Special report: The new economy
A survey of the new economy
Solving the paradox
IT is making America’s productivity grow faster at last, but for how long?
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EIGHTEEN years ago *Time* magazine declared the computer “person of the year”. But as for so many people and firms feted on the front cover of magazines, this proved to be a curse: computers failed to live up their billing. In 1987, Robert Solow, a Nobel laureate in economics, famously said; “You can see the computer age everywhere but in the productivity statistics.” The failure of massive investment in information technology to boost productivity growth became known as the productivity paradox. In fact, productivity growth slowed sharply in most countries in the 1970s and 1980s. The surge in America's productivity growth since the mid-1990s has therefore been seized upon with relish. Has the productivity paradox now been solved?

This is no trivial question, for productivity growth is the single most important economic indicator. It determines how fast living standards can grow. The reason why the average American today is seven times better off than his counterpart at the turn of the century is that he is seven times as productive. And faster growth not only lifts living standards, it also boosts tax revenues and makes it easier to pay for tomorrow's pensions.

Spending on IT equipment and software now accounts for about half of all investment by American firms. So why has it taken so long for that investment to show up in faster productivity growth? History suggests that there were also long lags before both steam power and electricity boosted productivity. Work by Paul David, an economist at Oxford University, shows that productivity growth did not accelerate until 40 years after the introduction of electric power in the early 1880s. This was partly because it took until 1920 for at least half of American industrial machinery to be powered by electricity. But firms also needed time to figure out how to reorganise their factories around electric power to reap the efficiency gains.

Mr David suggests that a technology will start having a significant effect on productivity only when it has reached a 50% penetration rate. American computer use has reached the 50% mark only recently, and other rich economies still lag behind (see chart 5). That puts IT at roughly the same stage now that electricity had reached in 1920. Almost exactly on cue, growth in labour productivity in America's business sector has increased to an annual average of 2.9% since 1996, from an average of 1.4% in 1975-95 (see chart 6). In the year to the second quarter of this year, productivity surged by 5.2%.

But economists disagree on whether this increase in productivity growth is sustainable. To complicate things, there are two different measures on offer: labour productivity (output per man-hour), and total factor productivity (TFP, which takes account of the efficiency with which both capital and labour inputs are used). To most people, it is labour productivity that matters, because this is what ultimately determines living standards. Economists, though, get more excited about TFP growth, which they see as a costless way of boosting growth without increasing scarce inputs. Faster TFP growth automatically increases labour-productivity growth.

IT can boost growth in labour productivity in three ways: by increasing the amount of capital deployed per worker (ie, capital deepening), as firms invest in IT; by speeding up TFP growth in IT-producing industries, thanks to technical advances; and by increasing TFP growth in sectors that use IT. Nobody can deny that productivity in the sector that produces IT goods has surged, with growth in the 1990s averaging 24% a year. The disagreement is about the effect of IT on the rest of the economy.
Of the flurry of studies on the spurt in American productivity that have appeared over the past year, one of the most optimistic is by Stephen Oliner and Daniel Sichel at the Federal Reserve in Washington. It probably also comes closest to the current thinking of the Fed's chairman, Alan Greenspan. The two economists conclude that IT has been the key factor behind America's improved productivity growth, and they expect a substantial portion of it to persist. They estimate that nearly half of the acceleration in productivity growth between the first and second halves of the 1990s was due to capital deepening as firms invested in IT. The other half was due to faster TFP growth, of which two-fifths came from efficiency gains in computer production. The authors conclude that roughly two-thirds of the increase in labour productivity was due directly to the production of or investment in computers.

Another study, by Dale Jorgenson, at Harvard University, and Kevin Stiroh, at the New York Fed, reaches similar conclusions: heavy investment in computers and faster productivity growth in the computer industry have substantially boosted labour-productivity growth. However, the authors worry that although TFP growth outside the computer sector has increased, there is little evidence that this is linked to IT. Indeed, the sectors which have invested most in IT have generally seen smaller productivity gains. This could be due to measurement problems, but for the moment it casts some doubt on the argument that IT is boosting TFP growth throughout the economy.

Nevertheless, Messrs Jorgenson and Stiroh conclude that labour-productivity growth of around 2.3% a year could be sustained over the next decade. That would allow America's GDP to grow at an average rate of almost 3.5% a year without pushing up inflation, compared with an average growth rate of around 3% in the two decades to 1995.

Tools or toys?

However, Robert Gordon, an economist at Northwestern University and one of the most outspoken new-economy sceptics (a stance that requires considerable courage in America today), is less impressed by America's productivity "miracle" than other economists. He reckons that the entire increase in total factor productivity outside the computer sector is due to the economic cycle. At times of rapid growth, firms work employees harder, so productivity rises; but then it falls again in the next downturn. Moreover, he finds that after excluding the manufacture of all durable goods as well as of computers, there has been absolutely no increase in labour productivity in the remaining 88% of the economy, after adjusting for the cycle. Yet this is where most of the investment in computers has taken place. He concludes that the productivity paradox is alive and well.

Mr Gordon is not surprised that IT has failed to lift TFP growth throughout the economy. Computers and the Internet, he says, do not rate as an “industrial revolution”, as did electricity and the car. Much Internet activity, he argues, is merely a substitute for things that are already being done. For example, downloading music simply replaces buying a CD; it does not create new products, in the way that electricity prompted the invention of the vacuum cleaner and the fridge. Indeed, the Internet can even reduce productivity in the workplace. The traffic on many consumer-oriented websites, he notes, peaks in the middle of the working day, not in the evening.

The main reason why Mr Gordon's conclusions differ from those of other researchers is that he adjusts productivity growth for the effects of the economic cycle. This is a reasonable thing to try to do, because falling unemployment shows that output has been growing faster than trend. But many economists are unhappy about the way he has done it. They are convinced that at least part of the increase in productivity growth is structural, if only because it is highly unusual for productivity to accelerate so late in an economic boom. The usual pattern is for it to slow down at that point.

Mr Greenspan recently dismissed the notion that the increase in productivity growth is largely cyclical. He also argued that the underlying rate of productivity growth was still accelerating. A study by economists at the OECD seems to give his view some support. After adjusting for the economic cycle, it
concludes that labour-productivity growth and TFP growth both increased significantly in America in the 1990s.

A second point of difference is that Mr Gordon's test of the economic importance of IT—whether it has boosted TFP growth in sectors that use IT—is tougher than that of the other studies, which merely ask whether IT has lifted labour-productivity growth in the economy as a whole.

Why does the composition of the increase in labour-productivity growth matter? If faster labour-productivity growth is largely due to capital deepening, growth will remain high only if the price of IT equipment continues to fall. If technological progress in the IT sector were to slow, then overall productivity growth would be hit by a double whammy: the rate of TFP growth in the IT industries would fall, and the pace of investment in IT in the rest of the economy would slow.

However, scientists are confident that the rapid rate of innovation, and hence the fall in prices, will continue for at least another decade. If so, capital deepening will persist for some time. In any case, the split between capital deepening and TFP growth is very sensitive to the method of calculation. Using a wider measure of TFP, the OECD estimates that cyclically adjusted TFP growth has been growing faster in recent years than Mr Gordon suggests.

Mr Gordon's wider dismissal of IT is also somewhat unfair. He concentrates mainly on consumer use of the Internet, yet the biggest economic effect is likely to flow from B2B e-commerce. This has only just got going, so any productivity gains would not be expected to show up yet. And although IT may not yet have created many new products, it has opened up many new opportunities. Genetics and biotechnology, mobile phones, online auctions and financial derivatives would all be impossible without low-cost computer processing power.

The evidence from aggregate economic data may be mixed, but studies that look at individual firms suggest that computers have yielded substantial gains. In an analysis of 600 big American firms between 1987 and 1994, Erik Brynjolfsson at MIT and Lorin Hitt at the University of Pennsylvania found that investment in computers appeared to boost annual TFP growth by 0.25-0.5%. The productivity gains got bigger over longer periods, confirming that it takes time for firms to reorganise their business before they reap the full benefits of IT. Their research also shows that firms that coupled IT investment with changes in their organisational structure, such as decentralisation, enjoyed the biggest productivity gains from IT.

Messrs Brynjolfsson and Hitt argue that much of the benefit of IT comes in the form of improved product quality, time savings and convenience, which rarely show up in official macroeconomic data (see article). Microeconomic studies are able to identify these gains because firms whose products offer such intangible benefits will enjoy higher revenues.

Outside America, much less research has been done on the economic effects of IT. Comparisons are difficult because different countries use different methods to measure IT and to allow for quality improvements. All things considered, it seems likely that official figures underestimate European productivity growth relative to America's. IT investment rose strongly in all the G7 economies in the 1990s, but its contribution to growth is much less significant in Japan and most European economies than in America, largely because IT equipment accounts for a much smaller share of the total capital stock: only 3% in Japan and 7% in America.

By far the best international study has been done by Andrea Bassanini, Stefano Scarpetta and Ignazio Visco, at the OECD. They find that after adjusting for the economic cycle, annual TFP growth increased by at least half a percentage point in the 1990s in Australia, Canada and the Scandinavian economies as well as America, but it fell in Japan and the big European economies.

Ranking revolutions

America has invested more, and earlier, in IT than the other big economies, so the economic benefits would be expected to emerge there first. It is still too early to judge how IT lines up against previous industrial revolutions, but it is possible to compare some of the growth forecasts now being made for the next decade with actual growth rates during the eras of steam and electricity.

Suppose, optimistically, that America's average rate of labour-productivity growth in the late 1990s were to be sustained for the next couple of decades as IT and the Internet continue to transform the way
In fact, previous technological revolutions resulted in more modest rates of overall productivity growth than most people realise. In its prime years in the 19th century, the world’s first industrial revolution produced average labour-productivity growth in Britain of barely 1% a year. Electricity provided a bigger spark, with America’s labour-productivity growth in manufacturing jumping to more than 5% a year in the 1920s. But the productivity growth rate across the whole economy was a less impressive 2.3% (see table 8).

New-paradigmers who suggest that rates of productivity growth of 3-4% a year are sustainable for the next decade or so are really saying that IT will have a far bigger economic impact than electricity, telephones and cars. That is very ambitious. More likely, America’s long-term trend rate of labour productivity and hence per capita growth might be lifted to an annual 2.5%. That might not sound much, but it would make IT at least as significant as electricity.

Over the past 200 years, growth in GDP per head has gradually accelerated from 0.6% a year in 1800-40 to 2.3% in 1960-99 (see chart 9). A growth rate in GDP per head of around 2.5% over the next few decades would fit this trend. Paul Romer, the father of new growth theory, believes that the rate of growth has increased over time because of increasing returns to knowledge. Knowledge builds upon itself: the more that mankind discovers, the better it gets at the process of discovery. That rings true, but as Jack Triplett at the Brookings Institution points out, simply to keep productivity growth constant, the pace of introduction of new technology and new products needs to keep increasing.

The recent spurt in labour-productivity growth in America is almost certainly exaggerated by the current economic boom. But at the same time the official figures will probably understate the likely full effect of IT on the structural rate of productivity growth, for two reasons. First, official statistics significantly understate growth. Second, many economists believe that the Internet will trigger faster productivity growth by prompting firms to reorganise from top to bottom. Bigger gains may therefore lie in the future. But will they be big enough to justify the current level of share prices?