The Slowdown in Manufacturing Productivity Growth

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The past decade has seen slowdowns in measured labor productivity growth across a broad swath of developed economies. Aggregate labor productivity growth in the U.S. averaged 1.3% per year from 2005 to 2015, less than half of the 2.8% average annual growth rate it sustained over 1995-2004. Similarly sized decelerations were observed between these two periods in 28 of 29 other countries for which the OECD has compiled productivity growth data (Syverson, 2016). These do not appear to reflect cyclical phenomena. Slowdowns are still observed in the U.S. and in 24 of the 29 countries in the OECD data if growth rates from 2008-09 are excluded from the totals, and Cette, Fernald, and Mojon (forthcoming) marshal considerable evidence that the slowdowns started before the onset of the Great Recession.

The drops in productivity growth have struck some as paradoxical, given the seemingly brisk pace of technological progress and plethora of new products that have been introduced and diffused throughout the world during the slowdown period. Indeed, many (e.g., Brynjolfsson and McAfee, 2011 and 2014; Mokyr 2014; Alloway, 2015; Byrne, Oliner, and Sichel 2015; Feldstein 2015; Hatzius and Dawsey 2015; Smith 2015) have suggested that the slowdown is substantially illusory, a figment of the inability of current economic statistics to capture the true rate of technological advance in standard productivity metrics. However, recent systematic analyses of such mismeasurement claims (Cardarelli and Lusinyan (2015); Byrne, Fernald, and Reinsdorf (2016); Nakamura and Soloveichik (2016), and Syverson (2016)) have found using varied approaches and data that the slowdown is not primarily a mismeasurement phenomenon. Instead, it reflects a true reduction in the rate of technological growth.

In this note, I focus on the productivity growth slowdown in the manufacturing sector. The sector holds particular interest for several reasons. First, it far "outpunches its weight" in terms of formal R&D. For example, the U.S. manufacturing sector conducts about 70 percent of

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R&D preformed by private business, even though it accounts for only about 10 percent of private employment. Thus the sector is a core source of technological progress, either through direct productivity gains it obtains within its own processes or through spillovers it confers on the many sectors that use manufactured products as inputs. Second, the sector often receives particular policy attention due to its historical role as a base of middle class employment. Third, the sector, and durable goods manufacturing in particular, played a central role in the brisk productivity gains observed in the 1995-2004 decade, especially in the U.S. (e.g., Jorgenson, Ho, and Stiroh (2008)). Thus decelerating productivity growth in the sector might be a critical piece of explaining the broader slowdown observed in the economy-wide productivity statistics.

The data do indeed reflect parallel slowdowns in both economy-wide and manufacturing productivity growth. Table 1 reports average annualized quarterly labor productivity growth rates for U.S. manufacturing (the entire sector as well as breakouts for its durables and nondurables components) during three periods: 1987-1994, 1995-2004, and 2005-2015. For comparison, also shown are productivity growth rates for the entire U.S. nonfarm private business sector, which accounts for about three-fourths of employment in the economy (this is the standard aggregate productivity series reported for the U.S.).

All parts of manufacturing saw first accelerations and then decelerations in labor productivity growth across the periods, consistent with the qualitative patterns observed in aggregate labor productivity growth over the same timeframe.

Table 1. U.S. Manufacturing Average Annual Labor Productivity Growth Rates

	Nonfarm Private	Manufacturing	Durables Mfg	Nondur Mfg
1987-1994	1.5%	2.7%	3.4%	1.7%
1995-2004	2.8	4.5	5.2	3.5
2005-2015	1.3	2.5	2.6	1.5
Slowdown, 1995-2004 to 2005-2015	-1.6%	-2.1%	-2.6%	-2.1%
p-value for test of slowdown = 0	0.007	0.064	0.053	0.021

Source: Author's computations from U.S. Bureau of Labor Statistics quarterly labor productivity series

The slowdowns from 1995-2004 to 2005-2015 were substantial. Overall manufacturing labor productivity growth fell over two percentage points per year, falling by half in durables manufacturing and more than half in nondurables. Given the small samples and inherent volatility of the productivity growth series, these differences however are marginally statistically significant, with *p* values for *t*-tests of equality of mean labor productivity growth rates in the 1995-2004 and 2005-2015 periods of 0.064 for the entire sector, 0.053 for durables, and 0.021 for nondurables.

Also in line with aggregate productivity patterns, the deceleration in manufacturing is spread broadly across economies. Labor productivity growth fell between the 1996-2004 and 2005-2014 periods in the manufacturing sectors of 17 of 20 countries with available OECD productivity data.[2]

Manufacturing's Contribution to the Aggregate Productivity Growth Slowdown

A natural question arising from the parallelism in aggregate and manufacturing labor productivity is to what extent the slowdown in the former is driven by the latter (manufacturing of course being itself a component of the aggregate). I calculate this contribution by multiplying manufacturing's productivity growth rate by the sector's ratio of gross output to aggregate value added. As Domar (1961) showed (expanded upon later by Hulten (1978)), this is the theoretically correct weight for aggregating sector-specific contributions to aggregate productivity.[3] For the U.S., the weight is 0.342. Multiplied by the 2.1 percent drop in manufacturing labor productivity growth over the two periods, this implies that the manufacturing sector accounted for nearly half of the aggregate slowdown: 0.7 percentage points of the 1.6 percentage point fall in aggregate productivity growth.

A similar calculation for the countries in the OECD data—applying the same weight of 0.342, as country-specific gross output figures are unavailable—yields considerable variation in the shares of the countries' aggregate slowdowns accounted for by their manufacturing sectors. However, across the 20 countries in the data these shares average just under half, similar to the U.S. figure.

[2] These periods are each one year shorter than in the comparable U.S. figures because of data availability. The three OECD data countries where manufacturing labor productivity growth did not slow were Denmark, Italy, and Spain.

[3] Given that I am aggregating growth rates, I follow the Törnqvist index practice of using the average of the sector's Domar weights across the period over which the growth rate is computed. Here, this is the average of the 2004 and 2015 weights.

Quantifying the Manufacturing Slowdown

To further place in perspective the magnitudes of this deceleration, I compute the counterfactual productivity levels that would exist in manufacturing had the sector sustained its average 1995-2004 productivity growth rate throughout 2005-2015. The drop in average quarterly labor productivity growth in U.S. manufacturing between 1995-2004 and 2005-2015 is 0.516%, so counterfactual labor productivity at the end of 2015 is $LP_c = LP_{2004}(1.00516)^{44}$, where LP_c is counterfactual labor productivity, LP_{2004} the actual observed labor productivity at the end of 2004, and 44 the number of quarters between the end of 2004 and the end of 2015. Labor productivity in manufacturing would therefore be 25 percent higher in 2015 ($1.00516^{44} = 1.254$) had the sector sustained its earlier productivity growth rates. In the OECD data, the average slowdown across the countries for which data are available, including the three that saw productivity growth accelerations, was 1.752 percent per year (0.438 percent a quarter). Implied counterfactual labor productivity in 2015 for these countries would be 21 percent higher.

In Syverson (2016), I inferred from counterfactual aggregate labor productivity figures that GDP too would be equally higher in the counterfactual scenario, based on the notion that aggregate employment would stay as observed but with each worker-hour producing more output. That may be a reasonable assumption for aggregate output, but it may not apply equally well to a specific sector like manufacturing. The reason is that, if manufacturing productivity were to have increased as implied by the counterfactual calculations, this supply shift would likely create a movement along a downward-sloping demand curve for manufactured goods as their relative prices fall. This would result in a counterfactual increase in manufacturing output that is smaller than the productivity increase, with the size of the difference depending on the slope of manufacturing demand. Given that total U.S. manufacturing value added in 2015 was $2.17 trillion, this puts an upper bound on the counterfactual increase in output (value added) of $543 billion.

The Sources of the Slowdown

To start to dig into possible sources of the productivity slowdown, I next analyze the contributions of total factor productivity (TFP) growth and capital deepening in statistically explaining the drop in manufacturing labor productivity. These two factors in combination drive labor productivity variation.[4] For this analysis, I use the TFP series for manufacturing computed by the U.S. Bureau of Labor Statistics and the capital-per-worker-hour data for the sector from the U.S. Bureau of Economic Analysis.[5]

There is a clear connection between labor productivity and TFP growth in manufacturing. Average annual TFP growth in the sector fell from a robust 2.2 percent per year over 1995-2004 to 0.4 percent per year during 2005-2013. Notably sized decelerations occurred in both durables (from 3.0 percent per year to 1.1 percent) and nondurables (from 0.7 percent per year to -0.4 percent per year). This 1.8 percent per year drop in manufacturing TFP growth is almost as large as the 2.1 percent drop in labor productivity. Higher frequency relationships between labor productivity and TFP growth are also strong, albeit more subsector specific. For overall manufacturing, the correlation in the annual growth rates of labor productivity and TFP over 1995-2013 was 0.68. However, this appears to reflect the combination of a very strong association within durables (correlation of 0.87 in annual growth rates) while little relationship in nondurables (correlation of 0.09).

The ties between labor productivity growth and capital deepening are more tenuous. The long differences are aligned; between 1995-2004 and 2005-2014 average annual growth in capital per worker-hour in manufacturing fell from 4.2 to 2.6 percent per year. The corresponding drop in durables manufacturing was from 4.2 to 1.8 percent per year with a smaller decline of 4.5 to 3.7 percent per year in nondurables. However, the year-by-year relationship between labor productivity growth and capital deepening is much less evident than between labor productivity and TFP growth. Indeed, the correlation between manufacturing labor productivity growth and the rate of capital deepening in the sector over 1995-2015 is negative (-0.49). Further inspection of the data indicates this is almost completely driven by what happened in the sector in 2009, when labor productivity dropped 6.9 percent as capital per worker rose 13.6 percent. Removing this single year from the data reduces the correlation to a

[4] For example, if the production function is Cobb-Douglas with constant returns to scale, $Y = AK^{\alpha}L^{1-\alpha}$, then $Y/L = A(K/L)^{\alpha}$, and the relationship between labor productivity, TFP, and capital intensity is log-linear. More general production functions will imply a nonlinear relationship with (logged) capital intensity. Here I remain agnostic about the form of the production function and focus on correlations rather than specific functional forms of the relationships.

[5] The BLS uses the term "multifactor productivity" rather than "total factor productivity." This data is more limited than the labor productivity series; it is only available annually rather than quarterly and just through 2013 at this writing, The BEA capital and hours data for the sector are also at an annual frequency but available through 2014.

statistically and economically insignificant -0.06. Similar results obtain for durables and nondurables sector breakouts. While the oddity of 2009 might account for the negative correlation between annual labor productivity growth and capital deepening, this doesn't change the fact that one does not observe what might be expected to be a strong positive correlation. Thus while the time series trends in capital deepening in manufacturing match those of labor productivity, the relationship between the two series at higher frequencies is much weaker than between labor productivity and TFP.

These results point to a deceleration in TFP growth in manufacturing as being a primary driver of slowing labor productivity in the sector, at both high and lower frequencies. A reduction in the rate of capital deepening might also account for part of the decade-long deceleration in labor productivity growth, though it is less clear that these effects are manifested at annual frequencies.[6]

Recent research has pointed to two, not mutually exclusive possible explanations for the slowdown in TFP growth.

One is that the "easy wins" among information-technology-sourced TFP gains have largely been won, and producers have entered a period of diminished returns from these technologies. There is considerable evidence that information technologies (IT) were a key force behind the productivity acceleration of 1995-2004 (e.g., Jorgenson, Ho, and Stiroh, 2008). More recent work like Fernald (2015) and Byrne, Oliner, and Sichel (2015) have presented evidence that these IT-based gains have slowed over the past decade, however.

The second explanation, proposed by Andrews, Criscuolo, and Gal (2015), is that a productivity growth rate gap has opened between frontier firms and their less efficient industry cohorts. Andrews et al. (2015) show that companies at the global productivity frontiers of their respective industries did not experience reductions in their average productivity growth rates throughout the 2000s. However, most other firms in their industries did see decelerations. It appears that something has impeded the mechanisms that diffuse best technologies and practices through an industry. It is not clear what that something is at this point, however.

[6] Hall (2016), using a different analytical approach, finds roughly equal contributions of TFP and capital deepening decelerations in explaining the slowdown in aggregate labor productivity growth.

Implications for the Future of Manufacturing Productivity Growth

An obvious question raised by the findings and discussion above is what one should expect of manufacturing productivity growth going forward. Will the slowdown continue? Are there steps that could be taken to raise expected growth rates?

I am not aware of any definitive answers, but the analysis above and related research offers some guidance.

In terms of steps to improve the productivity growth rate environment, the increasing laggardness of non-frontier firms in industries might be the most amenable to policy. Many elements affect the rates and depths at which best technologies and practices diffuse through industries. These include the presence and efficacy of "eco-systems" where the information and inputs necessary to implement better ways of doing things are readily available. They also involve competition policies to shape markets that encourage and reward more efficient firms, and factor markets that allow those more efficient companies to hire the inputs necessary for growth while at the same time allowing persistent underperformers to shrink and if need be, exit.

Policy choices could affect not just diffusion rates but the underlying rate of innovation in manufacturing as well. One might wonder, however, that if the "easy wins" from IT are in the past, could any policy have more than a marginal effect given the low expected returns from innovation? This is a valid concern, but history offers some guidance as to the pattern of productivity gains from general purpose technologies like IT. As I point out in Syverson (2013), the productivity growth from electrification and the internal combustion engine—a prior diffusion of a general purpose technology—came in two waves separated by a decade-long slowdown. While certainly not inherently predictive of future gains from IT, this does demonstrate that productivity accelerations spurred by general purpose technologies need not be one-off events. The 1995-2004 accelerations in manufacturing and the broader economy do not have to be the end of IT-driven boosts to productivity growth.

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