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Information Technology and Productivity: It ain't what you do it's the way that you do I.T.

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INFORMATION TECHNOLOGY AND PRODUCTIVITY
IT AIN'T WHAT YOU DO IT'S THE WAY THAT YOU DO I.T.

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Introduction

What has been the impact of information technologies (I.T.) on productivity? This has been a burning question for policy makers and business leaders for many decades. But it is only in recent years that computer power itself has enabled researchers to statistically interrogate large-scale datasets on firms and providing some more definitive answers to this issue. 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 the examination of the use of IT by global businesses. Multinational enterprises (MNEs) in general, and US multinationals in particular appear to have higher productivity and this appears to be linked to a distinct pattern in their use of IT. This fact may help unravel some of the puzzles in the macro-economic 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 organized their management structures in a way that makes better use of IT than their European counterparts.

Within this paper we first set the historical scene within the last few decades by paying particular attention to the end of the "Solow Paradox". Then we discuss the firm-level evidence regarding the impact of IT on firm performance, focusing on the role of the organisational factors that make the difference between IT projects being a success and failure. Finally, we delve into some new research on the impact of IT in multinationals.

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

The macro picture: Solow paradox lost?

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

The first period, starting after the Second World War, was one of strong productivity growth in the developed world – to be interrupted in the mid 1970s, following the first Oil Shocks. Despite this slowdown in productivity growth, between the mid 1970s and the 1990s Europe continued to catch up with the US productivity levels and some nations even overtook the US. This was the era of the "Solow Paradox". Nobel Laureate Robert Solow remarked that computers appeared to be everywhere except in the productivity figures. Information technology appeared to be pervasive in the 1970s and 1980s – in offices, homes, factories and shops – and most people and economists expected this new technology to boost productivity. Productivity growth appeared to slow down, however, just at the time that computerization seemed to take off.

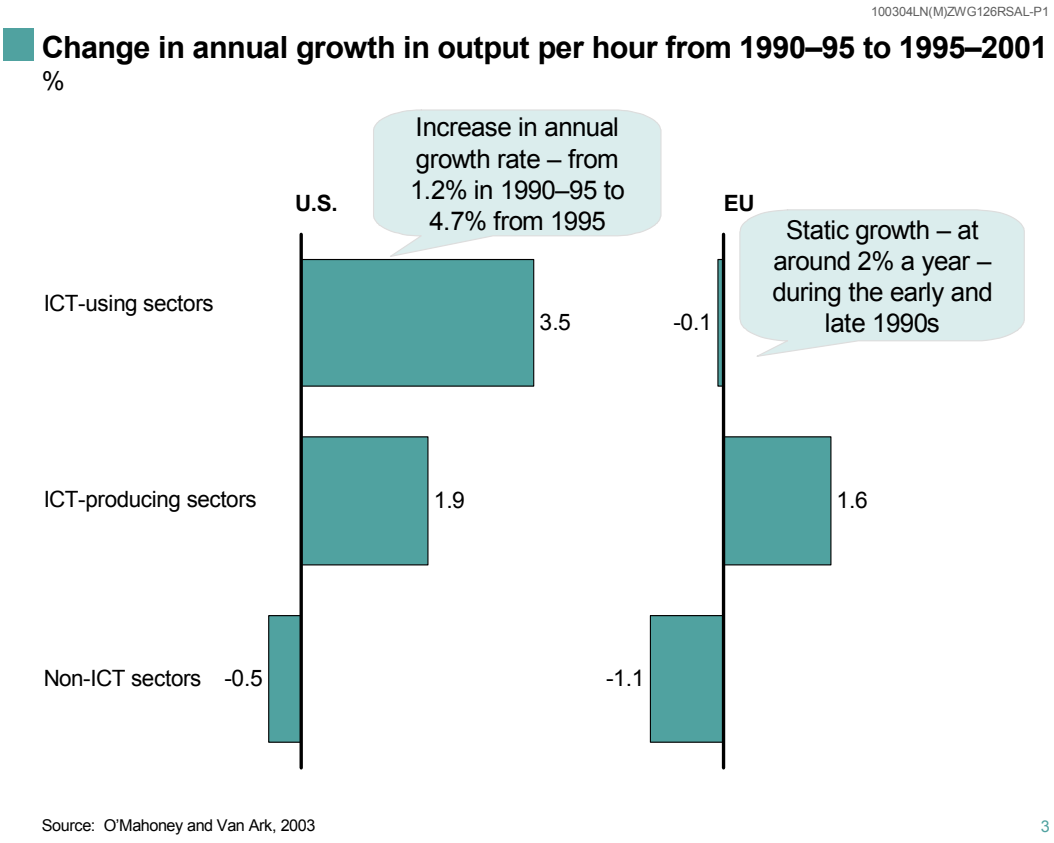
After the mid 1990s, however, a new picture emerged. The US economy bounced back and productivity growth returned to the healthy Post-War levels. Productivity growth continued to surge ahead even in the face of High Tech crash after 2000 and the terrorist attacks of 9/11. By contrast, European countries did not experience an acceleration on productivity growth after 1995. For the last ten years the long catching up process between the level of productivity of Europe and the US has ground to a halt.

IT does matter if we want to understand the US "productivity miracle". Imagine we split the economy into three sectors:

(1) industries which intensively produce IT (e.g. semi-conductors, computing)
(2) sectors which intensively use IT (e.g. retail, wholesale, finance)
and
(3) all other sectors in the economy

Surprisingly it turns out that the IT producing and using sectors essentially account for *all* of the acceleration in US productivity (Stiroh, 2002a). This is shown in Figure 1 which presents the acceleration in productivity in the US and European productivity growth since 1995. Beginning with the US picture on the left side of the figure we see that productivity growth accelerated by 3.5 percentage points per annum in the ICT-using sectors (from 1.2 per cent p.a. pre-1995 to 4.7 per cent p.a. post 1995). It accelerated by 1.9 per cent in the ICT producing sectors. But there was actually a small deceleration in all the other sectors of the economy.

Figure 1:Since 1995 US productivity growth accelerated in ICT using sectors and the ICT producing sectors



Source: O'Mahony & Van Ark (2003)

Lying behind this is the enormous fall in the quality adjusted prices of IT since 1995, which has its roots in technical progress in the semi-conductor industry. Rapid improvements in the power of semi-conductors lead to big increases in productivity growth in the IT producing sectors. Moore's Law seemed to accelerate post 1994 and this fall in the price of a key input lowered prices across a whole range of products in the IT producing sectors. As the price of IT products plunged, firms deepened their use of IT capital and this was naturally strongest in sectors that intensively used ICT. Increasing usage of IT per worker hour, increased output per hour tremendously.

Looking at Europe we also see a big increase in productivity in the IT producing sectors of 1.6 per cent a year. The big difference between the US and Europe is in the IT using sectors - here there was no productivity acceleration in the late 1990s as there was in the US. Productivity growth remained static at about 2 per cent a year. Since IT is available throughout the world at broadly similar prices this raises a question – why were European

firms not able to reap the same benefits from IT as their US counterparts? We will return to this question later. In order to answer it we have to delve beneath the macro numbers into the firm level evidence.

The micro-economic picture: paradox regained?

Advances in computer technology have enabled large datasets on company productivity and IT to be amassed and also improved the ability of econometricians to analyse this data. The basic methodology to assess the return to IT is to analyse a "production function". The researcher will try and statistically account for the output of the firm with a large number of inputs, the input of most interest being ICT. Since IT is one form of capital it is important to control for other forms of non-IT capital (e.g. buildings, vehicles, non-IT equipment, etc.). Labour and material inputs also have to be controlled for as well as other factors such as plant age, region and the state of the business cycle. The best studies use longitudinal data where the same forms are followed over time so the researcher can see if a burst of IT capital is followed by a burst of productivity after controlling for other factors.

Several interesting findings have emerged. First, on average IT does appear to be statistically 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 IT on productivity. The reason why the earlier industry level studies struggled to find much of an impact may be because the industry averages disguise large differences between firms within industries.

Second, the magnitude of the association between IT and company productivity is substantial. If IT was simply a "normal" form of capital earning the usual market return we would expect that a doubling of the IT capital stock would increase output by approximately the share of IT in total revenues. Since the relevant share was about one to 2 percent in most studies it is interesting that most studies appear to find impacts much greater than this. Kevin Stiroh (2002b) of the New York Fed reported a "meta-analysis" looking at the results of 20 different studies of the association of productivity with IT. He investigated the "Elasticity of productivity with respect to IT", in other words by what percentage would productivity increase if a firm doubled its use of IT? Taking the studies as a whole he found this elasticity

was about 5 percent. In other words a doubling of the IT capital stock was associated with an increase in productivity of 5 percent. This is much larger than one would expect if IT was just another form of capital such as buildings. This would seem to suggest that there are some special features of IT compared to other forms of capital.

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

In order to understand this heterogeneity we must move beyond only looking at technology and investigate other features of the firm.

Beyond ICT: the role of complementary factors

An important reason why the returns to IT differ across firms is that different firms have very different environments into which IT is placed. Often IT spending is only the tip of the iceberg – there are a whole host of other investments made in the firm to enhance the use of IT - consultancy expenses for example. Skills are also important: there is a lot of evidence that educated workers tend to be much better at coping with the uncertainties of new IT systems than less skilled workers. Other organizational factors such as decentralisation of decision making and the steepness of the managerial hierarchy have been found to be important. Old-style "Tayloristic" organizations are characterized by large bureaucracies, rigid and centralised hierarchies where decisions made by senior managers are cascaded down to people below. These firms have, on average, produced much lower returns to IT than more "organic" flexible firms with flatter hierarchies, less centralized control and more autonomy for lower level employees.

Whether firms make these investments in complementary organisational capital seems to be very important. Bresnahan et al (2002) examined the impact of IT on productivity in over 300 large US companies. Doubling the IT stock was associated with an increase in productivity of

3.6 per cent, but this increased to 5.8 per cent if a firm became more decentralized (in their study a one unit increase on a decentralization index, based around teamwork and autonomy of workers). Similarly, a study by researchers at the London School of Economics' Centre for Economic Performance and McKinsey found that major increases in IT intensity were associated with 20 per cent higher productivity in the best managed firms (defined as those who scored in the top quartile of managerial good practices), but the same increase in IT intensity only raised productivity by 2 per cent for the poorly managed (defined as firms in the bottom quartile of managerial good practices).

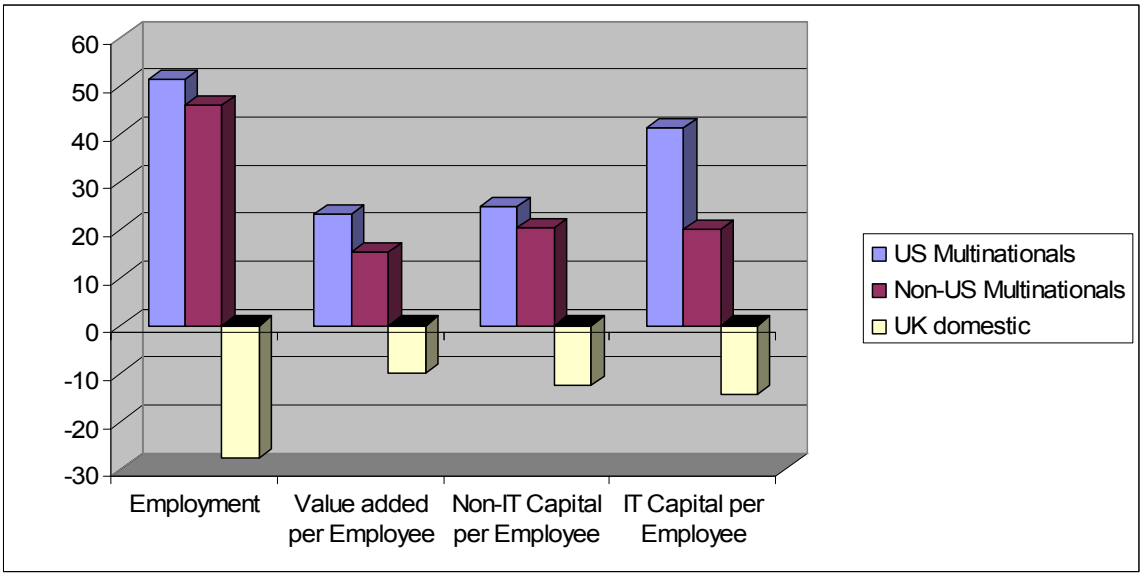
Although this literature is in its early stages as it is tricky to quantify these organisational and managerial factors precisely. But the existing studies do suggest that organizational factors interact with the use of IT which then cannot be studied in isolation.

The role of global businesses: US multinationals do IT better

One stylized fact emerging from the study of firm productivity is that plants belonging to multinational firms are more productive than plants of wholly domestic firms. This is not surprising as MNEs need to be more efficient in order to start operating outside their home market. What is more interesting is that plants belonging to US multinationals appear to be more productive than non-US multinationals. This is true both within the United States and in other countries. For example, Figure 2 shows data from over 7,500 establishments located in the UK studied by Bloom, Sadun and Van Reenen (2005). In terms of value added per worker US multinationals are 23 per cent more productive than the industry average. Non-US multinationals are 16 per cent more productive than the industry average and domestic plants are about 11 per cent less productive. In terms of output per worker the US advantage over domestic firms is 21.5 per cent and non-US advantage is 17.5 per cent. This is consistent with evidence that the plants of multinational US firms are more productive despite 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 per cent more materials and 4 per cent more non-IT capital than non-US multinationals. But Figure 2 shows that IT capital may also be a very important factor: US firms use a whopping 40 per cent more IT capital per worker on average whereas non-US multinationals use only 20 per cent more.

But this difference in the usage of IT is only one part of the story. While estimating a production function we found that US establishments were 8.5 per cent more productive than establishments owned by a UK firm with no international operations (a purely "domestic" firm) after accounting for labour, non-IT capital, materials and a host of other factors (i.e. US firms' total factor productivity, TFP, was significantly higher than that of UK owned firms). Controlling for the fact that US firms used more IT accounted for only one percentage point of this gap (i.e. the gap in total factor productivity dropped from 8.5 per cent to 7.5 per cent). What mattered was the way that US firms *used* IT. A doubling of the IT stock was associated with an increase in productivity of 5 per cent for a US firm but only 4 per cent for a non-US firm. US firms appeared to simply get more productivity out of the same amount of IT (this was not true of non-IT capital).

Figure 2: Characteristics of establishments in the UK by ownership type (% difference from 4 digit industry mean in 2001)



Source: Bloom, Sadun and Van Reenen (2005)
Notes: Observations - 576 US multinationals; 2,228 non-US other MNE; 4,770 domestic UK

A second interesting finding in Bloom et al (2005) was that the bigger returns to IT usage for US firms were only found in certain sectors of the economy. These were exactly the same "IT-using" sectors of wholesale and retail that accounted for the US productivity miracle discussed above. In other words it was only in the IT using sectors in Figure 1 where US firms' IT productivity was much higher.

Why were the returns so much higher for US firms? We investigated a wide variety of hypotheses, including whether the US firms simply had more skilled workers or better software? Neither of these seem to be the culprit, rather, we suspect that the main reason lies in the managerial structure of US firms. In some joint work with McKinsey & Co (see Bloom et al, 2005) we scored firms in four countries (US, UK, France and Germany) on a range of managerial "best practices" such as incentives (e.g. merit-based promotion and pay), the use of lean manufacturing techniques, performance management and effective targets. Across all firms, US firms were significantly better managed on average than European firms. Looking within Europe at US subsidiaries we also found that they were significantly better managed than non-US subsidiaries and domestic firms. Furthermore, US subsidiaries were 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 is their organisational and managerial structures that enable them to get the most out of their technology.

Discussion

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

So why have European firms not adopted American forms of business organisation more wholeheartedly? There is some evidence that they are beginning to do so. For example, the Wal-mart model is explicitly copied by the UK's largest supermarket, Tesco. It has also been transplanted directly, as Wal-mart has acquired Asda which is now the UK`s second largest supermarket.

Organisational changes are large and costly events, however, so change is often slow and difficult. Furthermore, there are regulatory and cultural constraints to adopting US business practices in Europe. For example, removing poorly performing workers is extremely difficult especially for longer tenured workers in larger firms. This is due to strong labour regulation protecting workers against dismissal. These enable managers and workers to block changes that may threaten their vested interests. Rapid promotion of very talented workers is also problematic as young employees are often expected to go through extensive training and unions prefer tenure based promotion systems to those based on individual performance. In

the US, change often occurs due to the entry of new firms and plants but this is difficult to bring about while there are entry regulations protecting incumbents against the threat of new entry. All of these barriers should not be over-emphasised however, as US multinationals appear to be able to do as well in the European outlets as they do back home (Starbucks, McDonalds, etc).

A deeper question to consider is whether European firms really should change so radically? The older organisation forms served Europe well during the catching up period and it may well be that there is an "innovation cycle". This is where, at first, a radical innovation (a "general purpose technology", to use the jargon) generates many new technologies where returns are highly uncertain because no firm really knows how to use them efficiently. Flexible economies with more entrepreneurial firms are able to successfully adopt the new technologies because they allow a much greater degree of experimentation – they are prepared to see many new firms enter and fail. But as the risks and returns for these new technologies become better understood other countries are also beginning to adopt them successfully. European institutions may simply be better at the latter "adoption" stage of the cycle than they are at the earlier stage. 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.

Japan is similarly an interesting case. Although there has been less economic research into it, general trends in productivity for Japan are, it seems, more like Europe than the US: there has been no sign of the productivity "miracle" in Japan. This disappointment could be blamed on the specific macro-economic problems (of deflation and bad debts) that have plagued Japan since the bursting of the asset bubble economy at the end of the 1980s. This excuse is not available for Europe however. This suggests that the productivity difference between America and the other main advanced countries is not simply due to particular country-specific macro-economic differences but is rather, more fundamental.

Conclusions

The rebound of US productivity growth has been a major economic development over the last decade. This "miracle" is linked to IT as the productivity acceleration was particularly strong

in those sectors that used IT 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, micro-economic studies is that IT *does* have an economically and statistically significant impact on productivity but this varies dramatically between firms: having the right organisation helps greatly in making the most of ICT. We have suggested that these organisational differences also lie behind the different productivity performance between the US 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?

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