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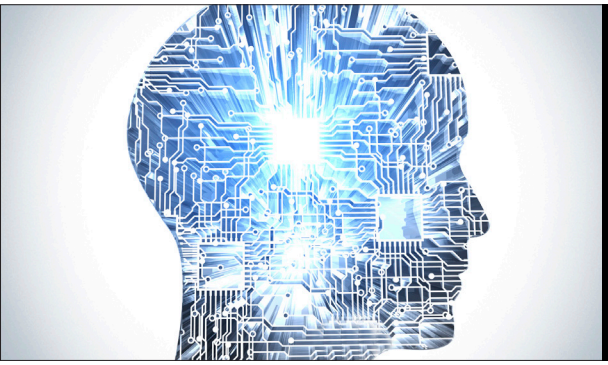


Economic Letter

U.S. Productivity Growth Flowing Downstream

by Michael Sposi and Kelvinder Virdi

ABSTRACT: Measurements of U.S. productivity growth have declined, particularly in the high-tech sector. This may reflect increased U.S. specialization in upstream activities in the global supply chain. Those activities tend to experience slower productivity growth.

Productivity is the most important component of sustained, long-run economic growth. Sluggish productivity growth has been a primary reason for the weak U.S. recovery following the Great Recession.

U.S. real (inflation-adjusted) gross domestic product (GDP) growth had averaged 4.2 percent per year in the four years following recessions during the postwar era. However, since the trough of the 2007–09 Great Recession, output has grown at less than half that rate.

GDP per worker has increased an average of 0.4 percent per year since 2010, compared with 1.8 percent from 1947 to 2009.

Researchers and policymakers have proposed two explanations for declining productivity growth, particularly in high-tech sectors.

The first is "secular stagnation," in which there is excess saving and insufficient demand for investment along with fewer innovations that improve productivity.

The second is the "mismeasurement hypothesis," which holds that the decline in productivity growth is not as severe as it seems because of a failure to accurately measure output.

But a third hypothesis may better explain what has occurred: Production in the U.S. has become increasingly concentrated upstream in global supply chains, particularly in the high-tech sector.

Upstream activities occur early in the production process and include such high-value, service-oriented activities as research and development.[1] Because productivity growth is naturally slower in upstream than downstream activities, greater upstream activity contributes to lower overall measured productivity growth.

Measuring Productivity

Productivity is the rate at which production inputs convert to outputs. Production requires labor, physical capital (machines and buildings) and intermediate inputs (materials and business services).

Labor and capital add value in the process of converting intermediate inputs into output. As such, value added is defined as the compensation for labor and capital. Intermediate inputs are treated as non-value-added factors of production in order to avoid double counting of value added.[2]

To measure productivity, the values of the inputs and outputs are each deflated by their corresponding price indexes to isolate changes in quantities of inputs and outputs. The focus is on total factor

productivity (TFP) growth, defined as the growth in the value added that is unaccounted for by expansion of effective hours worked and the stock of capital.

Examining High Technology

TFP growth has declined in almost all manufacturing industries in the U.S. (*Chart 1*). Computer and electronic products is one standout industry. The industry's TFP growth averaged an annualized 2.14 percent in 2010–13, compared with 16.51 percent during 1999–2009.[3] For other manufacturing industries, TFP growth slipped an average of 0.57 percentage points to 0.01 percent.

U.S. firms' movements along supply chains may partly explain discrepancies in changes in productivity growth across industries. "Supply chain" refers to the sequence of production, beginning with design (upstream) and ending with assembly and sale (downstream). There are many stages in between, and each stage can be fragmented in various geographic locations.[4]

New technologies tend to be developed and produced upstream—innovations such as software, machines to automate assembly, precision equipment for manufacturing specialized devices, and faster computers for communications networks. These technologies are often applied to later stages of production, resulting in increased productivity growth in downstream activities.

While upstream activities can realize higher productivity from new technologies, the rate that productivity grows upstream is often slower because upstream tasks are also burdened with the responsibility of discovering and producing those new technologies.

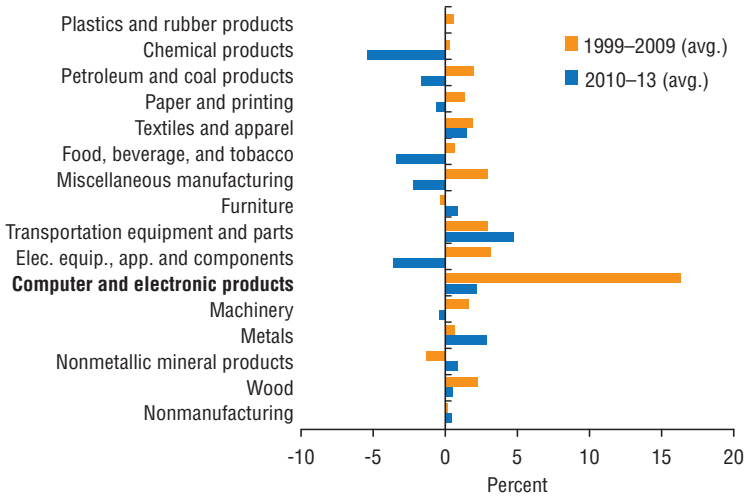
Direct measurements of productivity through supply-chain stages do not exist. However, a common feature of advanced economies is that productivity growth is slower in services than in manufacturing. During the postwar era in the U.S., the difference averaged 1 percent per year. Five economists, led by Marcel Timmer of the University of Groningen, show that advanced countries have become increasingly specialized in tasks carried out by highly skilled workers.[5]

Tasks and industries that use highly skilled workers the most intensively are service oriented—for example, scientific, technical, computer systems and data processing. These are also tasks commonly employed in upstream activities within manufacturing, such as computers and electronics. Thus, it is natural that measured productivity growth declines as production becomes more concentrated upstream.

Three key pieces of data indicate that the U.S. computer and electronic products industry has become more concentrated upstream.

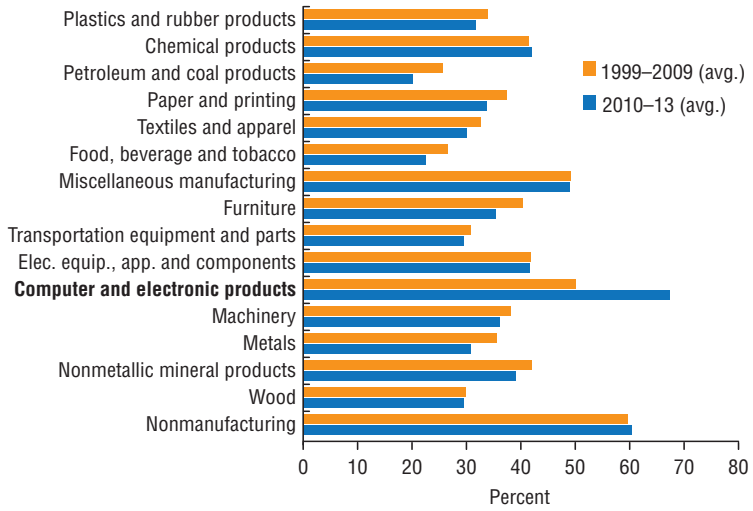
First, the share of value added in the total output of computers and electronics increased from 50 percent before 2009 to 67 percent in 2010–13 (*Chart 2*). This contrasts with a decreasing share in every other manufacturing industry except chemicals, which increased by a small margin. When production moves upstream, it becomes more value-

Chart 1 Total Factor Productivity Growth Mostly Declines in 2010–13



SOURCES: Bureau of Economic Analysis; authors' calculations.

Chart 2 Computer and Electronic Products Leads in Value Added



SOURCES: Bureau of Economic Analysis; authors' calculations

added intensive. Downstream activities tend to use intermediate inputs more intensively.

Second, the share of computer and electronic product sales destined for intermediate use, as opposed to final use, increased from 59 percent before 2009 to 72 percent in 2010–13 (*Chart 3*). This increase is the largest among the manufacturing industries and is indicative of a higher concentration of upstream activity as firms become increasingly removed from the final consumer.

Third, the share of imports in total expenditures on computers and electronics increased from 44 percent before 2009 to 53 percent in 2010–13 (*Table 1*).

There are two possible reasons for this increase. One is that the U.S. is becoming less internationally competitive in the computer and electronic products industry. If that were true, we would see a declining share of industry output going to exports, but Table 1 shows the opposite is true. The other possible reason is that the U.S. is importing more downstream goods. Because the value of downstream imports includes the value of output from upstream activities, value added is double counted. As a result, the value of the imports is larger.

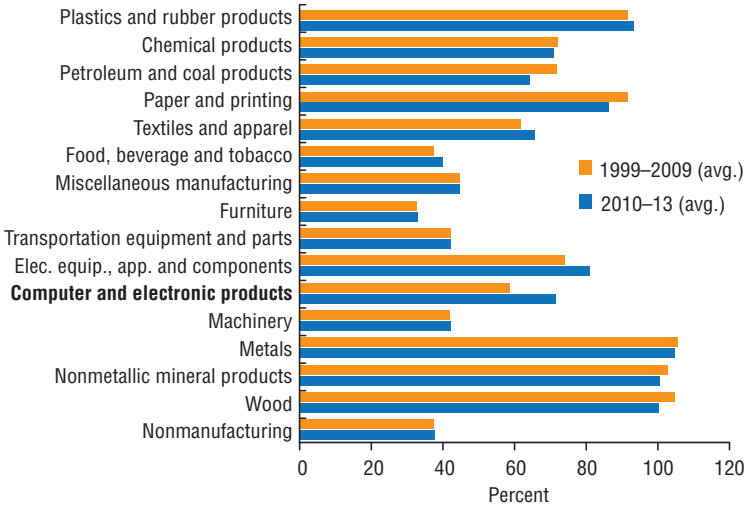
Alternative Explanations

Of the two leading explanations for declining U.S. measured productivity growth, the first is secular stagnation, coined in 1938 and repopularized by Lawrence H. Summers of Harvard University in the context of the sluggish recovery following the Great Recession.[6]

According to this hypothesis, the imbalance between the supply of savings and demand for investment is growing. The increased supply of saving is thought to be driven by, among other things, aging populations in advanced economies, while the decline in demand for investment is thought to be driven by insufficient investment opportunities. An outcome of the imbalance is a declining real rate of return on investment.

Proponents of the hypothesis point to declines in real returns on government debt at various maturities.[7] One study argues that returns on government (unproductive) capital are not natural in this context and that one should look

Chart 3 Share of Intermediate Sales Grows for Computer and Electronic Products



SOURCES: Bureau of Economic Analysis; authors' calculations.

Table 1 Average Relative Shares of Imports, Exports

Sectors	Import share of expenditures*		Export share in output*	
	1999–2009	2010–13	1999–2009	2010–13
Plastics and rubber products	13.9	19.4	9.5	12.1
Chemical products	23.0	25.4	17.9	20.6
Petroleum and coal products	15.7	13.9	7.4	14.0
Paper and printing	8.7	9.3	6.9	9.5
Textiles and apparel	57.9	69.9	12.9	16.6
Food, beverage and tobacco	7.4	8.9	5.6	7.3
Miscellaneous manufacturing	38.7	39.4	16.8	20.5
Furniture	24.9	32.9	3.6	5.7
Transportation equipment and parts	30.1	33.7	20.4	25.6
Elec. equip., app. and components	37.0	46.4	19.5	24.4
Computer and electronic products	**43.6**	**53.0**	**27.8**	**29.4**
Machinery	30.8	34.3	27.6	31.6
Metals	17.9	20.2	8.4	11.0
Nonmetallic mineral products	16.3	18.8	6.3	8.9
Wood	16.9	15.8	4.5	6.6
Nonmanufacturing	1.8	2.5	2.6	3.5

*Includes intermediate and final expenditures/output.
SOURCES: Bureau of Economic Analysis; authors' calculations.

instead at returns on private (productive) capital. The study shows that returns on productive capital have not declined and, in fact, are comparatively high relative to the past 30 years.[8] Thus, it appears that a main premise of the secular-stagnation hypothesis isn't supported by the data.

The second alternative explanation, the mismeasurement hypothesis, is that we simply are not fully measuring all of the output produced. The idea is that many new high-tech products are generating a "consumer surplus" that is not showing up in GDP.[9] Examples include "free" search engines and smartphone apps. The extent to which this consumer surplus is not measured in output is referred to as "missing GDP."

Nonetheless, there is no reason, a priori, to assume that the values of the new products are not showing up elsewhere in GDP. That is, consumers are paying for smartphones, computers and internet service, while the search engine and application developers earn revenues through various selling activities, including advertising space, which is used to sell goods to consumers. All of this shows up in aggregate GDP even if the consumer does not directly pay for each use of the search engine or smartphone app.

While there is undoubtedly some mismeasurement of output, the hypothesis needs to show the size of the mismeasurement and its downward bias to be valid. More importantly, the hypothesis must show that the mismeasurement gets larger over time. A recent paper shows that mismeasurement is unlikely to account for the majority of the decline in measured productivity growth.[10]

Shifting Production Implications

The decline in measured productivity growth in high-tech industries may reflect a shift toward upstream, service-oriented activities that are subject to slower productivity growth. High-tech industries are unique in that their output is often used to enhance productivity in all sectors of the economy. A change in productivity in the computer and electronic products industry can affect productivity in other industries as well as the aggregate economy.

The fact that measured productivity growth in the high-tech sector is decreasing does not suggest that the changes in specialization along the global supply chain are restricting growth. In fact, supply chains allow for greater specialization at different stages of production and this typically improves overall productivity.

The ever-changing nature of production will require the discovery of technologies that improve efficiencies in upstream activities. Investment will have to emphasize human capital accumulation—knowledge, discovery and innovation. This is a time-consuming and uncertain process, but no machine can replace the labor needed to produce these efficiencies.

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Notes

[1] Upstream activities include such early-stage activities as software development, while downstream activities are those that are closer to the final end use of the product.

[2] Double counting of value added occurs because intermediate goods themselves are produced using labor, capital and other intermediates.

[3] TFP can also be viewed as the rate at which capital and labor (value-added factors) are converted into output.

[4] If the component is outsourced to an overseas firm, it can also be called offshoring.

[5] See "Slicing Up Global Value Chains," by Marcel P. Timmer, Abdul Azeez Erumban, Bart Los, Robert Stehrer and Gaaitzen J. de Vries, *Journal of Economic Perspectives*, vol. 28, no. 2, 2014, pp. 99–118.

[6] See "U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound," by Lawrence H. Summers, *Business Economics*, vol. 49, no. 2, 2014, pp. 65–73, and "Demand Side Secular Stagnation," by Summers, *American Economic Review*, vol. 105, no. 5, 2015, pp. 60–65.

[7] Summers looks at five-year, five-year-forward rates for Treasury inflation-protected securities.

[8] See "The Return to Capital and the Business Cycle," by Paul Gomme, B. Ravikumar and Peter Rupert, *Review of Economic Dynamics*, vol. 14, no. 2, 2011, pp. 262–78, and "Secular Stagnation and the Returns on Capital," by Gomme, Ravikumar and Rupert, Federal Reserve Bank of St. Louis *Economic Synopses*, no. 19, 2015.

[9] "Consumer surplus" is the difference in value between what a consumer pays for a good and the value the consumer derives, or is willing to pay, for the good.

[10] "Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown," by Chad Syverson, National Bureau of Economic Research, NBER Working Paper no. 21974, February 2016.

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