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Where has all the productivity growth gone?

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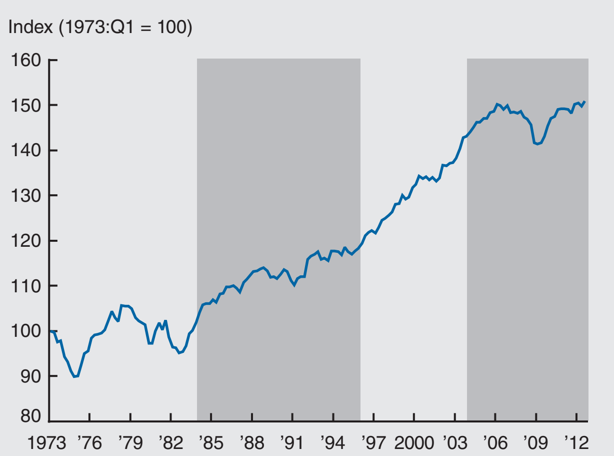
The productivity of an economy is a measure of the efficiency with which that economy uses its resources—such as its labor and investments in capital—to produce valuable goods and services. Productivity is important because growth in the amount of goods and services produced for a given amount of labor and capital is the ultimate determinant of growth in living standards in an economy over time.

In this *Chicago Fed Letter*, we describe the recent behavior of productivity in the United States and in other advanced economies around the world. We show that there has been a dramatic reduction in the rate of growth of productivity across almost all advanced economies over the past ten years. Moreover, this reduction began prior to the onset of the global economic crisis and, hence, it appears to reflect a fundamental decline in the rate of growth of efficiency of economies, not simply declines in factor utilization.

1. U.S. multifactor productivity growth, 1973–2012



SOURCE: Fernald (2012).

We discuss a number of alternative hypotheses for the decline in productivity growth and argue that one prominent hypothesis—that the decline results from the exhaustion of efficiency gains due to the incorporation of new information and communications technologies (ICT)—is unable to explain the simultaneous decline across all advanced economies.

U.S. productivity growth

Although productivity is a simple enough concept to describe, its measurement can be quite complicated. One measure that is easy to compute is *labor productivity*, which simply compares the value of output produced by an economy with the amount of labor input (for example, hours worked, possibly adjusted by some measure of the skills of the labor force) used to produce it.

Labor productivity, however, does not take into account the impact of changes in an economy's deployment of other factors of production, such as its investments in capital. Consequently, it is useful to examine *multifactor productivity*, which combines estimates of labor inputs with estimates of other factors of production, such as capital, in proportion to their importance in production.

Measures of multifactor productivity growth are available from many sources and vary according to how the inputs of different factors of production are measured, as well as how they are combined. One particularly good recent measure was presented by Fernald (2012)[1] and is available at a quarterly frequency. A strength of the Fernald measure is that it pays particular attention to differences in the type and quality of factor inputs, combining data on 13

2. U.S. multifactor productivity growth, 1996–2011

	Quarterly estimates			Annual estimates				
		Fernald			Fernald			
	Naive	Unadjusted	Utilization adjusted	Naive	Unadjusted	Utilization adjusted	BLS	Conference Board
1996–2004	2.34	1.72	1.52	2.34	1.69	1.59	1.75	0.84
2004–present	0.94	0.45	0.28	1.08	0.30	0.06	0.49	0.17

NOTES: Annualized log differences. Quarterly estimates compare 2012:Q3 with 2004:Q1 and 2004:Q1 with 1996:Q1. Annual estimates end in 2011 except naive data, which end in 2010.

SOURCES: Naive estimates constructed by authors using data from Ohanian and Raffo (2011) and the Organisation for Economic Co-operation and Development (OECD), *Quarterly National Accounts*, as described in the appendix. Utilization-adjusted and unadjusted total factor productivity for U.S. business sector from Fernald (2012). U.S. Bureau of Labor Statistics (BLS) multifactor productivity data, available at www.bls.gov/mfp/; and Conference Board data from The Conference Board, 2012, *Total Economy Database*™, January, available at www.conference-board.org/data/economydatabase/.

different types of capital and weighting the efforts of different workers by a measure of skill derived from wage data constructed by researchers at the Chicago Fed.[2]

Figure 1 plots Fernald's measure of the level of multifactor productivity of the U.S. business sector (i.e., excluding general government and household production) quarterly from 1973 to 2012. The data are scaled so as to equal 100 in 1973:Q1. The figure identifies four distinct periods of productivity growth. The first is the ten years beginning in 1973, which corresponds to the well-known productivity slowdown of the 1970s. This was succeeded by a period of modest growth of productivity that continued into the mid-1990s. In the third period, multifactor productivity growth increased again to 1.7% per year.

The fourth and final period shows a dramatic decline in the rate of growth of multifactor productivity to about 0.5% per year. This period begins somewhere around 2004, in advance of the Great Recession. The Great Recession is associated with a large temporary drop in the level of multifactor productivity, reflecting the fact that both labor and capital were underutilized during the recession.

As noted earlier, measures that differ in their calculation of labor or capital will give different estimates of multifactor productivity growth. Is the recent productivity growth slowdown merely an artifact of this particular measure? Figure 2 presents results for a number of different measures and shows that the slowdown in growth after 2004 is robust across a range of different estimates of multifactor productivity.

The first three columns present results using quarterly data. The first column presents an estimate that we calculated using aggregate data on hours worked and capital and combined input growth using the observed factor share for labor as in Solow (1957).[3] We refer to this as a "naive" measure, because we do not control for differences in labor quality or capital inputs. The next two columns present the estimates of Fernald (2012) depicted in figure 1, along with another estimate that controls for differences in capacity utilization. All three measures generate a significant slowdown in multifactor productivity growth, with the slowdown only slightly smaller for both of the Fernald measures. Importantly, controlling for the decline in factor utilization during the Great Recession does not alter the basic picture of a fundamental decline in productivity growth.

The remaining columns present estimates using annual data, including annualized versions of the first three measures, as well as a series constructed by the U.S. Bureau of Labor Statistics (BLS) and another put together by The Conference Board and the Groningen Growth and Development Center. Again, all five annual measures depict a similar productivity growth slowdown.

What can explain the recent productivity slowdown? One widely cited explanation (see, e.g., the literature reviewed by Oliner, Sichel, and Stiroh, 2007)[4] is that the increase in productivity growth that started in the mid-1990s, as well as the decline in growth that followed, were both driven by the process of adoption of new information and communications technologies (ICT). According to one version of this story, the development of new ICT induced firms in all sectors to invest in the organizational capital required to take advantage of these new technologies. As much of the accumulation of organizational capital is intangible and not measured as investment, measured productivity growth is initially lowered as resources are diverted to this unobserved investment. Later, measured productivity grows as firms benefit from the extra organizational capital. As investments in ICT began in the early 1990s and peaked in about 2000, the lags in this process could explain the faster multifactor productivity growth between 1995 and 2004, and the slow growth thereafter.

If this hypothesis is correct, we would expect to see different patterns in countries that have different histories of ICT adoption. To test this, we review the experience of other advanced economies during this period.

Productivity growth in the developed world

In order to eliminate differences resulting from different methodologies, we use estimates of multifactor productivity growth produced by The Conference Board using the same method for a large number of countries. Figure 3 collects data for 21 advanced economies and compares growth rates over the 1990s with those from the 2000s. As shown in the figure, in 20 of the 21 countries, multifactor productivity growth rates were lower in the 2000s than in 1990s. Furthermore, in 14 countries, multifactor productivity growth rates in the 2000s were negative.

Although the levels of productivity growth are affected by the Great Recession, the productivity growth slowdown is not. Figure 3 also presents estimates of multifactor productivity growth for the period 2000–06, prior to the Great Recession. Compared with the 1990s, productivity growth was lower in this period for 18 countries and negative for eight countries.

The common productivity growth slowdown across countries suggests a common cause. Could intangible investments in organizational capital that are complementary to ICT explain the global

3. Developed world multifactor productivity growth, 1990–2010

	Annual % growth			Annual % growth	
	1990–2000	2000–10	Difference	2000–06	Difference
Australia	0.69	–0.71	–1.40	–0.56	–1.25
Austria	1.29	0.59	–0.70	0.78	–0.51
Belgium	0.46	–0.50	–0.96	–0.28	–0.74
Canada	0.28	–0.52	–0.80	–0.18	–0.46
Denmark	0.41	–0.39	–0.80	0.17	–0.24
Finland	1.83	0.31	–1.52	1.15	–0.68
France	0.38	–0.41	–0.78	0.12	–0.26
Germany	1.25	0.41	–0.84	0.93	–0.32
Greece	0.12	–0.95	–1.07	0.32	0.20
Ireland	2.59	–0.86	–3.44	–0.21	–2.79
Italy	0.53	–0.85	–1.38	–0.70	–1.23
Luxembourg	0.94	–0.76	–1.70	0.26	–0.68
Netherlands	0.70	0.16	–0.54	0.47	–0.23
New Zealand	0.23	–0.22	–0.44	–0.11	–0.33
Norway	1.87	–1.03	–2.90	0.11	–1.76
Portugal	–0.12	–1.23	–1.11	–1.48	–1.36
Spain	–0.07	–0.80	–0.73	–0.74	–0.67
Sweden	0.87	0.53	–0.33	1.68	0.82
Switzerland	–0.02	0.34	0.36	0.57	0.59
United Kingdom	0.83	–0.01	–0.84	0.65	–0.18
United States	0.70	0.39	–0.31	0.63	–0.07

NOTE: Annualized log differences.
SOURCE: Authors' calculations, based on data from The Conference Board (2012), cited in figure 2.

productivity slowdown? Recall that, for the U.S., ICT investment accelerated in the early 1990s and peaked in 2000 (according to data from The Conference Board, ICT capital grew on average by 13% per year in the U.S. in the 1990s, peaking at almost 19% in 1999, and by only 8% per year in the 2000s). This could explain the observed patterns in multifactor productivity growth, if one postulated a lag of four to five years between observed investments in ICT and the delayed effect of unobserved complementary organizational capital accumulation.

The relationship between ICT investment and productivity growth in other developed economies differs substantially. Some countries—like Australia, New Zealand, Canada, Spain, Norway, Germany, France, and Belgium—experienced a productivity growth slowdown, despite the fact that their ICT capital continued to grow strongly throughout the 2000s. Of those countries that experienced a slowdown in ICT investment in the 2000s, some—like Greece and the Netherlands—follow the U.S. pattern, while in others—like Sweden—multifactor productivity continued to grow long after ICT capital growth peaked. In some countries—like Denmark, Finland, Ireland, and Italy—the productivity growth slowdown either coincides with or precedes the peak of ICT investment.

The lack of a stable relationship across countries between ICT capital growth and productivity growth does not eliminate unmeasured investments in ICT-complementary capital as a possible cause of the slowdown—differences in the deflation of ICT investment across countries, the size of the ICT sector, or the incentive to invest in complementary technologies might explain some differences in its observed relationship to productivity growth. However, the onus is on researchers to establish that the cross-country variations in the relationship can be explained by these national differences.

Where has all the multifactor productivity growth gone?

If unmeasured investments in ICT-complementary capital are not the explanation for the fast productivity growth of the 1990s and the ensuing slowdown of the 2000s, then what explains the slowdown? Does the productivity slowdown presage a period of low growth in living standards?

It is possible that the current slowdown is a short-term aberration, and that as the advanced economies emerge from this period of economic crisis, faster productivity growth will also reemerge. If not, then it is tempting to revisit explanations that were proposed for the 1970s productivity slowdown. Is it perhaps simply a problem of measurement related to the increasing share of the economy devoted to services—in particular, business and financial services—for which it is difficult to measure output (and, hence, productivity)? Or is it perhaps due to a more widespread problem with the measurement of intangible investments (see, e.g., Aizcorbe, Moylan, and Robbins, 2009)?[5] Alternatively, might it be due to the exhaustion of the gains from the information technology revolution? Or to declines in the quality of education and, hence, the quality of the labor force? Or even to declines in government investments in infrastructure? Depending on the answer, slow *measured* productivity growth may be consistent with continued rising living standards or a period of stagnation in the developed world.

Appendix: Naive estimates of total factor productivity

The naive estimates of multifactor productivity growth presented in figure 2 are calculated as the percentage change

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in real gross domestic product (GDP) less the percentage change in capital, weighted by the capital share, and the percentage change in labor, weighted by the labor share in the corresponding period. The real GDP data are from the OECD. Retrieved from the OECD's online database, the OECD iLibrary (www.oecd-ilibrary.org), the data are seasonally adjusted quarterly levels, deflated using the seasonally adjusted national base/reference year series. Capital is calculated using the perpetual inventory method with a 2% quarterly depreciation rate. Real gross fixed capital formation data are from Ohanian and Raffo (2011).[6] The initial stock of capital is calculated as the average investment to GDP ratio for the first ten years of data, over the average of GDP growth for the first ten years of data, multiplied by real GDP. Total hours data are from Ohanian and Raffo (2011). Labor share is calculated as labor compensation, over the total of labor compensation and gross operating surplus. Labor compensation and gross operating surplus data are from the Bureau of Economic Analysis (BEA). Labor share data come from the BEA's *National Income and Product Accounts of the United States*. The capital share is calculated as 1 less the labor share.

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1 See John Fernald, 2012, "A quarterly, utilization-adjusted series on total factor productivity," Federal Reserve Bank of San Francisco, working paper, No. 2012-19, September.

2 See Daniel Aaronson and Daniel Sullivan, 2001, "Growth in worker quality," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 25, Fourth Quarter, pp. 53–74, available at www.chicagofed.org/digital_assets/publications/economic_perspectives/2001/4qepart5.pdf.

3 See Robert M. Solow, 1957, "Technical change and the aggregate production function," *The Review of Economics and Statistics*, Vol. 39, No. 3, August, pp. 312–320.

4 See Stephen D. Oliner, Daniel E. Sichel, and Kevin J. Stiroh, 2007, "Explaining a productive decade," Finance and Economics Discussion Series, Board of Governors of the Federal Reserve System, working paper, No. 2007-63, August.

5 See Ana M. Aizcorbe, Carol E. Moylan, and Carol A. Robbins, 2009, "Toward better measurement of innovation and intangibles," *Survey of Current Business*, Bureau of Economic Analysis, Vol. 89, No. 1, January, pp. 10–23.

6 See Lee E. Ohanian and Andrea Raffo, 2011, "Aggregate hours worked in OECD countries: New measurement and implications for business cycles," National Bureau of Economic Research, working paper, No. 17420, September.