

It's taken a long time to confirm that computers boost productivity. But as **Nick Bloom**, **Raffaella Sadun** and **John Van Reenen** show, the key to their success seems to lie in management – and that's where US firms have been far more effective than their European counterparts.

It ain't what you do, it's the way that you do I.T.

What has been the impact of information and communication technologies (ICT) on productivity? This has been a burning question for policy-makers and business leaders for several decades. But it is only in recent years that computer power itself has enabled researchers to conduct the statistical interrogation of large-scale datasets on firms that can give us some more definitive answers. In this article, we report and synthesise some of the main messages emerging from this new line of research.

Perhaps the most intriguing finding comes from examining the use of ICT by global businesses. Multinational enterprises in general and US multinationals in particular appear to have higher productivity, and this seems to be linked to a distinct pattern in their use of ICT.

This fact may help unravel some of the puzzles in the macroeconomic data such as why the productivity acceleration witnessed in the United States since the mid-1990s has not been reflected in Europe. It may be that US firms have organised their management structures in a way that makes better use of ICT than their European counterparts.

We first set the historical scene over the last few decades, paying particular attention to the end of the paradox described by Nobel Laureate Robert Solow whereby computers were ubiquitous but seemed to have no effect on productivity. Then we discuss firm-level evidence on the impact of ICT on firm performance, focusing on the role of the organisational factors that make the difference between ICT projects being a success and failure. Finally, we delve into new research on the impact of ICT in multinationals.

The bottom line is that economists have confirmed what business leaders have long known: the returns to ICT are extremely variable and what makes the key difference is the management and organisation of the firm into which the ICT is placed.

The macro picture: Solow paradox lost?

Labour productivity – or output per hour worked – is the key indicator of material wellbeing as it allows sustainable income and consumption growth (which can be in the private sector or the public sector). Over the last 60 years, roughly three periods can be distinguished.

The first one, starting after the Second World War, was a period of strong

productivity growth in the developed world, interrupted in the mid-1970s after the first oil shock. Despite this slowdown in productivity growth, between the mid-1970s and the mid-1990s, Europe continued to catch up with US productivity levels and some countries even overtook the United States. This was the era of the 'Solow paradox': the observation that we could see computers everywhere except in the disappointing productivity statistics.

Since the mid-1990s, a new picture has emerged. The US economy experienced a rebound in productivity growth almost back to the levels seen between 1945 and 1973. Productivity growth continued to surge ahead even in the face of the bursting of the high-tech bubble in 2000 and the terrorist attacks of 9/11. By contrast, European countries did not have a productivity acceleration and the long catching-up process ground to a halt.

ICT matters for understanding the US 'productivity miracle'. Imagine we split the economy into three sectors: industries that intensively produce ICT (such as semi-conductors and computing); sectors that intensively use ICT (such as retail, wholesale and finance); and all other sectors in the economy. Surprisingly, it turns out that the ICT-producing and ICT-

using sectors essentially account for *all* of the acceleration in US productivity (see Stiroh, 2002a).

This is shown in Figure 1, which presents the acceleration in productivity in US and European productivity growth since 1995. Beginning with the US picture on the left hand side of the figure, we see that productivity growth accelerated by 3.5 percentage points a year in the ICT-using sectors: from 1.2% pre-1995 to 4.7% post-1995. It also accelerated by 1.9 percentage points in the ICT-producing sectors. But there was actually a small deceleration in all the other sectors of the economy.

Lying behind this was the enormous fall in the quality-adjusted prices of ICT since 1995, which has its roots in technical progress in the semi-conductor industry. Rapid improvements in the power of semi-conductors led to big increases in productivity growth in the ICT-producing sectors. Moore's Law (a rule of thumb for the rate at which computer power increases) seemed to accelerate after 1994

and the resulting fall in the price of a key input lowered prices across a whole range of products in the ICT-producing sectors.

As the price of ICT products plunged, firms deepened their use of ICT capital and this was naturally strongest in sectors that intensively used ICT. Increasing ICT per hour increased output per hour tremendously.

Looking at Europe, we also see a big increase in annual productivity growth rates in the ICT-producing sectors of 1.6 percentage points. The big difference between the United States and Europe is in the ICT-using sectors: in Europe, there was no productivity acceleration in the late 1990s as there was in the United States. Productivity growth remained static at about 2% a year.

The US productivity 'miracle' has been strongest in sectors like retail and wholesale, which use ICT intensively

Since ICT is available throughout the world at broadly similar prices, this raises a puzzle: why were European firms not able to reap the same benefits from ICT as their US counterparts? To answer this, we have to delve beneath the macroeconomic numbers into the firm-level evidence.

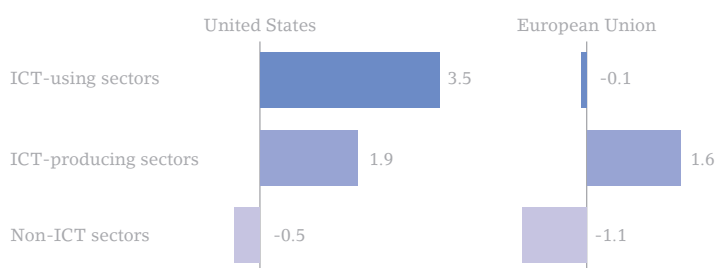
The microeconomic picture: paradox regained?

Advances in computer technology have enabled large datasets on company productivity and ICT to be amassed; they have also improved the ability of economists to analyse these data. The basic methodology to assess the return to ICT is to analyse a 'production function': the researcher will try to account statistically for the output of the firm with a large number of inputs, the input of most interest being ICT.

Since ICT is one form of capital, it is important to control for other forms of non-ICT capital, such as buildings, vehicles and non-ICT equipment. Labour and material inputs also have to be controlled



Figure 1: Changes in annual growth rates in output per hour from 1990-95 to 1995-2001 (percentage points)



Source: O'Mahony and Van Ark (2003)

for as well as other factors such as plant age, location and the state of the business cycle. The best studies use longitudinal data where the same firms are followed over time so the researcher can see if a burst of ICT capital is followed by a burst of productivity after controlling for other factors.

Several interesting findings have emerged from this research programme. First, on average, ICT does appear to be significantly associated with higher firm-level productivity. This stands in contrast with some of the earlier industry- and macro-level studies that struggled to find any effect of ICT on productivity. The

reason why the industry-level studies found little impact may have been because the industry averages disguise large differences between firms within industries.

Second, the magnitude of the association between ICT and company productivity is substantial. If ICT was simply a 'normal' form of capital earning the usual market return, we would expect that a doubling of the ICT capital stock would increase output by approximately the share of ICT in total revenues. Since the relevant share was only about 1 or 2% in most studies, it is interesting that they appear to find effects much greater than this. The meta-analysis of 20 studies reported in Stiroh (2002b) finds an average ICT elasticity of 5%, suggesting that a doubling of the ICT stock increases productivity by 5%. This would seem to suggest that there are some special features of ICT compared with other forms of capital.

Third, there is a huge variation around the average impact of ICT on firm productivity between different studies. Stiroh (2002b) reports estimates ranging from an upper end of over 25% to negative 5%. Some of these differences are due to methodological differences. But it is more likely that a large amount of this variation is due to genuine differences in the impact of ICT across firms and this is reflected in the different results from different datasets.

To understand this heterogeneity, we must move beyond looking only at technology and investigate other features of the firm.

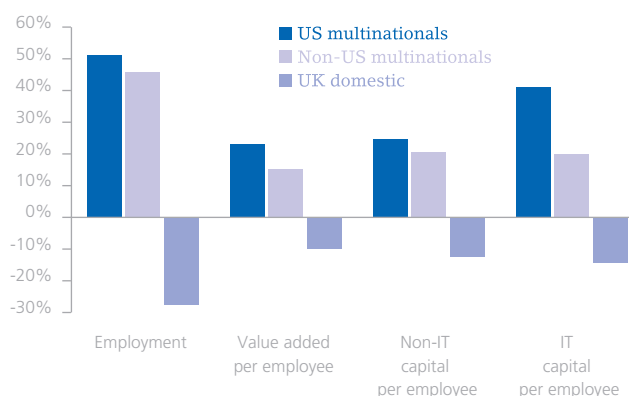
Beyond ICT: the role of complementary factors

An important reason why the returns to ICT differ across firms is that different firms have very different organisations into which ICT is placed. Often ICT spending is only the tip of the iceberg, and there are a whole host of other investments made in the firm to enhance the use of ICT (such as consultancy expenses).

Skills are also important. There is a great deal of evidence that educated workers tend to be much better at coping with the uncertainties of new ICT systems than less skilled workers. Other organisational factors such as decentralisation of decision-making and the steepness of the managerial hierarchy have been found to be important. Old-style

Figure 2:

Characteristics of establishments in the UK by ownership type (percentage differences from four-digit industry averages in 2001)



Notes: data from 576 US multinationals, 2,228 non-US multinationals and 4,770 domestic establishments

'Taylorist' organisations with rigid centralised hierarchies have, on average, produced lower returns to ICT than more 'organic' flexible firms.

Whether firms make these investments in complementary organisational capital seems to be very important. Bresnahan et al (2002) examined the impact of ICT on productivity in over 300 large US companies. A doubling of the ICT stock was associated with an increase in productivity of 3.6%, but this increased to 5.8% if a firm became more decentralised (in their study, a one unit increase on a decentralisation index based around teamwork and autonomy of workers).

Although this literature is in its early stages as it is tricky to quantify these organisational and managerial factors, the research suggests that other factors interact with the use of ICT, which cannot be studied in isolation.

The role of global businesses: US multinationals do IT better

One stylised fact emerging from the study of within-firm productivity is that establishments owned by multinational firms are more productive than establishments of wholly domestic firms. This is not surprising as multinationals have to be more efficient in order to start operating outside their home market. What is more interesting is that establishments owned by US multinationals appear to be more productive than those of non-US multinationals. This is true both within the United States and in other countries.

As an example of the evidence for this stylised fact, Figure 2 shows data from over 7,500 establishments located in the UK, which we have studied (see Bloom, Sadun and Van Reenen, 2005). In terms of value added per worker, US multinationals are 23% more productive than the industry average, non-US multinationals are 16% more productive than the industry average and domestic establishments are about 11% less productive. In terms of output per worker, the US advantage over domestic firms is 21.5% and the non-US advantage is 17.5%.

This is consistent with evidence that the plants of multinational US firms are more productive whether the plants are based on US soil or foreign soil. The US productivity advantage is partially linked to greater use of inputs: US establishments use about 10% more materials and 4% more non-ICT capital than non-US multinationals. But Figure 2 shows that ICT capital may also be a very important factor: US firms use a whopping 40% more ICT capital per worker than average whereas non-US multinationals use only 20% more.

But this difference in the usage of ICT is only one part of the story. When estimating a production function, we find that US establishments are 8.5% more productive than domestic firms after accounting for labour, non-ICT capital, materials and a host of other factors.

Controlling for the fact that US firms use more ICT accounts for only one percentage point of this gap. What matters is the way that US firms use ICT. A doubling of the ICT stock is associated

with an increase in productivity of 5% for a US firm but only 4% for a non-US firm. US firms appear simply to get more productivity out of the same amount of ICT (and this does not seem true of non-ICT capital).

A second interesting finding in our study is that the bigger returns to ICT usage for US firms are only found in certain sectors of the economy. These are exactly the same ICT-using sectors of wholesale and retail that account for the US productivity miracle. In other words, it is only in the ICT-using sectors in Figure 1 where US firms' ICT productivity is much higher.

Why are the returns so much higher for US firms? We investigated a wide variety of hypotheses such as whether the US firms simply had more skilled workers or better software. These do not seem to be the culprits. We suspect the main reason lies in the managerial structure of US firms.

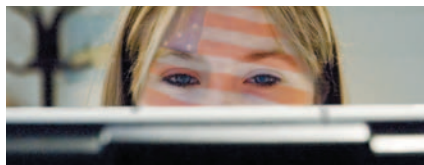
In joint work with McKinsey & Co (see Bloom, Dorgan et al, 2005, and the Summer 2005 issue of *CentrePiece*), we scored firms in four countries (France, Germany, the UK and the United States) on a range of managerial 'best practices', including incentives such as merit-based promotion and pay, the use of lean manufacturing techniques, performance management and effective targets. Across all firms, US firms are on average significantly better managed than European firms.

Looking within Europe at US subsidiaries, we also find that they are significantly better managed than non-US subsidiaries and domestic firms. What's more, US subsidiaries are also much more likely to allow greater autonomy to employees, a factor associated with higher returns from ICT. This suggests that what gives US firms their advantage are the organisational and managerial structures that they have that are conducive to getting the most out of ICT.

Taken together, these findings suggest that a reason for the slower growth of productivity in ICT-using sectors in Europe is that US firms have better internal firm organisation to get more from their ICT.

Changing European business practices

So why do European firms not adopt more US-style forms of business organisation? There is some evidence that they are doing



To obtain US-style productivity advances, European firms must adopt more US-style business processes

so. For example, the Wal-Mart system of supply chain management has been explicitly copied by Tesco, the UK's largest supermarket. It has also been transplanted directly as Wal-Mart has acquired Asda, which is now the UK's second largest supermarket.

But organisational changes are large and costly events so change is often slow and difficult. Furthermore, there are regulatory and cultural constraints to adopting US business practices in Europe – although these should not be overstated as US multinationals like Starbucks and McDonald's appear to be able to do as well in their European outlets as they do back home.

A deeper question is whether European firms really should change so radically? The older organisational forms served Europe well during the post-war catching-up period and it may be that as the new technologies bed down, they will again prove themselves reliable. On the other hand, if we have genuinely entered a new phase of development where individual performance, flexibility, decentralisation and general education are needed, then such complacency could be fatal.

Conclusions

The rebound of US productivity growth has been a major economic development over the last decade. This 'miracle' seems to be linked to ICT as the productivity acceleration was particularly strong in those sectors that used ICT intensively such as retail and wholesale. Europe did not experience this acceleration in the same sectors.

We have shown that the bulk of the evidence from firm-level, microeconomic studies is that ICT *does* have an economically and statistically significant impact on productivity but this varies dramatically between firms: having the right organisation helps a lot in making the most of ICT.

We have suggested that these organisational differences also lie behind the different productivity performance between the United States and Europe – US firms are better placed to take advantage of ICT. It is likely that European firms will have to adopt more US-style business processes to obtain the same level of productivity advances. This is probably simply a matter of time. The question is how long will it take?

Nick Bloom is assistant professor of economics at Stanford University and director of CEP's research programme on productivity and innovation. **Raffaella Sadun** is a research economist in the programme. **John Van Reenen** is director of CEP and professor of economics at LSE.

Further reading

Nick Bloom, Raffaella Sadun and John Van Reenen (2005), 'It Ain't What You Do, It's the Way that You Do I.T.: Testing Explanations of Productivity Growth using US Affiliates', Office for National Statistics (http://www.statistics.gov.uk/articles/nojournal/sadun_bvr25.pdf).

Nick Bloom, Stephen Dorgan, John Dowdy, Tom Rippin and John Van Reenen (2005), *Management Practices across Firms and Nations* (<http://cep.lse.ac.uk/management/management.pdf>).

Tim Bresnahan, Erik Brynjolfsson and Lorin Hitt (2002), 'Information Technology, Workplace Organization and the Demand for Skilled Labor', *Quarterly Journal of Economics* 117(1), 339-76.

Mary O'Mahony and Bart Van Ark (2003), *EU Productivity and Competitiveness: An Industry Perspective*, European Commission.

Kevin Stiroh (2002a), 'Information Technology and the US Productivity Revival: What Do the Industry Data Say?', *American Economic Review* 92(5), 1559-76.

Kevin Stiroh (2002b), 'Reassessing the Role of IT in the Production Function: A Meta Analysis', mimeo, Federal Reserve Bank of New York.