Economic Analysis

Digitization and Productivity: Where is the Growth?

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- **Technological progress is in a low-growth state**
- **Information technology is in a high-growth state and boosts the productivity growth rate**
- **Digitization will keep labor compensation growth subdued**
- **Digitization distorts theoretical measures of productivity as the distinction between technology and capital as two separate factors of production fades away**

Forty years after the first personal computers (PCs) were commercially sold and 22 years after the World Wide Web became available free of charge, it is still an unresolved matter in economics whether electronic inventions as well as the dot.com boom heightened the growth rate of U.S. productivity. In the new digital era, even more controversial has been the extent to which big data collection and processing and the proliferation of new apps have contributed to productivity growth, since the productivity growth rate over the last five years has slowed significantly to 0.5%. Contrast this to the 3% average productivity growth rate that the U.S. saw in the historic time periods from post-WWII to 1973 and from 1996 to 2004.

Our estimations show that the recent slowdown in U.S. productivity growth rates has been structural in nature and will persist beyond the current cyclical decline and post-great recession "muddle through" recovery. With that in mind, the questions that remain unresolved are how digital innovations will contribute to the future path of productivity growth and whether U.S. productivity growth can reverse its path and switch into high gear mode in the long run.

Table 1
Growth Rates of Productivity and Labor Compensation

	Nonfarm Business Sector					
	Year-over-Year Growth Rates (%)					
	Productivity	Real Compensation	Real Output	Nominal Compensation	Business Sector Inflation	All Persons Hours
1948 to 1973	2.9	4.3	4.3	6.8	2.6	1.4
1973 to 1995	1.5	3.0	3.1	7.9	4.9	1.7
1996 to 2004	3.1	3.9	3.9	5.3	1.4	0.8
2005 to 2015	1.3	1.4	1.8	3.1	1.7	0.5
2011 to 2015	0.5	2.8	2.6	4.3	1.6	2.1

Source: BLS & BBVA Research

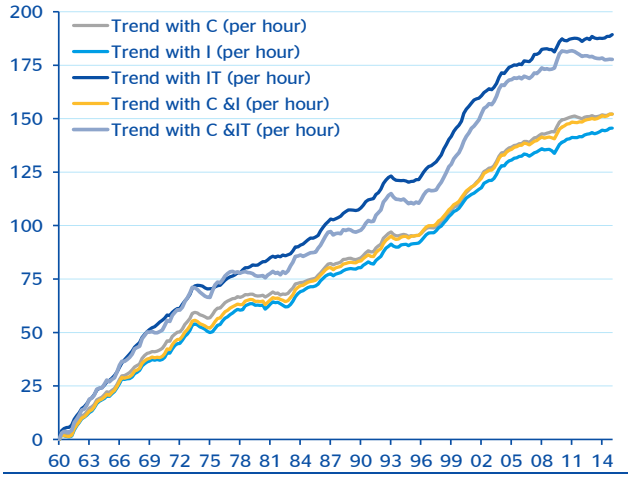
Measuring Technology: Current State of the Productivity Trend

Technological progress forms the underlying trend in productivity growth, while sustained productivity growth is a primary source of growth in long-term living standards. However, aggregate measure of productivity, measured as labor productivity – nonfarm business output per labor hours – is volatile and dominated by transitory, cyclical fluctuations. Stripping out the strong cyclical component of productivity growth and understanding the long-term trend in productivity growth is essential. Assessment and timely measurement of the productivity trend is crucial for policy makers in evaluating correctly recessionary or inflationary output gaps and in conducting growth-promoting policies.

Measuring productivity with a multifactor approach yields a reliable and more suitable estimate of the long-term productivity trend, where the productivity trend measure of technology encompasses everything that permanently raises output per hour – total factor productivity (TFP),[1] capital deepening and growth in human capital. The multifactor approach has its roots in neoclassical growth theory with the implication that labor productivity, labor compensation, consumption, and investment share a common trend. The trend measures the level of technological progress. Additionally, modeling the productivity trend as a process whose mean growth rate has two regimes, with a probability of switching between the two at any point in time, allows differentiating low-growth and high-growth regimes for the trend.

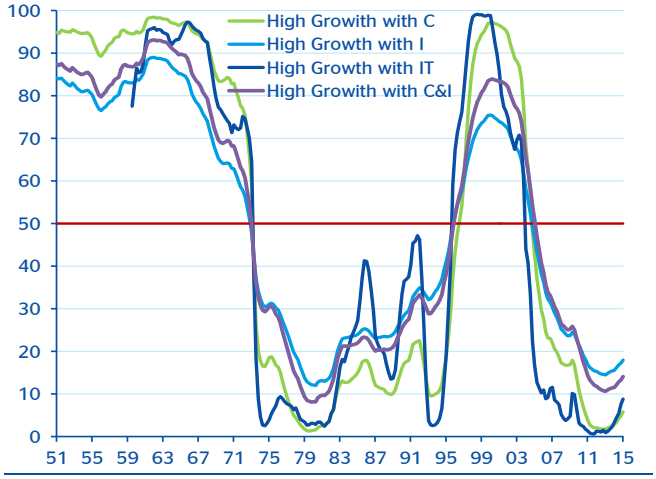
Notably, as depicted in Chart 2, long-term productivity has been in a low-growth regime since 2004. The U.S. post World War II growth rates of productivity mark four distinct time-periods that alternated between high-growth and low-growth rates. The first high-growth period ended in 1973, coinciding with the oil crisis-recession. Yet while the rest of the developed nations remained in the low growth state, the U.S. economy shifted to higher growth levels in 1996. However, this high growth period lasted for only 8 years, shifting back to low-growth in 2004.

Chart 1
Multifactor Productivity Trend
(Per Labor Hour, Logarithmic Scale, 4Q59=0)



Source: BBVA Research

Chart 2
Probability of High Growth State of Productivity Trend
(Per Labor Hour, %)



Source: BBVA Research

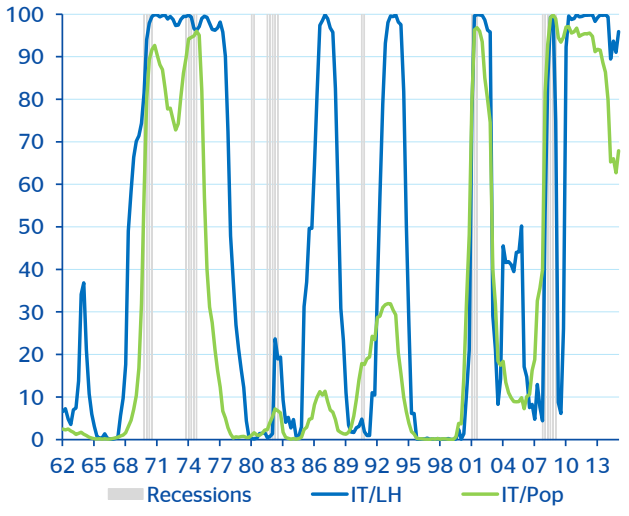
[1] TFP is a variable which accounts for effects in total output not caused by traditionally measured inputs of labor and capital. TFP is measured as a residual, often called the Solow residual. If all inputs are accounted for then TFP is taken as a measure of an economy's long-term technological change.

The original estimation of the regime-switch model for productivity, however, excluded investment.[2] Yet gross domestic investment is an important part of measuring productivity and technological progress. To understand the contribution of technology to productivity growth, several additional models were estimated beyond the benchmark model, which is estimated with labor productivity, labor compensation, and consumption. These additional models utilize estimation of productivity growth where a) consumption (C) is replaced with investment (I), b) consumption is replaced with investment expenditures on information processing equipment, software and research and development (IT), c) investment is added to the benchmark, named (C&I), and d) where information technology is added to the benchmark, named (C&IT). These models yield the result that models containing investment expenditures have a lower productivity trend, while models containing IT expenditures have a higher productivity trend.

Measuring Technology: Information Technology Expenditures

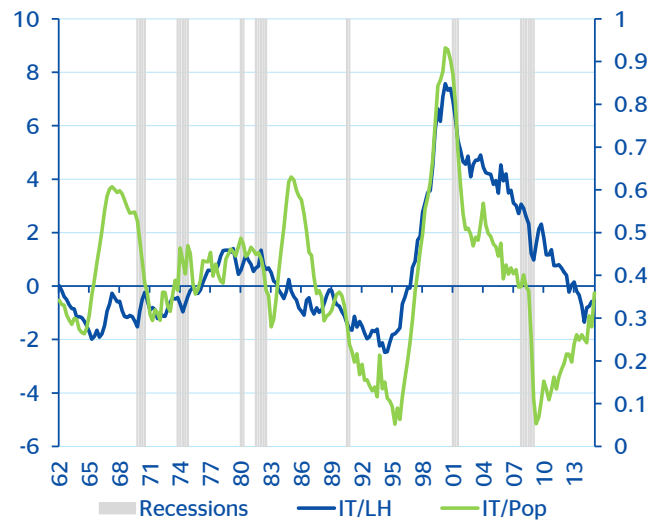
Similar to productivity itself, the IT expenditures component of U.S. investments also has a dominant cyclical component. However, splitting the cyclical competent of IT from the long-term trend reveals quite a different outcome. While always dropping during the recessionary periods, IT has larger swings in comparison to U.S. business cycles. At the same time, the switch in the IT trend from the high-growth to low-growth state does not coincide with the dates of U.S. recessions and exhibits several more high-growth episodes than does the productivity trend. Both per capita and per labor measures of IT trend are currently in a high-growth state.

Chart 3
Probability of High-Growth State of IT Trend
(%)



Source: BBVA Research

Chart 4
Cyclical Component of IT
(%)



Source: BBVA Research

[2] James A. Kahn and Robert W. Rich from Federal Reserve Bank of New York Research Department, draw on growth theory to identify variables other than productivity, such as consumption and labor compensation, to estimate trend productivity growth in "Tracking the New Economy: Using Growth Theory to Detect Changes in Trend Productivity," *Journal of Monetary Economics*, 2007.

Does Digitization Distort Measures of Productivity?

While economic theory regards technology as an input that integrates capital and labor to produce output, technology today has a more comprehensive role in production than merely being an integrating factor. Technology creates new resources. It also creates a downward bias on monetary measures of existing resources and is feared to cause structural displacement of labor. Both the decline in the price of labor as well as the substitution of labor by capital, the price of which has also declined, are found to be the cause of the decline of labor share– the portion of current-dollar output remitted to labor.

Digitization and Labor: The digital era has put downward pressure on wage growth as both automation and globalization have heightened competition for jobs. Digitization has prompted globalization of labor, creating an economic system where the mobility of labor has increased due to the increasing ability to work globally without the need to relocate. Studies confirm that the factors of production are becoming increasingly mobile and can be moved to labor's location with low friction costs. Additionally, technological advancement has prompted automation, advancing the economic system to a point where intelligent machines are comparatively cost effective and can replace low-skill labor. Studies illustrate that the decline in the price of computers and industrial robots has led firms to invest more in technology and less in the size and remuneration of the labor force.[3] As a result of the trend toward globalization and automation, the numbers of jobs in the tradable sector are stagnant while saturated domestic labor markets compete globally for the non-tradable sector jobs.

Digitization and Capital: Increasingly, the dividing line between technology and capital as two separate factors of production is fading. Technological advancements in information technology and "gadgetization" have created a new category within capital – digital capital. The specifics of digital capital are the opposite of the traditional economic assessment of physical capital since the cost of ownership of many types of digital capital is very low. More and more, many goods, services and processes are becoming codified and, once codified, can be digitized, replicated, and shared around the world at low cost. The prospects for digital capital are for it to grow into a resource that is abundant, has low marginal costs and is fundamental for all industries. Continuing substitution of physical capital with digital capital in aggregate will result in permanent reductions firms' investment expenditures and downward pressure on the price of capital.

What the Future Holds: Economists Disagree

Economists studying productivity and innovation are divided. Prominent economists like Larry Summers,[4] who popularized secular stagnation theory, and Robert Gordon[5] are very much at odds with pro-Silicon Valley economists' views on productivity and growth. The pro-Silicon-Valley stance is that despite current stagnant productivity growth rates, a steep pick-up in productivity is on the horizon. The co-founder of MIT's Initiative on the Digital Economy, Erik Brynjolfsson[6] assesses that the electronic age and the internet have created an abundance of innovation that can reach the globe through already established internet networks and that can be

[3] Loukas Karabarbounis and Brent Neiman, University of Chicago, "The Global Decline of the Labor Share," *The Quarterly Journal of Economics*, 2014, 129: 61-103
[4] Lawrence H. Summers is the Charles W. Eliot University Professor and President Emeritus at Harvard University. He served as the 71st Secretary of the Treasury for President Clinton and the Director of the National Economic Council for President Obama.
[5] Robert J. Gordon is the Stanley G. Harris Professor of the Social Sciences at Northwestern University. He has written extensively about the problems of economic growth. He has authored hundreds of scholarly including: "Is US Economic Growth over? Faltering Innovation Confronts the Six Headwinds," (NBER Working Paper No. 18315; 2012) and "Why Innovation Won't Save Us" (Wall Street Journal, December 21, 2012).
[6] Erik Brynjolfsson is Schussel Family Professor of Management Science at the MIT Sloan School of Management and Co-Founder of MIT's Initiative on the Digital Economy.

digitalized and copied at near zero cost.[7] The pro-Silicon-Valley economists also argue that while we live in the economics of abundance, we refuse to pay for the digitalized services and products, thereby creating a measurement problem for GDP and productivity growth. This view is well summarized by Varian, Google's chief economist, stating that "the U.S. doesn't have a productivity problem, it has a measurement problem." [8] Brynjolfsson estimates that GDP as it is currently measured misses over 300 billion dollars per year in free goods and services on the Internet.

On the other hand, influential macroeconomist Gordon, who has devoted most of his academic life to studying productivity, is an outspoken representative of the opposite camp and has a contrary assessment of the future of the U.S. He is certain that the past discoveries of electricity, heating and the internal combustion engine have been "infinitely more important for boosting productivity and enhancing living standards than anything produced by the dot.com boom" and the new digital era.[9] Most importantly, he predicts that the contributions to productivity from the technological advancements of the last few decades and of the near term future will be reduced because of existing structural headwinds, such as demographics, education, debt, and inequality.

Bottom Line

The digital era has already resulted in a significant increase in the quality of numerous products and services while also being coupled with a downward pressure on prices. Some will argue that "maybe our mysterious productivity gain is in the form of less inflation than we deserve." [10] Additional economic efficiencies in production and resource allocation are likely to soar from digitization, the utilization of digital information, and from big data processing. Digitization has an uneven impact across countries and industry sectors and can result in deepening income inequality with primarily higher rewards and economic opportunities for the higher skilled and more educated portions of the labor force. In the long-run, the growing economic importance of automation coupled with increased resource mobility due to rapid globalization and technological advancements will keep labor compensation growth subdued. Thus, while a boost to long-term growth will arise from richness in innovation and from a continual increase in the quality of products and services, it is also true that demographics, education and growing income inequality will continue to restrain productivity growth. Overall, policies that yield higher returns from education and workforce training, encourage innovation, deepen inclusive information and communication technologies infrastructure, and promote both private and public capital and telecommunication investment can potentially have a high impact on future living standards.

[7] Erik Brynjolfsson's TED "The Key to Growth? Race with the Machines" (February, 2013) https://goo.gl/GIMefy
[8] "Silicon Valley Doesn't Believe U.S. Productivity is Down," The Wall Street Journal, July 16, 2015
[9] Robert Gordon TED "The Death of Innovation, the End of Growth" (February, 2013) https://goo.gl/joNX6j
[10] Andrew Mcafee, Co-Founder of MIT's Initiative on the Digital Economy, "Silicon Valley Doesn't Believe U.S. Productivity is Down," The Wall Street Journal, July 16, 2015