WHY IS U.S. PRODUCTIVITY GROWTH SO SLOW?

POSSIBLE EXPLANATIONS AND POLICY RESPONSES

Martin Neil Baily and Nicholas Montalbano

The Brookings Institution

SUMMARY

Productivity is the most important determinant of the growth in living standards over the long run and its growth has been weak since 2004 and dismal since 2010. The simplest productivity measure is output per hour worked. Multifactor productivity growth adjusts for the contribution of capital and materials and provides a measure of the pace of technological change.

There has been considerable frustration felt by many researchers, commentators and policymakers trying to understand and do something about slow productivity growth. While many important questions remain, recent research shows that substantial progress has been made towards a better understanding of what is going on. And that opens the door to policies that could lead to faster growth.

1. The period from World War II through the early 1970s was unusual in the productivity opportunities available to the economy. Over the long run, productivity growth is unlikely to match the 3 percent rate of increase of that period.
2. If productivity growth were better measured, particularly in health and other services, the growth rate would look better than is currently reported.
3. The surge in productivity in the US economy for nine years starting after 1995 was linked to the rapid drop in semiconductor prices. In addition, efforts to eliminate negative productivity numbers in service industries contributed to the post-95 acceleration in measured growth.
4. The most promising sign for future growth is that the most productive firms are growing faster than the rest. The frontier is still moving out. The most challenging finding is that diffusion of best practices is not pulling the rest of industry along. The natural force of competition among firms should work to prevent the dispersion of productivity from widening continuously and something appears to be blocking that process.[1]
5. Policy efforts to mitigate this problem should focus on increasing competitive intensity, including through regulatory reform.
6. Another reason for the widening of the productivity distribution is lack of managerial and worker capabilities to take advantage of the current wave of complex, information technology related innovation.
7. Weakness in capital formation has contributed substantially to slow growth in labor productivity. Two policies to increase the rate of investment are: first, stimulate aggregate demand; and, second, reform of corporate taxation which should, in turn, increase business investment.

The authors would like to thank Mekala Krishnan, Andrew Sharpe, Louise Sheiner, Robert M. Solow, Sree Ramaswamy, David Wessel and many participants in a September 8-9 Brookings productivity conference for very helpful comments on an earlier version of this paper. The research has been financed in part by a grant from the Nomura Foundation. Views expressed are those of the authors and do not represent the staff or trustees of the Brookings Institution.

[1] We are reminded of Mancur Olson's book The Rise and Decline of Nations which argues that economies tend to become more rigid and less competitive over time.

“Finally, and most ambitiously, as a society we should explore ways to raise productivity growth. Stronger productivity growth would tend to raise the average level of interest rates and therefore would provide the Federal Reserve with greater scope to ease monetary policy in the event of a recession. But more importantly, stronger productivity growth would enhance Americans’ living standards. Though outside the narrow field of monetary policy, many possibilities in this arena are worth considering, including improving our educational system and investing more in worker training; promoting capital investment and research spending, both private and public; and looking for ways to reduce regulatory burdens while protecting important economic, financial, and social goals.” - Janet Yellen, speech made on 8/26/2016

WHAT IS PRODUCTIVITY AND WHY IS IT IMPORTANT?

Productivity is defined as the efficiency at which inputs are converted into outputs. It is important because productivity growth is a significant source of growth in national income and is fundamental to raising living standards. There are multiple measures of productivity that are used to describe and analyze economic performance. Each of these measures provide a different lens through which to view the economy. The two main measures of productivity are labor productivity and multifactor productivity (MFP).

The simplest measure of productivity is output per hour worked, or labor productivity. Growth in labor productivity is strongly linked to average growth in worker compensation (wages) and to increases in the average standard of living. Slow growth in labor productivity has been one important reason for the sluggish growth in GDP of the US economy in recent years, and the same is true for other advanced economies. Labor productivity growth comes from increases in the amount of capital available to each worker (capital deepening), changes in the education and experience of the workforce (labor composition), and improvements in technology (MFP growth).

The MFP measure shows how inputs to production (capital, labor, intermediate inputs) are used to generate output. MFP growth reflects changes in output that cannot be accounted for by changes in inputs. MFP growth occurs through improvements in technology, higher quality products and services, and better organization of production.

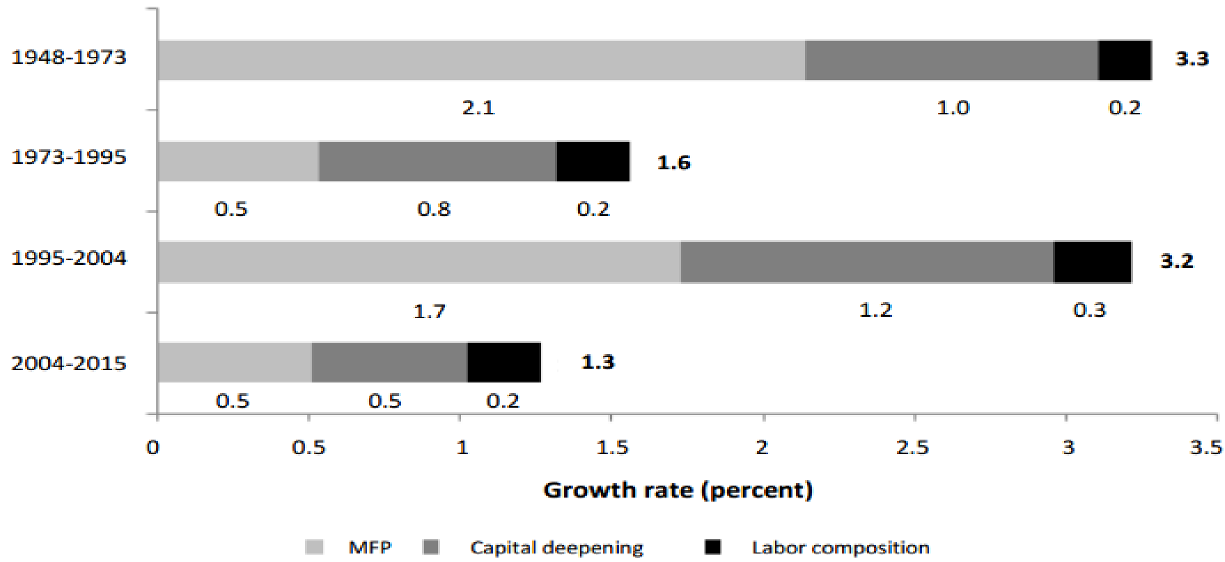
POST-WAR US PRODUCTIVITY TRENDS

Since the end of World War II the United States has experienced distinct periods of fast and slow growth in labor productivity. Looking at the private business sector in the post-war period: from 1948-1973 the US experienced strong labor productivity growth averaging 3.3 percent per year, with strong MFP growth contributing 2.1 percentage points of the improvement. There was then a growth slowdown and in the period 1973-1995, the growth in labor productivity fell to 1.6 percent per year, less than half its previous rate, and growth in MFP dropped to 0.5 percent. There was then a re-acceleration from 1995-2004, when labor productivity growth returned to its high level of 3.2 per year and MFP grew at a1.7 percent rate. The second slowdown started around 2004 and over the period 2004-2015[2] improvements in labor productivity slowed to 1.3 percent per year and MFP growth dropped back down to 0.5 percent.

---

[2] Note the slowdown began prior to the financial crisis according to Fernald (2015) and Cette, Fernald, and Mojon (2015).

Figure 1: Slow U.S. productivity growth was from MFP weakness and slow capital accumulation



Source: BLS Multifactor Productivity Database for Private Business Sector

As Figure 1 illustrates, the largest cause of the ups and down of labor productivity growth, numerically, was the shift in MFP growth. However, the contribution of capital deepening reinforced this pattern, especially since 2004. Slow MFP growth has been accompanied by weak capital accumulation with the causality running in both directions. When MFP is growing slowly, businesses see less reason to invest. When investment is low, there is less opportunity for MFP growth and technology which is often embodied in new capital.[3]

THE 1970S SLOWDOWN

The slowdown in the early 1970s was unexpected and had a substantial impact on the economy, as real wage growth slowed and living standards stagnated. The slowdown coincided with a sharp rise in oil prices and some researchers argued that this was cause and effect because companies were substituting labor for energy. That argument faltered as the slowdown continued: energy was not a big enough factor of production to explain such a large loss of productivity over so many years. Why sacrifice $100 of output to save $1 of energy? Moreover, energy prices collapsed in 1986 but strong productivity growth did not resume. This period was one of macroeconomic instability and high inflation which likely contributed to the reduction in investment and slow growth of capital services.

One important characteristic of the first slowdown was that it seems to have impacted service industries more so than manufacturing. William Baumol and William Bowen (1966) posited that slow growth in some service industries was inevitable because of the nature of production processes. Baumol’s disease, the increasing importance of slow productivity growth services, became a popular explanation for slow growth.

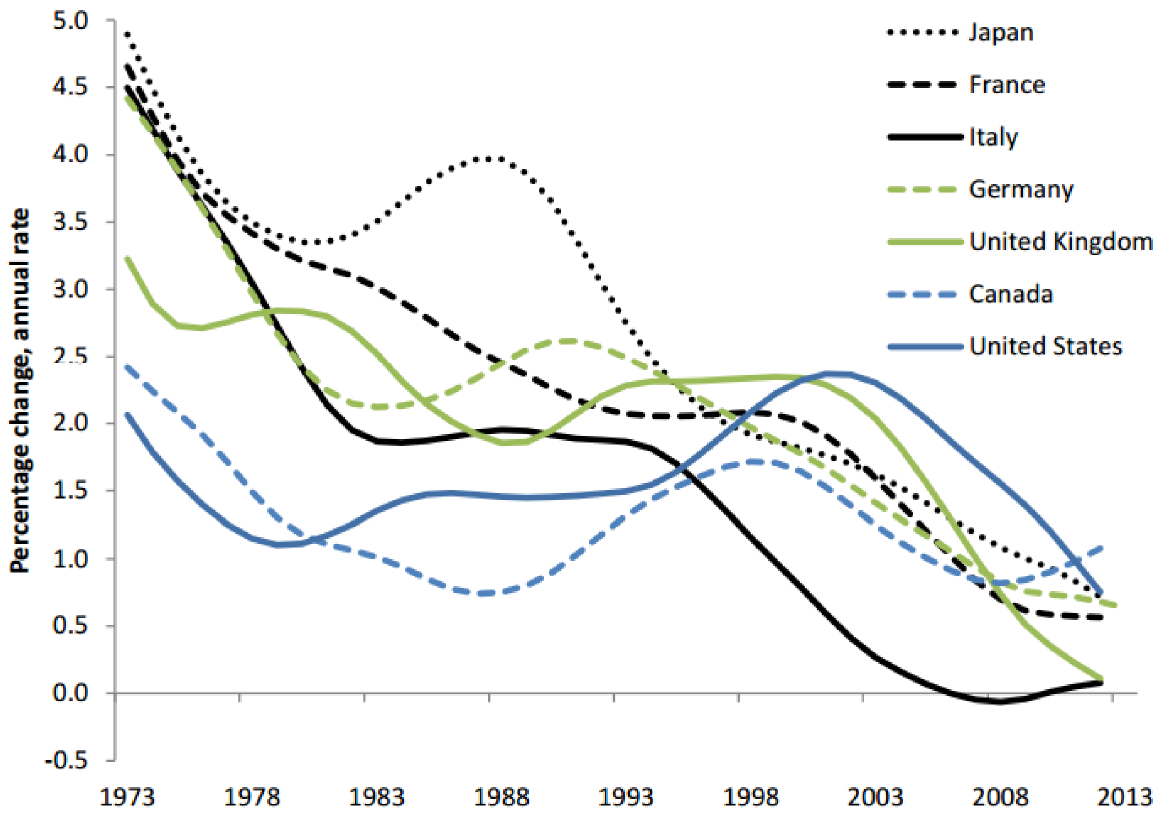
[3] The decomposition of growth into MFP and capital services is dependent on how capital goods prices are determined. If these prices are quality adjusted, the embodied technology will mostly be attributed to an increase in capital services.

There were a number of other explanations advanced for slow growth, including increased regulation, but in the end there was no consensus explanation of this first slowdown. Probably the most widely-held view was that innovation and investment opportunities were unusually strong for many years after the war, but these low-hanging fruit had been exhausted by the early 1970s.[4]

PRODUCTIVITY GROWTH IN OTHER ADVANCED ECONOMIES

Productivity growth in the United States was rapid in the postwar period, but less rapid than in Japan and in Europe. These countries were catching up to US productivity levels; a process of convergence was taking place.[5] A slowdown in productivity growth in the early 1970s happened in almost all of the advanced economies, but most of them continued to grow faster than the US economy, sustaining the convergence process through the 1980s and early 1990s. When the US economy experienced rapid productivity growth for ten years after 1995, the other advanced economies did not see a corresponding surge.

Figure 2: Labor productivity trend growth in G-7 countries, total economy



Source: OECD Productivity Statistics (database), http://dx.doi.org/10.1787/pdtvy-data-en, February 2016.

---

[4] Dale W. Jorgenson has been the leading analyst of postwar growth see, for example, his 1995 compendium of papers.

[5] Paul Romer pointed out that convergence was selective. From the 1950s through the 1980s most of the world's economies were falling further behind the frontier and not converging. This led Romer to develop models of endogenous growth. As countries such as China and India began to grow rapidly, it became clear that liberalizing markets, reducing corruption, enforcing the rule of law, mobilizing sufficient savings, having adequate education, and being open to global trade and technology, are preconditions for economic convergence.

Today, the most productive European economies, such as France and Germany, have a level of productivity that is close to that of the United States, measured by GDP per hour worked. They work many fewer hours, so GDP per worker is much lower. All the advanced economies in Europe and Japan are currently experiencing slow productivity growth similar to that in the United States. We are all in the same boat. Figure 2 shows this clearly. It illustrates the slowdown in productivity growth in all the G-7 economies that dates back to the 1970s and continues up to the present. Although it is not shown here, the declining productivity trend is also true for smaller economies.

WHAT DO THE US INDUSTRY LEVEL DATA SHOW?

Analyzing data aggregated at the total economy level can hide much of what is going on within an economy. Looking at productivity by industry can give insight into which parts of the economy are rising and falling and are most responsible for the slowdowns and accelerations. To do this analysis we utilize the Bureau of Labor Statistics' MFP database, which provides industry productivity data from 1987-2014. Using this data, we find three distinct time periods: the years leading up to the productivity acceleration (1987-1995), the productivity acceleration (1995-2004), and the productivity slowdown (2004-2014).[6]

Figure 3 shows the MFP growth rates of the major sectors for these selected time periods. The post-1995 acceleration and post-2004 slowdown is prevalent among many of the industries. Notable in the post-2004 slowdown were manufacturing, wholesale trade, and retail trade. These industries went from strong growth in the 1995-2004 timeframe to zero and even negative growth in the 2004-2014 slowdown. Manufacturing dropped from 2.0 to zero percent, wholesale trade dropped from 2.8 to -0.1 percent, and retail trade dropped from 2.3 to -0.2 percent. A counterweight to the slowdown was mining, which boomed post-2004 with a growth rate of 2.7 percent. Over the entire timeframe from 1987-2014, most industries showed productivity growth. The outliers were construction and services, which had negative growth over the entire period 1987- 2014.

Figure 3: Industry multifactor productivity by timeframe

Industry Multifactor Productivity by Timeframe
Average annual rate of change

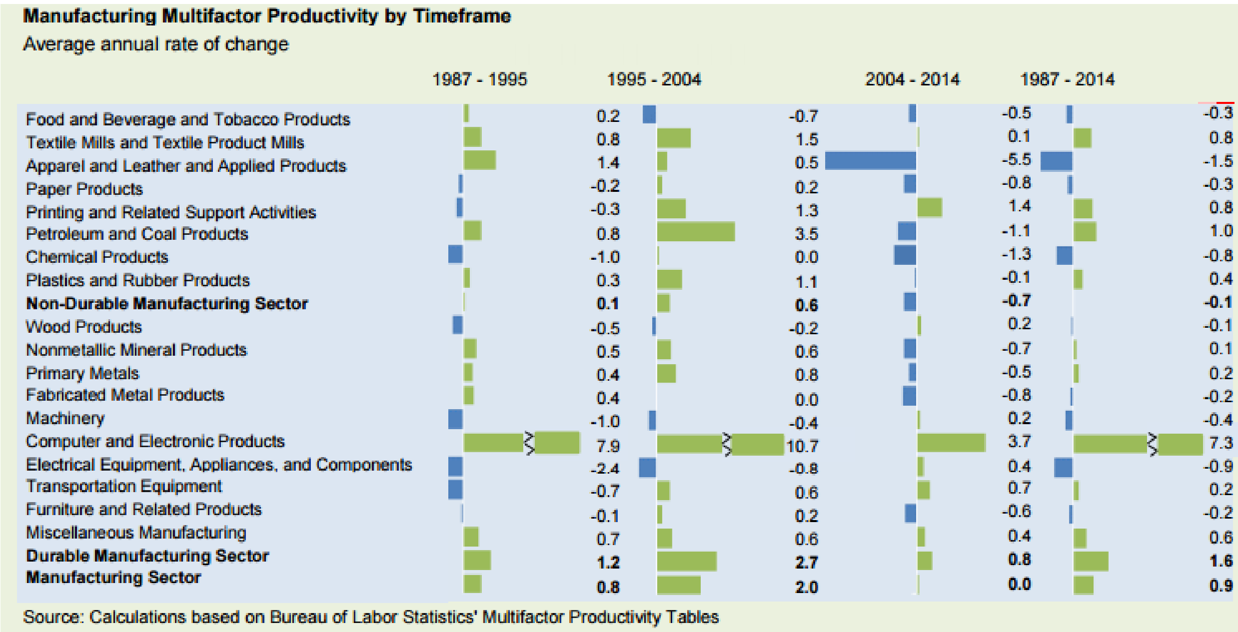
	1987-1995	1995-2004	2004-2014	1987-2014
Agriculture, Forestry, and Fishery	-0.1	3.3	0.5	1.3
Mining	1.8	-0.4	2.7	1.4
Manufacturing Sector	0.8	2.0	0.0	0.9
Utilities	2.4	-0.4	0.3	0.7
Construction	0.1	-0.5	-1.1	-0.6
Wholesale Trade	1.3	2.8	-0.1	1.3
Retail Trade	1.7	2.3	-0.2	1.2
Transportation and Warehousing	1.0	1.4	0.3	0.9
Information	0.3	1.0	1.5	1.0
Finance, Insurance, and Real Estate	-0.3	0.1	0.9	0.3
Services	-0.8	0.3	0.0	-0.2
Private Business Sector	**0.6**	**1.7**	**0.5**	**1.0**

Source: Calculations based on Bureau of Labor Statistics' Multifactor Productivity Tables

[6] Andrew Sharpe of the Center for the Study of Living Standards in Ottawa reports findings similar to those shown here using labor productivity data.

To take a more detailed look at these numbers, we can break the major sector industries down into sub-industries. This allows us to pinpoint the areas responsible for the growth and variability in the major industries. Manufacturing is of particular interest since it has a large influence over growth for the whole economy. Figure 4 takes a closer look at the breakdown of the manufacturing sub-industries to see which were responsible for manufacturing's variability.

Figure 4: Manufacturing multifactor productivity by timeframe



Manufacturing Multifactor Productivity by Timeframe

Average annual rate of change

	1987 - 1995	1995 - 2004	2004 - 2014	1987 - 2014
Food and Beverage and Tobacco Products	0.2	-0.7	-0.5	-0.3
Textile Mills and Textile Product Mills	0.8	1.5	0.1	0.8
Apparel and Leather and Applied Products	1.4	0.5	-5.5	-1.5
Paper Products	-0.2	0.2	-0.8	-0.3
Printing and Related Support Activities	-0.3	1.3	1.4	0.8
Petroleum and Coal Products	0.8	3.5	-1.1	1.0
Chemical Products	-1.0	0.0	-1.3	-0.8
Plastics and Rubber Products	0.3	1.1	-0.1	0.4
Non-Durable Manufacturing Sector	**0.1**	**0.6**	**-0.7**	**-0.1**
Wood Products	-0.5	-0.2	0.2	-0.1
Nonmetallic Mineral Products	0.5	0.6	-0.7	0.1
Primary Metals	0.4	0.8	-0.5	0.2
Fabricated Metal Products	0.4	0.0	-0.8	-0.2
Machinery	-1.0	-0.4	0.2	-0.4
Computer and Electronic Products	7.9	10.7	3.7	7.3
Electrical Equipment, Appliances, and Components	-2.4	-0.8	0.4	-0.9
Transportation Equipment	-0.7	0.6	0.7	0.2
Furniture and Related Products	-0.1	0.2	-0.6	-0.2
Miscellaneous Manufacturing	0.7	0.6	0.4	0.6
Durable Manufacturing Sector	**1.2**	**2.7**	**0.8**	**1.6**
Manufacturing Sector	**0.8**	**2.0**	**0.0**	**0.9**

Source: Calculations based on Bureau of Labor Statistics' Multifactor Productivity Tables

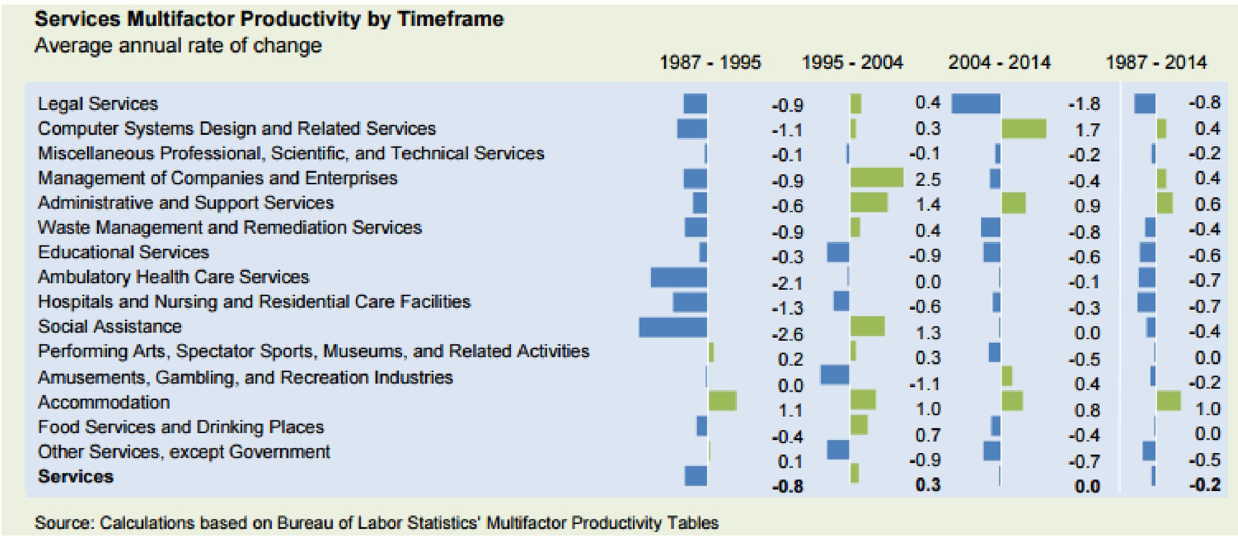
As shown by this figure, MFP growth in computer and electronic products was extremely variable between the slowdown and acceleration. In the post-1995 acceleration, computer and electronic products had an enormous 10.7 percent growth rate. Then in the post-2004 slowdown, it dropped over 7 percentage points to 3.7 percent. In the late 1990s the United States was entering the peak of the dot-com era and computer manufacturing was a huge part of the growth in productivity. Today, however, this segment of manufacturing shows slower growth as well as having declined as a share of output as much of ICT equipment is now imported.

Beyond computers and electronics, it is striking how weak MFP growth is in other parts of manufacturing post 2004, with negative numbers commonplace. The largest MFP decline occurred in apparel, which was heavily impacted by imports, but the post-2004 "malaise" in manufacturing is broad and striking. Excluding computers, manufacturing has been an area of strikingly weak productivity performance. The change in MFP averaged a negative 0.3 percent between 1987 and 1995, improved to 0.5 in 1995-2004, and then fell at an annual rate of -0.4 percent in 2004-14.

The other major industry group worth looking at is services, which also shows considerable variability by period and negative MFP growth over the full time-period. Figure 5 looks at the subindustries within services and many of them show negative growth rates. Health and education are large industries that fall into this group.

One could readily conclude that these service industries are displaying the pattern described by Baumol, but we are not convinced of this. For one thing, real output and productivity are badly measured in these industries, so we do not know whether the weak performance is for real or not. There is a lot of innovation in health care that has improved the quality of treatment, but it is not being fully measured in the output concept. We also think there are opportunities for productivity improvement in these industries that are often highly regulated and afflicted by restrictive practices. These issues take on growing importance because services are a large and increasing share of the economy.

Figure 5: Services multifactor productivity by timeframe



GROWTH CONTRIBUTIONS BY INDUSTRY

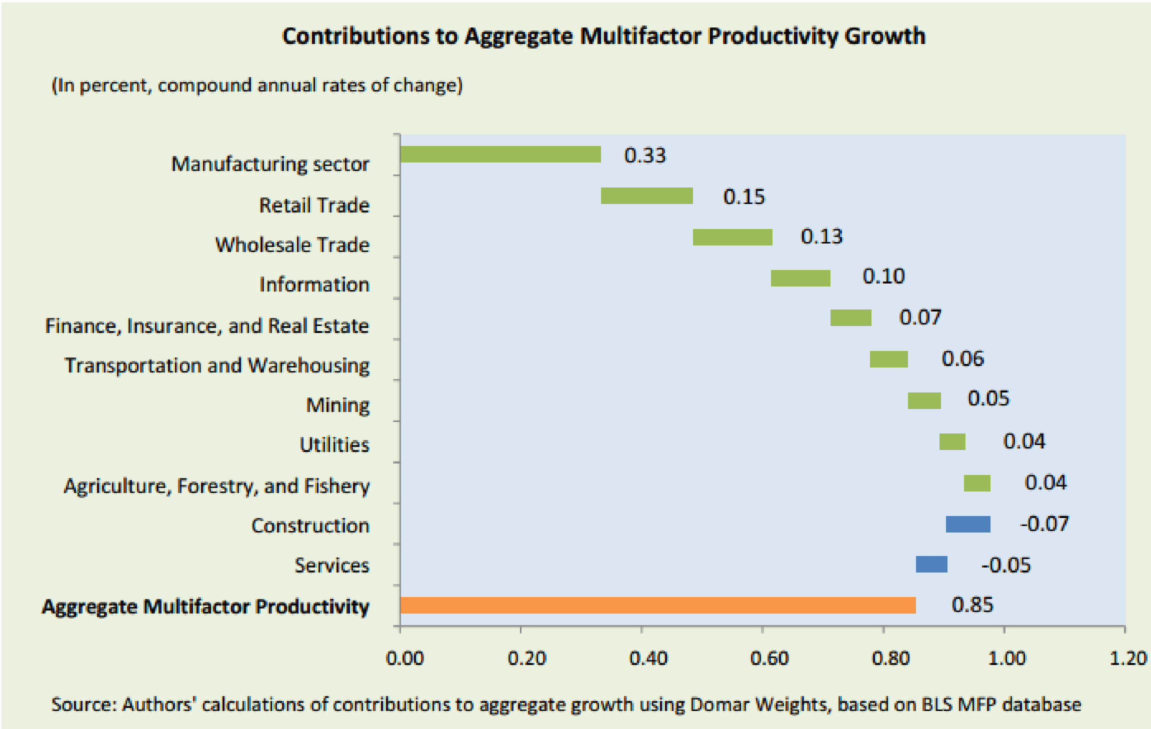
In the previous section, we calculated MFP at the disaggregated level to find which industries had stronger or weaker productivity growth in each timeframe. The part missing from this analysis is estimates of how much each industry contributed to aggregate MFP growth. Doing this will allow us to determine which industries were the most important in driving the pattern of aggregate growth, acceleration, and deceleration. Beyond its own growth rate, the relative importance of each industry depends on how large its output share is in the total and the conversion from the gross output concept used in the industry analysis and value added in the measure to GDP. Each industry is given a weight based on the analysis by Evsey Domar, where he showed how to disaggregate total MFP growth into the industry contributions.[7]

Figure 6 shows the contribution of each major industry to the aggregate for the entire time period, 1987-2014. This figure shows that the manufacturing sector contributed 0.33 percentage points of the aggregate 0.85 percent growth in this timeframe. It is by far the largest contributor. Retail and wholesale trade were also large contributors with a combined 0.28 percentage points added to the aggregate. As noted, construction and services were laggards that dragged down the overall MFP growth. Here we can see exactly how much: construction slowed aggregate MFP by 0.07 percentage points and services slowed aggregate MFP by 0.05 percentage points.

---

[7] An industry's Domar contribution to aggregate multifactor productivity growth is the industry's MFP growth multiplied by its Domar weight. Each industry's Domar weight is the ratio of the industry's current-dollar value of gross output to aggregate value added.

Figure 6: Contributions of each industry to aggregate MFP growth, 1987-2014



Next, we determine which industries contributed the most to the post-1995 acceleration. To do this, we calculate how much more an industry contributed to aggregate MFP growth in the 1995-2004 timeframe than it did in the prior period 1987-1995. Looking at Figure 7, it is clear that services and manufacturing were the largest contributors to the post-1995 acceleration. It is interesting and frustrating that the largest contribution to the post 1995 growth acceleration was the services sector that is so badly measured. This “acceleration” was because of a negative contribution of -0.30 to aggregate MFP growth before 1995 and then a modest +0.14 percentage points after 1995, combining to give the 0.44 percentage point boost to the productivity acceleration.

Manufacturing was also very important to the post-1995 acceleration. It went from contributing 0.33 percentage points in the first period to contributing 0.72 percentage points post 1995 and that led to a net 0.39 percentage point contribution to the productivity acceleration. As we saw in the previous section, computers and semi-conductors were responsible for much this contribution of manufacturing to the growth acceleration. Even though the post-95 productivity acceleration was concentrated in two large sectors, it was still pretty broad based with several other industries contributing.

Mining, construction, and utilities were the three industries that missed out on the productivity growth surge; they counteracted the acceleration coming from elsewhere.

Most economists see evidence of the spread of information and communications technology (ICT) as the reason for the acceleration. That is undoubtedly the case for the computer and semiconductor industry’s contribution, but the ICT link is less obvious in the other contributing industries.

Figure 7: Difference in the contribution of each industry to MFP growth, post-95 minus pre-95

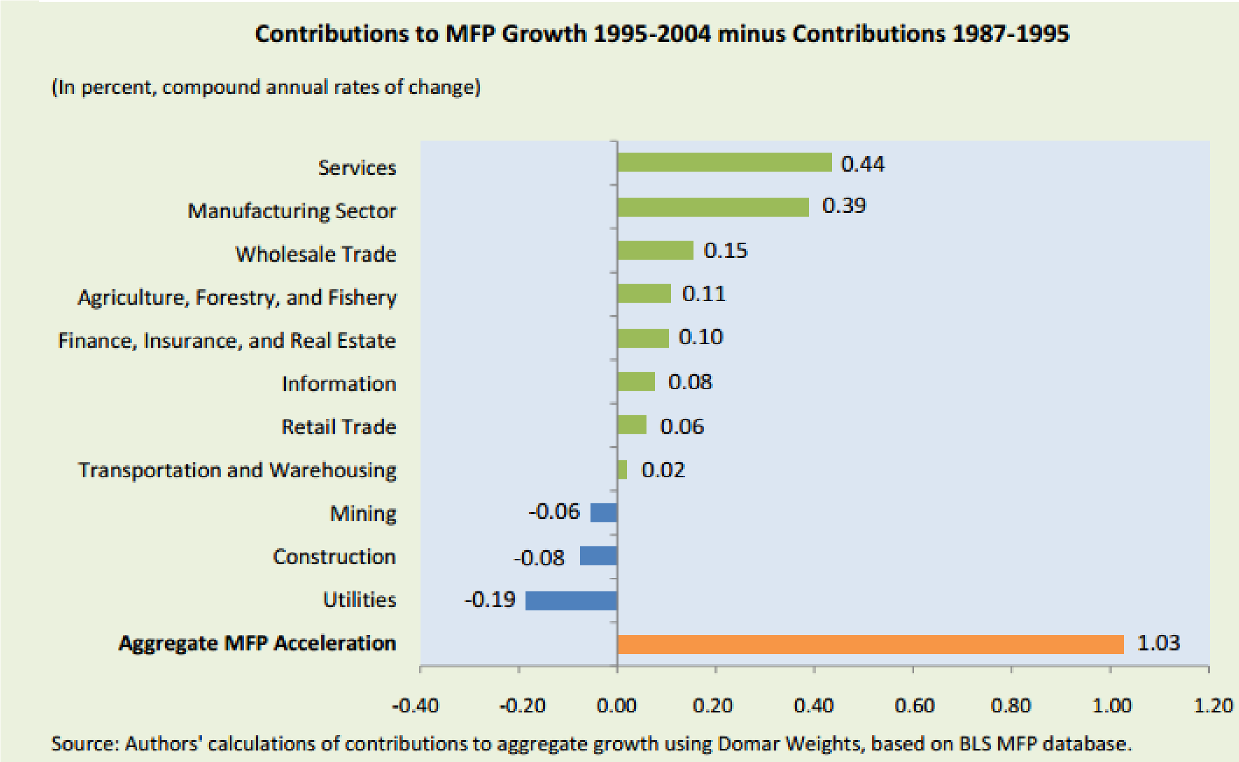


Figure 8: Difference in the contribution of each industry to MFP growth, post-04 minus post-95

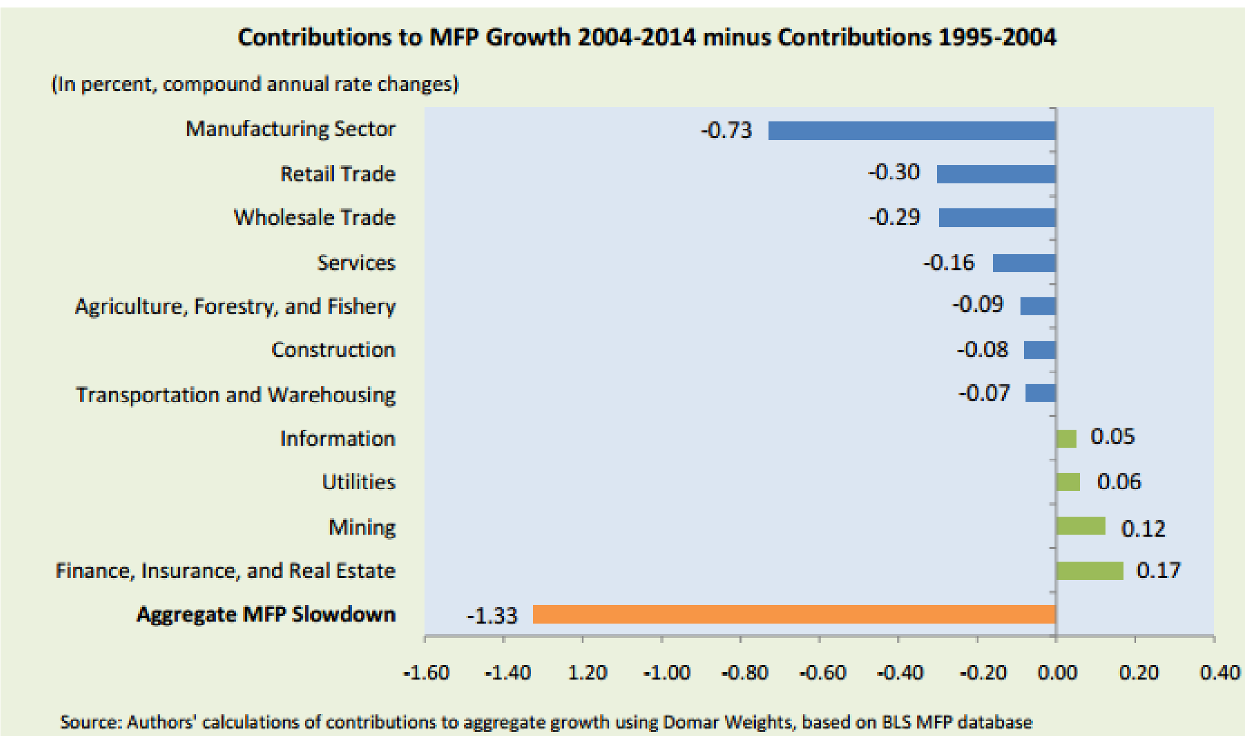
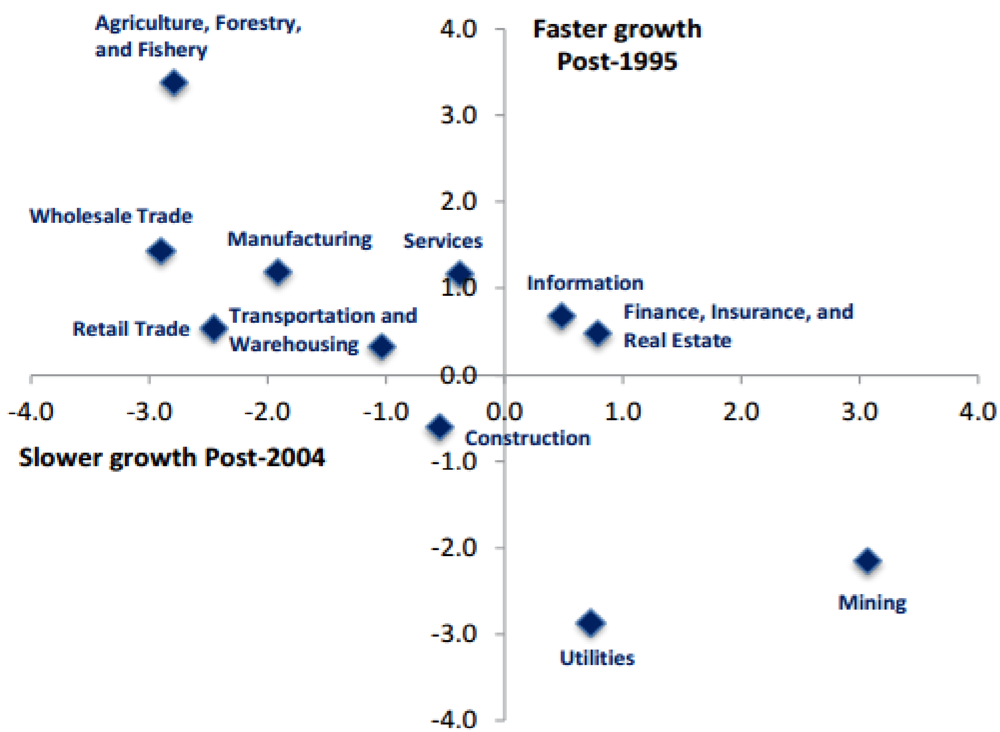


Figure 8 now shows the contributions by industry to the slowing of aggregate MFP growth after 2004. Many of the industries that contributed to the acceleration of growth after 1995 also were important to the subsequent growth slowdown. Manufacturing; services; wholesale trade; agriculture, forestry, and fishery all showed increased growth contributions post-1995 and then slowed significantly in the post-2004 deceleration. Manufacturing by itself was responsible for over half of the slowdown, with its contribution dropping 0.73 percentage points, from 0.72 percent to -0.01 percent. Retail and wholesale trade also dropped significantly, falling 0.30 and 0.29 percentage points, respectively. We note that from a purely arithmetic viewpoint, manufacturing and trade can account for 100 percent of the slowdown in growth post 2004. Wholesale and retail trade had strong growth for a number of years as big box retailers expanded their market share and drove out small stores. By the post-2004 period, this effect had been completed and there was some over-capacity in retailing. The rest of the industries are then scattered with positives and negatives. Services, which was the largest contributor to the acceleration, fell from 0.14 percent to -0.02 percent, a drop of 0.16 percentage points. Of the three laggards in the acceleration, mining and utilities ended up with positive contributions to growth after 2004. Finance, Insurance, and Real Estate (FIRE) also acted as a counterweight to the slowdown, showing a strong 0.17 percentage point increase in growth contribution compared to the previous time period. Of course measurement is a problem in FIRE.

Figure 9: Changes in MFP growth for acceleration and slowdown, major sectors



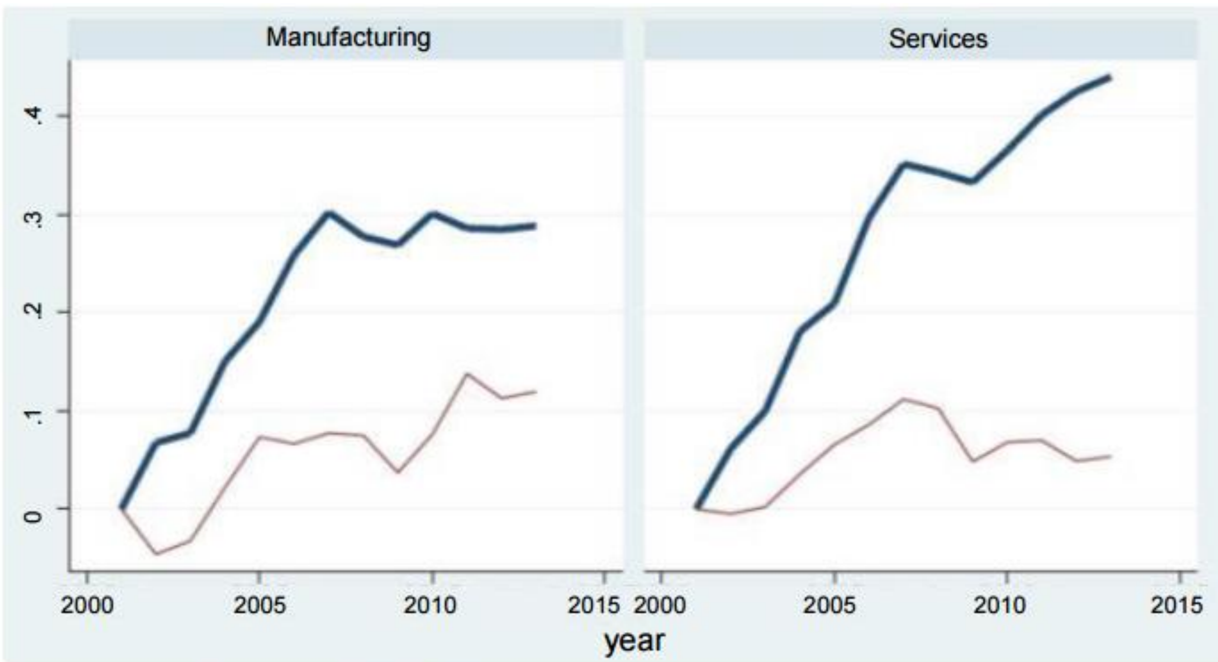
Authors' calculations based on BLS MFP database.

We noted above that, mostly, the industries that had contributed to the post-95 growth acceleration were also the industries that had slowed down after 2004. We wanted to check out that relationship directly and Figure 9 provides a striking confirmation of the pattern. Rather than look at contributions by industry we went back to industry MFP growth rates, and the figure confirms the industries whose growth rates increased after 1995 were also the industries that slowed after 2004. The level of aggregation is very high in Figure 9 and so we checked the result using all of the industries in the BLS database and the pattern holds very strongly, as can be seen in the Appendix. What does this correlation say about causality?

A productivity shock hit the economy around the mid-1990s creating an opportunity for some but not all industries to grow faster. The shock was short-lived, and by the early 2000s it was over. The industries that had been able to accelerate growth, then fell back to their old, slow pace of growth. The ICT shock is certainly a candidate for what happened and this was a period of strong demand, full employment and high investment.

THE FIRM LEVEL DATA SHOW INCREASED PRODUCTIVITY DISPERSION AND DECLINING DYNAMISM

Figure 10: Firm level productivity over time. Frontier firms and the rest, manufacturing and services



Source: Andrews, Criscuolo, and Gal (2016).

There were two papers presented at our technical conference held September 8, 2016 that use firm level data whose conclusions we examine now.[8] First, a team based at the Economics Directorate of the OECD[9] has used the Orbis dataset of firms around the world and estimated their productivity, both labor productivity and MFP. The team found that the frontier firms (within each industry) have been increasing their level of productivity, but the rest of the firms in the industry are being left behind so that average productivity growth for all firms has been slow. As seen in Figure 10, which is taken from their paper, a very large gap has opened up between the frontier firms within an industry (the most productive ones, shown in the solid black line in the figure) and the average of the rest of the firms (shown by the narrow red line). The figure plots

---

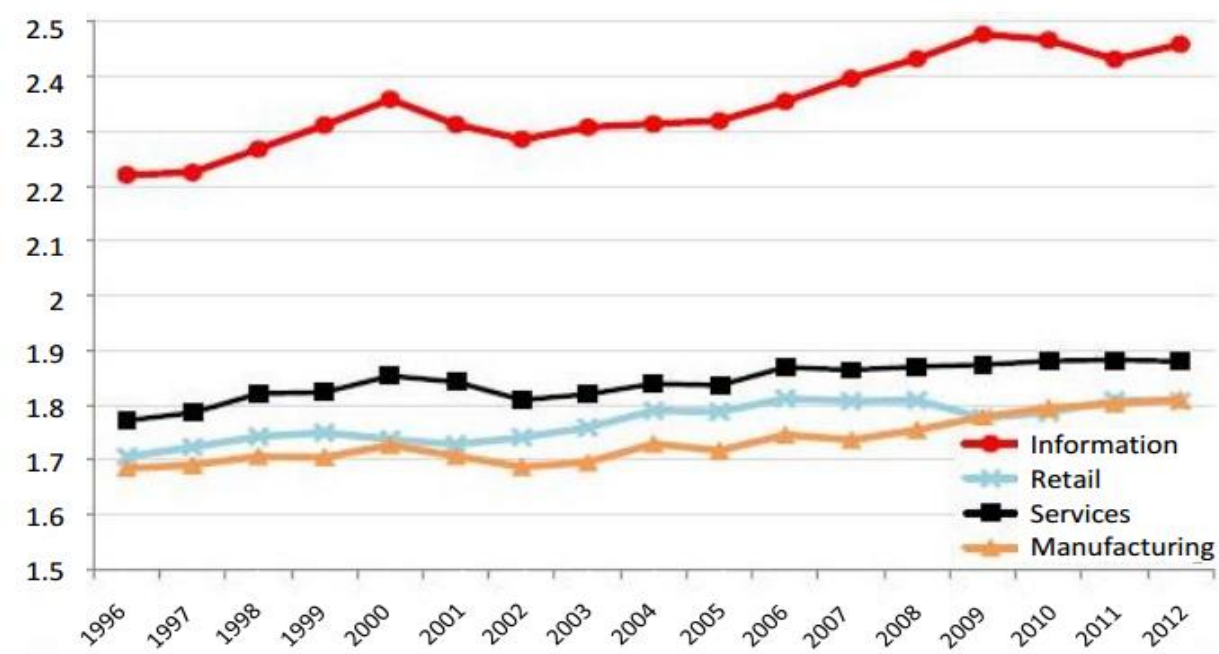
[8] A third paper looked at firm data in the UK and we discuss that finding later. Of course there has been a large literature based on firm and establishment data cited in these two papers.

[9] See: Andrews, Criscuolo, and Gal (2016).

an index of productivity for each group of firms over time and uses a logarithmic scale. The productivity index in the first year is unity, which is zero on a log scale, so the figure starts at zero and rises over time, rising a lot for the frontier firms and not so much for the rest. The gap between the frontier and the rest was seen most strongly in services, where firms are much less exposed to international trade. For the manufacturing firms, it appears that even the frontier firms have seen a stagnation of growth starting around 2007 (the productivity line goes flat in that year) but in services the frontier firms have continued to experience strong productivity growth.

The authors have interpreted their results as showing the productivity frontier has not stopped moving out (at least in services, which make up a far larger fraction of the economy than does manufacturing). Rather than attribute the productivity growth slowdown to a lack of innovation, they suggest the problem is a lack of diffusion of best practices from the frontier firms to the rest.

Figure 11: Productivity dispersion within industries has been increasing



Note: Y axis does not begin at zero. Data reflect interdecile range of log labor productivity deviated from industry by year means. Sectors are defined on a consistent NAICS basis. Author calculations from the RE-LBD.

Source: Decker, Haltiwanger, Jarmin, and Miranda (2016).

The paper by Decker, Jarmin, Haltiwanger and Miranda[10] looks at firms in the US economy and is based on Census data. Traditionally, productivity analysis from Census data has looked most intensively at the manufacturing sector because there is much more comprehensive coverage of capital, materials and energy inputs for this sector. In this paper, Decker et al. cover both manufacturing and non-manufacturing firms but it means they are unable to estimate MFP by company. Instead, they use a simple indicator of firm-level productivity, defined as revenue per

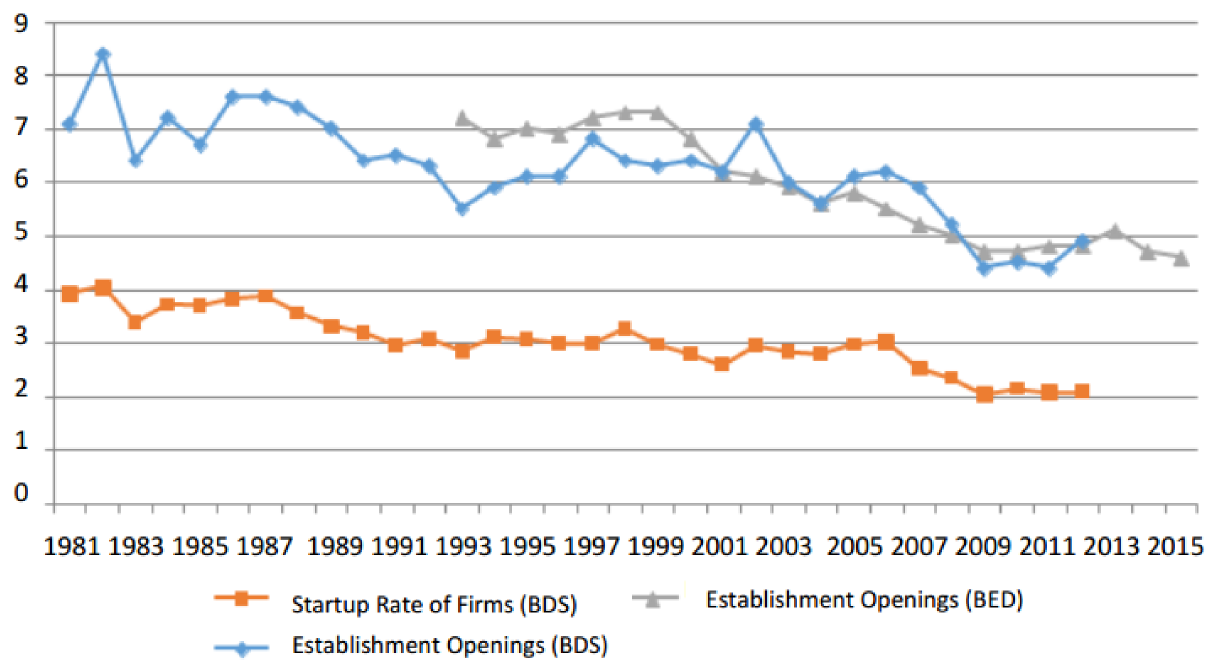
[10] See: Decker, Haltiwanger, Jarmin, and Miranda (2016)

employee.[11] There are three main results in this paper. The first looks at the dispersion of productivity within US industries, and the findings are shown in Figure 11, where the information, retail, services and manufacturing sectors are shown separately. The measure of dispersion used reflects the gap in productivity between firms at the 10th percentile of the productivity distribution and those at the 90th percentile. For all of the sectors shown, the dispersion has risen over time with the greatest increase (and highest level of dispersion) found in the information sector. In retail, the increase in 90-10 dispersion is fairly strong until 2008 and then flattens out. Their measure of dispersion also uses a logarithmic scale.

The difference in approaches between the two papers are important, but there is a broad agreement in which both sets of authors find a widening gap between the most productive and the less productive firms.

The second main result in Decker et al. is shown in Figure 12 which reports the rate of startups (entering firms) and firm exits, for an extended period going back to 1981.[12] Despite some volatility, the trend in the startup rate is very clearly downwards. The startup rate shows some cyclical sensitivity with declines in the 1990, and 2001 recessions and then a very steep step decline in the Great Recession, a time that also saw a jump in firm exits.

Figure 12: The declining rate of startups over time



Source: Decker, Haltiwanger, Jarmin, and Miranda (2016).

The third main result in this paper relates to the decline in the contribution to overall productivity growth that arises from "reallocation." An important characteristic of the US economy is that the share of production and employment in more productive firms in the economy expands and the share of the less productive firms' declines. It is also the case that the probability of a firm failing

[11] Although in principle the Orbis data covers millions of firms in all regions, in practice this dataset is not considered very reliable in its US coverage. Although there are doubtless exceptions, it is usually the case that patterns observed in labor productivity carry over to patterns in MFP.
[12] Hathaway and Litan (2014) also look at declining dynamism.

rises if its productivity is low. This reallocation effect is a quite substantial source of overall productivity growth and one that fits naturally into a Schumpeterian selection process among firms, the survival and growth of the most productive firms. What Decker et al. find is that the contribution of reallocation to overall productivity growth in the US economy is declining over time (see Figure 12 of their paper, which we have not reproduced here). Schumpeter has not completely left the building, but the productivity benefits of reallocation have been greatly reduced.

Given the rising dispersion in productivity, one would have expected the forces of competition to be working more strongly so that the more productive incumbent firms would expand aggressively and drive out the less productive firms. Instead of this happening, the forces driving convergence and diffusion of best- practice productivity appear to be diminishing. A substantial puzzle.

These results do need care in interpretation. For example, the decline in the rate of startups in retailing in the 1990s reflected the expansion of the big box stores and did not indicate industry stagnation. And for the distribution of productivity within an industry, there is a long history of people suggesting that if only the firms with relatively weak productivity performance could be brought up to best practices, then average productivity would rise. The problem with this argument has always been that the existence of a wide distribution of productivity across firms in the same industry is a very persistent feature of the data.

Despite these caveats, the micro studies are telling us something new and important. The productivity gap between the top and the bottom or the top and the average has actually been widening. That is a sign of weakening in the dynamic adjustments that have traditionally fueled productivity growth. Or on the positive side, it suggests that future growth could be faster if the laggard companies were able to catch up—or else fail.

A SUMMARY OF KEY FINDINGS FROM THE DATA

We have presented aggregate data, international data, industry data and firm level data, so it may be helpful to provide a summary of key findings.

- ***Finding One:*** The slowdown in productivity growth has affected almost all the advanced economies and started in the early 1970s.
- ***Finding Two:*** US productivity growth first slowed in the 1970s but then there were nine years or so of
  strong growth starting after 1995. This pattern was not matched by other advanced economies.
- ***Finding Three:*** In the US data there is a marked relationship between the pace of MFP growth and the contribution of capital services and they move together. Since 2004, there has been slow MFP growth and a very small contribution from increased capital services per hour worked. Capital accumulation has been very weak.
- ***Finding Four:*** Contributions to the acceleration of US productivity growth after 1995 were heavily concentrated in two sectors, services and manufacturing. In services, the acceleration was a shift from negative MFP growth before 1995 to

low positive productivity growth after 1995, notably in health care. In manufacturing, the acceleration was concentrated in computers and semiconductors but there was a modest improvement in other parts of manufacturing also.

- ***Finding Five:*** The deceleration of US productivity growth after 2004 was very heavily concentrated in manufacturing (over half of the total). Computers and semiconductors slowed sharply and are now a smaller share of output. Productivity growth has also been weak in other manufacturing industries. Wholesale and retail trade were also important contributors to the slowdown.
- ***Finding Six:*** There is a pretty strong correlation such that the industries that accelerated the most after 1995 are also the industries that decelerated after 2004. This suggests an earlier productivity surge that impacted some but not all industries. Once the effect of this surge was passed, the industries that had grown rapidly fell back to their previous slow growth path.
- ***Finding Seven:*** Two separate analyses of firm data have found that the gap between the most productive firms and the less productive firms has widened over time.
- ***Finding Eight:*** The analysis of US firm data also documented declining dynamism in the US economy (fewer startups and less productivity-enhancing reallocation of production among firms).
- ***Finding Nine:*** Although it was not detailed in this paper, an analysis of UK firms presented at the Brookings conference asserted that about a third of the decline in trend productivity in that economy was because of financial frictions, particularly the condition of the banks, which impacted smaller firms.
- ***Finding Ten:*** An analysis of productivity weakness in Europe suggested that low interest rates had led to a misallocation of capital, especially in Spain and Italy.
- ***Explanations of Slow Growth in US Productivity.*** These can be categorized in three ways:
    1. Productivity is being mis-measured and is actually doing better than is believed.
    2. The productivity frontier is now moving out more slowly than in past periods because of an exhaustion of important innovations.
    3. The frontier is moving out, but most of the firms in the economy are not keeping pace with the frontier. There is a variety of explanations of what might be causing such a problem—lack of competition, lack of managerial capability to adopt best practices, lack of worker skills, continued cyclical weakness, and regulation.

THE MEASUREMENT ISSUE

Is there sufficient error in the way economic output is measured that this could explain why growth seems so slow when, to many people, it appears that innovation is so rapid? It is helpful to separate out two hypotheses here. The first says that measurement error has always been a problem and productivity growth has been understated for a long time. The second hypothesis says that something changed that affected productivity measurement and that explains the post-2004 productivity slowdown. Measurement methodology did not change much around that time, so this second hypothesis would depend on finding changes in the economy that caused a large part of growth to be missed.

The case that measurement error does not explain the post-2004 slowdown. In a 2016 paper, Chad Syverson explains how hard it would be to explain the post-2004 slowdown as a measurement problem.

If productivity growth had continued at its old rate after 2004, GDP would be about $3 trillion higher than it actually was. In their 2016 paper given at the Brookings Panel, Byrne, Fernald and Reinsdorf also examine in detail whether measurement errors could possibly fill that large output gap and they conclude it could not.

One possible measurement error arises because standard output and productivity measures exclude Google and Facebook and thousands of other computer or phone applications that are funded by advertising. Consumers do not pay directly when they use these apps and so they do not add to final expenditure. The cost of a smartphone and its service are paid for and so these go into output but the part supported by advertising is not. As Byrne et al. point out, this is not new. In the United States television was exclusively supported by advertising for many years, so that the introduction of television was not counted as an innovation that contributed to US productivity growth. They suggest that it would not be correct to count production that is not paid for directly by consumers as it is a form of consumer surplus. Consumer surplus is the value to consumers over and above the amount they pay for a good or service, and so for free goods and services that means the whole value is consumer surplus. In general, measures of productivity increase have not tried to capture consumer surplus. Productivity is meant to capture changes taking place in the production and business part of the economy and is not intended as a measure of consumer welfare.[13]

We understand the argument about consumer surplus, but it is not so clear to us that all free goods should be excluded from productivity. After all, search technology was an important innovation affecting both consumers and businesses. There is ongoing R&D and innovation in the search technology area, and sizable investments in servers and other infrastructure to provide the services. The provision of these new services have many of the characteristics of innovations that are counted in productivity.

Economists can debate whether or not free goods and services should be counted as part of output, but an important contribution of the Byrne et al. paper is to estimate the impact on output

[13] Markets where the price for users is zero are often ones where it is expensive or impossible for providers to assert property rights, and where the marginal cost of serving an additional user is very low. Using advertising then becomes the preferred way to fund operations. Bloomberg is a company that sells information because it is able to maintain sufficient property rights over its information, in part because timeliness is so important to its users. Google sets a zero price to users of its information and relies on advertising.

and productivity from free services if they had been counted. They find these have not been big enough to make much difference to aggregate productivity calculations so far.

Another measurement error that has been seen as perhaps significant involves the prices of information and communications technology equipment. The decline in US manufacturing productivity growth was heavily impacted by the slowdown in the computer and semiconductor industries. In practice, the rate of productivity growth in ICT production is determined almost entirely by the rate of decline in the product prices, largely coming from the semiconductor sector. In the 1990s, the prices of CPUs were falling extraordinarily rapidly (after quality adjustment) as manufacturers were able to put more and more transistors on a chip. The price declines were also driven in part by competitive pressure in the industry and from Intel's pricing strategy in that period. There has been some concern that perhaps the BLS measurement methodology has not kept up with the changing structure of the industry. Prices of semiconductors are not falling as fast but the cost of cloud storage is falling very fast. Byrne et al. make a careful assessment of ICT pricing and conclude that the errors may go the wrong way, because the understatement of the product improvements was even greater prior to 2004. Using alternative and experimental price indexes probably makes more difference 1995-2004 than in the most recent period.

Byrne et al. and Syverson, therefore, make a strong case that the post 2004 slowdown in productivity growth was not the result of measurement error. At the same time, it would be a mistake to conclude that measurement errors are not still an ongoing and important problem.

The case that measurement error is important. One sign that measurement error may be important arises because the broad industry that contributed the most to the acceleration of aggregate productivity growth after 1995 was services, according to Figure 7. This, in turn, was because several of the subindustries within that sector shifted from large negative MFP growth rates before 1995 to zero or modestly positive growth rates after 1995 (see Figure 5). Around that year there was a lot of concern about price and productivity measurement. Zvi Griliches' 1994 address as President of the American Economic Association suggested that measurement errors might explain why productivity growth had been so weak since the early 1970s.

In 1996, Alan Greenspan suggested that negative productivity figures were implausible and must be symptomatic of measurement errors.[14] And the Boskin Commission was appointed by the Senate in 1995 to look into possible measurement problems with the Consumer Price Index.

In short, there was a lot of pressure on the statisticians to examine their methods and, in the case of Greenspan's concerns, to explain why they were finding large negative productivity changes in some industries. The professional staff at BEA and BLS have been justly proud of their independence and we are sure they did not simply bow to pressure. However, there must have been, and should have been, some double-checking to see if the negative productivity figures were right. We think it likely that the shift in the service productivity data around 1995 was the result of a reassessment of the numbers.

[14] See David Wessel, writing in the Wall Street Journal of November 27, 1996, says that Alan Greenspan "tells anyone who will listen" that US productivity is doing better than government statistics say. Wessel refers to an October 16, 1996 speech to the Conference Board where Greenspan refers to a Federal Reserve Staff study by Corrado and Slifman. This study was subsequently published in 1999 in the American Economic Association papers and proceedings.

Productivity growth in services is hard to measure, and the same is true also for finance insurance and real estate. These two large sectors account for over half of the post-1995 acceleration of productivity growth shown in Figure 7.

Measurement Error and Longer Run Productivity Growth. If the post-95 acceleration of productivity growth was just a temporary surge plus a data correction, it makes the longer run pattern of slow growth since the early 1970s more of the story. And that puts the spotlight on health care, education and other service industries where productivity measurement is really hard. With health care headed towards 20 percent of GDP, it is vital to get a better handle on how this sector is really performing.

In his presentation at the Brookings productivity conference, Hal Varian, Google's Chief Economist and Emeritus Professor at Berkeley, made the case that measurement error is more important than was being recognized by Syverson or Byrne et al. He looked at free goods, like search, but he also pointed to other areas where mismeasurement may be important. He reported, as an example, that in 2000 there were 80 billion photographs taken globally while in 2015 he estimated there were about 1.6 trillion photos taken, 20 times as many. This represents a huge increase in the productivity of photo-taking technology and was brought about by the fact that the price per photo has declined from around 50 cents to almost zero as consumers use their phones to take pictures. He also gave the example of GPS devices that cost $1,000 in the late 1990s but were now built into our phones. Quality adjustment for smart phones has not nearly kept pace with the true increase in their quality, he argued.

Varian also pointed to the problems created for productivity measurement by global supply chains. Much of the design and innovation that is built into today's products comes from the United States but the products are manufactured in Asia or elsewhere and sold around the world. Most of the productivity growth generated in the United States is missed. In the example of the iPhone, there is an export of $350 from China to France for one phone, of which $200 should be counted as an export from the United States to France with only $150 in manufacturing costs, spread among suppliers from many countries. Android phones account for 80 percent of mobile phones sold globally but the operating system is open source and none of the value is attributed to the US economy. Varian argued that this accounting problem was bigger than just high technology. Much of the design and R&D for motor vehicles, consumer electronics, furniture, toys and clothing sold in the United States is done here, while a lot of the manufacturing is done around the world.

In his remarks to the Brookings conference Harvard Professor Martin Feldstein also stressed mismeasurement as a serious problem, both because of the treatment of new products and the lack of quality adjustment in existing products. The nominal or dollar value of output has to be adjusted for inflation in order to get an estimate of real output and hence productivity. The price index for any class of products is computed by looking at the subset of the products that are on the market in two consecutive periods. In practice that means that new products do not enter into price index estimates for a while, often for a few years. This then means that the period of rapid price decline that often occurs with new products can be missed. Until it is part of the sample used for a price index, a new product impacts inflation and hence productivity measures only to the extent it holds down the prices of existing products that compete with the new product. Feldstein mentioned the health care area as one where the impact of new products can be hugely understated. Statin drugs were introduced starting in the 1980s and have become one of the largest class of pharmaceuticals, used by millions. These drugs have contributed to the extraordinary decline in deaths from heart disease, representing a very large value to consumers that is not counted as a productivity increase. In commenting on Feldstein's presentation, Peter Orzsag noted that new treatment protocols have reduced readmission rates for hospitals, saving health care costs but not counted as a productivity improvement.

In summary, while no one at the conference disagreed with the conclusion that the whole productivity slowdown could not be explained by mismeasurement, several of the participants stressed the overall importance of mismeasurement and the potential for understating long run growth.

THERE ARE NO MORE MAJOR INNOVATIONS TO BE FOUND

Robert J. Gordon's economic history of the United States laid out his view that slow growth in the recent past and in the future is the result of the exhaustion of major innovations. He describes compellingly how economic life has been transformed by big innovations since the start of the industrial revolution, including steam power, electricity, the internal combustion engine, antibiotics and, most recently, digital technology. He argues that most of the major sources of innovation and growth were coming to an end by the early 1970s (hence the slowdown at that time), but the period of very rapid decline in computer and semiconductor prices starting in the early 1990s resulted in a temporary surge of productivity. That last wave of innovation has now passed and we should expect only incremental changes and hence slow productivity increase going forward. Gordon concludes that the slow productivity growth that prevailed for most of the period from 1973 to the present is the normal pattern, what we should expect in the future.

His book is not just about productivity, since Gordon also documents other headwinds facing the US economy, especially demographic change,[15] but the focus here is on his conclusions about productivity. While we are full of admiration for the historical sweep of Gordon's book and the picture it paints of life in America, we are less admiring of the evidence presented about ongoing innovations and the potential for future breakthroughs. He argues that it is possible to look ahead to the future by evaluating the technologies that are in development and he then provides a breezy review of various new technologies being described by technology optimists, such as Erik Brynjolfsson and Andrew McAfee. He dismisses their list of innovations and others as being of minor significance. This part of the book lacks the heft of his historical review of past growth.

In assessing the potential for future growth Gordon does not seem to accept the lessons of his own history, including the importance of incremental innovations and the "soft" innovations that follow a major new technology and are very important in sustaining productivity growth years after an initial major innovation. Take the automobile as an example. Gordon describes the major innovation contributed by Henry Ford in developing the production line, a huge productivity boost that, over time, impacted much of the manufacturing sector. And he documents the gains in the postwar period in the auto industry, finding that the quality of automobiles has improved, their fuel economy is better, their safety is improved and their horsepower is greater, with improvements occurring all the way until the present. Thus, he finds the production line has been yielding tangible and substantial incremental innovations and productivity gains from the 1920s until today. It is therefore puzzling that he concludes that the

[15] A more optimistic view of U.S. growth prospects is given by Jorgenson, Ho and Samuels (2016).

digital revolution has already run its course.[16] The digital revolution is complex and still provides scope for new products and services and improvements in the way companies operate.

Gordon has a distinguished foil in his Northwestern colleague, economic historian Joel Mokyr, who is a technology optimist. Mokyr gives three reasons why we should not expect scientific or technological exhaustion. First, the rate of progress of technology depends upon the tools available to make that progress and computing power and other advances have enormously enhanced those tools. Second, the global economy has greatly expanded, allowing innovators in China, India and throughout the world to contribute to advancing technology. And third, communications technology allows scientific and technological progress to be shared much more quickly and this fuels collaboration and change.[17]

How do the data conclusions in this paper bear on the Gordon hypothesis? As documented here, almost all of the advanced economies have experienced growth slowdowns, and this seems to provide additional empirical support for Gordon's view. Not so. Not all countries are at the technology frontier and these should be expected to have continued productivity growth as they to converge towards the frontier. Japan is not at the frontier; southern Europe is not at the frontier. The US economy is not at the productivity frontier in all industries. China is certainly not at the frontier since its average productivity is only a fraction of the level of advanced economies, and yet China has experienced a sharp productivity growth slowdown.

Most importantly, the micro analysis of firm data reported here runs very much counter to Gordon's argument for it finds an alternative explanation for slow growth in the expanding gap between the best companies and the rest.

While we reject the extreme technological pessimism of Gordon, there is room for partial agreement with his view, as discussed earlier. The period from the end of World War II through the early 1970s was one where productivity opportunities were very strong.

BARRIERS THAT PREVENT DIFFUSION AND POLICIES TO INCREASE PRODUCTIVITY

In this section we will look at the alternative explanations for the widening gap between best practices and the rest while at the same time looking at policies that might help speed up the diffusion process.

Increase Competitive Intensity. Traditionally, the level of competition in an industry was considered important as a way of keeping price close to marginal cost. Empirical studies then found that there was a relation between industry structure and the amount of innovation, with the lowest level of innovation taking place in highly fragmented industries, but low innovation also occurring with monopoly or stable oligopoly. It was generally assumed in these models that firms would profit maximize given the technology they knew about.

In a series of studies starting in the 1990s designed to understand why a given industry in one country had higher or lower productivity than in another country, the McKinsey Global Institute found that companies often operated inefficiently, in the sense that they did not adopt best

[16] It is also puzzling that the book contains no mention of the Toyota production system, a revolution that used lean production, worker feedback, products designed for easy assembly and close relations with suppliers to drive year after year of productivity growth. It is anecdotal evidence, but based on conversations with experts in lean production we can report that most US companies are miles away from reaching the frontier in the use of lean methods, particularly service sector companies.

[17] Joel Mokyr (2014).

practice methods even when they knew what those were.[18] This was a pervasive pattern in industries that were comfortable oligopolies, or in industries protected from competition. The unwillingness of US auto companies to adopt lean production until they were forced to do so by threat of bankruptcy is perhaps the best-known example, but there were many others. Retailing and other service industries in Japan operated below best practice. Banks in many countries operated inefficiently, even leaving aside the risk-taking problem of the crisis.[19] The solution proposed by these McKinsey studies was to break down the barriers to competition, such as tariffs and quotas, subsidies, special zoning requirements, barriers to foreign investment, or restrictive labor rules. This same recommendation has also been made by other writers.[20]

Could a lack of competitive intensity explain why the average productivity level within industries is falling behind the frontier? To us, it appears that it must explain part of the story because the micro data are showing levels of productivity at the frontier (or at the 90th percentile) that is three, four or even six times the average of the lowest decile. Wage rates are lower in lower productivity firms, but not by enough to sustain a competitive equilibrium. Another sign of the lack of competitive pressure is the increase in the profit rate occurring at a time of weak investment and generally slow growth.[21]

What can be done to increase competitive pressure on companies? Traditionally, anti-trust actions were the remedy of choice for monopoly, together with refusing to grant permission for mergers. There are skeptics about the value of anti-trust actions in practice[22] but we think it is worth using anti-trust as a restraint on the business sector. Another approach is to undertake a regulatory review, which we look at shortly.

Another strategy to increase competitive pressure is to review the working of the patent system, looking at whether too many patents are being granted and whether patent lives should be reduced. The patent system was introduced as a way of extending property rights to innovators and thereby increasing the amount of innovation, but there is a growing sentiment in the economics profession that the patent system is being used to restrict competition. Of course, the patent system was designed to charge consumers for the cost of innovation by means of higher prices but patents now seem to be a strategic game aimed at limiting competition and extracting as much as possible from consumers or from insurance companies that pay for medications. This was certainly the sentiment voiced in a forum in the Journal of Economic Perspectives. Moser (2013) uses historical and cross-country evidence to assess whether or not patents succeed in fostering more innovation. He concludes not:

> "Historical evidence suggests that in countries with patent laws, the majority of innovations occur outside of the patent system. Countries without patent laws have produced as many innovations as countries with patent laws during some time periods, and their innovations have been of comparable quality."

And on the dangers of the patent system in reducing competition, Boldrin and Levine (2013) say, "The patent system arose as a way to limit the power of royalty to award monopolies to

[18] The purpose here is not to debate the validity of the profit-maximizing model of economics. That model is of great value and can always be rescued in some form by specifying imperfect information or bounded rationality or labor or other regulations.
[19] Syverson (2004) looks at the productivity distribution and how product differentiation may sustain it.
[20] Martin Neil Baily and Robert M. Solow (2001) and William W. Lewis (2004).
[21] Jason Furman and Peter Orszag (2015).
[22] Robert W. Crandall and Clifford Winston (2003).

favored individuals; but now its primary effect is to encourage large but stagnant incumbent firms to block innovation and inhibit competition."

These authors have views that are on the extreme of economic opinion, and the politics of Congress would make it difficult to eliminate the patent system. Still, it would be worth a systematic review of the patent system with a willingness to push back against the small number of large global companies that get most of the benefits from patents. The economy needs more effort at innovation and fewer expensive court battles over intellectual property. The political climate may actually be favorable for a reduction in patent lives.

Simplify and rationalize economic regulation. The paper by Andrews et al. suggested that regulatory barriers may be preventing average firms from closing the gap with the frontier firms, particularly in Europe. In the United States, there are many complaints about financial regulation, the Affordable Care Act, environmental regulations, and restrictions on oil drilling and pipelines. The complexity of dealing with multiple federal agencies as well as state and local entities is also cited as a discouragement to business investment. Blaming regulation for slow productivity growth is not new. The slowdown in growth in the 1970s was often blamed on regulation, with pages in the federal register correlated with productivity growth. Partly in response to that pressure, the deregulation movement got its start in the Carter Administration and was continued through the Reagan-Bush years and included the financial deregulation of the 1990s.

To the extent that there has been increased regulation since then, it is partly a backlash against some of the side effects of deregulation, notably the financial crisis. Also, climate change has raised awareness that externalities in production and consumption can create huge problems.

Where might regulatory reform help? It is certainly worthwhile to undertake a review of the impact of regulations on competition and entry barriers. Beyond this, the industry data shown earlier in this paper points to the importance of laggard industries, particularly health care and education in the services sector. Both are highly regulated sectors where the forces of competition are not usually available to drive productivity improvement.

The introduction of competition in education through charter schools has not proven to be the spark for major quality improvements that was hoped for, but competition is surely a positive force for improvement over the long run. Federal funding for demonstration projects for new educational technology can help in the development and diffusion of best practices.

In health care, true productivity is surely increasing even if the BLS data do not show it[23] because there is very little quality adjustment currently done to the price deflators. One important step is to fund a major effort by the statistical agencies to improve the quality of the data on costs and outcomes in health care. Even though productivity growth may be currently understated, there is considerable room for further efficiency improvement. Hospitals and doctors' offices are not models of lean production or effective use of information technology. Patients search for the best possible treatment and this has driven innovation but also over-treatment and a lack of cost pressure on providers. Third-party payment, the threat of malpractice suits and US tax laws all encourage overconsumption. This industry is one where incomplete and asymmetric information abound so that market failures are inevitable, but policy changes can still make a difference.

[23] See the papers in Triplett (1999).

Health care imposes strict licensing arrangements on persons working in the field. Some program of quality assurance is surely necessary for health care but the current system restricts the tasks that can be performed by nurses and technicians, restricts interstate competition and prevents foreign competition, such as overseas reading of X-rays and other images. Another area for reform is medical malpractice, where the quality of care could be improved and money redistributed towards patients and away from lawyers.

The problem of excessive certification requirements goes beyond health care. Hershbein, Boddy and Kearney report that 30 percent of US jobs now require a license up from 5 percent in the 1950s.[24] It seems that every profession has developed certification requirements, including florists, dance teachers and manicurists. The expansion of licensing seems designed to restrict entry into these professions rather than to protect consumers.

Improve managerial capability to adopt best practices. The paper by Cette et al. discusses the problem that many companies in Europe are not able to take advantage of new business methods enabled by ICT. This argument is also made by the McKinsey Global Institute as they report that most industries have reached only a fraction of the level of digital adoption that would bring them to best practices.[25] Small and medium- sized companies say they would love to introduce some of the new ICT driven tools to improve their operations, design and marketing, but they simply do not have anyone in house that knows how to do that. And it is difficult and expensive to hire people with the necessary skills.

This lack of capabilities may also interact with the resistance to change described earlier and have an impact even on large firms. An example illustrates the problem. A large insurance company computerized its accounts and record keeping many years ago, retaining an Indian outsourcing company and then hiring many of the people brought in as consultants to stay as permanent employees. Today the IT department of the company is firmly entrenched and sees no reason to change the way the company does business. Senior management are aware of the need to upgrade and improve the company's capabilities, and they have retained a new technology consulting firm to help. While senior managers see the need for change, they do not understand what specific steps need to be taken and hence are unable to overcome internal staff resistance and force change.

What can be done about this problem? Probably not much in the short run. In the longer run, new generations of managers are more familiar with ICT and its capabilities. Undergraduate colleges could require basic ICT proficiency from all of their students and so could business schools. Beyond this we have to hope that improved competitive intensity throughout the economy will put pressure on laggard companies.

One reason that senior managers and CEOs are resistant to change is that it often results in a decline in profits in the short term in order to increase returns in the long run. CEOs report that equity markets punish companies that miss short term profit targets even if they are investing for the long run. Our Brookings colleagues Kamarck and Galston (2015) argue that short-termism is reducing investment and slowing growth. They argue that corporate governance needs to be changed to provide more incentive for managers to make long term investments.

[24] See Brad Hershbein, David Boddy and Melissa S. Kearney (2015).
[25] McKinsey Global Institute (2015).

Invest in worker skills. Managerial skills are only part of the story in improving capabilities. Worker skills are important also. Although lack of worker skills has not been shown to be a major reason for the weakness in productivity, we know that the US labor market has undergone substantial change with a sharp reduction in the number of jobs that offer good pay and career advancement to workers with a high-school education.[26] Some of this change is the result of the decline in manufacturing employment; also skill-biased technical change has transformed the jobs of bank tellers and retail managers, putting the skills into the technology and taking away much of the need for judgments by employees. This allows companies to hire lower-skill workers at lower pay. If improvement in productivity is to lead to stronger wage growth it is important workers have the skills to justify higher returns. Surveys of CEOs report that lack of worker skills is a key problem cited for their reluctance to invest more in their US operations.[27]

Germany and Denmark are both countries that provide superb apprenticeship and retraining programs. The Danish flexicurity system is admired globally. However, the rates of productivity growth in these economies have been dismal, telling us that doing well with worker training is not a sufficient condition for strong productivity growth. For the United States, though, there is the potential to combine Silicon Valley innovations with Danish training programs and that could be a winning combination.

OTHER POLICIES TO INCREASE PRODUCTIVITY GROWTH

Stimulate aggregate demand with infrastructure investment. Lawrence Summers (2015) has argued for increased infrastructure spending, suggesting that demand stimulation would increase both productivity and labor force participation. Can the productivity slowdown be attributed to the financial crisis and subsequent recession?

John Fernald has argued that the Great Recession cannot be the reason for slow productivity growth in the United States because the slowdown started around 2004.[28] And the OECD trend analysis of the G-7 economies reported in Figure 2 goes further back, dating the start of the slowdown to the early 1970s. Based on these findings, it is unlikely that cyclical factors have been the only reason for slow productivity growth. Nevertheless, it is possible that weak demand, plus problems in the financial sector resulting from the crisis have exacerbated weakness in productivity. In the United States, the sluggish recovery from the Great Recession may account for the unusually slow growth of investment and hence the slow growth in the contribution of capital to labor productivity growth seen in Figure 1 of this paper. The paper by Besley et al. on the UK reports that the increase in credit market frictions were the result of the post-crisis weakness of the banks, plus the increase in default probabilities of small firms, making it harder for them to finance investment. The productivity figures reported in Cette et al. (see their Figure 7) show a striking downward movement of productivity in Germany, France, Italy and Spain that coincides with the crisis. Their paper argues that low interest rates following the crisis resulted in capital being misallocated, particularly in Spain and Italy as low-productivity firms were kept in existence.

While it is unlikely that an infrastructure program will have a large impact on productivity growth, it does seem possible that a demand boost would help stimulate investment and improve the

[26] Goldin and Katz (2010) and Autor and Dorn (2013).
[27] Committee for Economic Development (2015).
[28] Fernald and Wang (2015).

really dismal productivity of the advanced economies since 2007. For the United States, the case for an infrastructure program is strong because the current condition of the roads and bridges is so lousy. Such a program has a sporting chance of being agreed to on a bipartisan basis in the new Congress.

Enhance US Manufacturing. As we saw in a previous section, manufacturing played a large role in overall productivity growth in the United States. Is there a case for policies to support US manufacturing as a way to support US productivity growth?

Usually, the arguments for support of manufacturing are based on restoring jobs in the sector. This is largely a waste of time. The share of manufacturing jobs in total payroll employment has been on a steady decline for over 50 years both in the United States and other advanced economies.

On the other hand, policies to boost manufacturing output are more possible. Firstly, there is some chance that the internet of things, cheaper and better robots, 3-D printing and machine learning could make manufacturing production in the United States cost effective. Production worker labor costs are becoming small enough as a component of total costs that labor arbitrage is no longer as important. Energy is cheap in the United States, and regulation is favorable relative to many other countries.

One of the obstacles to expanding production in the United States is the corporate tax. Profits earned on US-based production are taxed at a much higher (marginal) rate than in most other countries. Tax reform to bring US tax rates into line with other economies is an essential step. The Economic Report of the President (2015) lays out concerns about the current corporate tax and the need for reform. Proposals to lower the tax rate and broaden the tax base by eliminating tax preferences have bogged down in policy gridlock so far but there should be a renewed effort to make progress on this important policy reform.

Manufacturing is an important performer of R&D and a user of scientific and technology advances made in universities and research institutions. Federal support for science and technology has lagged in recent years (shown in the Appendix), which seems like false economy.

CONCLUSION

Access to firm level data has revealed the widening of the productivity distribution and provided insight into the cause of slow growth in the advanced economies. It has also given hope that there might be ways to reverse or partially reverse the slowing of growth, either through policy actions or through the natural forces of a market economy. Such data were not available when productivity first slowed in the early 1970s. In addition, the industry data has shown the outsized importance of computer and other high technology manufacturing to aggregate trends. And it has shown how quirks in measurement contributed to the acceleration and deceleration of growth.

BIBLIOGRAPHY

Andrews, Dan, Chiara Criscuolo and Peter N. Gal. 2015 “Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries”, OECD Productivity Working Papers, 2015-02, OECD Publishing, Paris.

Autor, David and David Dorn, ""The Growth of Low Skill Service Jobs and the Polarization of the U.S. Labor Market." American Economic Review, 2013, 103(5), 1553 – 1597.

Baily, Martin Neil and Robert M. Solow, "International Productivity Comparisons Built from the Firm Level," Journal of Economic Perspectives, 15 (3), Summer 2001

Baumol, William J and William G Bowen. 1966. Performing Arts, The Economic Dilemma. New York: Twentieth Century Fund.

Boldin, Michele and David K Levine. 2013. "The Case Against Patents". Journal of Economic Perspectives 27 (1): 3-22. doi:10.1257/jep.27.1.3.

Bosworth Barry P. and Jack E. Triplett. 2004. Productivity in the U.S. Services Sector: New Sources of Economic Growth. Brookings Institution.

Bosworth Barry P. and Jack E. Triplett. 2007. "The Early 21st Century U.S. Productivity Expansion is Still in Services. International Productivity Monitor". Centre for the Study of Living Standards (14): 3-19.

Brookings Institution, 2013. U.S. Productivity Growth: An Optimistic Perspective.

Brynjolfsson, Erik and Lorin M. Hitt. 1998. "Beyond The Productivity Paradox". Communications of the ACM 41 (8): 49-55. doi:10.1145/280324.280332.

Byrne, David M., John G. Fernald, and Marshall B. Reinsdorf. 2016. "Does The United States Have a Productivity Slowdown or a Measurement Problem". Finance and Economics Discussion Series 2016 (017): 1-74. doi:10.17016/feds.2016.017.

Byrne, David M., Stephen D. Oliner, and Daniel E. Sichel. 2013. "Is The Information Technology Revolution Over?". SSRN Electronic Journal. doi:10.2139/ssrn.2240961.

Cette, Gilbert, Benoit Mojon, and John Fernald. 2015. "The Pre-Great Recession Slowdown in Productivity". SSRN Electronic Journal. doi:10.2139/ssrn.2758506.

Committee for Economic Development, Which Skills are Most Important on the Job and Which Skills are in Short Supply?" September 22, 2015. https://www.ced.org/blog/entry/which-skills-are-most-important- on-the-job-and-which-skills-are-in-short-su

Cowen, Tyler. 2011. The Great Stagnation. New York: Dutton.

Crandall, Robert W. and Clifford Winston, "Does Antitrust Policy Improve Consumer Welfare? Assessing the Evidence," Journal of Economic Perspectives, Vol. 17, No. 4, Fall 2003, pp. 3-26.

Davis, Steven and John Haltiwanger. 2014. "Labor Market Fluidity and Economic Performance". doi:10.3386/w20479.

Decker, Ryan John Haltiwanger, Ron S Jarmin, and Javier Miranda. 2013. "The Secular Decline in Business Dynamism in the U.S." Manuscript, University of Maryland.

Domar, Evsey D. 1961. "On The Measurement of Technological Change". The Economic Journal 71 (284): 709. doi:10.2307/2228246.

Fernald, John G. 2015. “Productivity and Potential Output Before, During, And After the Great Recession”. NBER Macroeconomics Annual 29 (1): 1-51. doi:10.1086/680580.

Fernald, John, and Bing Wang, The Recent Rise and Fall of Rapid Productivity Growth, Federal Reserve Bank of San Francisco, February 9, 2015, http://www.frbsf.org/economic-research/publications/ economic-letter/2015/february/economic-growth-information-technology-factor-productivity/

Furman, Jason and Peter Orszag, “A Firm Level Perspectiv on the Role of Rents in the Rise in Inequality,” Presentation at Columbia University in Honor of Joseph Stiglitz, October 16, 2015.

Goldin, Claudia and Lawrence F. Katz, The Race Between Education and Technology, Harvard University Press, 2010.

Gordon, Robert J. 2016. The Rise and Fall of American Growth. Princeton: Princeton University Press. Hathaway, Ian and Robert Litan, “The Other Aging of America: The Increasing Dominance of Older Firms,

Hathaway, Ian and Robert Litan, “The Other Aging of America: The Increasing Dominance of Older Firms, Brookings, July 2014.

Harper, Michael J., Bhavani Khandrika, Randal Kinoshita, and Steven Rosenthal. 2010. “Nonmanufacturing Industry Contributions to Multifactor Productivity, 1987–2006”. Monthly Labor Review 133 (6): 3-15.

Hershbein Brad, David Boddy and Melissa S. Kearney, “Nearly 30 Percent of Workers in the U.S. Need a License to Perform their Job,” Upfront blog, The Brookings Institution, January 27. 2015. https://www.brookings.edu/blog/up-front/2015/01/27/nearly-30-percent-of-workers-in-the-u-s-need-a-license-to-perform-their-job-it-is-time-to-examine-occupational-licensing-practices/

Jorgenson, Dale W., Productivity Volume 1; Postwar U.S. Economic Growth, MIT Press, Cambridge, 1995.

Lewis, William W., The Power of Productivity, University of Chicago Press, 2004.

Jorgenson, Dale W., Mun S. Ho and Jon D. Daniels, Education, Participation and the Revival of U.S. Economic Growth, NBER Working Paper 22453, July 2016.

Kamarck, Elaine and William A. Galston, More Builders and Fewer Traders: A Growth Strategy for the American Economy, The Brookings Institution, June 30, 2015, https://www.brookings.edu/research/ more-builders-and-fewer-traders-a-growth-strategy-for-the-american-economy/

McKinsey Global Institute, Digital America: A Tale of the Haves and Have-Mores, December 2015. McKinsey Global Institute, 2011. Growth and Renewal in The United States: Retooling America’s Economic Engine.

Measuring Productivity - OECD Manual. 2001. Paris: OECD Publishing.

Mokyr, Joel, "The Next Age of Invention: Technology's future is brighter than pessimists allow." in Brian C. Anderson ed., City Journal, Manhattan Institute, Winter 2014, pp. 14-20
Olson, Mancur, The Rise and Decline of Nations, 1982.

Summers, Lawrence H. Keynote Address, Making Sense of the Productivity Slowdown, Symposium at the Peterson Institute for International Economics, November 16, 2015, https://piie.com/events/making-sense-productivity-slowdown

Syverson, Chad. 2016. "Challenges to Mismeasurement Explanations for The U.S. Productivity Slowdown". doi:10.3386/w21974.

Syverson, Chad, "Product Substitutability and Productivity Dispersion'" Review of Economic Statistics, 2004

Syverson, Chad. 2011. "What Determines Productivity?". Journal of Economic Literature 49 (2): 326-365. doi:10.1257/jel.49.2.326.

Triplett, Jack, ed., Measuring the Prices of Medical Treatments, Washington, D.C.: The Brookings Institution, 1999.

APPENDIX

Figure A1: Changes in MFP growth for acceleration and slowdown, all industries

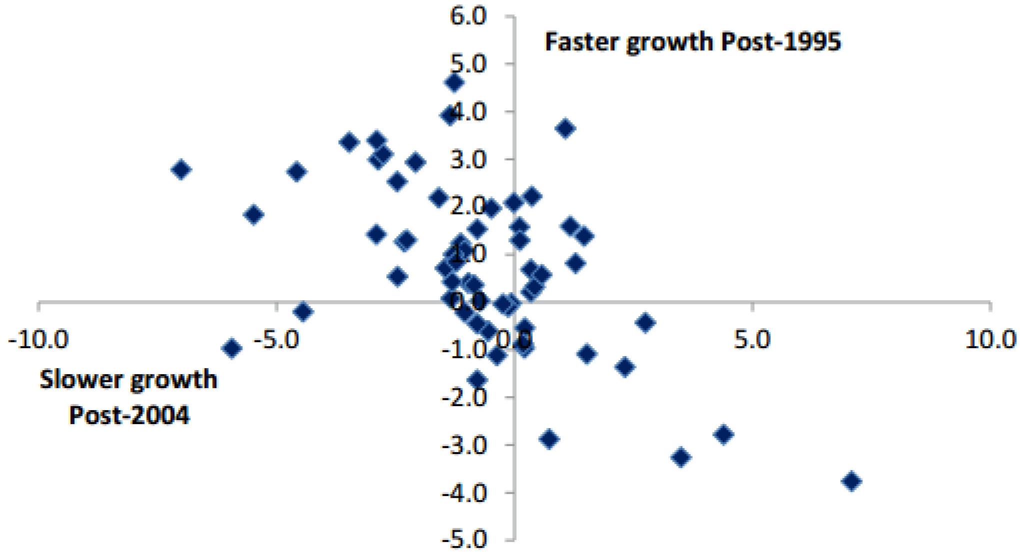
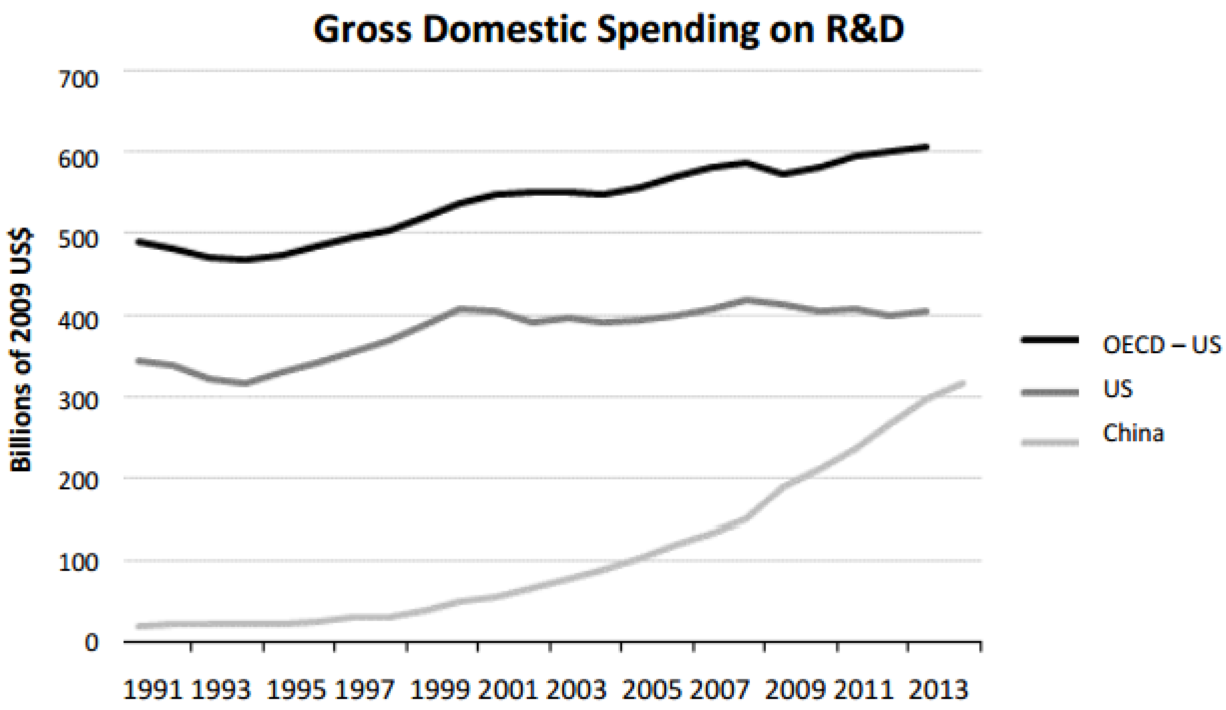


Figure A2: Gross domestic spending on R&D



Source: OECD (2016), Gross domestic spending on R&D (indicator). doi: 10.1787/d8b068b4-en (Accessed on 29 August 2016).