedup period to the speedup period was not due to capital services growth expanding but was from *labor input growth shrinking*. While capital services growth sped up slightly, from 4.2 percent to 4.5 percent, labor input growth was reduced substantially, from 2.3 percent to 0.8 percent. This reduction in labor input growth is not altogether surprising, given that the speedup period contained both the recession of 2001 and the "jobless recovery" of the early 2000s.

So, it can be said that the change in the capital-to-labor ratio—and thereby the contribution of capital intensity—during the speedup period was boosted up to such a high degree from unusually low labor input growth, with capital services growth lying not far outside the norm. In contrast, for the slowdown period it was the *inverse*: most of the slowing in the measure came from unusually low capital services growth, with labor input growth not far outside the norm.

Slowdown in capital investment in the post-2005 slowdown period

So, what might have led to such below-average capital services growth during the slowdown period? As noted earlier, David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel offer that the fragile financial condition of the economy following the Great Recession may have hindered investment during the recovery.[62] Robert E. Hall agrees, stating that "at the end of 2013, [the capital stock] was 13.2 percent below its trend path. The crisis and Great Recession, including amplification mechanisms, appear to be responsible for the shortfall."[63] Also, the work of Ravi Bansal, Mariano Max Croce, Wenxi Liao, and Samuel Rosen indicates specifically that *uncertainty* during and following the Great Recession may have also played a role, and especially hurt innovative and productivity-driving firms, observing that "volatility shocks are more disruptive for innovation-oriented firms both in terms of market valuation and contraction in their investments. According to the data, when uncertainty increases there exists a relative reallocation effect that penalizes investments in R&D-intensive firms, that is, investments that are important to sustain long-term growth."[64]

Taking a slightly longer view and analyzing the entire 2005-2018 slowdown period, Germán Gutiérrez and Thomas Philippon point out that the U.S. business sector has under-invested relative to "measures of profitability and valuation, particularly Tobin's Q,[65] and that this weakness starts in the early 2000's."[66] In terms of a theoretical underpinning that could explain this, the authors specify that while it is possible for firms to under-invest either because of a low Q or despite a high Q, the data do not support the first case, and so instead the authors focus on the latter case, in which they find evidence of three main drivers: "rising intangibles, decreased competition, and changes in corporate governance that encourage payouts instead of investment."[67]

With regard to the rise of intangibles—intellectual property including software, R&D, patents, trademarks, and goodwill—as a share of overall capital investment, the authors estimate that this component "can explain a quarter to a third of the observed investment gap."[68] Namely, this is because these assets are both difficult to measure, which may lead to their undercounting, and also "difficult to accumulate, due to higher adjustments costs," leading to "a higher equilibrium value of Q, even if intangibles are correctly measured."[69]

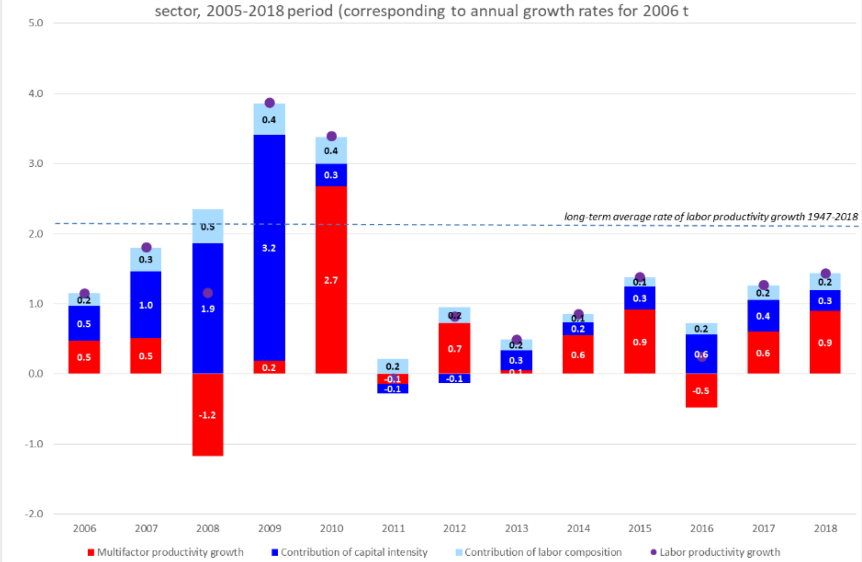
The remainder of the under-investment likely comes from some combination of decreased competition and changes in corporate governance, according to the authors. With regard to the former, the evidence indicates that "industries with more concentration and more common ownership invest less, even after controlling for current market conditions. Within each industry-year, the investment gap is driven by firms that are owned by quasi-indexers[70] and located in industries with more concentration and more common ownership. These firms spend a disproportionate amount of free cash flows buying back their shares."[71] And, and in terms of the latter, Gutiérrez and Philippon cite increased shareholder oversight, particularly in guarding against mangers' desire to expand capital investments beyond an amount that would be in shareholders' best interests,[72] as well as short-termism, in which "stock-based compensation incentivizes managers to focus on short-term capital gains" via share buybacks rather than making long-term capital investments in their firm.[73]

Annual contributions to the productivity slowdown

In addition to analyzing the labor productivity slowdown from a full-period perspective as we have done thus far, we can also look at the individual years of the slowdown period itself, to see how the path of each component developed over time. Figure 6 illustrates how the three series underlying labor productivity growth—MFP growth, the contribution of capital intensity, and the contribution of labor composition—progressed over the course of the slowdown period, from 2005 to 2018.

In the first year of the slowdown period—2006, which in Figure 6 represents the growth observed from 2005 to 2006, as we are displaying the growth from one year to the next—MFP growth and the contribution of capital intensity not only had the same rate of growth, but were also similarly below their respective long-term average rates: a 0.5 percent increase in MFP in 2006 was below its long-term average of 1.1 percent, and a 0.5 percent increase in contribution of capital intensity was also below its long-term average of 0.9 percent. However, over the next few years, it is remarkable how each of these measures diverged from one another as the Great Recession began and wore on. In each year from 2006 through 2009, the contribution of capital intensity incrementally expanded, reaching a series-high 3.2 percent in 2009 and composing the vast majority of the above-trend labor productivity growth in that year.

Figure 6. Contributions to labor productivity growth: MFP growth, contribution of capital intensity, contribution of labor composition, annual growth rates, private nonfarm business sector, 2005-2018 period (corresponding to annual growth rates for 2006 t



This acceleration in the contribution of capital intensity was due to an outsized decline in underlying labor input: though capital services growth did slow from 3.7 percent in 2006 to 1.1 percent in in 2009, labor input growth plummeted from

2.6 percent in 2006 to -6.6 percent in 2009. This difference in magnitudes makes sense, given that it is easier for businesses to lay off workers than sell capital equipment during a recession.

At the same time as the contribution of capital intensity was expanding during the Great Recession, MFP growth was stagnating. After recording a below-average value in 2007 (0.5 percent), the measure sunk well into negative territory in 2008 and then climbed barely back into positive territory in 2009. What might have brought about this below-average MFP growth during the Great Recession? John G. Fernald notes that “factor utilization ‘explains’ the plunge and rebound in [MFP]. Utilization fell below the range of historical experience in the recession, then recovered rapidly during the recovery.”[74] Nicholas Bloom, Max Floetotto, Nir Jaimovich, Itay Saporta-Eksten, and Stephen J. Terry cite uncertainty, noting that “plant-level [MFP] shocks increased in variance by 76 percent during the recession” and that “bad times, defined in terms of low rates of output, are also uncertain times in terms of increased cross-sectional dispersion of [MFP] shocks.”[75] And, Lucia Foster, Cheryl Grim, and John Haltiwanger claim that the Great Recession was an atypical recession in terms of its effect on MFP growth, in that it did not the offer the usual boost from increased reallocation as most recessions do, finding that “the intensity of reallocation fell rather than rose and the reallocation that did occur was less productivity enhancing than in prior recessions.”[76]

Following the end of the Great Recession in 2009, we observe another year of strong labor productivity growth (3.4 percent) in 2010, though with a sudden reversal in the underlying contributions. MFP growth and the contribution of capital intensity were virtually mirror images of one another in those two years, with MFP growth accelerating from 0.2 percent in 2009 to 2.7 percent in 2010, and the contribution of capital intensity slowing down from 3.2 percent in 2009 to 0.3 percent in 2010. What might have brought about this result? As noted above, Fernald cites increased utilization a potential explanation for the rebound in MFP growth during this early phase of the recovery. Also, it is often the case when emerging from a recession—especially one as a large as the Great Recession—that firms may still remain apprehensive about hiring until the recovery begins in earnest, with a lag in employment recovery relative to output recovery. This was the case with the recovery from the Great Recession, with labor hours falling for an additional quarter more than output, in the third quarter of 2009, and then remaining virtually flat for two additional quarters—while output was simultaneously rising—and hours not beginning to recover in earnest until the second quarter of 2010.[77] This lag in the labor hours recovery contributed to both the dramatic increase of MFP growth in 2010 as well as the diminution of the contribution of capital intensity in that year.[78]

In the years following 2010, labor productivity growth stagnated, with an average rate of just 0.8 percent—well below the 2.1 percent long-term average rate since 1947. These early years of the recovery were particularly weak for the underlying measures, with the contribution of capital intensity receding into slightly negative territory in both 2011 and 2012, and MFP growth having a negative showing in 2011 and a 0.1 percent increase in 2013. More recently, the situation has improved somewhat relative to those early years, with labor productivity rising above one percent in three of the last four years, though still remaining below the long-term historical trend and thus extending the productivity slowdown for over a decade.[79]

One significant fact about the growth during the historically weak recovery period—specifically, after 2011—is how remarkably consistent and steady the growth rates have been during these years, with labor productivity growth staying within an historically narrow range of between 0.3 percent and 1.4 percent. This phenomenon reflects the combination of a steadily weak output recovery and a consistently moderate labor input recovery. And, in terms of labor productivity growth's underlying series, MFP growth was below-average during these years as weak output growth was paired with moderate combined-input growth from labor and capital. And, the contribution of capital intensity was also low throughout these years, as moderately-increasing labor input was paired with similarly-moderate capital services growth.

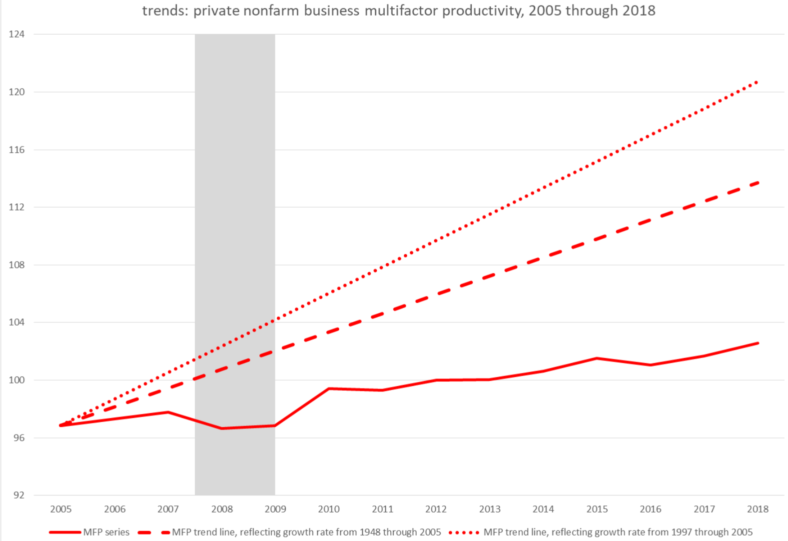
Also, it might be of interest that, in contrast to its typical steadiness over the course of full periods (see Figure 2), the contribution of labor composition actually exhibited some *within-period* variation during the slowdown period from 2005 to 2018 (see Figure 6), and made a contribution to the swings in labor productivity during this period. Specifically, the contribution of labor composition rose at above-average rates during the Great Recession, with a high of 0.5 percent in 2008, and then grew at below-average rates since, of 0.1 or 0.2 percent. These movements in the contribution of labor composition over the slowdown period—particularly within the post-2007 business cycle—are not surprising, given that lower-skilled or less-experienced workers are more likely to be laid off during recessions, and then may gradually be reintegrated into the workforce as a recovery progresses.[80]

Trend comparisons for MFP and the contribution of capital intensity

In addition to determining the extent to which each component series contributed to labor productivity growth within each year of the slowdown period, we can also look at how each of these component series tracked during these years relative to its own previously-observed long-term average *trends*—particularly its speedup period trend rate (1997-2005) and its long-term trend rate (1948-2005). This will allow us to see how much the movements after 2005 either stayed on course with, or diverged from, the growth trends that had been previously and historically been observed for these series. We will do this for the two contributors to the slowdown: MFP growth and the contribution of capital intensity.

The path of the MFP index series over the course of the slowdown period, as well as the long-term trend rate and the speedup period trend rate for this series, are shown in Figure 7. We see that in 2006 and 2007, MFP was already falling slightly behind both the speedup period and long-term period trend lines, and then this gap widened substantially during the recession. Then, in 2010, one year of high MFP growth partially shrank the gap, but subsequently, from 2011 to 2018, below-average MFP growth widened the gap substantially. Strikingly, we can see from the figure that every annual movement from 2005 to 2018 other than the gain in 2010 acted to widen the

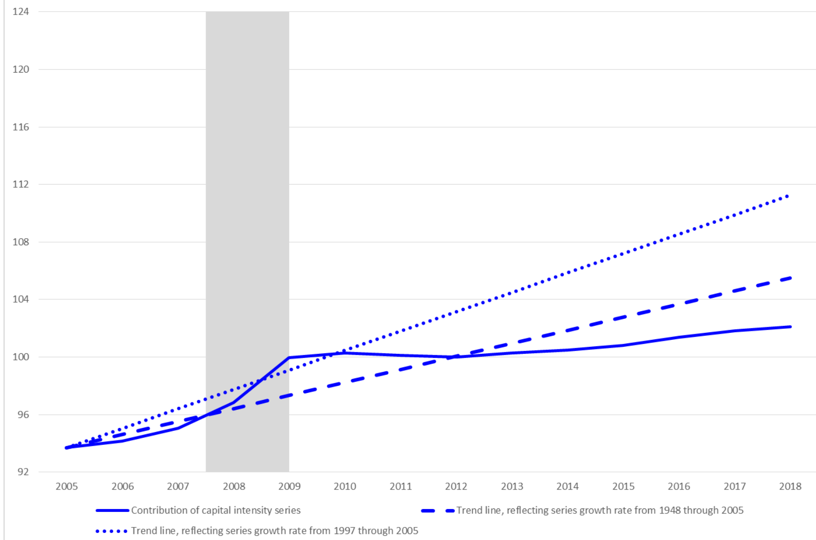
Figure 7. Comparing the multifactor productivity series during the slowdown period with past trends: private nonfarm business multifactor productivity, 2005 through 2018



gap, either with a negative annual change or a positive change which was slower than the historical trend.

The contribution of capital intensity index series took a much different path through the slowdown period, as is illustrated by Figure 8. As discussed above, the contribution of capital intensity took an inverse path relative to MFP during the Great Recession, and this is evident in this figure, in which an increase in 2008 and a surge in 2009 sent the series above *both* the long-term and speedup period trend lines by 2009. However, the subsequent stagnation in the series, with virtually no growth over the next four years, submerged it below both trend lines by 2013, and widened the gap from that point onward. At the same time, it is worth noting that this cumulative gap in the growth of the contribution of capital intensity was, as of 2018, less than that of MFP, which is cumulatively much further behind its historical trends (see Figure 7).

Figure 8. Comparing the contribution of capital intensity series during the slowdown period with past trends: private nonfarm business contribution of capital intensity, 2005 through 2018



To give us a sense of the sizable gains in two these series which would be required in coming years to make up for their below-average growth since 2005 and pull them back up to their long-term historical trends, we can make hypothetical calculations for each. For instance, for the MFP growth rate of the post-2005 period to catch up to the 1.2 percent long-term historical trend rate seen from 1948 to 2005, it would require an MFP growth rate of 4.8 percent during each of the next three years. This rate would be *more than ten times* the average rate of MFP growth during the slowdown period thus far, from 2005 to 2018. And, for contribution of capital intensity to catch up to its long-term trend rate, it would need to grow 2.1 percent during each of the next three years. This rate would be *more than three times* its rate during the slowdown period thus far. Thus, we can say that the gap between MFP growth and its historical trend rate is more than three times larger than the gap between the contribution of capital intensity and its historical trend rate.

Dollar and time costs of the productivity slowdown

In addition to analyzing the productivity slowdown in terms of percent changes as we have done up to this point, we may also wonder: how much of a real-world impact did the labor productivity slowdown have in terms of dollars of lower output or hours of lost leisure time, for participants of the U.S. economy? Before undertaking this analysis, we should clarify that it is not possible to know in what combination the additional productivity growth—if growth had continued at average historical rates following 2005, rather than at the low rates we have observed—would have translated into greater output and additional leisure time. However, these calculations will give us a sense of the losses that have been incurred by Americans due to the productivity slowdown.

We will first make an analysis assuming the added productivity growth would have all contributed to producing additional output, and then make an analysis assuming the added productivity growth would have all contributed to accumulating additional leisure time. In order to estimate the total loss in output, it is first necessary to ascertain how much total output was produced during the slowdown; this amount is $175.2 trillion. Then, a hypothetical total output can be calculated, incorporating a consistent 2.3 percent labor productivity growth rate;[81] this amount is $186.1 trillion. So, the difference in output, representing the loss due to the productivity slowdown, is $10.9 trillion. Furthermore, as there were, on average, 114.6 million workers in the nonfarm business sector during these years, this translates into a loss of $95,000 in output on a per-worker basis.[82]

The productivity slowdown can also be framed in terms lost time, specifically the lost leisure time which could have been available for workers to consume if there had not been a slowdown.[83] To do this, we first add up all hours worked during the slowdown period, which comes to 2.51 trillion. Then, assuming that labor productivity has grown at a consistent rate of 2.3 percent throughout the period, and that all of the effect of the added productivity growth contributed to a reduction in hours worked, this would yield a hypothetical total hours worked of 2.37 trillion. This results in a hypothetical gain in leisure time of 138.5 billion hours, or 1,209 per worker. And, given that the average weekly hours during these years would have been 30.7 in this case,[84] this would result in a total of 39.4 weeks of leave lost due to the slowdown in productivity growth during this period, or, correspondingly, 3.0 additional weeks of leave per year.

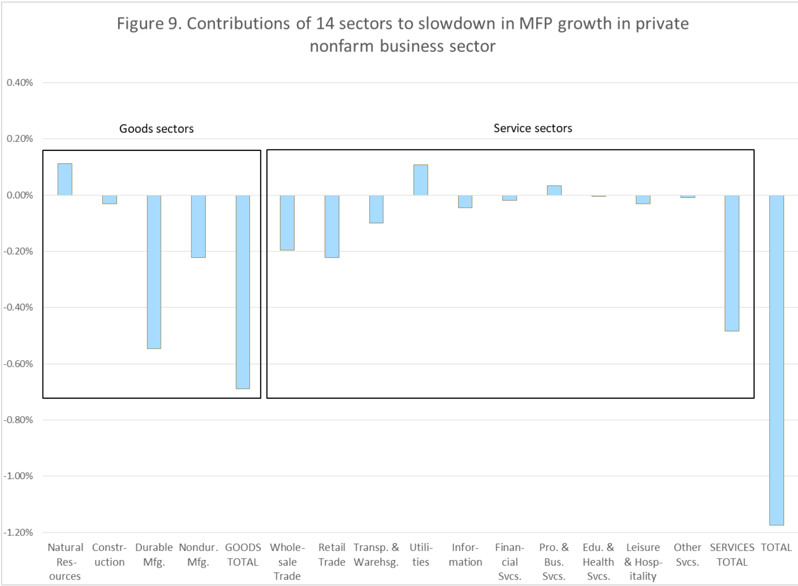
II. Industry-level analysis of the U.S. labor productivity slowdown

Up to this point, we have analyzed the U.S. labor productivity slowdown from an economy-wide perspective. We can also examine more-detailed data to determine which industries made the largest contributions to the slowdown. In breaking out the U.S. labor productivity slowdown into its industry-level components, we will be investigating the two series contributing to the slowdown—MFP growth and the contribution of capital intensity—to see which industries contributed most to the economy-wide slowdown via these two factors. This can be done by calculating Domar-weighted growth rates of these two factors, for all the industries which make up the private nonfarm business sector.[85] First, we will be looking at the industry contributions to the MFP slowdown, followed by the industry contributions to the slowdown in the contribution of capital intensity.

Industry contributions to the MFP slowdown

When breaking out the economy-wide MFP slowdown into its components, it is instructive to disaggregate the data into both sectors and industries, as these can each provide a slightly different perspective and deepen our understanding of the issue. With this approach in mind, we will begin with a look at contributions at the 14-sector level, and then take a look at the contributions at the 59-industry NIPA level.[86]

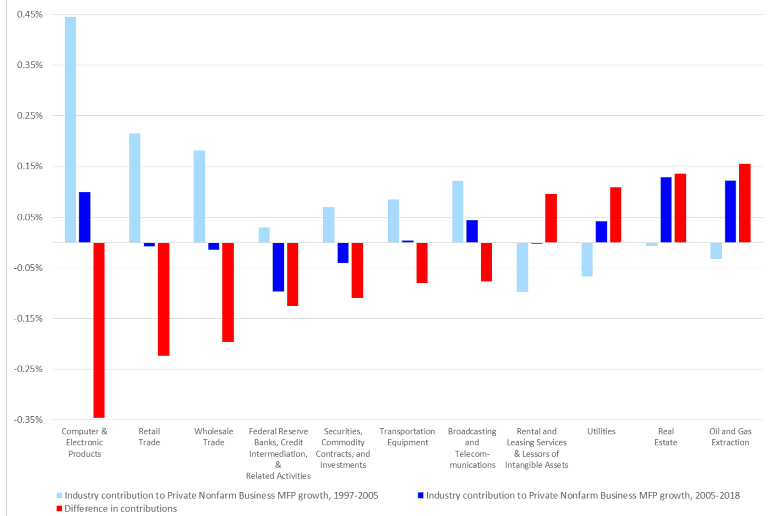
The sector-level contributions to the economy-wide MFP slowdown are shown in Figure 9, along with the corresponding contributions of the overall goods sector and service sector. First, we notice that the goods sector made a contribution (0.69 percentage point) to the MFP slowdown that was larger than the contribution made by the services sector (0.48 ppt.). The fact that the goods sector made a larger contribution is at first glance somewhat surprising, given that it is much smaller than the services sector, and produces just 25 percent of private nonfarm business output. The potency of the contribution from the goods-producing sector can be isolated to the manufacturing sector, and most prominently, durable goods manufacturing, which itself contributed 0.55 ppt., or nearly half of the overall contributions to the private nonfarm business sector (1.17 ppt.).[87] When the durable goods sector contribution is combined with the nondurable goods sector contribution, the total manufacturing sector accounted for 66 percent of the private nonfarm business MFP slowdown.



For the services sector, the largest contributors to the slowdown were retail trade (0.22 ppt.), wholesale trade (0.20 ppt.), and transportation & warehousing (0.10 ppt.), and these three sectors together more than explain the overall contribution to the MFP slowdown coming from the service sector (0.48 ppt). It is also worth pointing out that two sectors had notable productivity speedups, especially considering their small size—natural resources and mining (0.11 ppt.) and utilities (0.11 ppt.); natural resources and mining makes up just 2.7 percent of the private nonfarm business sector, and utilities makes up just 2.3 percent. Also, though the financial activities sector and the professional & business services sector made relatively flat contributions to the slowdown, there were a number of industries within those two sectors that made significant contributions to the slowdown (which will be discussed below). However, these industry-level slowdowns largely canceled with speedups in other industries within the same sector, leaving just a small overall contribution for these two sectors.

The industry-level contributions to the economy-wide MFP slowdown are shown in Figure 10, specifically for a selection of the largest contributions (positive or negative).[88] It is not surprising that the largest industry-level contributor to the slowdown (computer & electronic products) is from within the largest sector-level contributor to the slowdown (durable manufacturing). Computer & electronic products underwent a massive slowdown, with a contribution to MFP growth of 0.45 ppt. from 1997 to 2005 dwindling to one of 0.10 ppt. from 2005 to 2018. A startling fact about this industry is that, even after having the largest MFP slowdown among all the industries, computer & electronic products still possessed a positive contribution and, in fact, the third-largest contribution among all 59 industries during the 2005-2018 period, behind only real estate (0.13 ppt) and oil & gas extraction (0.12 ppt.).[89] The MFP slowdown in computer & electronic products represented 63 percent of the slowdown in durable manufacturing, and 29 percent of the slowdown in the private nonfarm business sector.

Figure 10. Industries with largest differences in contributions to private nonfarm business sector MFP growth, between 1997-2005 period and 2005-2018 period



MFP slowdown of the computer & electronic products industry

Numerous researchers have focused on the historic acceleration and subsequent moderation in the growth of the computer & electronic products industry as being a major driver of the economy-wide productivity slowdown. Many had been aware of the remarkable growth of computer & electronic products in the late 1990s and early 2000s, with Stephen D. Oliner and Daniel E. Sichel observing that the trend at that time was already apparent and strong: "the multifactor productivity contributions from computer and semiconductor producers moved up sharply during 1996-99, reaching 0.26 and 0.39 percentage point per year, respectively," and that "the increases largely reflect the faster decline in relative prices of computers and semiconductors…and the rising output shares of computer and semiconductor producers."[90] David M. Byrne and Carol Corrado also emphasize the rapidly declining prices during those years: "the greatest computer [price] declines, and the greatest gap, occurs in the 1994 to 2000 period, when [microprocessor unit] prices were falling especially fast."[91]

However, during the mid-2000s, the pace of microprocessor unit price declines began to stall.[92] And, more recently, price declines have become even smaller, with Byrne and Corrado citing "*extremely* small declines of late, after having gradually lost force since 2004."[93] At the same time, Byrne, Oliner, and Sichel argue that there has not been a slowdown in technological progress that the paltry price declines might indicate, clarifying that "technical progress in the semiconductor industry has continued to proceed at a rapid pace."[94] So, might there be mismeasurement occurring with regard to these prices? Yes, there was, argue Byrne, Fernald, and Reinsdorf, who say that in "IT-related hardware and software…mismeasurement is sizable."[95] However, the authors also note that this was not a new issue in the mid-2000s, and that IT price mismeasurement was evident even *before* the productivity slowdown, clarifying that they "find no evidence that biases have gotten worse since the early 2000s."[96] In fact, they point out that consistently adjusting for mismeasurement across time actually makes the labor productivity slowdown *worse*, given that "mismeasurement of IT hardware [was] significant prior to the slowdown," and also that "the domestic production of these products has fallen, [and thus] the quantitative effect [of mismeasurement] on productivity was larger in the 1995-2004 period than since, despite mismeasurement worsening for some types of IT."[97] Chad Syverson concurs with Byrne, Fernald, and Reinsdorf, asserting that mismeasurement is unlikely to be a driver of the productivity slowdown, observing that "the productivity slowdown has occurred in dozens of countries, and its size is unrelated to measures of the countries' consumption or production intensities of information and communication technologies," further contending that "if measurement problems were to account for even a modest share of this missing output, the properly measured output and productivity growth rates of industries that produce and service ICTs would have to have been multiples of their measured growth in the data."[98]

So, what factors might have led to the slowdown in the productivity growth of IT goods? Decker et al. point out that a slackening in the "marginal employment growth response of businesses to idiosyncratic productivity draws…is especially large in the high-tech sector, with the responsiveness of young firms in the post-2000 period only about half (manufacturing) to two thirds (economy-wide) of the peak responsiveness in the 1990s," with the authors concluding that "the timing of reallocation and responsiveness patterns in high-tech is consistent with the timing of the productivity slowdown, which evidence indicates was driven by ICT-producing and using industries."[99]

The waning responsiveness of young high-tech firms that is cited by Decker et al. could potentially be explained, at least in part, by the work of Mordecai Kurz, who finds growing market power in the IT sector which may be stifling the entry and growth of young firms.[100] Kurz reports that "declining or slow growing firms with broadly distributed ownership have been replaced by IT based firms with highly concentrated ownership," and that "IT innovations enable and accelerate the erection of barriers to entry and once erected, IT facilitates maintenance of restraints on competition."[101] Foster, Grim, Haltiwanger, and Wolf also reference the concentration within high-tech industries, noting that, in contrast to the late-1990s, when "the productivity surge in the high-tech sectors [had] a high contribution of increased within-industry covariance between market share and productivity, … the productivity slowdown in the post-2000 period in high tech is due to both a decrease in within-firm productivity but also a decrease in this covariance."[102] Titan Alon, David Berger, Robert Dent, and Benjamin Pugsley offer further evidence to support this finding, noting that "over the last three decades, the U.S. business sector has experienced a collapse in the rate of new startups alongside an enormous reallocation of economic activity from entrants and young firms to older incumbents."[103] Alon et al. clarify that this finding is not just particular to high-tech industries, but is "widespread across industries and geographic markets",[104] so that while this could be relevant in high-tech industries, it could also help to explain the productivity slowdowns in other industries. And, more generally, Gustavo Grullon, Yelena Larkin, and Roni Michaely observe that "more than 75 percent of U.S. industries have experienced an increase in concentration levels over the last two decades."[105] These authors offer lax antitrust enforcement as a potential explanation, noting that such enforcement, "as measured by the number of cases filed by the Department of Justice under Section 2 of the Sherman Act, has weakened since early 2000, whereas the probability of M&A deal completion has increased."[106]

And, beyond the concentration argument, David Autor, David Dorn, Gordon H. Hanson, Gary Pisano, and Pian Shu propose another potential contributor to the productivity slowdown in IT, particularly in IT-intensive manufacturing industries, which is a reduction in U.S. innovation caused by increased foreign competition from China.[107] The authors observe that, "despite accounting for less than one-tenth of U.S. private non-farm employment, U.S. manufacturing still generates more than two-thirds of U.S. R&D spending and corporate patents," and claim that "increased imports from

China ramped up competitive pressure on publicly listed U.S. firms", and that "this increase in competitive pressure caused U.S. firms to *decrease* their output of innovations as measured by patent grants."[108] However, this phenomenon is more long-term and may not apply only or specifically to the 2005-2018 slowdown period, though it could potentially be a contributor.

In addition to the slowdown in the computer & electronic products industry, it has also been widely noted that the trade sectors accounted for a sizable portion of the economy-wide productivity slowdown. Specifically, retail trade and wholesale trade made contributions of 0.22 ppt. and 0.20 ppt., respectively, to the MFP slowdown, and when combined they actually exceed the size of the slowdown in computer & electronic products. These trade sectors transitioned from making sizeable positive contributions to MFP growth during the speedup period to being virtually flat during the slowdown period.

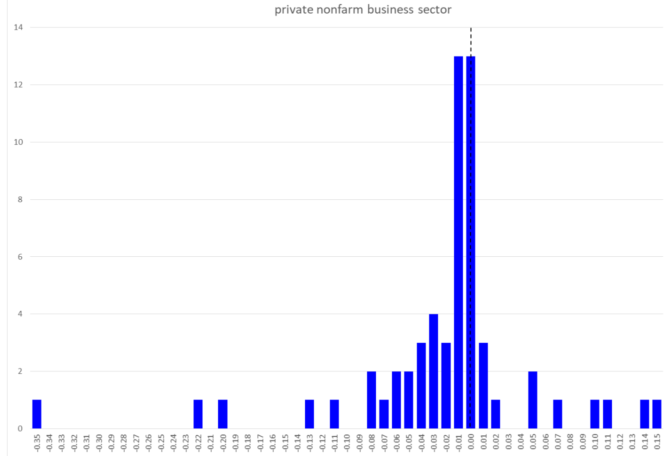
MFP slowdown of the retail trade sector

Might the size and coincidence of these slowdowns in the trade sectors and those in the IT-related industries be related? The answer is likely yes, according to several researchers, at least with regard to the retail trade sector. Lucia Foster, John Haltiwanger and C. J. Krizan assert that "the retail trade sector underwent a massive restructuring and reallocation of economic activity in the 1990s. Retail businesses changed their ways of doing business with intensive adoption of advanced information technology, including everything from improvements in inventory control to the introduction and widespread use of scanners and rapid credit card processing technologies. Structural changes occurred with entering establishments from large multiunit national firms displacing single-establishment firms."[109] This was widely seen in the economy, with the proliferation of "big box" stores such as Wal-Mart, Home Depot, and Best Buy that swept the country and displaced many small businesses that could not compete with the advanced IT that these corporations were utilizing.[110] Emek Basker argues that the effect was particularly powerful with regard to Wal-Mart, "because Wal-Mart competes with retailers across many categories, including general merchandise stores, drugstores, apparel stores, and grocery stores."[111] Foster, Haltiwanger, and Krizan contend that, in their firm-level analysis of the dispersion and reallocation dynamics in play within the retail trade sector, "virtually all of the productivity growth in the retail trade sector over the 1990s is accounted for by more productive entering establishments displacing much less productive existing establishments," which they clarify is due to a combination of "selection effects and post-entry learning effects. That is, establishments that enter might be immediately more productive than the establishments they are displacing, or it may take time for the productivity gap to widen or emerge."[112]

Several other notable downward contributors to the slowdown in MFP growth include: Federal Reserve banks and credit intermediation (0.13 ppt), securities, commodity contracts, and investments (0.11 ppt.), transportation equipment (0.08 ppt), and broadcasting & telecommunications (0.08 ppt). Also, there are few industries that worked in the opposite direction of the overall slowdown, actually accelerating in MFP growth during this period: oil & gas extraction (0.15 ppt.), real estate (0.14 ppt), utilities (0.11 ppt.), and rental & leasing services and lessors of intangible assets (0.10 ppt.). The increase for the oil & gas extraction industry during the slowdown period catapulted it from being the fifty-fifth ranked industry among all 59 industries as of the speedup period, to a rank of 2 as of the slowdown period. This astounding turnaround, note David Popp, Jacquelyn Pless, Ivan Haščič, and Nick Johnstone, may reflect technological innovations in this industry, in which the "rise of hydrofracturing lowered fossil fuel prices so much that natural gas is now the primary fuel for electricity generation in the U.S."[113] The real estate industry had a similarly extraordinary turnaround in its MFP growth contribution, rising from a rank of 49 to 1.

Given that there were both negative and positive contributors to the MFP slowdown, with sizable contributors on both sides, it may be of interest to look at the distribution of these industry-level data (see Figure 11). The first item to note is that there were more large negative contributors (those slowing by 0.05 ppt. or more) than large positive contributors (those expediting by 0.05 ppt. or more), with the net slowdown of the large-contributing industries being 0.78 ppt., with 1.45 ppt. of the large contributors on the negative side and 0.66 ppt. on the positive side. The remaining 0.39 ppt. of the economy-wide slowdown comes from the small contributors, specifically from the fact that there were many more small negative contributors than small positive contributors. While there were just four industries with a contribution of between 0.01 and 0.04 ppt., there were *twenty-three* of between -0.01 and -0.04 ppt. These negative small contributors had a combined slowdown of 0.43 ppt., greatly outweighing the positive small contributors, which had a combined speedup of just 0.06 ppt. So, we can say that though there were numerous large contributors to the overall slowdown on the negative side (particularly computer & electronic products and the trade industries), there was also a widespread, generalized negative slide among the vast majority of the industries, which also helped bring about the historic decline in MFP growth at the economy-wide level.

Figure 11. Distribution of percentage-point industry contributions to slowdown in MFP growth, private nonfarm business sector



Industry contributions to the slowdown of the contribution of capital intensity

The slowdown in the contribution of capital intensity came more from the services sector than the goods sector. This can be seen in Figure 12, which shows the sector-level contributions to the overall slowdown in the contribution of capital intensity. The services sector accounted for 0.45 ppt. of the overall slowdown in this measure, with goods sector contributing 0.26 ppt.

The largest sector contribution to the slowdown was from the financial services sector, with a contribution of 0.23 ppt. There were also noteworthy contributions from professional & business services (0.12 ppt.), durable manufacturing (0.13 ppt.) and nondurable manufacturing (0.09 ppt.).

Figure 12. Contributions of 14 sectors to slowdown in contribution of capital intensity in private nonfarm business sector

Figure 13 shows the large industry-level contributions to the slowdown in the contribution of capital intensity, including those with contributions of 0.05 or greater in either direction, positive or negative. Five of six large contributors were negative and were of similar sizes. The three largest outliers each had slowdowns of 0.06 ppt.; these were rental & leasing services and lessors of intangible assets, retail trade, and computer & electronic products. Insurance carriers & related activities, and miscellaneous professional, scientific, & technical services, slowed by 0.05 ppt. The broadcasting & telecommunications industry had a speedup of 0.05 ppt.

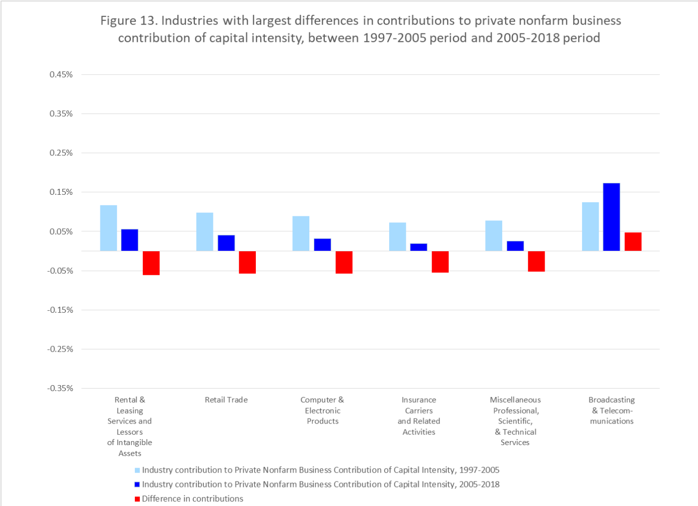


Figure 13. Industries with largest differences in contributions to private nonfarm business contribution of capital intensity, between 1997-2005 period and 2005-2018 period

The distribution of industry contributions to the economy-wide slowdown in the contribution of capital intensity skews heavily negative (see Figure 14), with *31 negative contributors* and just 4 positive contributors. At the same time, the net contribution to the slowdown from the large contributors (0.23 ppt.) was less than half the net contribution from the small contributors (0.48 ppt.), indicating that there were relatively few outliers with regard to the slowdown in the contribution of capital intensity, especially when compared with the case of the MFP slowdown, which had some substantial outliers. To sum up, the bulk of the slowdown in the economy-wide contribution of capital intensity came from relatively small slowdowns in this measure, in a substantial number of industries.

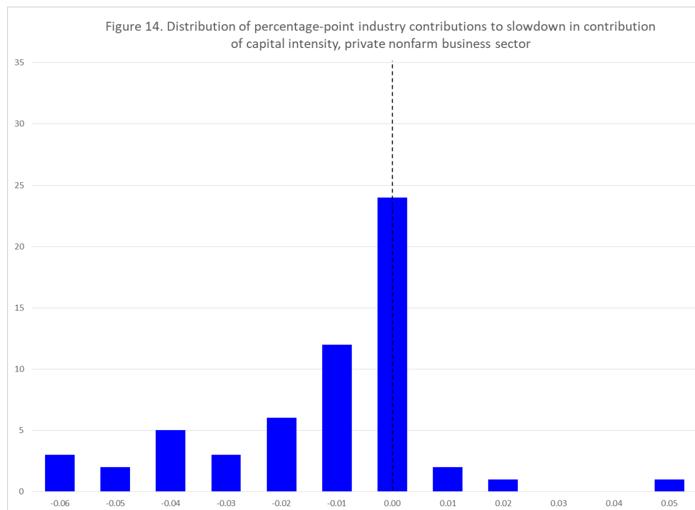


Figure 14. Distribution of percentage-point industry contributions to slowdown in contribution of capital intensity, private nonfarm business sector

Looking ahead

So, we may be wondering, where might we go from here? Well, it is unclear at the present time whether or not trends in U.S. labor productivity growth will at some point regain the heights of the 1950s and 1960s, or the late-1990s, or whether they will even be able to climb back up to the long-term trend from 1948 to 2018. However, as several researchers have pointed out, there are new technologies that are forthcoming which may provide a boost to growth in the future, and, it is clear from the story of the past two decades that is extremely difficult to make predictions about future growth prospects, positive or negative.

At the same time, one thing that we are certain of at the present time is that the productivity slowdown of the past decade-and-a-half has left the U.S. economy in a weaker position, yielding a sizable loss of potential output during these years, and, perhaps even more importantly, it has also left the economy in a weaker position going forward. This is because it has resulted in a lower base of output from which to grow onward from here, relative to where the economy would be if productivity had continued to grow at the long-term historical trend following 2005.

Thus, it will be important for participants of the U.S. economy to keep an eye on productivity data in coming years, to see whether this slowdown since 2005 represented a periodic variation in trend which can be explained from recent cyclical and noncyclical factors, as some observers have claimed, or whether it comes to be seen as the "new normal" of lower growth that was a continuation of the situation from the last few decades of the 20th Century. BLS productivity data, including labor productivity, multifactor productivity, and capital and labor data, both at the economy-wide and industry levels, will continue to shed light on the issue.

Appendix Table 1. Industry contributions to slowdown in private nonfarm business labor productivity growth, from 1997-2005 period to 2005-2018 period, percentage points

	Contributions from industry MFP growth			Contributions from industry contribution of capital intensity		
Industry	1997-2005 period	2005-2018 period	Difference	1997-2005 period	2005-2018 period	Difference
Forestry, Fishing, and Related Activities	0.010	-0.001	-0.011	0.002	0.002	0.001
Oil and Gas Extraction	-0.033	0.122	0.155	0.004	-0.037	-0.041
Mining, except Oil and Gas	0.013	-0.019	-0.032	0.000	0.014	0.014
Support Activities for Mining	-0.004	-0.004	0.000	-0.004	-0.001	0.003
Utilities	-0.067	0.042	0.109	0.044	0.028	-0.015
Construction	-0.091	-0.123	-0.032	0.036	0.014	-0.023
Food and Beverage and Tobacco Products	0.018	-0.024	-0.042	0.022	-0.001	-0.023
Textile Mills and Textile Product Mills	0.010	-0.001	-0.012	0.004	0.001	-0.004
Apparel and Leather and Applied Products	0.000	-0.001	-0.001	0.007	0.000	-0.007
Wood Products	0.001	0.004	0.003	0.002	0.001	-0.001
Paper Products	0.003	-0.001	-0.004	0.010	0.003	-0.007
Printing and Related Support Activities	0.022	0.009	-0.013	0.006	0.003	-0.003
Petroleum and Coal Products	0.019	-0.031	-0.050	0.014	0.018	0.004
Chemical Products	0.004	-0.064	-0.068	0.103	0.070	-0.033
Plastics and Rubber Products	0.027	-0.004	-0.031	0.016	0.002	-0.014
Nonmetallic Mineral Products	0.003	-0.004	-0.006	0.005	0.003	-0.002
Primary Metal Products	0.027	0.003	-0.024	0.004	0.005	0.001
Fabricated Metal Products	0.007	-0.019	-0.026	0.014	0.006	-0.007
Machinery	0.027	-0.011	-0.038	0.023	0.007	-0.017
Computer and Electronic Products	0.445	0.099	-0.346	0.090	0.032	-0.058
Electrical Equipment, Appliances, and Components	0.008	0.001	-0.007	0.009	0.003	-0.006
Transportation Equipment	0.085	0.004	-0.080	0.045	0.009	-0.036
Furniture and Related Products	0.000	-0.004	-0.003	0.004	0.002	-0.002
Miscellaneous Manufacturing	0.023	0.004	-0.020	0.012	0.007	-0.005
Wholesale Trade	0.181	-0.015	-0.196	0.100	0.059	-0.042
Retail Trade	0.215	-0.008	-0.223	0.098	0.040	-0.058
Air Transportation	0.056	0.044	-0.012	0.009	0.005	-0.004
Rail Transportation	0.012	0.001	-0.011	0.002	0.003	0.001
Water Transportation	-0.005	0.008	0.013	-0.003	0.001	0.004
Truck Transportation	-0.008	-0.007	0.001	0.007	0.008	0.000
Transit and Ground Passenger Transportation	0.003	-0.004	-0.007	0.003	-0.001	-0.004
Pipeline Transportation	0.009	0.007	-0.002	0.004	0.006	0.002
Other Transportation and Support Activities	0.029	-0.035	-0.064	0.001	-0.004	-0.005
Warehousing and Storage	0.015	-0.003	-0.018	-0.001	-0.002	-0.001
Publishing industries, except internet (includes software)	-0.006	0.042	0.049	0.073	0.053	-0.019
Motion picture and sound recording industries	0.025	0.021	-0.004	0.018	0.006	-0.012
Broadcasting and telecommunications	0.121	0.044	-0.077	0.125	0.173	0.048
Data processing, internet publishing, and other information services	0.027	0.014	-0.013	0.047	0.063	0.016

Federal Reserve Banks, Credit Intermediation, and Related Activities	0.030	-0.097	-0.126	0.111	0.071	-0.040
Securities, Commodity Contracts, and Investments	0.069	-0.041	-0.110	0.011	0.002	-0.009
Insurance Carriers and Related Activities	0.050	0.047	-0.003	0.073	0.019	-0.054
Funds, Trusts, and Other Financial Vehicles	0.008	-0.003	-0.011	0.006	-0.021	-0.027
Real Estate	-0.008	0.128	0.136	0.021	-0.020	-0.041
Rental and Leasing Services and Lessors of Intangible Assets	-0.098	-0.002	0.096	0.117	0.056	-0.061
Legal Services	0.006	-0.033	-0.039	0.012	0.006	-0.006
Miscellaneous Professional, Scientific, and Technical Services	-0.051	0.020	0.071	0.078	0.026	-0.052
Computer Systems Design and Related Services	0.047	0.095	0.048	0.019	-0.006	-0.025
Management of Companies and Enterprises	0.002	0.023	0.021	0.008	-0.003	-0.011
Administrative and Support Services	0.080	0.023	-0.057	0.046	0.019	-0.026
Waste Management and Remediation Services	0.007	-0.003	-0.010	-0.002	-0.001	0.002
Educational Services	-0.015	-0.007	0.008	-0.005	0.002	0.007
Ambulatory Health Care Services	0.035	0.033	-0.002	0.004	0.002	-0.002
Hospitals and Nursing and Residential Care Facilities	-0.012	-0.015	-0.003	0.009	0.011	0.003
Social Assistance	0.005	-0.002	-0.008	0.000	0.000	-0.001
Performing Arts, Spectator Sports, Museums, and Related Activities	0.006	0.011	0.005	0.005	0.002	-0.003
Amusements, Gambling, and Recreation Industries	-0.014	0.000	0.014	0.006	0.004	-0.002
Accommodation	0.007	0.006	0.000	0.015	0.008	-0.007
Food Services and Drinking Places	0.041	-0.008	-0.048	-0.006	-0.008	-0.001
Other Services, except Government	-0.023	-0.033	-0.010	0.009	0.003	-0.005

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[1] The overall estimated output loss figure ($10.9 trillion) represents the difference between (a) the sum of annual real output amounts in the Nonfarm Business sector for the years 2006 to 2018, and (b) the sum of annual real output amounts during this period assuming that labor productivity had continued to grow at the same long-term average rate observed from 1947 to 2005 and that all of the additional gains in labor productivity contributed to higher output rather than higher non-work time. For more information on the estimation of this figure, as well as an example in which the additional gains in labor productivity contributed to higher non-work time rather than higher output, please see the section "Dollar and time costs of the productivity slowdown." Also, please note that the loss for the entire U.S economy is likely significantly greater than the presented output loss figure, but because we cannot measure the productivity of the non-covered sectors which represent the difference (including general government, nonprofit institutions, and private households (including owner-occupied housing)), as output data for these sectors are not suitable for productivity measurement, we can only estimate what the effect would have been for the 76% of the U.S. economy covered by the Nonfarm Business sector. Also note that the estimated output loss per worker figure ($95,000) does not represent the loss in compensation per worker due to the slowdown, which would have been significantly less than that figure, given that only a portion of output accrues to workers as compensation for their labor (See: "Estimating the U.S. labor share" by Michael D. Giandrea and Shawn A. Sprague https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.htm).

[2] All percent changes in this article, unless otherwise noted, refer to average annual percent changes.

[3] MFP data for the U.S. private nonfarm business sector are available on an annual basis, beginning with data for 1948. This sector accounted for approximately 74 percent of the total U.S. economic output (GDP) as of 2017. As denoted by the term "business" in the series name, three non-business sectors are excluded from GDP: general government, nonprofit institutions, and private households (including owner-occupied housing). These three sectors are excluded because their output is measured largely with the use of compensation data, which measures an input to production rather than an output from production, thus rendering these sectors inappropriate for productivity measurement. Second, farm sector data are excluded to reduce volatility in the overall measure. And third, as denoted by the term "private" in the series name, government enterprises are excluded, as satisfactory capital measures are unavailable for this sector. Also, it should be noted that the term "MFP" is synonymous with "TFP", which is used throughout the economic literature to mean the same thing (for more information on this, please see the BLS Division of Productivity Research and Program Development FAQ page, here: https://www.bls.gov/dpr/faqs.htm#Q01). Also, it should be noted that, while for this article we are looking at private nonfarm business MFP growth, which only includes labor and capital as inputs, BLS also publishes other measures of MFP growth referred to as KLEMS, which include additional inputs as well.

[4] Specifically, the contribution of capital intensity is defined as $w_k \left[\left(\ln\frac{K_t}{K_{t-1}}\right) - \left(\ln\frac{L_t}{L_{t-1}}\right)\right]$where w_k is the two-year average cost share of capital.

[5] The BLS labor composition methodology can be found here: https://www.bls.gov/mfp/mprlabor.htm.

[6] There are two main ways of dividing time periods when doing an historical productivity analysis such as this one: using business cycles, or using variation in trends which are apparent in the data. For the present article, variation in trends were used to define the speedup period (1997-2005) and the slowdown period (2005-2018), because those two periods correspond to the periods which are generally discussed in the literature on this issue, and because it is clear from the data that the question-at-hand ("what were the sources of the slowdown?") could not best be addressed by operating strictly within the macroeconomic business cycle framework. One reason for this is that the industry-level sources of the slowdown exhibited their own trends which did not necessarily fit within the economy-wide business cycles. Another reason is that while for the slowdown period it made little difference to use either a cyclical or trend approach (because the current business cycle began just two years following the beginning of the trend-based period (2005)), for the speedup period it appeared to be preferable to use a trend-based approach, because the break in business cycles in 2001 would have split the widely-cited speedup period (1997-2005) which was based on apparent trends in the data roughly in half, disallowing for a one-to-one comparison of a speedup and slowdown period. If a business cycle approach had been taken instead, then the comparison would have been between two speedup periods (1990 to 2001 and 2001 to 2007) and one slowdown period (2007 to 2018), as parts of each of those two preceding periods contain a portion of the speedup in the trend, and the industry-level and broad-based changes in the economy during the speedup period from 1997-2005 would have been split up into two separate periods. It is notable that this disjuncture between business cycles and trend-based periods in terms of the current productivity slowdown did not occur with the last major productivity slowdown, in the 1970s, as the widely-cited slowdown which was apparent in the data beginning in 1973 also happened to represent a business cycle break as well, and as the speedup cycle prior to that break was representative of a sustained high-growth period over the decade of the 1960s. This is in contrast to the present slowdown, the period selection of which was not as clear-cut. As for defining the periods since 1947 which occurred prior to the speedup period (1997 to 2005), a grouped business cycle approach was used—by grouping adjacent business cycles with similar trends together—in order to make the inter-period comparisons in the figures a bit more concise and make the broad trends over the past 70 years easier to absorb. The fact that the last major productivity slowdown (in the 1970s) had a match between business cycle breaks and trend-period breaks made this 1948 to 1997 period somewhat easier to break up into periods. Also, for a strictly business cycle analysis of the present slowdown, please see "Below Trend: the U.S. Productivity Slowdown since the Great Recession" by Shawn Sprague (https://www.bls.gov/opub/btn/volume-6/below-trend-the-us-productivity-slowdown-since-the-great-recession.htm).

[7] Though Figure 2 shows a slight shift in the contribution of labor composition from 0.2 percent to 0.3 percent from the speedup period to the slowdown period, looking at these data with more precision reveal that the shift in the contribution of labor composition during the slowdown was trivial, with an upward shift of just 0.01 percentage point, and going from 0.24 percent in the speedup period to 0.25 percent in the slowdown period.

[8] While for this article we are looking at private nonfarm business MFP growth, which only includes labor and capital as inputs, BLS also publishes other measures of MFP growth referred to as KLEMS—this acronym refers to the inputs of capital, labor, energy, materials, and services—which include these additional inputs as well.

[9] From 1929 to 1933, GDP fell by a cumulative 26.3 percent, whereas from 2007 Q4 to 2009 Q2, GDP fell by a cumulative 2.7 percent. Data source: Bureau of Economic Analysis (NIPA Table 1.1.6)

[10] From 1933 to 1940, GDP grew at an average annual rate of 7.2 percent, and from 2009 Q2 to 2018 Q4, GDP grew at an average annual rate of 2.3 percent. Data source: Bureau of Economic Analysis (NIPA Table 1.1.6)

[11] The U.S. population grew at an average annual rate of 0.7 percent from 1929 to 1940 and from 2007 to 2018. Data source: Bureau of Economic Analysis, NIPA Table 7.1, Line 18.

[12] Though the recent downturn due to the effects of the 2020 coronavirus pandemic is already larger in size than the downturn from the Great Recession, this historical appraisal could unfortunately not include the 2020 coronavirus pandemic period, because multifactor productivity data are as of this article only available through 2018, and thus the scope of this article ends in 2018.

[13] Valerie Cerra and Sweta Chaman Saxena, "Growth Dynamics: The Myth of Economic Recovery," American Economic Review 98(1), 2008, pp. 439-57.

[14] Carmen M. Reinhart and Kenneth S. Rogoff, This Time is Different: Eight Centuries of Financial Folly, Princeton: Princeton University Press, 2009.

[15] Carmen M. Reinhart and Vincent R. Reinhart, "After the Fall," National Bureau of Economic Research (NBER) Working Paper 16334, 2010.

[16] International Monetary Fund, World Economic Outlook, October 2009: Sustaining the Recovery, Washington: IMF, 2009, p. 125.

[17] As noted above in footnote 3, in this article we are using MFP to refer to multifactor productivity, though others in the literature refer to the measure as TFP or total factor productivity; these acronyms and names refer to the same measure (for more information on this, please see the BLS Division of Productivity Research and Program Development FAQ page, here: https://www.bls.gov/dpr/faqs.htm#Q01).

[18] Daisuke Ikeda and Takushi Kurozumi, "Slow Post-Financial Crisis Recovery and Monetary Policy," Federal Reserve Bank of Dallas Globalization Institute Working Paper 347, October 2018, p. 4.

[19] These "include, most prominently, the demographic shifts of the surge of women into the labor force in the 1970s-1990s and, more recently, the baby boom[ers] beginning to retire." (p. 1) James H. Stock and Mark W. Watson, "Why Has GDP Growth Been So Slow to Recover?," Draft for the Boston Federal Reserve's conference, "The Elusive 'Great Recovery': Causes and Implications for Future Business Cycle Dynamics," October 2016.

[20] Ray C. Fair, "Explaining the Slow U.S. Recovery: 2010-2017", Cowles Foundation Discussion Paper No. 2124, March 2018.

[21] J. Bradford DeLong and Lawrence H. Summers, "Fiscal Policy in a Depressed Economy," Brookings Papers on Economic Activity, Spring 2012, pp. 233-4.

[22] Robert E. Hall, "The Routes Into and Out of the Zero Lower Bound," Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City, 2013, p. 3.

[23] Robert J. Barro, "The Job-Filled Non-Recovery," September 2016, p. 6.

[24] Daisuke Ikeda and Takushi Kurozumi, "Slow Post-Financial Crisis Recovery and Monetary Policy," Federal Reserve Bank of Dallas Globalization Institute Working Paper 347, October 2018, p. 4.

[25] David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "Is the Information Technology Revolution Over?," International Productivity Monitor, Vol. 25, 2013, p. 21.

[26] Romain Duval, Gee Hee Hong, and Yannick Timmer, "Financial Frictions and the Great Productivity Slowdown," IMF Working Papers, No. 17/129, May 2017, p. 1.

[27] Intangible assets are non-physical assets such as intellectual property including software, R&D, patents, trademarks, and goodwill. Gutiérrez and Philippon (2016) also cite decreased investment in intangibles; see box "Slowdown in capital investment in the post-2005 slowdown period." In addition to having an indirect effect on MFP growth measure, as noted by Duval, Hong, and Timmer, a slowdown in intangibles would also have a direct effect on the contribution of capital intensity measure, by explicitly reducing the numerator of the change in the capital-labor ratio.

[28] Ibid. p. 17. Additionally, the fallout from the Great Recession may have also hampered rates of reallocation—the process of moving greater resources towards high-productivity firms and away from low-productivity firms—according to Foster, Grim, and Haltiwanger (Lucia Foster, Cheryl Grim, and John Haltiwanger, "Reallocation in the Great Recession: Cleansing or Not?," National Bureau of Economic Research (NBER) Working Paper 20427, August 2014, abstract.). These authors observe faltering rates of reallocation during the Great Recession, which is the inverse of the typical case for recessions, perhaps indicating that the magnitude of this recession adversely affected prospects for productivity growth. Even worse, they state is that "the reallocation that did occur [during the Great Recession] was less productivity enhancing than in prior recessions." Bloom et al. (Nicholas Bloom, Max Floetotto, Nir Jaimovich, Itay Saporta-Eksten, and Stephen J. Terry, "Really Uncertain Business Cycles," National Bureau of Economic Research (NBER) Working Paper No. 18245, July 2012, p. 1-2.) also cite weak rates of reallocation, which they claim is undergirded by an increase in uncertainty during recessions, contending that "increased uncertainty also reduces productivity growth because it reduces the degree of reallocation in the economy. Higher uncertainty leads productive plants to pause expanding and unproductive plants to pause contracting, which in the … U.S. economy drives much of aggregate productivity growth."

[29] Fernald (2014) downplays the importance of the Great Recession in the post-2005 productivity slowdown, claiming that "the Great Recession seem[s] less important than trends related to IT that predated the Great Recession." (The effect of IT-intensive industries on the slowdown will be addressed in Part II of this article.)

[30] See Ryan A. Decker, John C. Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Changing Business Dynamism and Productivity: Shocks vs. Responsiveness," National Bureau of Economic Research (NBER) Working Paper 24236, January 2018. Also, in addition to the works cited in this section on the topic of productivity dispersion, it should be also noted that data on productivity dispersion are now available from BLS and the Census Bureau, via the Collaborative Micro-productivity Project (CMP), which has developed and published experimental statistics on within-industry dispersion. The public-use statistics developed via this project, Dispersion Statistics on Productivity (DiSP), were released in fall 2019 and cover all 4-digit NAICS industries in the manufacturing sector. Restricted-use establishment-level data with micro-based estimates of productivity as well as its underlying components (e.g., output and input measures) are also available to qualified researchers on approved projects in secure Federal Statistical Research Data Centers (FSRDCs). More information on these data can be obtained here: https://www.bls.gov/lpc/productivity-dispersion.htm.

[31] Michael Gort and Steven Klepper. "Time Paths in the Diffusion of Product Innovations," Economic Journal, 1982, 92(367), pp. 630-53.

[32] An in-depth discussion of high-tech industries, and their relationship to the economy-wide productivity slowdown, is in Part II of this article.
[33] Decker et al. (2018), p. 27.
[34] Ibid.
[35] Dan Andrews, Chiara Criscuolo, and Peter N. Gal, "The Global Productivity Slowdown, Technology Divergence and Public Policy: A Firm Level Perspective," Hutchins Center Working Paper #24, September 2016.
[36] Ibid. p. 2.
[37] Ibid. p. 3.
[38] Jan De Loecker, Jan Eeckhout, and Gabriel Unger, "The Rise of Market Power and the Macroeconomic Implications," working paper, 2018, p. 52.
[39] See Miguel Antón, Florian Ederer, Mireia Giné, and Martin C. Schmalz, "Common Ownership, Competition, and Top Management Incentives," European Corporate Governance Institute Working Paper, February 2018., and José Azar, Sahil Raina, and Martin C. Schmalz, "Ultimate Ownership and Bank Competition," Working Paper, 2016.
[40] John E. Kwoka, Jr. "Mergers, Merger Control, and Remedies: A Response to the FTC Critique", March 2017.
[41] Bruce A. Blonigen and Justin R. Pierce, "Evidence for the Effects of Mergers on Market Power and Efficiency," National Bureau of Economic Research (NBER) Working Paper 22750, October 2016.
[42] Council of Economic Advisers, "Occupational Licensing: A Framework for Policymakers," July 2015.
[43] Jason Furman, "Barriers to Shared Growth: The Case of Land Use Regulation and Economic Rents," Remarks at The Urban Institute, November 20, 2015.
[44] Jason Furman, "Market Concentration – Note by Jason Furman," OECD Directorate for Financial and Enterprise Affairs Competition Committee Hearing on Market Concentration, June 7, 2018.
[45] Brookings Institution panel discussion, "The Productivity Puzzle: How Can We Speed Up the Growth of the Economy," Sept. 9, 2016.
[46] Additionally, Liu, Mian, and Sufi theorize that the low interest rates of the past decade have helped increase concentration, asserting that "low interest rates encourage market concentration by raising industry leaders' incentive to gain a strategic advantage over followers, and this effect strengthens as the interest rate approaches zero." (Ernest Liu, Atif Mian, and Amir Sufi, "Low Interest Rates, Market Power, and Productivity Growth," National Bureau of Economic Research (NBER) Working Paper 25505, August 2019, abstract.)
[47] Jason Furman and Peter Orszag, "Slower Productivity and Higher Inequality: Are They Related?," Peterson Institute for International Economics, Working Paper 18-4, June 2018.
[48] Ibid. p. 2. See also: Alexander M. Bell, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenan, "Who Becomes an Inventor in America? The Importance of Exposure to Innovation," National Bureau of Economic Research (NBER) Working Paper 24062, November 2017., Frederico Cingano, "Trends in Income Inequality and its Impact on Economic Growth," OECD Social, Employment and Migration Working Papers, No. 163, 2014. Paris: OECD Publishing., and Jonathan D. Ostry, Andrew Berg, and Charalambos G. Tsangarides. "Redistribution, Inequality, and Growth." Staff Discussion Note, February 2014. Washington, DC: International Monetary Fund.
[49] Andrews et al. (2016), p. 3.
[50] Decker et al. (2018), p. 24. Additionally, there is another widely-cited firm-level theory that has been offered to explain the increased productivity dispersion, which is from Adalet McGowan, Andrews, and Millot (Müge Adalet McGowan, Dan Andrews, and Valentine Millot, "Insolvency Regimes, Zombie Firms and Capital Reallocation," OECD Economics Department Working Papers No. 1399, June 28, 2017), who remark that the prevalence of so-called "zombie firms," or low-productivity firms which are unable to properly service their debts, have increased in OECD countries since the mid-2000s. The authors hypothesize that the stubborn persistence of these low-growth firms are potentially not only keeping resources from reallocating to high-growth firms, but are also creating entry barriers and inhibiting the growth of new firms. However, this theory appears *not* to be relevant specifically for the U.S., which, unlike other OECD countries and especially European countries, has actually had a decline in the share of zombie firms in recent years (Dan Andrews and Giuseppe Nicoletti, "Confronting the Zombies, Policies for Productivity Revival," Presentation at the Peterson Institute for International Economics, January 23, 2018, slide 7.).
[51] Robert J. Gordon, "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," National Bureau of Economic Research (NBER) Working Paper 18315, August 2012.
[52] John G. Fernald, "Productivity and Potential Output Before, During, and After the Great Recession," Federal Reserve Bank of San Francisco Working Paper 2014-15, June 2014.
[53] Joseph A. Tainter, The Collapse of Complex Societies, Cambridge: Cambridge University Press, 1988, p. 114.
[54] See Bloom et al. (Nicholas Bloom, Charles I. Jones, John Van Reenen, and Michael Webb, "Are Ideas Getting Harder to Find?," National Bureau of Economic Research (NBER) Working Paper 23782, September 2017, p. 8.), and also see Bhattacharya and Packalen (Jay Bhattacharya and Mikko Packalen, "Stagnation and Scientific Incentives," National Bureau of Economic Research (NBER) Working Paper 26752, February 2020, abstract.), who argue that changing incentives may also be playing a role, specifically that an "emphasis on citations in the measurement of scientific productivity shifted scientist rewards and behavior on the margin toward incremental science and away from exploratory projects that are more likely to fail, but which are the fuel for future breakthroughs."
[55] Chad Syverson, "Will History Repeat Itself?," Comments on 'Is the Information Technology Revolution Over?,'" International Productivity Monitor, 2013, 25 (Spring), pp. 37-40.
[56] Ana Paula Cusolito and William F. Maloney, Productivity Revisited: Shifting Paradigms in Analysis and Policy, Washington, DC: The World Bank Group, 2018, p. 8.
[57] Ana Paula Cusolito and William F. Maloney, Productivity Revisited: Shifting Paradigms in Analysis and Policy, Washington, DC: The World Bank Group, 2018, p. 8.

[58] Joel Mokyr, "Is Technological Progress a Thing of the Past?," Vox EU, September 8, 2013, and Joel Mokyr, "Secular Stagnation? Not in Your Life," Chapter 6 in Secular Stagnation: Facts, Causes and Cures, edited by C. Teulings and R. Baldwin, 2014. Vox EU e-book.

[59] Philippe Aghion, Benjamin F. Jones, and Charles I. Jones, "Artificial Intelligence and Economic Growth," National Bureau of Economic Research (NBER) Working Paper 23928, October 2017.

[60] Lucia Foster, Cheryl Grim, John Haltiwanger, and Zoltan Wolf, "Innovation, Productivity Dispersion, and Productivity Growth," U.S. Census Bureau Center for Economic Studies Working Paper 18-08, February 2018, p. 27.

[61] Figure 2 shows that both the 2005-2018 slowdown period and the 1981-1997 period posted this low 0.7 percent rate, and at this level of precision these periods could be said to share this post-WWII low rate; however, it may be noted that, at slightly more precision, the 2005-2018 rate (0.66 percent) was actually nearly a percentage point lower than the 1981-1997 period rate (0.74 percent).

[62] David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "Is the Information Technology Revolution Over?," International Productivity Monitor, Vol. 25, 2013, p. 21.

[63] Robert E. Hall, "Quantifying the Lasting Harm to the U.S. Economy from the Financial Crisis," National Bureau of Economic Research (NBER) Working Paper 20183, May 2014, p. 13.

[64] Ravi Bansal, Mariano Max Croce, Wenxi Liao, and Samuel Rosen, "Uncertainty-Induced Reallocations and Growth," National Bureau of Economic Research (NBER) Working Paper 26248, September 2019, p. 1.

[65] Tobin's Q is was first introduced by Nicholas Kaldor in 1966 (See Nicholas Kaldor, "Marginal Productivity and the Macro-Economic Theories of Distribution: Comment on Samuelson and Modigliani," October 1966, Review of Economic Studies, Vol. 33, No. 4, pp. 309-319.) It was popularized a decade later, however, by James Tobin (James Tobin and W.C. Brainard, "Asset Markets and the Cost of Capital." Economic Progress, Private Values and Public Policy, Amsterdam: North-Holland Publishing Company, 1977.), who describes its two quantities:

> "One, the numerator, is the market valuation: the going price in the market for exchanging existing assets. The other, the denominator, is the replacement or reproduction cost: the price in the market for newly produced commodities. We believe that this ratio has considerable macroeconomic significance and usefulness, as the nexus between financial markets and markets for goods and services."

[66] Germán Gutiérrez and Thomas Philippon, "Investment-less Growth: An Empirical Investigation," National Bureau of Economic Research (NBER) Working Paper 22897, December 2016, abstract.

[67] Germán Gutiérrez and Thomas Philippon, "Investment-less Growth: An Empirical Investigation," Brookings Papers on Economic Activity, Fall 2017, p. 90.

[68] Ibid. p. 93.

[69] Ibid.

[70] "Quasi-indexers have diversified holdings and low portfolio turnover – consistent with a passive, buy-and-hold strategy of investing portfolio funds in a broad set of firms." (Gutiérrez and Philippon (2016), p. 28.)

[71] Germán Gutiérrez and Thomas Philippon, "Investment-less Growth: An Empirical Investigation," National Bureau of Economic Research (NBER) Working Paper 22897, December 2016, abstract.

[72] Ibid. p. 19. See also: Michael Jensen, "Agency costs of free cash flow, corporate finance, and takeovers," American Economic Review, 1986, 76(2), p. 323.

[73] Germán Gutiérrez and Thomas Philippon, "Investment-less Growth: An Empirical Investigation," Brookings Papers on Economic Activity, Fall 2017, p. 109. See also: Christine Jolls, "Stock Repurchases and Incentive Compensation," National Bureau of Economic Research (NBER) Working Paper 6467, March 1998, abstract.

[74] John G. Fernald, "Productivity and Potential Output Before, During, and After the Great Recession," Federal Reserve Bank of San Francisco Working Paper 2014-15, June 2014, p. 9.

[75] Nicholas Bloom, Max Floetotto, Nir Jaimovich, Itay Saporta-Eksten, and Stephen J. Terry, "Really Uncertain Business Cycles," National Bureau of Economic Research (NBER) Working Paper No. 18245, July 2012, p. 1-2.

[76] Lucia Foster, Cheryl Grim, and John Haltiwanger, "Reallocation in the Great Recession: Cleansing or Not?," National Bureau of Economic Research (NBER) Working Paper 20427, August 2014, abstract.

[77] See "Below Trend: the U.S. Productivity Slowdown since the Great Recession" by Shawn Sprague (https://www.bls.gov/opub/btn/volume-6/below-trend-the-us-productivity-slowdown-since-the-great-recession.htm).

[78] In that year, 2010, labor input jumped up by more than seven percentage points in a single year and transitioned from a 6.6 percent decline in 2009 to a 0.5 percent increase in 2010. This low and slightly positive labor input growth for 2010 helped to shrink the contribution of capital intensity and expanded MFP growth relative to what they had been in 2009. Specifically, labor input growth lowered the contribution of capital intensity in 2010 relative to 2009 because its low rate in 2010 (0.5 percent) was then very similar to the rate for capital services (0.8 percent), thus shrinking the capital-to-labor ratio relative to the prior year, and MFP growth was dramatically accelerated as the below-average gains in both labor and capital in that year were paired with rapidly recovering output growth (3.3 percent).

[79] Also, it may be of interest that the low productivity growth of the 2005-2018 period itself reduced the long-term rate since 1947 from 2.3 percent—what it had been as of 2005—to 2.1 percent as of 2018.

[80] The data underlying the labor composition series bear this out during the Great Recession: the labor cost share of workers under 45 and workers without a college degree plunged much more than it did for workers over 45 and workers with a college degree, during the Great Recession.

[81] In this case we are using the long-term historical trend rate from 1948 to 2005, which is 2.3 percent, rather than the rate from 1948 to 2018, which is 2.1 percent. This is because, in this exercise, we are attempting to determine what growth would have been after 2005 if it had continued at the rate observed prior to 2005.

[82] This per-worker loss in output technically should be viewed in terms of productivity analysis, with the output loss being represented relative to this input to production. Furthermore, the loss in output per worker does not equate to loss in compensation per worker, which would have been significantly less, as only a portion of output accrues to workers as compensation for their labor (See:

"Estimating the U.S. labor share" by Michael D. Giandrea and Shawn A. Sprague, https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.htm).

[83] It should be noted that, in this hypothetical case, some of this additional leisure or non-work time could potentially have been the result of lay-offs (which could have resulted in unemployment, voluntary retirement from work, or, for some workers, getting another job), to the extent that the reduction in overall hours was distributed inequitably among workers and resulted in lower employment rather than lower average weekly hours; to the extent that average weekly hours were reduced, this could have come in the form of increased vacation or sick leave offered and taken, a reduction in the workweek, or a transition from full-time to part-time work for some workers.

[84] For this hypothetical average weekly hours computation, we are assuming that all of the reduction in overall hours went to a reduction in average weekly hours and not to employment; this approach was taken to show the additional leisure or non-work time that would have been hypothetically available for this group of workers who were employed during the years 2005 to 2018.

[85] Evsey Domar—in his 1961 paper "On the Measurement of Technological Change" (Evsey D. Domar, "On the Measurement of Technological Change," Economic Journal, December 1961, Vol. 71, No. 284, pp. 709-729.)—developed a method for estimating industry contributions to overall MFP growth for an aggregate sector, and we will be utilizing this approach for breaking out industry contributions to private nonfarm business MFP growth. Domar showed that a given industry's contribution to an aggregate MFP growth rate is equal to the MFP growth rate for that industry, multiplied by a two-period average of the ratio of output in the industry to value-added in the sector. The sum of the Domar-weighted industry MFP growth rates approximates the private nonfarm business MFP growth rate. Also, to calculate the industry contributions to the private nonfarm business contribution of capital intensity, an approach which uses Domar's general approach and allows for the break out of this component will be utilized, based on an approach outlined in Inklaar, O'Mahony, and Timmer (Robert Inklaar, Mary O'Mahony, and Marcel Timmer, "ICT and Europe's Productivity Performance Industry-level Growth Account Comparisons with the United States," Groningen Growth and Development Centre Research Memorandum GD-68, December 2003, pp. 12-13.).

[86] We often refer to the 60-industry NIPA level (NIPA refers to the U.S. National Income and Product Accounts, published by the U.S. Bureau of Economic Analysis), but it is 59 here as we are excluding the farm sector from our analysis in this case, as it is for contributions to the private nonfarm business sector.

[87] The summed MFP contributions, using the Domar method, add to 1.17 percentage points, which is slightly different from the top-line private nonfarm business slowdown of 1.27 percentage points. For this section of the article, we will use the 1.17 figure as the overall value as it is consistent with the summed contributions.

[88] Also, the full list of industry contributions to the slowdown in private nonfarm business labor productivity growth, including contributions from both industry MFP growth and industry contribution of capital intensity, can be seen in Appendix Table 1.

[89] David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel note this fact, reporting that "since 2004 IT has continued to make a significant contribution to U.S. labor productivity growth, though it is no longer providing the boost that it did during the productivity resurgence from 1995 to 2004." (David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "Is the Information Technology Revolution Over?," International Productivity Monitor, Vol. 25, 2013, abstract).

[90] Stephen D. Oliner and Daniel E. Sichel, "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?," Journal of Economic Perspectives, Vol. 14, No. 4 (Autumn, 2000), p. 16.

[91] David M. Byrne and Carol Corrado, "ICT Prices and ICT Services: What do they tell us about Productivity and Technology?," Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C., 2017-015, February 10, 2017, p. 21.

[92] According to David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "the official price indexes for semiconductors developed by the [BLS] show that quality-adjusted semiconductor prices are not falling nearly as rapidly as they did prior to the mid-2000s." (David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "Is the Information Technology Revolution Over?," International Productivity Monitor, Vol. 25, 2013, p. 23.).

[93] See Byrne and Corrado, p. 1.

[94] David M. Byrne, Stephen D. Oliner, and Daniel E. Sichel, "Is the Information Technology Revolution Over?," International Productivity Monitor, Vol. 25, 2013, p. 23.

[95] David M. Byrne, John G. Fernald, and Marshall B. Reinsdorf, "Does the United States Have a Productivity Slowdown or a Measurement Problem?," Brookings Papers on Economic Activity, BPEA Conference Draft, March 10-11, 2016, p. 1.

[96] Ibid.

[97] Ibid., abstract. The authors also qualify that "the effect on [MFP of their adjustment] is more muted."

[98] Chad Syverson, "Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown," National Bureau of Economic Research (NBER) Working Paper 21974, February 2016, abstract.

[99] Ryan A. Decker, John C. Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Changing Business Dynamism and Productivity: Shocks vs. Responsiveness," National Bureau of Economic Research (NBER) Working Paper 24236, January 2018, p. 27.

[100] Mordecai Kurz, "On the Formation of Capital and Wealth," Stanford Institute for Economic Policy Research Discussion Paper No. 17-016, June 25, 2017.

[101] Ibid., abstract.

[102] Lucia Foster, Cheryl Grim, John Haltiwanger, and Zoltan Wolf, "Innovation, Productivity Dispersion, and Productivity Growth," U.S. Census Bureau Center for Economic Studies Working Paper 18-08, February 2018, p. 4.

[103] Titan Alon, David Berger, Robert Dent, Benjamin Pugsley, "Older and Slower: The Startup Deficit's Lasting Effects on Aggregate Productivity Growth," National Bureau of Economic Research (NBER) Working Paper 23875, September 2017, p. 2.

[104] Ibid. p. 2.

[105] Gustavo Grullon, Yelena Larkin, and Roni Michaely, "Are US Industries Becoming More Concentrated?," working paper, April 2017, abstract.

[106] Ibid.

[107] David Autor, David Dorn, Gordon H. Hanson, Gary Pisano, and Pian Shu, “Foreign Competition and Domestic Innovation: Evidence from U.S. Patents,” working paper, September 2018.

[108] Ibid. p. 2

[109] Lucia Foster, John Haltiwanger and C. J. Krizan, “Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s,” Review of Economics and Statistics, Vol. 88, No. 4 (Nov., 2006), p. 748.

[110] On this topic, also see: Ronald S. Jarmin, Shawn D. Klimek, and Javier Miranda, “The Role of Retail Chains,” Chapter 6, Producer Dynamics: New Evidence from Micro Data, Timothy Dunne, J. Bradford Jensen, and Mark J. Roberts, editors, Chicago: University of Chicago Press, January 2009.

[111] Basker, Emek, "Job Creation or Destruction? Labor-Market Effects of Wal-Mart Expansion," Review of Economics and Statistics, 87:1, Feb. 2005, 174-183. Quotation describing Basker’s article is from Lucia Foster, John Haltiwanger and C. J. Krizan, “Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s,” Review of Economics and Statistics, Vol. 88, No. 4 (Nov., 2006), p. 748.

[112] Lucia Foster, John Haltiwanger and C. J. Krizan, “Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s,” Review of Economics and Statistics, Vol. 88, No. 4 (Nov., 2006), p. 749.

[113] David Popp, Jacquelyn Pless, Ivan Haščič, and Nick Johnstone, “Innovation and Entrepreneurship in the Energy Sector,” National Bureau of Economic Research (NBER) Working Paper 27145, May 2020.