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Top of Mind

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Picking Apart the Productivity Paradox

From the editor: US productivity growth has been strikingly low over the past decade despite a seeming explosion of technological progress and innovation. Economists have debated this paradox for years: Is subdued productivity growth a sign of stagnation or just a case of measurement error? Rising pressure for the US to carry global growth—even amid softer domestic data and a stronger dollar—has made this question Top of Mind. We feature opposing views from Northwestern University colleagues Robert Gordon (the best innovations are behind us, and productivity growth will likely remain low) and Joel Mokyr (official statistics don't adequately capture recent innovation, and the sky is the limit on technological progress). Jan Hatzius offers his own conclusion that IT-related measurement error could be playing a large role in the apparent productivity slump. Finally, we drill down into two areas with promise for incremental productivity gains—commodities, and industrials companies on the Internet of Things (IoT) frontier.

Source: www.istockphoto.com

Inside

> "We're using software and computers now that are very similar to the ones we used ten years ago. So it is no surprise that productivity growth has been slower over this decade."
>
> **Robert Gordon**

> "[Weak productivity growth] looks inconsistent not just with everyday experience…but also with several aspects of current macroeconomic conditions… [A plausible hypothesis is] that a significant part of the slowdown reflects growing measurement error in the IT sector."
>
> **Jan Hatzius**

> "Product innovation has… [in my view] been particularly pronounced in the past 20 years. And if that's the case, productivity statistics systematically under-measure the rate of technological progress and its implications for economic welfare."
>
> **Joel Mokyr**

Editors: Allison Nathan | allison.nathan@gs.com | Marina Grushin | marina.grushin@gs.com
Macro Executive Committee: Jeffrey Currie | Jan Hatzius | Kathy Matsui | Timothy Moe | Peter Oppenheimer

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Picking apart the productivity paradox

Productivity growth in the United States, as in some other developed countries, has been strikingly low over the last decade despite a seeming explosion of technological progress and innovation. Economists have debated this paradox for years: Is subdued productivity growth—along with its stifling effects on wages, profits, and competitiveness—the new normal? Or do official measures of productivity simply fail to capture recent gains from innovation? With pressure rising for the United States to carry global growth—even amid softer domestic data and a stronger dollar—this question has become increasingly Top of Mind.

We begin by interviewing two outspoken voices on the topic—friends and Northwestern University colleagues Robert Gordon and Joel Mokyr. Gordon, an economist, believes productivity growth is faltering because society has exhausted the best benefits of innovation. In his view, productivity improvements in the modern era can hardly compare to breakthroughs like electricity, and are insufficient to outweigh demographic and other headwinds to economic performance. As such, he forecasts continued low productivity and GDP growth. Economic historian and techno-optimist Joel Mokyr disagrees, arguing that official statistics are out of step with the modern economy and often fail to account for tangible improvements in technology, medicine, and quality of life. He considers technological change a "tailwind of tornado strength" that can overcome even powerful economic headwinds.

We then turn to our Chief Economist, Jan Hatzius, whose research suggests that IT-related measurement error could in fact explain a sizable share of the apparent productivity slump. Among other things, this implies that inflation is even lower than the measured rate, supporting the case for continued accommodative monetary policy at the margin. More broadly, it affirms our sound long-run outlook for the US economy at a time when growth feels vulnerable.

How do we define productivity?

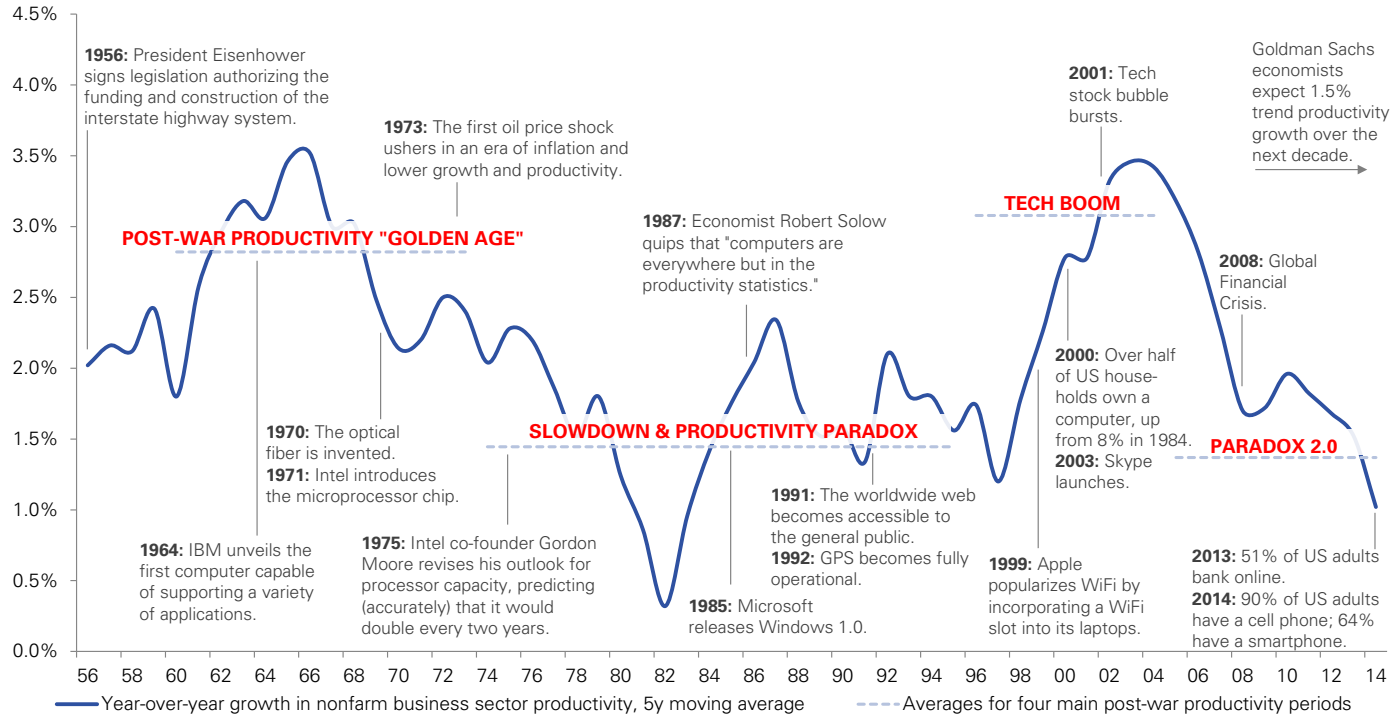
Productivity typically refers to productivity of labor, measured as output per hour of work or output per worker. Labor productivity growth is generally decomposed into contributions from improvements in the quality of labor (e.g., from educational attainment and skill development) and from the availability of capital (i.e., having more or better tools and equipment for workers to use). Any residual productivity growth that these measurable changes cannot explain is termed total factor productivity (TFP, sometimes referred to as multi-factor productivity or the Solow residual). The TFP contribution to labor productivity growth can represent gains from technological innovation, buildup of institutional knowledge, and better organizational management, among other things.

Looking beneath the macro level, we explore two areas of the economy with promise for incremental productivity gains. Senior Commodities Strategist Christian Lelong asserts that disciplined management and the pressure to cut costs should extend productivity growth in energy and mining well into the next decade, reinforcing our forecast of lower-for-longer commodity prices. And US Multi-Industry Analyst Joe Ritchie writes that industrials companies, the bulwarks of the "old economy," are in fact positioned to achieve substantial efficiency gains by adopting the Internet of Things (IoT). While obstacles to the industrial IoT revolution remain, the potential energy and cost savings are enormous—and give some reason not to despair over subdued productivity growth.

Allison Nathan, Editor

Email: allison.nathan@gs.com
Tel: 212-357-7504
Goldman, Sachs & Co.

Putting productivity growth in perspective



Source: BLS, Pew Research Center, US Census, PBS, various news sources, Goldman Sachs Global Investment Research.

Interview with Robert Gordon

Robert J. Gordon is Stanley G. Harris Professor in the Social Sciences and Professor of Economics at Northwestern University. His research focuses on inflation, unemployment, and productivity. He is an adviser to the Bureau of Economic Analysis and a member of the policy advisory panel of the Federal Reserve Bank of Chicago. A "techno-pessimist," he argues that the most transformative innovations are behind us, and continued weak productivity growth lies ahead.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.

Allison Nathan: Why has productivity growth stalled?

Robert Gordon: Let me put this in perspective. For the total economy, productivity growth was 2.7% from 1920 to 1970, 1.6% from 1970 to 1994, 2.3% from 1994 to 2004 during what we call the dotcom era, and just 1.0% from 2004 to the second quarter of 2015.[1] So the productivity growth of the last 11 years was not only slower than in the dotcom era, but even slower than in the so-called slowdown period beginning in the early 1970s.

The reason for the slowdown after 1970 is straightforward: we simply exhausted the productivity benefits of prior innovations. In the late 19th century, hugely important "general purpose" technologies, like electricity and the internal combustion engine, were invented. Then there were major developments in entertainment and communication in the form of the telephone, telegraph, radio, motion pictures and television. We made major breakthroughs in health. And we vastly improved working conditions. All of that came together between 1920 and 1970. The last three spin-offs of the great inventions—interstate highways, commercial air travel, and air conditioning in most businesses—were also largely complete by 1970. So at that point we had run through the productivity payoffs.

We have also now run through the payoffs of the digital revolution that followed. Between 1980 and 2005 there was a total transformation of business practices from paper and filing cabinets to flat screens and search engines. But that transition is over. And the temporary revival of productivity during the dotcom era was uniquely concentrated in a very short span, with remarkably few gains in productivity growth since. We're using software and computers now that are very similar to the ones we used ten years ago. So it is no surprise that productivity growth has been slower over this decade.

Allison Nathan: Are the productivity statistics simply failing to account for the impact of new technologies?

Robert Gordon: Many consumer benefits are clearly missing from the GDP statistics. But GDP has always suffered from this fault. For example, GDP completely failed to capture the transition from the horse to the motorcar and the enormous benefits that resulted from an environment free of horse manure droppings in the streets. If anything, I think a case could be made that what productivity statistics failed to capture in the first 50 years of the 20th century was larger and more important than what is missing now. At that time, we left out the benefits of conquering infant mortality; of going from the 60-hour work week to the 40-hour work week; of the new ability to travel with a car. In any case, what we're seeing now is more of the same: a general failure to translate new inventions into GDP, and therefore into productivity measures.

Allison Nathan: Should we be measuring productivity differently?

Robert Gordon: I think it's impossible to quantify the benefits of new inventions. Economists have done experimental work on specific inventions like tractors, and it is possible to come up with ballpark estimates. But quantifying those improvements has always been difficult. And the hypothetical measurement of the benefits of more recent inventions like smartphones and tablets is probably more difficult than most.

Allison Nathan: Could we be experiencing delays in seeing the effects of new technologies on productivity?

Robert Gordon: Yes, we could be seeing some of this dynamic. For example, the rollout of electronic medical records has been very slow even though we have had the necessary technology for a good 15 years. But the real delay happened in the early 2000s. Despite the sharp drop in the stock market and a tremendous collapse in high-tech investment from 2000 to 2003, productivity growth was very rapid throughout the whole decade from 1994 to 2004, reflecting the delay in learning how to make full use of the internet, which was first introduced in the early 1990s. My favorite example is the introduction of airport check-in kiosks, which took place between 2001 and 2005 using technology that had been invented a decade earlier.

Allison Nathan: You argue that recent technological developments don't hold a candle to the breakthroughs of the past. Are the world's best innovations truly behind us?

Robert Gordon: In my view, the inventions of the century from 1870 to 1970 utterly changed human life in a way that now is taken for granted. When you consider the immense progress in getting rid of disease, filth, manure; the advances in health with antibiotics and treatments for heart disease and cancer; the liberation of women from the chores of doing laundry with a scrub board; the transition away from steel workers working 12 hours a day, six days a week, there really is no comparison with the inventions taking place today. Smartphones and social networks are entertainment and not basic to human life. But "best" is subjective. Some people may think it is more important to have a social network than indoor plumbing.

Allison Nathan: Some would say that the productivity contributions of past inventions, particularly during the

[1] Note from GS Research: The figures cited here are for the overall economy; corresponding numbers for the US nonfarm business sector (the conventional measure) tend to run about 0.4 pp higher.

industrial revolution, did not properly account for environmental or other costs. What are your thoughts?

Robert Gordon: More than overstating productivity growth during the industrial revolution, I think we have understated the growth of productivity from 1970 to the turn of the 21st century when we had major improvements in air and water quality mandated by legislation. We have incorporated part of this clean-up into productivity statistics in a very subtle way by accounting for emissions control devices on auto engines. But most of the improvements in the environment are missing from GDP. That being said, the costs of current technology are probably lower than the costs of past industrialization, so these types of omissions are likely less prevalent today.

Allison Nathan: Are there any areas of innovation that hold substantial promise in your view?

Robert Gordon: Most of the excitement is centered on artificial intelligence and robots. Robots are nothing new. The first industrial robot was introduced by General Motors in 1961. Since then, robots have steadily replaced human labor in manufacturing, and they continue to create more rapid productivity growth in the manufacturing sector than in most of the service sector. Another place where robots are gradually appearing is warehousing. But they don't fetch individual items and bring them to a station for packing; they simply pick up an entire tier of shelves and bring it to a person who selects the right item and manually packs it. Developments in robotics have so far been unable to duplicate the actions of the human hand, even for many tasks that human beings do intuitively. So the gradual arrival of robots in the economy is very slow.

As far as artificial intelligence, computer technology has already steadily replaced human jobs. Think of the disappearing travel agent and reservation clerk, or, more recently, the legal associate. So there is a lot of excitement about technological change, but it is taking place at a very measured pace, especially to the extent that it is replacing human labor.

Allison Nathan: Will these innovations be sufficient to boost productivity?

Robert Gordon: Not meaningfully. I expect productivity growth over the next quarter-century of 1.2%, slightly above the 1.0% growth rate of the last 11 years but still below the 1.4% rate over the past 45 years if you take out the dotcom decade, which was an unusual period that I don't think will be repeated. That difference of 0.2% is the contribution of slower innovation compared to history. Keep in mind that this slowdown already occurred in the last ten years. So I am basically predicting more of the same, not some new arrival of stagnation.

Allison Nathan: How important is the pace of productivity to your overall outlook for US economic growth?

Robert Gordon: It's absolutely central. By definition, growth in real GDP is equal to growth in productivity plus growth in hours of work. The growth in hours of work is limited by population growth and growth in the number of hours that each member of the population works. The latter is going to be shrinking over the next 25 years due to the retirement of the baby boomers. So while US population growth should be about 0.8% per year, we can only expect growth in hours of work of 0.4%, much lower than what we observed in the latter part of the 20th century. Adding that to the 1.2% I expect for productivity growth, my projection for growth in real GDP is 1.6% a year. This is just the same as the last 11 years, but it is only half of the 3.2% growth rate we experienced from 1970 to 2004.

Allison Nathan: You seem skeptical of technological tailwinds and more focused on economic headwinds. Which headwinds concern you the most?

Robert Gordon: I see four main headwinds to economic growth. The first is rising inequality. Our winner-take-all society provides very high payoffs to the top rock stars, CEOs, lawyers, and so forth. And at the bottom, we have machines gradually but steadily replacing workers, and an erosion of manufacturing jobs from globalization and trade. So the gap between the very top and the mass of people in the middle and the bottom continues to widen inexorably. The second headwind is the end of the great expansion of education that brought Americans from completing only an elementary school education in 1900 to a great majority having a high school education by around 1970. There has been a gradual increase in the share of young people going to college, but the United States has fallen from its previous position of leadership in global education and now ranks about 16th among nations in the percentage of its young people completing a four-year college degree program.

The third headwind is the demographic shift I mentioned of baby boom retirement pushing down overall hours worked. And the final headwind, also related to aging, involves federal government expenditures on Social Security and Medicare increasing faster than the shrinking workforce's ability to provide the tax revenue to finance these benefits. This will eventually necessitate tax increases and/or benefit reductions, which will cause people's after-tax disposable income to grow even more slowly than their pre-tax income.

Allison Nathan: Does your outlook owe more to a measured pace of innovation or to these headwinds?

Robert Gordon: Quantitatively, the headwinds are more important. That said, there is a whole list of policies that would help address them, from a more progressive tax system and increased spending on pre-school education to massive immigration reform. And many of those proposals also deal with productivity by raising the quality of human capital.

Allison Nathan: You are often described as a "techno-pessimist." Is that a fair characterization?

Robert Gordon: I would certainly classify myself as a techno-pessimist. But, if you think about it, the terms techno-optimist and techno-pessimist belie the meaning of the words optimism and pessimism. Techno-"optimists" are predicting a future of massive technological unemployment with a quarter or half of the labor force unable to find jobs. Under the hood of their optimism, they are deeply pessimistic about the future of work. I think that technological change is proceeding slowly, just as it has over the past decade, which should allow us to keep our unemployment relatively low. So under the hood of my techno-pessimism, I'm very optimistic about the future of work. Where I see the real problem is not in finding a job for everybody, but in finding good jobs for people, and in dealing with the inevitable rise of inequality.

Productivity paradox 2.0

Jan Hatzius explains why official data likely overstate the slowdown in productivity growth

Economist Robert Solow famously said in 1987 that "you can see the computer everywhere but in the productivity statistics." At the time, labor productivity was growing at around 1½%, well below the 2½-3% pace seen until the early 1970s, and the measured contribution of information technology (IT) to GDP growth looked surprisingly small.

The Solow paradox was resolved over the following decade via a return of measured productivity growth to the pre-1970s trend and a sharp increase in the contribution of IT. But now the paradox seems to be back. Since 2005, labor productivity—i.e., real GDP per hour worked in the nonfarm business sector—has grown just 1.3% at an annual rate, with most of the renewed slowdown owing to a big drop in the measured contribution of IT. Over a period as long as a decade, we probably cannot blame much of the weakness on cyclical forces. We have therefore trimmed our assumption for the underlying trend in measured productivity to 1½%.

But is the weakness for real? It looks inconsistent not just with everyday experience, as per Solow's quip, but also with several aspects of current macroeconomic conditions—strong profits, low inflation, and a buoyant stock market. And there is a plausible alternative hypothesis that might explain the disconnect: that a significant part of the slowdown reflects growing measurement error in the IT sector. In theory, the IT contribution to growth might be understated either because of an inability to capture nominal GDP—e.g., because of shifts in retail distribution channels from malls to the internet that are only incorporated in official surveys with a lag—or because of an overstatement of IT price changes. In practice, price measurement is likely to be the more important issue. Specifically, we worry about three potential errors:

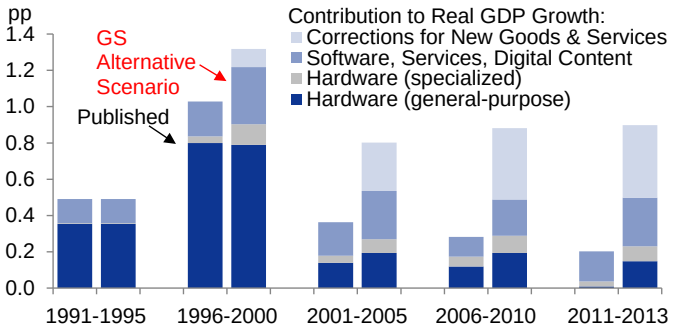
(1) A spurious slowdown in IT hardware deflation. An important recent study argues that much of the slowdown in measured semiconductor deflation since the early 2000s may reflect changes in industry structure, not a true slowdown in technological progress; similar issues may affect computer price measurement.[2] Further, the shift in US technology output from general-purpose products such as semiconductors and computers toward harder-to-measure special-purpose products such as navigational, measuring, electromedical, and control instruments may also have increased measurement error.[3]

(2) An increased GDP share of IT software and digital content. Measured prices in the software and digital products industries have been broadly flat for many years. One stark example is internet access. The official price index is basically flat, simply because the typical user still pays roughly the same monthly dollar amount for home internet access. There is no adjustment for the big increases in connection speeds or the availability of free internet access outside the home, let alone the fact that the expansion in online content makes "an hour of internet access" a much better product than it was a decade ago. This suggests that the true quality-adjusted price of internet access has been falling sharply. If this is a widespread problem in software and digital content, as we believe, the growing share of these industries in the economy has led to a growing understatement of real GDP and productivity growth.

(3) An increase in "new product bias" because of the proliferation of free digital products. Price indices do not always fully capture early-stage price declines and welfare gains associated with new products. Under normal circumstances, this "new product bias" can be minimized by including new products in the price index as soon as possible. But free digital products have no price and are never captured in the CPI, even though they may generate a substantial amount of consumer surplus (internet search is one example).

An alternative history

Contribution to real GDP growth (published and GS), pp



Source: Department of Commerce, Goldman Sachs Global Investment Research.

Our best estimates for the size of each of these biases suggest that IT-related measurement error may be holding down real GDP growth by a sizable amount, with a point estimate of 0.7pp per year now vs. only about 0.2pp in 2000. The corresponding downward bias on measured labor productivity growth in the nonfarm business sector—which accounts for about 75% of GDP—would be slightly larger at about 0.9pp now vs. 0.3pp in 2000. These estimates suggest that an increase in measurement error might explain a sizable share of the slowdown in consensus estimates of the underlying productivity trend from 2½% in the mid-2000s to barely above 1½% now. Our analysis has three main implications.

(1) Let's not despair. Our best estimate is that there has been some slowdown in productivity growth even after accounting for the potential measurement errors, but it may be far less dramatic than shown in the official data.

(2) Focus on employment, not GDP. Given the uncertainty around GDP, it is better to focus on other indicators to gauge the cumulative progress of the recovery and the remaining amount of slack. Workers are much easier to count than GDP.

(3) Another reason to keep policy accommodative. Our story implies that true inflation is lower than the already-low measured inflation rate. At the margin, this probably reinforces the case for continued accommodative monetary policy.

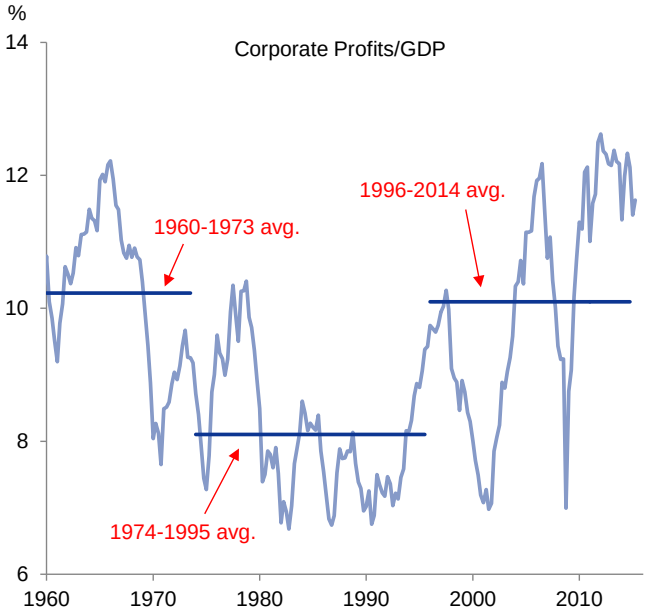
Jan Hatzius, Chief Economist

Email: jan.hatzius@gs.com *Goldman, Sachs & Co.*
Tel: 212-902-0394

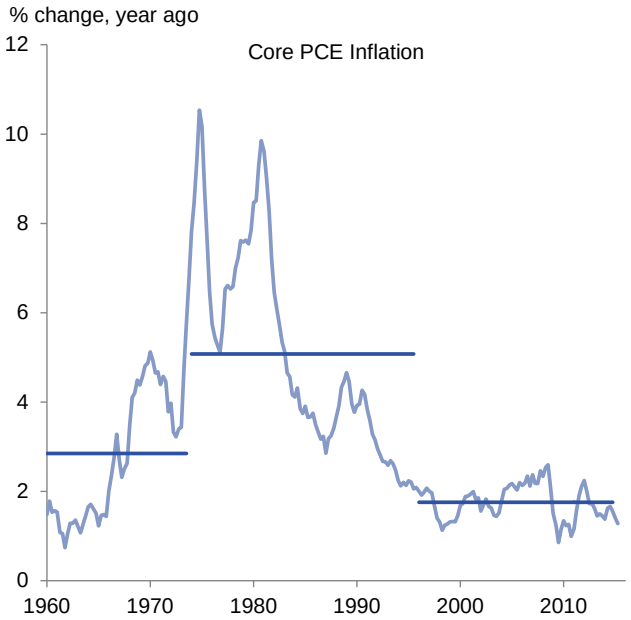
[2] David Byrne, Stephen Oliner, and Daniel Sichel, "How Fast Are Semiconductor Prices Falling?" NBER Working Paper No. 21074, April 2015.
[3] David Byrne, "Domestic Electronics Manufacturing: Medical, Military, and Aerospace Equipment and What We Don't Know about High-Tech Productivity," FEDS Notes, June 2, 2015.

Several aspects of the economic and financial environment over the last decade look quite different from the conditions that characterized the productivity slowdown of the 1970s. While these observations are not conclusive, it seems safe to say that neither the overall economy nor the technology sector is signaling a major IT-led productivity deceleration.

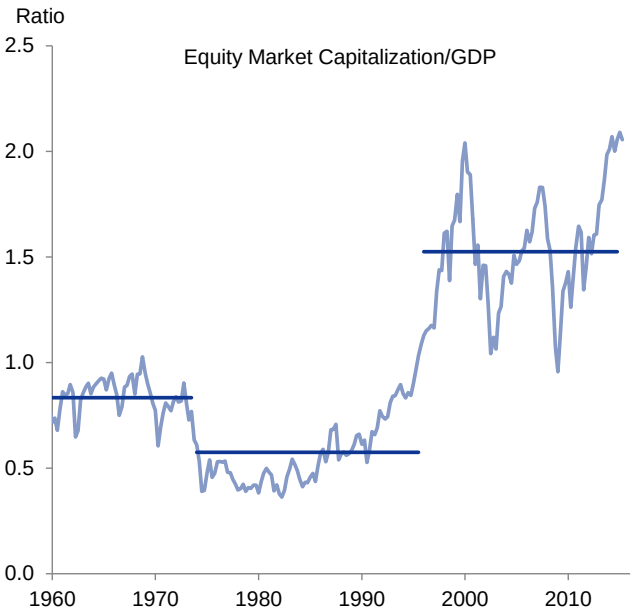
Corporate profits have been strong



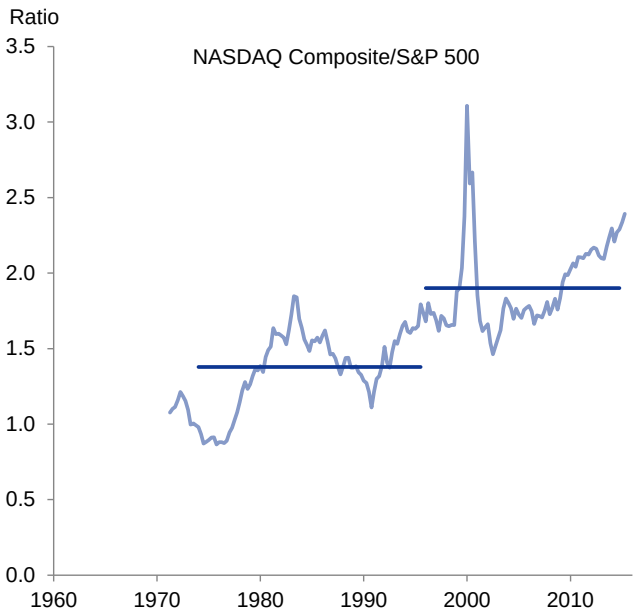
Inflation has remained low



Equity prices have surged



Technology stocks have outperformed

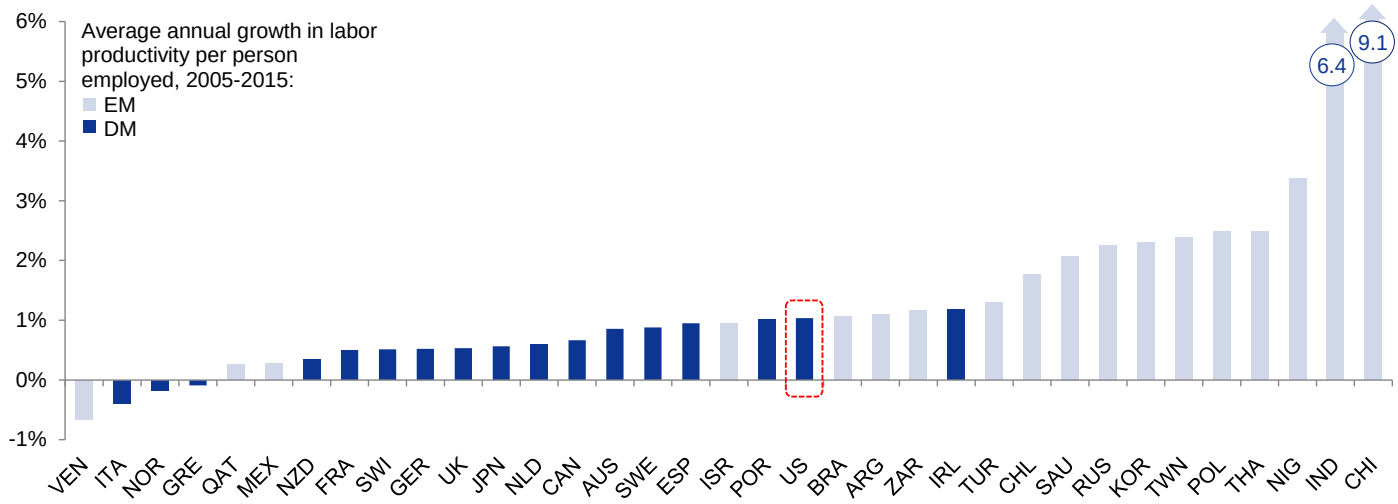


Federal Reserve Board. NASDAQ. Department of Commerce. Department of Labor. Goldman Sachs Global Investment Research.

Not just a US phenomenon

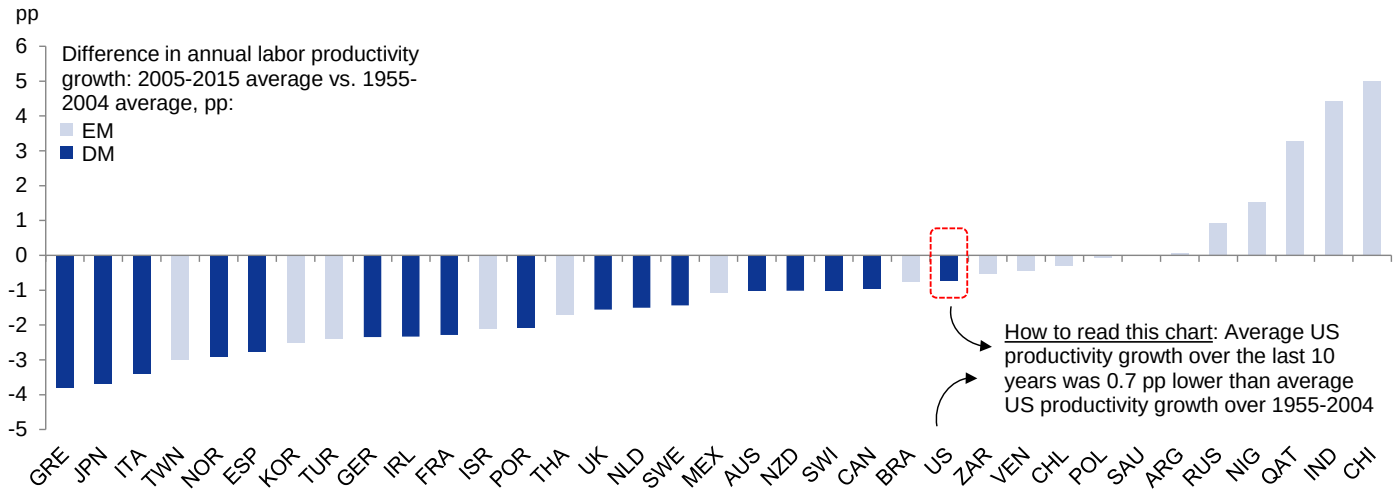
Paltry productivity growth across the developed world

Average annual growth of labor productivity per person employed, 2005-2015, %



Productivity growth in many countries has slowed even more than in the US

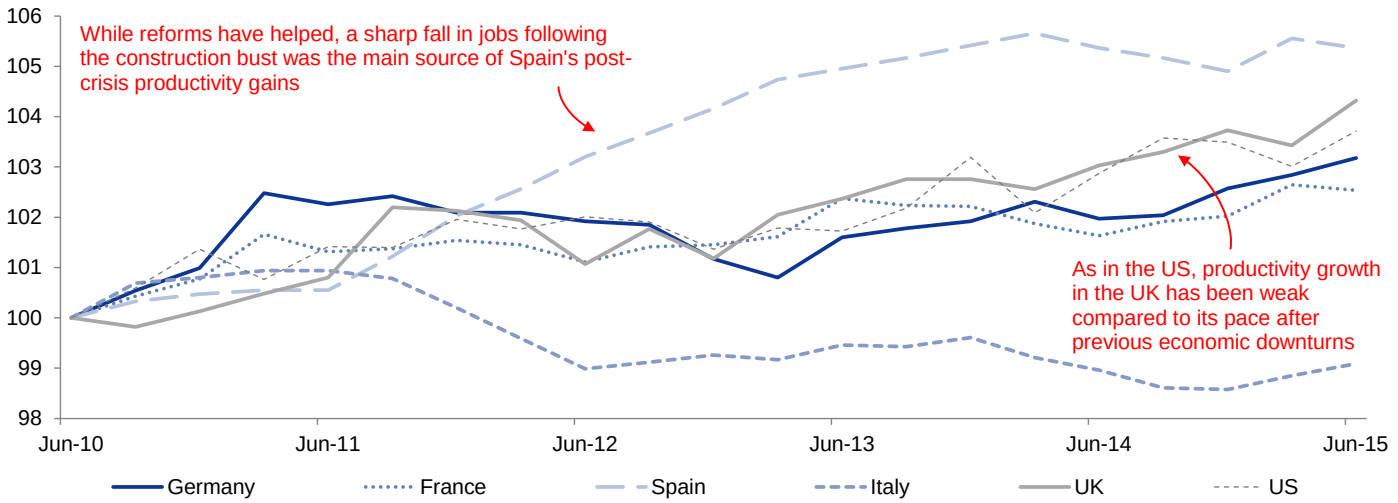
Difference in average annual growth of labor productivity per person employed, 1955-2004 period vs. 2005-2015 period, pp



Source for both charts above: The Conference Board. 2015. The Conference Board Total Economy Database™, May 2015, http://www.conference-board.org/data/economydatabase/, Goldman Sachs Global Investment Research.

Across the pond, recent productivity developments have been diverse

Productivity growth by country indexed to 100 at 1Q2010



Source: National statistics bureaus, Haver Analytics, Goldman Sachs Global Investment Research.
For more on Spain's recent productivity dynamics, see *European Economics Daily: The Spanish Productivity Puzzle,* September 2015.

Is the IoT the next industrial revolution?

US Multi-Industry Analyst Joe Ritchie explores the potential of the Internet of Things to transform industrial business models and, in turn, boost productivity

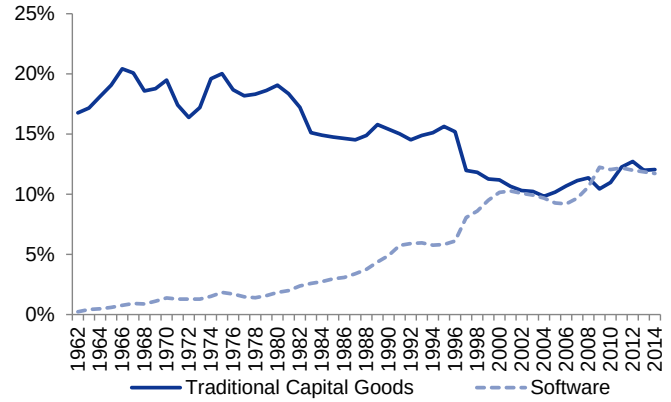
The Internet of Things (IoT) is taking shape as the next mega-trend for industrials. Industrial companies are recognizing the need to connect more devices to improve user experience, energy efficiency, remote monitoring, control of physical assets, and productivity (see *The next industrial revolution: Moving from B-R-I-C-K-S to B-I-T-S*, July 2014). Indeed, in the context of the current productivity paradox, IoT offers a potential solution to increase productivity both for industrial companies themselves as well as for their customers.

IoT will be pervasive throughout Industrials

We expect industrials will be one of the first sectors to adopt the IoT, accounting for $2tn of the $7tn IoT total available market by 2020. To this end, fixed investment growth is already moving towards software as opposed to traditional capital goods equipment. In our view, this shift creates new business models that more closely integrate hardware/ software offerings.

The next industrial revolution has already started

% of total investment in US fixed assets, software vs. cap goods



Source: BEA, Goldman Sachs Global Investment Research.

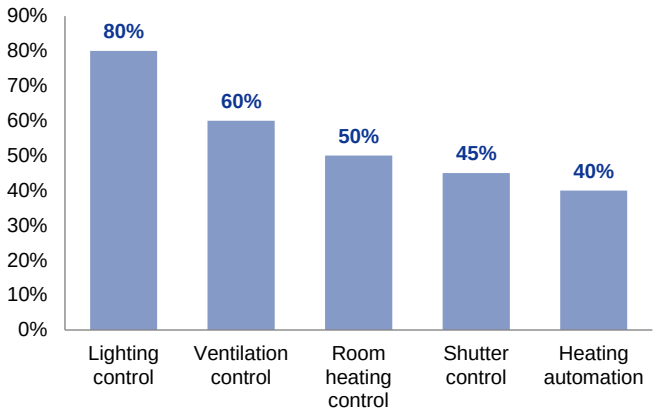
In turn, this new business model could offer a compelling value proposition by supporting higher recurring revenue streams and customer stickiness. For instance, GE monitors 50mn data elements from 10mn sensors on $1tn of managed assets daily and has begun leveraging its knowhow by licensing its IoT software, Predix, to its customers as well. By 2017, GE expects its IoT-enabled Predictivity™ solutions revenues to amount to $4-5bn from $0.8bn in 2013. Similarly, Cisco and Rockwell Automation have enjoyed a decade-long partnership resulting in over 50 jointly developed products that both companies believe will enhance higher-margin service revenues.

Enormous efficiency and cost savings are possible

A key attraction that the IoT presents for industrial companies is the potential to save energy and costs, both in manufacturing processes as well as in solutions offered to customers, which could meaningfully boost the sector's productivity. To the former, McKinsey estimates that the application of IoT could reduce maintenance costs by up to 25% and cut unplanned outages by 50%, while Rockwell Automation believes that IoT could yield 4-5% in productivity improvement annually. In fact, according to Rockwell, 82% of companies using smart manufacturing have seen an improvement in efficiency already. As it relates to customers, one area that we see at the forefront of IoT adoption is building controls. Buildings represent one of the largest sources of electricity consumption, and per ABB, building control systems usually offer >40% electricity savings potential to the user. However, only about 60% of corporations have actually invested in some form of energy management control, and most only through lighting controls, suggesting there is significant untapped potential.

IoT could help drive significant energy and cost savings

% of reduced energy consumption by building control type



Source: ABB.

But roadblocks remain to widespread adoption

While we believe IoT adoption represents an exciting shift by industrial companies to a more hybridized hardware/software business model that could have tangible impacts on productivity, several challenges remain to more widespread use. A key debate is whether IoT represents a clear, new profit pool or will simply become par for the course for industrial companies in the suite of products/services offered. A corollary to this concern is the emergence of new competitors to industrial companies (e.g., IT companies/service providers, tech companies). For instance, Apple's foray into the home automation market with HomeKit is a direct competing product to similar offerings from Honeywell and Ingersoll Rand. Further, universal networking standards have yet to be established, a situation that could lead to clashing ecosystems. This represents a potential constraint on adoption given 40% of the potential economic value of IoT will likely depend on interoperability (McKinsey). Privacy and security of data are also of paramount importance given that the vast amounts of data generated in industrial processes likely require analytics off-site from the production location. Lastly, industrial companies are also subject to investment cycles, and given the recent malaise in industrial capex spending, which we believe could last for a prolonged period, this could slow or limit IoT implementation.

Joe Ritchie, US Multi-Industry Analyst

Email: joseph.ritchie@gs.com *Goldman, Sachs & Co.*
Tel: 212-357-8914

What are the productivity stats missing?

Affecting productivity takes time

Dates of invention, commercialization (1%), and diffusion (50%)

Innovation	Year of Invention	US Household/ Business Penetration	
		1%	50%
Business Applications			
Steam Engine	1712	c.1830	c.1870
Electric Motor	1821	c.1895	c.1917
Telegraph	1830	1870s	N/A
Computer	1947	1960s	1997
Consumer Applications			
Telephone	1876	c.1890	1946
Radio	1895	1923	1932
TV	1920s	1949	1954
Computer	1947	1980	2000
Internet	1969	1991	2001
Mobile Phone	1973	1989	2003

Source: Department of Commerce, About.com, Atlantic Monthly, Goldman Sachs Global Investment Research. Special thanks to Andrew Tilton.

Innovation can go unmeasured

Select statistics on the productive value of internet and IT

Average extra time spent to answer a question in the absence of an internet search engine, according to a 2013 University of Michigan Study — **15 minutes**

$150 bn, or just under 1% of GDP — Value of time saved using internet search, as estimated by Hal Varian, Chief Economist at Google

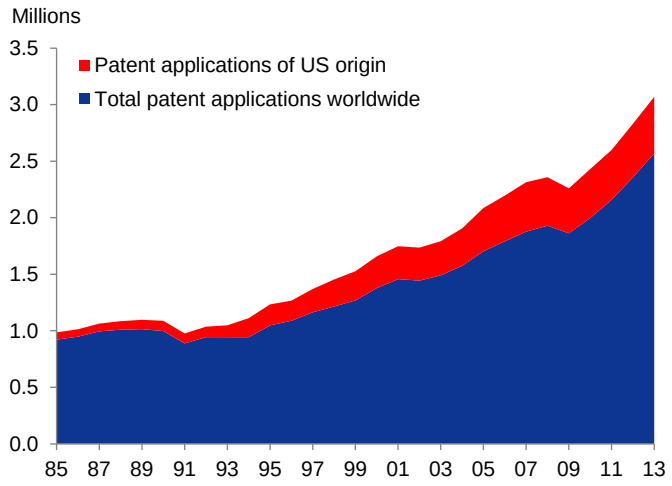
GS-estimated boost to US real GDP growth from adjusting for measurement error in the IT industry — **0.7 pp**

Note: First two figures are not GS estimates.

Source: Yan Chen, Grace YoungJoo Jeon, and Yong-Mi Kim, "A Day without a Search Engine," University of Michigan, March 2013. GS GIR.

Patents are piling up

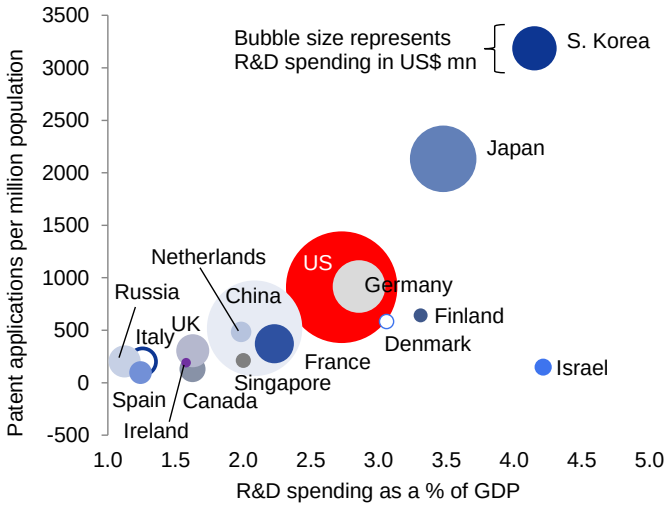
Annual patent applications, millions



Source: WIPO.

Innovative by international comparisons

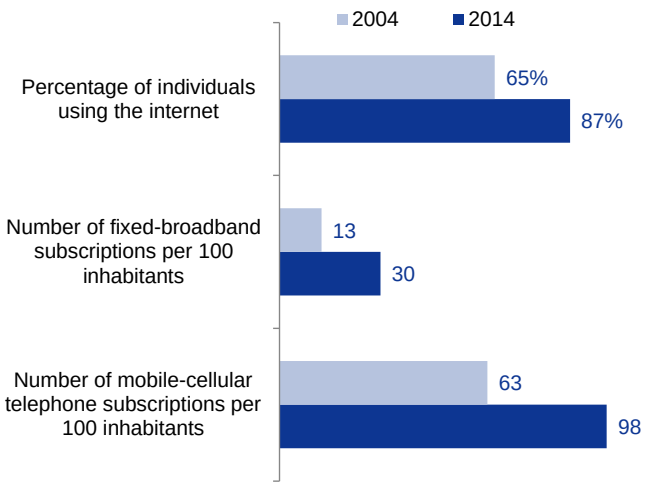
X axis: R&D spending as a % of GDP; Y axis: patent applications per million population; Bubble size: R&D spending in US$mn



Data from 2013/2014 or latest available. Source: OECD, WIPO, GS GIR.

Solid growth in online activity

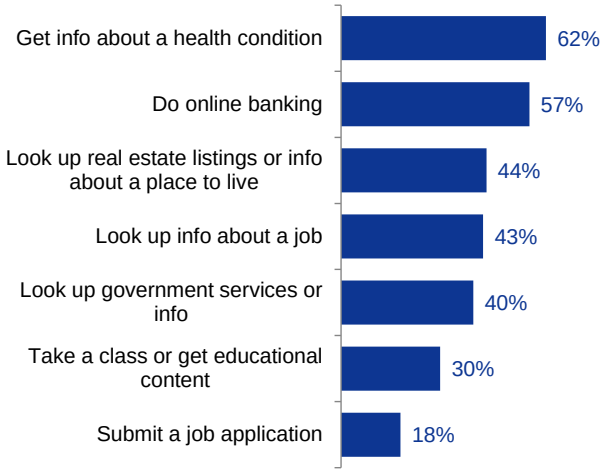
US internet and mobile penetration, 2004 and 2014



Source: ITU.

The mobile age of productivity

US smartphone owners who have used their phone in the last year to…

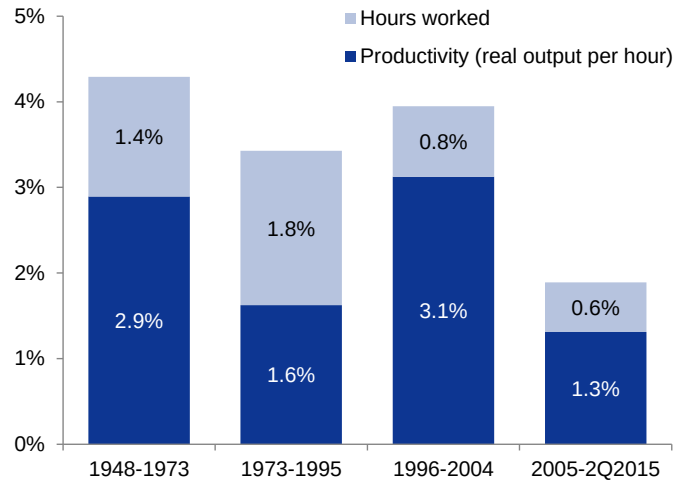


Source: Pew Research Center American Trends Panel Survey, October 2014.

US productivity in pics

Gone are the good old days

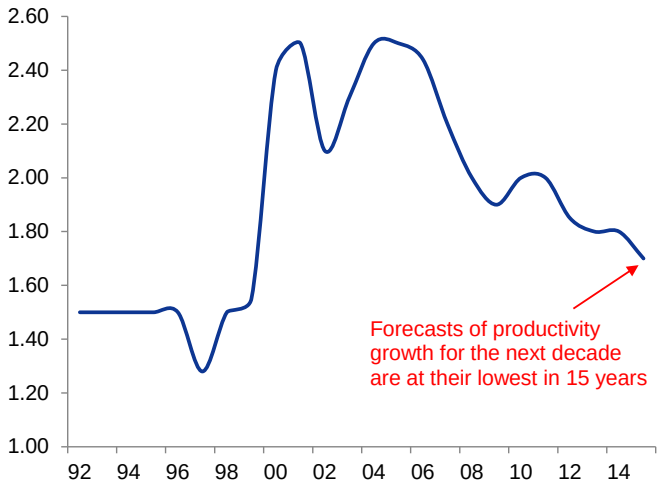
Contribution to growth in nonfarm business sector output, %



Source: BLS, Haver Analytics, Goldman Sachs Global Investment Research.

Falling expectations

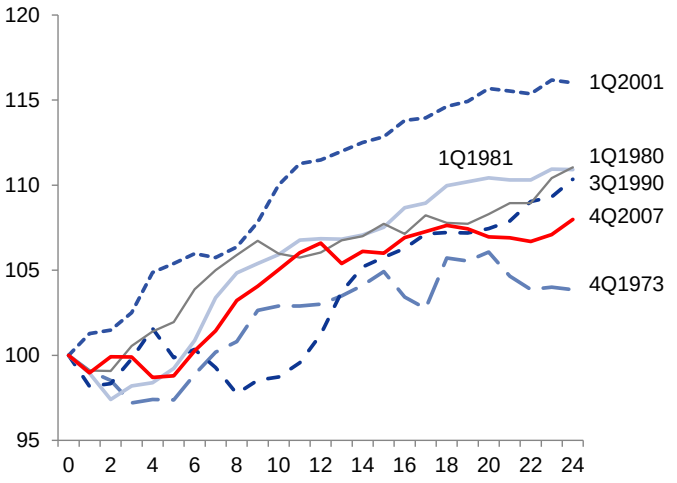
Median forecast for US productivity growth over the next 10 years, %



Source: Federal Reserve Bank of Philadelphia Survey of Prof. Forecasters.

An underwhelming recovery

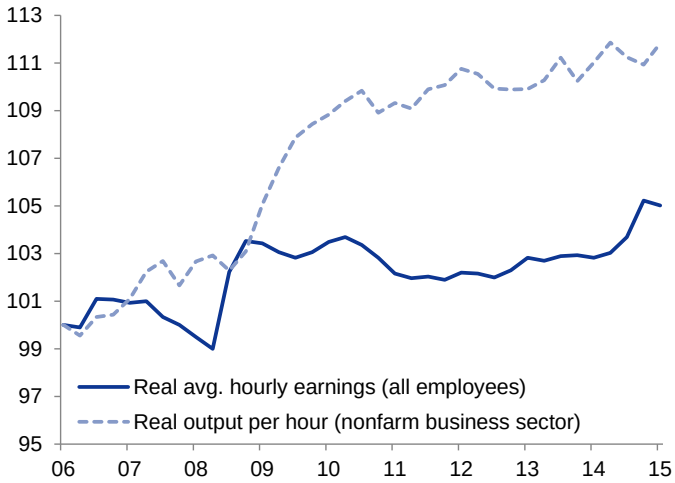
US output per worker indexed to 100 at each business cycle peak



Source: BLS, Haver Analytics, Goldman Sachs Global Investment Research.

Not so bleak—at least compared to wage growth

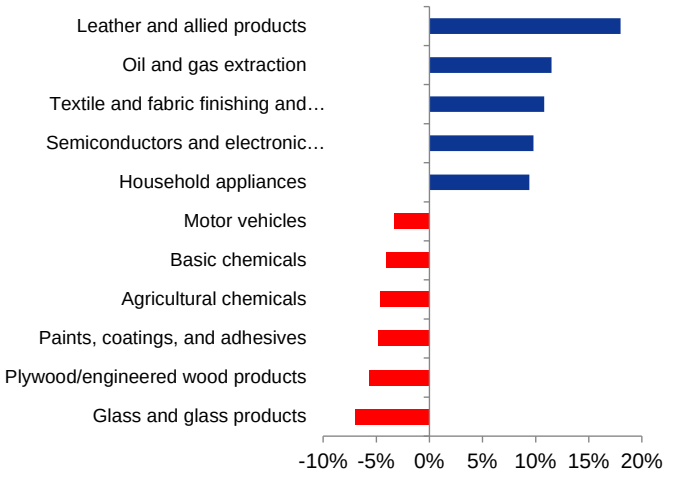
US real avg. hourly earnings and real output per hour, 2006=100



Source: BLS, Goldman Sachs Global Investment Research.

Manufacturing sectors pulling their weight (or not)

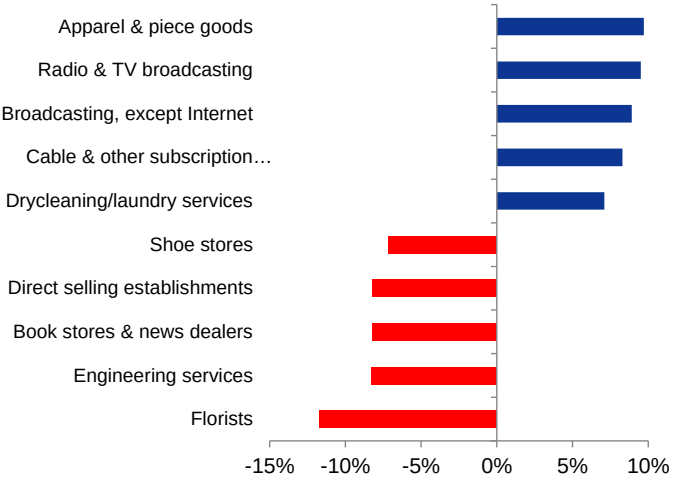
Change in output per hour (2013 to 2014) for manufacturing and mining sectors with the fastest/slowest productivity growth, %



Source: BLS, Goldman Sachs Global Investment Research.

Non-manufacturing sector highs and lows

Change in output per hour (2013 to 2014) for non-manufacturing/mining sectors with the fastest/slowest productivity growth, %



Source: BLS, Goldman Sachs Global Investment Research.