ICT, Corporate Restructuring and Productivity

IFS Working Paper W09/10

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April 2009

Abstract: Stronger productivity growth in the US than the EU over the late 1990s is widely attributed to faster, more widespread adoption of information and communication technology (ICT). The literature has emphasised complementarities in production between ICT and *internal* restructuring as an important mechanism. We investigate the idea that increased use of ICT has facilitated outsourcing of business services, and that these are complementary activities in production because they allow firms to focus on their core competencies. This is consistent with evidence from the business literature and aggregate trends, and we show evidence from microdata that is consistent with this idea.

JEL Classification: D2, O3, O4
Key words: ICT, outsourcing, productivity

Acknowledgements: We would like to thank Nick Bloom, Bronwyn Hall, Rupert Harrison, Mari Sako, Helen Simpson, and seminar participants at the 2006 CAED Conference in Chicago, HM Treasury, ZEW Mannheim, and the University of Nottingham for helpful comments and discussions. The analysis contained in this paper was funded by the ESRC/EPSRC Advanced Institute of Management Research (AIM) and the ESRC Centre at the IFS.

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Executive Summary

A large and growing literature has emphasised the importance of the adoption and use of information and communication technology (ICT) as one of the main factors behind the strong US productivity growth over the late 1990s. A number of papers have suggested that to reap the benefits of ICT adoption firms need to make complementary changes to their internal organisation. A number of empirical studies have showed that complementarities in production between ICT and the internal reorganization of the firm are one reason why ICT investment has been so productive - i.e. firms become more productive when they both adopt ICT *and* restructure. The literature has also emphasised the impact of ICT on the ability of firms to vertically disintegrate production facilities and to outsource business services. Less empirical work has considered the existence of a further complementarity in production between ICT and corporate restructuring in the form of outsourcing business activities.

In this paper we empirically investigate whether the adoption of ICT and corporate restructuring in the form of outsourcing of business services are complementary for firm-level productivity. The idea is that by outsourcing their non-core business processes to specialised business services providers firms can focus on their core activities, and this enables them to better exploit ICT to introduce further innovations, such as changes in the processes they use, the products they produce, and other organisational changes. At the same time firms that invest more in ICT are better able to outsource business services and to gain a productivity advantage from focusing on their core competencies and introducing other organisational changes. These complementarities generate productivity gains that are additional to the direct gains created by investment in ICT and outsourcing of business services. This is consistent with evidence from the business literature and aggregate trends, and we show evidence from microdata that is consistent with this idea. We find that establishments that use ICT more intensely have higher productivity and that it is even higher for those that also make greater use of outsourced services, compared to other firms within their industry. We investigate whether these correlations are consistent with other alternative explanations by allowing more flexibility in the production function in a number of directions; we allow the elasticity of ICT to vary with other characteristics such as ownership and with other inputs. Our main result holds up - ICT and services outsourcing appear to be productive complements.

1. Introduction

A large and growing literature has emphasised the importance of the adoption and use of information and communication technology (ICT) as one of the main factors behind the strong US productivity growth over the late 1990s. [1] A number of papers have suggested that to reap the benefits of ICT adoption firms need to make complementary changes to their internal organisation. A number of empirical studies have showed that complementarities in production between ICT and the internal reorganization of the firm are one reason why ICT investment has been so productive - i.e. firms become more productive when they both adopt ICT *and* restructure.[2] The literature has also emphasised the impact of ICT on the ability of firms to vertically disintegrate production facilities[3] and to outsource business services.[4] Less empirical work has considered the existence of a further complementarity in production between ICT and corporate restructuring in the form of outsourcing business activities.[5]

In this paper we empirically investigate whether the adoption of ICT and corporate restructuring in the form of outsourcing of business services are complementary for firm-level productivity. The idea is that by outsourcing their non-core business processes to specialised business services providers firms can focus on their core activities, and this enables them to better exploit ICT to introduce further innovations, such as changes in the processes they use, the products they produce, and other organisational changes.[6] At the same time firms that invest more in ICT are better able to outsource business services and to gain a productivity advantage from focusing on their core competencies and introducing other organisational changes. [7] These complementarities generate productivity gains that are

[1] See, *inter alia*, Jorgenson (2001), Stiroh (2002), Oliner and Sichel (2002), van Ark et al (2002), Inklaar, O'Mahony and Timmer (2003), Van Ark and Piatkowski (2004).
[2] See, for example, Brynjolfsson and Hitt (2000) for a summary of this literature and Bartel, Ichniowski and Shaw (2005), Bresnahan, Brynjolfsson and Hitt (2002) and Bloom, Sadun and Van Reenen (2007).
[3] See, for instance, Baker and Hubbard (2002), Feenstra (1998), Grossman and Helpman (2005) Antras (2003) and Hitt (1999).
[4] Abramovsky and Griffith (2006) showed that firms that were more ICT intensive also purchased a greater amount of services in the market, and they were more likely to purchase offshore, when compared to less ICT intensive firms.
[5] Broersma and van Ark (2007) is the only study to our knowledge that investigates the complementarities in production between ICT and purchases of business services. They use industry level data from the Netherlands.
[6] Broersma and Van Ark (2007) suggest that the purchases of (knowledge intensive and specialised) business services reflect a change in the purchasing firm's ability to manage specialised and complementary expertise and capabilities and to undertake more complex projects and technologies. Purchases of business services also reflect an organisational innovation to the extent that firms are purchasing specialised services to consultants and engineers to introduce changes in their organisation.
[7] Brynjolfsson and Hitt (2000, 2003) suggest that ICT have a role in changing the ways businesses interact with their suppliers, hence boosting purchasers' productivity growth.

additional to the direct gains created by investment in ICT and outsourcing of business services.

Growth in outsourcing of business services has been one of the major changes to firms' corporate structures, as evidenced by a range of aggregate statistics. Trade in intermediate services has been one of the fastest-growing economic activities around the world.[8] A large range of business services such as finance and accounting, human resources, sales and marketing, supply chain management, and even research and development, which were previously seen as core to a firms' business, are now increasingly being outsourced.[9] The importance of business service outsourcing is also apparent from the very rapid growth in employment in business service sectors in the US and UK, accounting for around one-third of the total employment growth in the US and over 40% in the UK between 1995 and 2001.[10] Examples of high profile deals of this sort include the $600 million seven-year contract between BP and Exult, the $650 million deal between Motorola and ACS, and the $400 million ten-year deal between Proctor & Gamble and IBM Business Consulting Services. The business services outsourcing market in 2004 was estimated at £126 billion, with analysts predicting continued growth. [11]

The business and management literatures emphasise that outsourcing non-core activities allows firms to focus on their core activities and thus increase productivity in these activities. [12] This is illustrated, for example, in a quote from the Finance Director of Manpower, *"Importantly, outsourcing technical functions helps improve productivity levels by increasing internal efficiency."* (Williams, 2004). Also, a survey carried out by Accenture found that 86% of senior executives credit outsourcing with increasing their sense of control over business performance.[13] The economic literature has also emphasized the increasing incentives for firms to scale down and specialise,[14] with greater competitive pressures and rapidly changing technologies meaning that smaller and more adaptable firms are increasingly favoured by the market.

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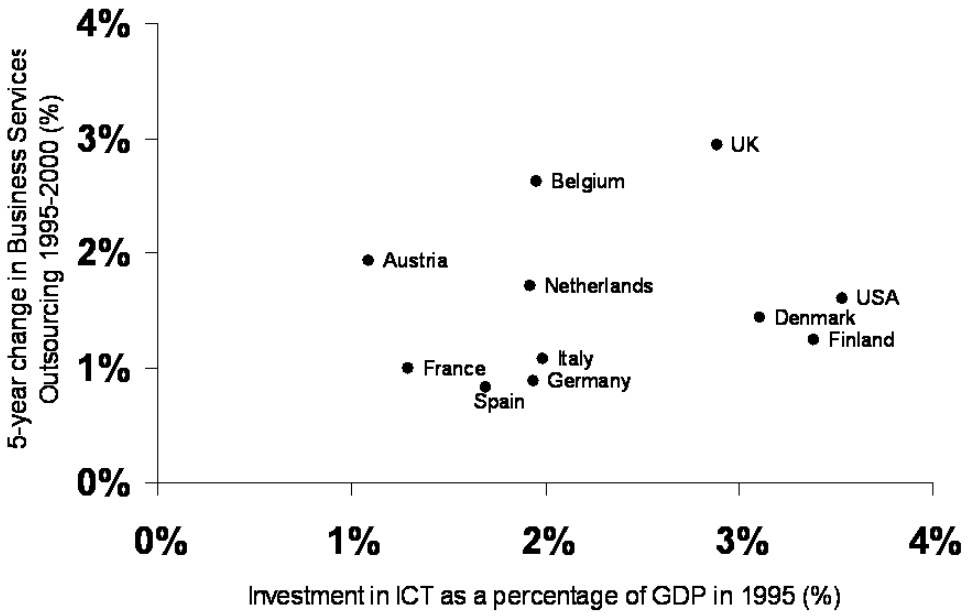
[8] WTO (2004), Annual Report 2004 (Geneva: World Trade Organization Conference on Trade and Development), Helpman (2006).
[9] See Adler (2002) and Sako and Tierney (2005).
[10] Authors' calculations using GGDC data on total persons engaged in employment. See also Goodman and Steadman (2002) and Abramovsky, Griffith and Sako (2004) for more detail analysis of the growth in business services.
[11] NelsonHall, Global BPO Market Forecast: 2005-2009 (NelsonHall, 2005), p.6.
[12] Hamel and Prahald (1990) first introduced the concept of the core competencies in the business literature. See, *inter alia*, Corbett (1995) and Quinn and Hilmer (1994) for a discussion on how outsourcing can enhance firms' performance on core activities and have net gains in productivity.
[13] See 'High Performance Outsourcing: Gaining Control through Outsourcing', at www.accenture.com.
[14] See, for instance, Milgrom and Roberts (1990), Athey and Schmutzler (1995) and Marin and Verdier (2003).

The rapid decline in the price of ICT[15] has meant that transactions that previously had to be conducted face-to-face within the firm can now be effectively conducted at arms-length. ICT reduces the external transaction and coordination costs, and makes it feasible for firms to outsource a host of activities which it was previously prohibitively expensive to do. Figure 1 shows that developed economies have experienced an increase in business services outsourcing between 1995 and 2000 (for example, in the UK it increased from 6.5% to 9.5%), and importantly that this is positively correlated with the level of ICT investment in 1995.

Figure 1: Business services outsourcing and ICT investment



Note: Investment in ICT is calculated as gross fixed capital formation in IT and communication equipment and software divided by GDP, in current prices in 1995. The 5-year change in business services outsourcing is the absolute change in the intermediate consumption of business services as a percentage of gross output between 1995 and 2000.
Source: Timmer, Ypma and van Ark (2003), updated June 2005 and OECD Input-Output Database, 2006 edition revision 1.

If there are complementarities in production between ICT and outsourcing of business services we would expect to see that the two variables are positively correlated in their adoption; and that firms that invest more in ICT *and* outsource business services will achieve higher levels of productivity in their core activities than those firms that invest less.

[15] See, *inter alia*, Jorgenson (2001).

Abramovsky and Griffith (2006) showed that investment and use of ICT and outsourcing of business services were positively correlated. In this paper we investigate whether investment in software and outsourcing of business services are complementary in production. We use a large nationally representative cross-section of data at the line of business level for the UK. The UK is an interesting place to investigate this question. It lags the US in productivity and ICT adoption, but compared to other European countries it exhibits higher investment in ICT, has experienced faster growth in ICT capital stock,[16] and faster growth in business services outsourcing (see Figure 1). In addition, the business services sector in the UK has grown substantially in the last decade.[17] We find that establishments that both invest more in software *and* make greater use of outsourced business services than other firms within their industry are more productive. This is consistent with complementarities between software and outsourced business services. Although our results relate to software, we note that software is an important part of ICT and that investment in software and other forms of ICT (hardware and communication technologies) are positively correlated.[18] In the remainder of the paper, we consider software as a *proxy* for ICT.

As in Bresnahan et al (2002) we argue that while firms face a common reduction in the price of ICT, we assume that they face different costs of adjustment in ICT and outsourcing, which are determined by past shocks and choices made by the firm, and this allows us to identify the coefficients of interest. We are not able to provide a causal interpretation of these coefficients, but even as correlations these results prove interesting. We also consider alternative explanations for the correlations that we find, and find them less plausible.

This paper is related to several strands of the literature. There is a literature on the determinants of vertical integration and how changes in technology, in particular changes in ICT that decrease *external* coordination costs, may enable a move towards more disintegrated organization structures.[19] Recently, several papers have considered individual and industry characteristics as determinants of firms' organizational form.[20] Most of these empirical

[16] The US and the UK have higher ICT capital stock levels relative to total capital stocks than France and Germany, (authors' calculations based on GGDC data).
[17] See Abramovsky, Griffith and Sako (2004).
[18] For example, the share of software investment in total ICT investment in current prices was on average 43% in the UK and 45% in the US between 2000 and 2004 (authors' calculations based on GGDC data). See, also, Jorgenson (2001).
[19] See survey in Klein (2004) and a recent example in Baker and Hubbard (2002).
[20] See, Antras (2003) and Acemoglu et al (2004). Helpman (2006) provides an excellent review of the theoretical models on trade, FDI and firms' organizational choices.

studies have focused on outsourcing of materials and have not looked explicitly at the relationship between changes in ICT adoption, outsourcing of services and productivity. There is also a growing literature on the impact of (international) outsourcing on productivity.[21]

This paper also relates to the literature on ICT adoption, organizational change and productivity. This literature emphasises the complementarities between ICT and *internal* reorganisation, flexible management and decentralized structures within the firm or plant. Bresnahan, Brynjolfsson and Hitt (2002) is a key example using US firm level data.[22] Brynjolfsson and Hitt (2000, 2003) also discuss evidence of how computers contribute to business performance and economic growth, stressing the role of ICT-enabled internal reorganization of the firm. They also suggest that ICT may have a role in changing the ways businesses interact with their suppliers, hence boosting productivity growth.

The remainder of the paper is structured as follows. The next section discusses our empirical approach and presents the data. Section 3 presents estimates of the correlation of ICT with productivity in the UK and their interaction with outsourcing of business services. A final section concludes.

2. Empirical Approach and Data

2.1. Empirical Approach

We assume that establishments in an industry face a general production function of the form

$$Y_i = A_i F_j\left(L_i, K_i, C_i, S_i, G_i\right), \qquad (1)$$

where *i=1...N* index establishments, Y: output, L: employment, K: total capital, C: information and communication technologies; S: purchased services, G: purchased goods, A: establishment specific productivity factor and $F_j(.)$ represents the part that is common across establishments within an industry *j*.

We are interested in whether ICT and outsourcing of business services are complementary in production, that is if the marginal returns to ICT increase as the level of business services outsourced rises. i.e. $\frac{\partial Y_i}{\partial C_i \partial S_i} > 0$.

[21] See, for example, Amiti and Wei (2006).
[22] See also Caroli and Van Reenen (2001).

We follow Klette (1999) and express the production function in terms of log deviations from a common reference point within industry (which can be thought of as a representative firm within the industry):[23]

$$\tilde{y}_i = \alpha_l \tilde{l}_i + \alpha_k \tilde{k}_i + \alpha_c \tilde{c}_i + \alpha_s \tilde{s}_i + \alpha_g \tilde{g}_i + a_i, \qquad (1)$$

where lower case and tilde (~) indicates that the variable is measured as the log deviation from the industry mean (for example, $\tilde{y}_i = \ln Y_i - \ln \bar{Y}_j$), and $\bar{Y}_j$ is the mean gross output across establishments in the 4-digit industry *j*. All right-hand side inputs are transformed in the same way. This allows us to control for unobserved industry specific factors, including price deflators, without imposing too many restrictions on the production technology. We are interested in whether ICT and purchased services are complements. In our main specification we therefore parameterize the output elasticity with respect to ICT for an establishment *i* which operates in industry *j* as,

$$\alpha_c = \alpha_{c0} + \alpha_{cs} \tilde{s}_i . \qquad (2)$$

A positive estimate of α_{cs} suggests that establishments that both invest more in ICT and outsource more services than the average firm in their industry, also have higher productivity than the average establishment in their industry, consistent with the idea that there are complementarities between these two inputs. As a robustness check, we also allow the output elasticity with respect to other factors to vary with ICT.

Our data are a cross-section pooled across four years.[24] This means that we are not able to control for unobserved establishment-specific productivity shocks. We include several observed characteristics, which we hope will help control for heterogeneity. We model the establishment specific productivity term as composed of an establishment's age, whether the establishment is owned by a US multinational firm (*us*) or by a non-US multinational (*mne*), whether it is part of a multi-establishment group (*partg*), an indicator of the region the establishment is located (η_r, r indexes region), an indicator of the establishment's 4-digit industry (γ_j), year dummies (δ_t) and an iid shock (ε_{it}). Therefore the establishment specific productivity term takes the form:

$$a_i = \beta_{age} age_i + \beta_{us} us_i + \beta_{mne} mne_i + \beta_{partg} partg_i + \eta_r + \gamma_j + \delta_t + \varepsilon_i . \qquad (3)$$

[23] See Klette (1999) for a discussion of this approach (specifically page 454), this relies on the multivariate generalized mean value theorem.

[24] While the data span four years, very few establishments are observed in more than one year (see data section). We cluster standard errors at the firm level to account for correlation between establishments under common ownership.

Combining equations (1), (2), and (3) gives our main empirical specification:

$$\begin{aligned}\tilde{y}_i = {} & \alpha_l \tilde{l}_i + \alpha_k \tilde{k}_i + \alpha_{c0} \tilde{c}_i + \alpha_{cs} (\tilde{s}_i \tilde{c}_i) + \alpha_s \tilde{s}_i + \alpha_g \tilde{g}_i + \\ & + \beta_{age} age_i + \beta_{us} us_i + \beta_{mne} mne_i + \beta_{partg} partg_i + \eta_r + \gamma_j + \delta_t + \varepsilon_i \end{aligned} \quad (4)$$

2.2 Identification and interpretation

A number of issues arise to do with identification and interpretation of our main results. We are interested in the idea that investing in ICT and outsourcing non-core business services comprise a system of complementary innovations which allow establishments to focus on their core competencies, to better use ICT and introduce further innovations that lead to increases in their productivity. Hence, we are interested in identifying the complementarity in production of ICT and outsourcing for the purchaser of services.[25]

Our approach to identify the complementarities of these two innovations in the production function is similar to Bresnahan et al (2002). We consider the decline in the price of ICT as exogenous to the establishment. This reduction in price leads to increased investment. Increased levels of ICT mean that it is now feasible to outsource many more business services and firms are able to focus on core competencies and increasing their productivity. This in turn leads to firms to be able to better exploit ICT, leading to further ICT investment, enhancing firms' ability to innovate in their core competencies, becoming more productive.

We argue that establishments face different costs of adjustment in ICT and outsourcing, determined by past shocks and choices made by the establishment that gives rise to firm level heterogeneity. While improvements in ICT are quickly available throughout the economy, establishments may need some time to make other complementary changes to fully exploit the returns to ICT, due to the existence of frictions either in the establishment itself or in the establishments' environment. For example, the existing literature has emphasised that in order to exploit ICT firm need to move towards more flexible and flatter hierarchies within firms, which can involve changing the skill mix of the workforce through firing, hiring or re-training workers. The outsourcing of services is also likely to be subject to frictions in the

[25] Identifying the parameters of a production function is notoriously difficult, see, *inter alia*, Griliches and Mairesse (1998), Blundell and Bond (1998), Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg and Caves (2003) and Bond and Soderbom (2005). Estimation procedures that require panel data are not feasible because we would need to restrict our sample of establishments to a highly selected sample of establishments observed at least five years consecutively, which are larger establishments. The OLS results for this sample are similar to the results using the whole sample, in that the coefficient on the interaction between ICT and outsourcing of services is positive and significant. The estimated coefficient for the interaction using GMM System is also positive and significant but the Hansen test for over-identification restrictions is not passed.

short run if establishments need to search for the best supplier, or fire some employees working in the outsourced non-core activities.

This approach enables us to identify correlations between ICT, outsourcing of business services and productivity, consistent with the existence of complementarities, but we emphasise that what we present in this paper can only be considered as correlations.[26]

In addition to these identification issues, we might be concerned that we are capturing other mechanisms than the complementarities between ICT and outsourcing of business services. We consider a number of issues related to the interpretation and the robustness of our results in section 3.2.

Finally, it is also worth commenting on how productivity improvements in the service provider will affect our results. Outsourcing means that specialised service providers are able to exploit economies of scale and scope. Independent service providers may also have greater incentives to innovate, as they are residual claimants on returns to innovation.[27] Cheaper ICT has increased the ability of independent providers to adapt business services to be more compatible with the needs and technologies of the purchasers of these services. Suppliers are better able to customise services for individual clients, yet still exploit returns to scale.[28] While this represents an aggregate benefit to the economy, it is not the focus of our interest here. However, if the nominal value of the outsourced services is measured with error and the level of services inputs are understated, then the level of productivity of the purchaser would be overestimated. Also, if the nominal value is correctly measured, but if prices do not reflect quality improvements, this could be reflected by an increase in measured productivity of the establishment that is outsourcing the service. To the extent that the value of these services is well measured and adjusted by quality and productivity growth in the service provider; this should not be captured in increased measured productivity of the establishments purchasing services.[29]

[26] Athley and Stern (1998) also provide a discussion of how unobserved heterogeneity can yield a positive correlation between inputs in the production function, even if the choices do not interact in determining productivity, in particular when the unobserved returns to the different choices are positively correlated.
[27] See Acemoglu et al (2004).
[28] For example, IBM's has moved towards providing *"asset-based services, which are more repeatable, predictable and efficient than traditional labour-based services."* Tom Kucharvy, Summit Strategies, see http://www.summitstrat.com/assets/TK2oct05COL
[29] See, *inter alia*, Griliches and Siegel (1992).

2.4 Data

Our main data come from the Annual Business Inquiry (ABI-ARD) conducted by the UK Office of National Statistics (ONS) and contain information on establishments operating in the years 2000 to 2003. A Data Appendix gives further details.

Production data

The ABI-ARD data are a nationally representative stratified sample of establishments located in the UK.[30] Response is mandatory. Information is collected on inputs and output. Large establishments are sampled every year along with a random stratified sample of small establishments. We observe few establishments in consecutive years, particularly in the service sectors where most firms are below the large size threshold. We therefore treat the data as a pooled cross-section of establishments. Establishments answer one of two forms - the short or a long form. Both forms ask for total output, employment, total capital investment and total intermediate purchases. However, only those establishments answering the long form report a breakdown of intermediate purchases between goods and services. Information on this breakdown for establishments answering the short form is imputed. We include an indicator of whether the establishment answered the long or short form in all regressions.[31]

Outsourcing of business services

We measure outsourcing of business services (s) using data on the establishment's intermediate expenditure on services. This measure includes, for example, purchases of advertising, marketing and other professional services such as accounting and consulting, and payments to employment agencies. A detailed list of the intermediate purchases included in our measure is provided in the appendix. This variable potentially includes establishments' intermediate purchases from other establishments belonging to the same firm. However, only 13% of the establishments in our sample are part of a multi-establishment firm (see table 1). For those establishments that are part of a group, we found that there were relatively few firms that both produced and purchase services.

[30] See Barnes and Martin (2002) and Griffith (1999) for a description of the data. Agriculture and the financial sector are not included.

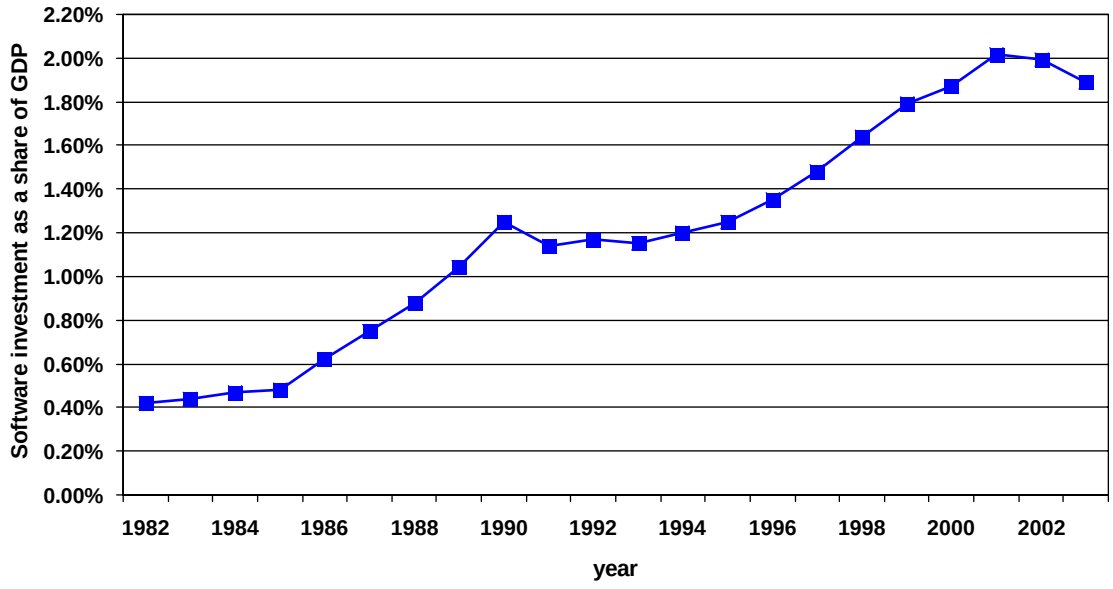
[31] The results estimated using the sub-sample of establishments that answered the long form are not qualitative different from the main results in table 2 using the whole sample. In particular the coefficient on the interaction between ICT and outsourced services is still positive and significant, with a magnitude of 0.004 and a standard error of 0.001.

ICT

Our main ICT variable comes from the establishment level ABI-ARD questionnaire. Establishments are asked to report investment in purchased computer software and computer software developed by the establishment's own staff (in thousands of pounds). The ONS also use data from other surveys that provide information on firms' investments.[32] The capital stock variable also includes software investment, so the coefficient on the ICT variable is an approximation to the output elasticity of ICT.[33] Figure 2 shows that there has been a rapid increase in total software investment in the UK.

This measure of ICT has the drawback that it does not contain information about total ICT expenditure (it excludes telecommunications equipment and computers).[34] However, it has the advantage that it is measured at the establishment level and is available for a representative group of UK firms.

Figure 2: Software investment as a percentage of UK GDP



Source: Software investment comprises purchased software and own account software and the figures come from "Survey based measures of software investment in the UK", ONS February 2006; and GDP series is YBHA series from ONS Blue Book.

[32] See Appendix in Bloom, Sadun and Van Reenen (2007) for a description of how the data has been constructed, the depreciation rate assumed and the extrapolations made.

[33] The output elasticity to ICT is given by the expression $\frac{C}{K+C}\alpha_k + \alpha_c$. Given that C/(K+C) is very small (from Table 1 this is 0.0036 evaluated at the median), α_c is a good approximation.

[34] Software is harder to measure but it appears to be more important than computer investment in the second half of the 1990s in the US as evidenced in Jorgenson (2001). In the US, only in 1999 meaningful measures of pre-packaged, custom and own-account software were included in the national accounts by the BEA.

Our second measure of ICT comes from the ONS annual E-commerce survey.[35] We use the proportion of employees with a PC with internet access. We construct this measure at the 5-digit industry and establishment size level. For the few cases (around 10% of the sample) where we were not able to match the E-commerce data at the 5-digit and firm-size level, we use data at the 4-digit industry and firm size level.

2.4 Descriptive statistics

Table 1 provides descriptive statistics for our sample. The median establishment employs 48 workers, indicating that the sample contains a significant proportion of small firms, while the mean establishment employs 288 workers, indicating the presence of a few very large establishments.

[Table 1 here]

On average, software capital stock as a share of gross output is around 1.2%, although the distribution is very skewed, as indicated by the 75th percentile of 0.7%. As a reference point, we take the figure for software capital stock as a share of value-added reported by Basu *et al* (2003) using aggregate data for the UK economy, which is around 2.6% in 2000. In order to compare this to the revenue share of software in our data we have to take into account the fact that their measure differs from our measure in that to construct software capital stock they multiply the software investment flows by three (this is to make UK figures comparable to US figures); and the denominator in their measure is valued-added, whereas we use gross output. If we take these factors into account, our figure of 1.2% looks comparable to the Basu *et al* (2003) figure of 2.6%.

Table 1 also shows that, on average, establishments purchase almost three times more intermediate goods than services. Around 4% of establishments are owned by US firms, and around 8% are owned by other foreign firms. This is similar to the proportions that Criscuolo and Martin (2005) report using the ABI-ARD data for the years 1996-2000.

3. Results

We now turn to consider estimates of equation (4). All our results are estimated using Ordinary Least Square. As discussed above, results should be interpreted as correlations rather than causal relationships.

[35] This is a statutory postal survey of 9,000 businesses randomly sampled from the Inter-departmental Business Register (stratified by employment size). The sampling methodology ensures wide coverage of the UK economy and the estimates produced cover almost all private sectors.

3.1 Main results

Table 2 presents our main results. We start by presenting estimates of a baseline production function in column 1, which includes total intermediate materials purchased, capital and labour and the set of control variables specified in equation (4). The estimates of the coefficients on all inputs are positive and significant, and reasonable compared to other empirical studies.[36] The coefficient on labour is around one third, the coefficient on capital is around one sixth and the one on intermediate purchases is almost a half. The coefficient on US ownership is positive and significant, and higher than the coefficient on other MNE, as found in other studies.[37]

[Table 2 here]

In column 2 we split total intermediate purchases into services and goods purchased. The coefficient on labour remains the same, while the coefficient on capital increases somewhat. The coefficient on goods purchased is considerably lower than its average revenue share (0.39 reported in Table 1), while the coefficient on services is only slightly higher. In column 3, we include our main ICT measure. The estimated elasticity of output with respect to ICT is 0.010. This can be compared to the average revenue share of ICT of 0.012 (see Table 1), suggesting normal returns to ICT investments.[38]

Column 4 shows our main result. The coefficient on the interaction of the level of ICT with the level of purchases of services is positive and significant, with a magnitude of 0.005 and a standard error smaller than 0.001. This is consistent with the existence of complementarities between ICT and purchasing of services, in a way that is positively associated with productivity. These estimates suggest that for an establishment with the average level of purchases of services relative to its industry mean the contribution of ICT to productivity is 0.020. This is positively correlated with purchased services - an establishment that purchases 1% more services than the average in its 4-digit industry is 0.005% more productive than at the average (so has an elasticity with respect to ICT of 0.025), while an

[36] See, for example, Blundell and Bond (2000).
[37] See, inter alia, Griffith and Simpson (2004), Criscuolo and Martin (2005) and Bloom *et al* (2007).
[38] Under the assumption of perfect competition in the factors and product markets, in the long run the parameters α for each input are equal to their revenue shares, hence yielding "normal returns". Other studies in the literature, using data for the US and a different time period, have found higher than normal return for ICT investments, For example, Bresnahan, Brynjolfsson and Hitt (2002) report an estimated IT elasticity that corresponds to higher than normal returns to IT. Bloom *et al* (2007) report an elasticity of around 0.04 with an average revenue share of 0.01. The survey by Stiroh (2004) suggests that the median estimate across a large number of studies was around 0.046.

establishment that purchases 1% less services than average has an elasticity with respect to ICT of 0.015. One concern is that the measure of business services outsourcing (s) includes purchases of computer services (not included in investment in software) and that this might be driving our results; our result holds if we exclude purchases of computer services from our measure of purchased business services.

In columns 5 and 6 we allow the output elasticity of ICT to vary with the ownership status of the establishment, as indicated by equation (5). This has little impact on our estimates. Bloom *et al* (2007) find that the coefficient on the interaction between ICT and ownership is positive and significant for the US but not for other multinationals. We find this result if we estimate a slightly different specification, where we transform the variables as deviations from the mean of the log across industry, rather than the log of the mean as we do here. In that specification we also find that once we allow the output's elasticity of ICT to vary with purchases of services and ownership, US ownership is no longer associated with a higher contribution of ICT to productivity (in fact it is negative). It may be that the advantage of US establishments is that they are better at exploiting ICT, one reason being that they may be more able to restructure by outsourcing business services, and thus have higher purchases of services.

In the final column we allow the output elasticity of ICT to vary with the use of all inputs. The coefficient on the interaction of ICT with purchases of services remains positive and significant. The fact that our main result holds up for after allowing the output elasticity with respect to ICT to vary with establishments' labour usage is reassuring.

3.2 Robustness

We consider four issues related to robustness: Are results driven by a change in the composition of activities undertaken by the establishment? Are the results robust to allowing all parameters of the production function to vary across industries? Do the results reflect complementarities with skilled workers, as has been shown in some papers, as opposed to complementarities with ICT? Are the results sensitive to using an alternative measure of ICT?

Composition effect

It is possible that we may see an increase in productivity due to a change in the composition of activities undertaken by the establishment - if they have outsourced lower productivity activities and retained higher productivity activities, then measured productivity

at the establishment level will rise. We investigate the empirical importance of this possibility by splitting the sample into industries where the level of productivity is above versus below the level of productivity of business services. If the composition effect is dominant, we should see that our results only hold in those industries with productivity above business services.

In columns 1 and 2 of Table 3 we split industries into high and low labour productivity relative to average labour productivity in business services. We also split by high and low average wage, shown in columns 3 and 4 of Table 3. The results are similar across the two groups, confirming that it is not simply a composition effect.

Variation across industries

First, we show results for manufacturing and services separately in columns 5 and 6 of Table 3. The coefficients are remarkably similar across manufacturing and services, and the interaction between ICT and purchases of services is positive and significant in both these sectors. The magnitude of coefficient on the level of ICT and the interaction with purchased services is higher for service providers than manufacturing establishments, corresponding to the higher factor usages, shown in Table A3. In columns 7 and 8 we report the mean and median coefficient when we estimate the production function separately for each 2-digit industry. The mean is similar to the pooled estimates, though the median is lower.

[Table 3 here]

Complementarities between ICT and skills

There is empirical evidence that ICT is complementary to skilled labour[39] and one potential problem is that the positive correlation between ICT, outsourcing of services and productivity showed in Table 2 might be driven by the complementarity between skills and ICT. This may be the case if firms outsourcing services are outsourcing unskilled labour-intensive services, hence becoming more skill intensive and more productive. The negative and significant correlation between ICT and labour in Table 2 is consistent with these inputs being substitutes. This could be driven by unskilled labour. To explore this interpretation further we augment the production function with a measure of the skill composition of workers in the 2-digit industry and region of each establishment. These data are taken from the Labour Force Survey, described in the Data Appendix.

[Table 4 here]

[39] See, for instance, Bresnahan, Brynjolfsson and Hitt (2002) and Bartel, Ichniowski and Shaw (2007).

In column 1 of Table 4 we include a measure of skills into the equivalent specification as shown in column 3 of Table 2, suggesting that establishments with a higher proportion of skilled workers are more productive. In column 2, ICT is interacted with skills, and the coefficient on this is interaction is positive and significantly different from zero, which is consistent with skill-technology complementarity. In column 3, ICT is interacted with purchased services, but also controlling for the level of skills, and we get the same result as in column 4 of Table 2. In column 4, we allow the elasticity of ICT to vary with both the skill level and with purchased services, and again our result holds up. Finally, in column 4 we allow it to vary with all inputs. These estimates are in line with those shown in column 7 of Table 2 and provide convincing evidence that it is a complementarity between ICT and purchased services, rather than skilled labour, that is driving our results.

Alternative measure of ICT

Finally, we turn to one final issue, the robustness of our results to using an alternative measure of ICT - the proportion of employees with a PC and internet access. This is measured at the industry and establishment size band level. Since this is an aggregate variable, we do not transform the variable as a log deviation from the industry-year mean, since this would get rid of almost all the variation in the variable. Instead, we include all inputs in logs and include industry and year dummies. In column 1 we include only the level of ICT, which is positive and significant. In column 2 we allow the output elasticity of ICT to vary with the level of purchased services, and show that the interaction between ICT and purchases of services is robust to using this alternative measure of ICT.

[Table 5 here]

4. Summary and discussion

In this paper we consider whether empirical evidence is consistent with the idea that ICT has played an important role in productivity growth through facilitating corporate restructuring in the form of outsourcing the production of intermediate services. We find suggestive evidence that it is - establishments that use ICT more intensely have higher productivity and that it is even higher for those that also make greater use of outsourced services, compared to other firms within their industry. This is consistent with the idea that there are complementarities between ICT and outsourced services. We investigate whether these correlations are consistent with other alternative explanations by allowing more flexibility in the production function in a number of directions; we allow the elasticity of ICT

to vary with other characteristics such as ownership and with other inputs. Our main result holds up - ICT and services outsourcing appear to be productive complements.

Much attention has been paid to the fact that productivity growth rates in European economies have lagged behind the US, particularly since the mid-1990s. The empirical evidence points to the slower adoption of information and communication technologies (ICT) as a key factor in explaining the divergence in productivity growth, as the US experienced particularly strong productivity growth in sectors that use ICT intensively. We also see that business service sectors in EU countries are smaller than in the US.[40] Investment in ICT has also picked up over this period. The results in this paper suggest one mechanism that might be important.

[40] See C. Pissarides (2006), "What future for European jobs?", Centre Piece, Volume 11, Issue 1, Summer 2006.

Data Appendix

Production data

Gross output *Y* is constructed using measured revenue in current thousands of pounds at the establishment level. Labour input L uses total workers employed at the establishment level. Total capital input K is measured by the ONS - they construct a real capital stock series using investment data reported by establishments.

We measure outsourcing of services *s* using data on the establishment's intermediate expenditure on services. A list of the intermediate purchases included in our measure *s* is provided below. Other intermediate purchases are considered to be intermediate expenditure on goods *g*. We also use a measure of total intermediate purchases (the sum of goods and services) *m*.

Other covariates at the establishment level include whether the establishment is owned by a non-US multinational, by a US multinational or is part of a multi-establishment firm, and the establishment's age.

Sample

Table 1 shows the sample of data on which we can estimate the production function. We start with 177,750 establishments in the ABI-ARD in 2000, 2001, 2002 and 2003. We clean the data by dropping those establishments with higher intermediated purchases than turnover and drop establishments with non-positive values of our main variables, leaving us with 70,044 establishments. These establishments are on average larger in terms of turnover and number of employees than those in the original sample, they have higher value-added per employee and lower capital per employee.

[Table A1 here]

Services purchased include (the code in parenthesis refers to the question in the ABI questionnaire):

- payment for hiring, leasing or renting plant, machinery and vehicles (wq405);
- commercial insurance premiums (wq406);
- purchases of road transport services (wq407);
- purchases of telecommunications services (wq408);
- purchases of computer and related services (wq409) – excludes hardware and software included in investment flows;
- purchases of advertising and marketing services (wq410);

- other services purchased (wq411) – this includes amounts payable to others for the services of accountants, agents, solicitors, technical researchers;
- purchases of services for resale without processing (wq433);
- payment to employment agencies for agency staff (wq430)

Table A3 reports descriptive statistics splitting the sample into manufacturing and services industries. As expected, the manufacturing industries purchase fewer services as a share of gross output. Services industries invest more in ICT than the manufacturing industries (the means are statistically different at the 1% confidence level).

[Table A3 here]

Skill measure

We use the Labour Force Survey in 2000 and calculate the proportion of workers that hold a degree-level qualification out of the total workers in a 2-digit industry, in a given region. The definition of regions is the one used at the ARD and comprises 10 regions within Great Britain.

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Table 1: descriptive statistics for main sample

Variable		*Mean*	*Sd*	*Median*	*25th percentile*	*75th percentile*
Gross output	Y	36,418	300,187	3,846	802	15,109
Number of employees	L	288	2175	48	14	156
	L/Y	0.0204	0.035	0.0136	0.00758	0.0228
Employment cost	L cost	6,127	44,839	933	205	3,379
	L cost/Y	0.271	0.191	0.239	0.128	0.372
Capital stock	K	24,853	271,300	1,671	303	8,550
	K/Y	0.912	32.3	0.549	0.202	0.978
Goods and Services purchases	M	21,700	191,288	1,865	302	8,444
	M/Y	0.539	0.253	0.559	0.343	0.74
Services purchased	S	5,931	77,501	403	70	1,789
	S/Y	0.146	0.136	0.108	0.0612	0.183
Goods purchased	G	15,769	158,527	1,067	145	5,675
	G/Y	0.392	0.259	0.387	0.16	0.596
Software capital stock	ICT	291	6,250	7	1	36
	ICT/Y	0.0125	0.159	0.002	0.001	0.007
Proportion of employees with PC and internet access (%)	PCINT	35.6	27	29.5	13.7	53
Skills (% of employees with university degree)	SK	21.40	13.70	17.10	10.50	31.40
Age	Age	10.7	8.59	8	6	10
UK single	UK single	0.649	0.477	1	0	1
UK group	UK group	0.153	0.360	0	0	0
UK multi	UK multi	0.077	0.267	0	0	0
US	US	0.041	0.198	0	0	0
Other foreign	Other foreign	0.079	0.270	0	0	0

Source: Authors' calculations using the ABI-ARD for years 2000-2003.

Note: The number of observations is 70,044. All nominal variables are in thousands of pounds adjusted by GDP deflator. Descriptive statistics are for years 2000-2003. The variable SK is at the 2-digit industry and region level, from LFS. Sample size is slightly lower if SK or PCINT are included (61,358 and 53,277 respectively).

Table 2: Production function estimates

Dependant variable: ln (Gross output)$_i$	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
ln $(L)_i$	0.333	0.344	0.342	0.341	0.342	0.341	0.284
Labour	(0.004)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.007)**
ln $(K)_i$	0.147	0.214	0.207	0.210	0.207	0.209	0.227
Capital	(0.004)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.008)**
ln $(M)_I$	0.487						
Purchased Goods and Services	(0.005)**						
ln $(S)_i$		0.165	0.165	0.182	0.165	0.185	0.212
Purchased Services		(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.007)**
ln $(G)_i$		0.248	0.249	0.250	0.249	0.250	0.244
Purchased Goods		(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.006)**
ln $(ICT)_i$			0.010	0.020	0.009	0.027	0.021
ICT			(0.001)**	(0.002)**	(0.002)**	(0.002)**	(0.002)**
ln $(ICT)_i$ *ln $(Services)_i$				0.005		0.007	0.016
				(0.000)**		(0.000)**	(0.002)**
US_i	0.166	0.178	0.178	0.160	0.187	0.140	0.164
	(0.013)**	(0.015)**	(0.015)**	(0.015)**	(0.016)**	(0.017)**	(0.014)**
US_i*ln$(ICT)_i$					0.008	-0.013	
					(0.006)	(0.006)*	
MNE_i	0.122	0.124	0.123	0.108	0.125	0.080	0.108
	(0.008)**	(0.008)**	(0.008)**	(0.008)**	(0.009)**	(0.009)**	(0.008)**
MNE_i*ln$(ICT)_i$					0.001	-0.021	
					(0.003)	(0.004)**	
ln $(ICT)_i$ *ln $(Labour)_i$							-0.020
							(0.002)**
ln $(ICT)_i$ *ln $(Capital)_i$							0.008
							(0.002)**
ln $(ICT)_i$ *ln $(Goods)_i$							-0.003
							(0.002)

Source: Authors' calculations using the ABI-ARD for years 2000-2003.

Note: Results are obtained using OLS. There are 70,044 observations pooled across all industries. R-squared is over 0.94 in all columns. Robust standard errors are in parentheses, clustered at the enterprise group level. * significant at 5%; ** significant at 1%. Variables are transformed as deviations from the log of the mean at the 4-digit industry level for each variable. All regressions include region dummies, year and 4-digit industry dummies, establishment's age, whether it is part of a group, and whether it answered the long form questionnaire.

Table 3: Production function estimates, by sector

Dependant variable: ln (Gross output)$_i$	*(1)* industries with high Labour Productivity	*(2)* industries with low Labour Productivity	*(3)* industries with high average wage	*(4)* industries with low average wage	*(5)* Manufacturing	*(6)* Services	*(7)* Mean 2-digit industry	*(8)* Median 2-digit industry
ln (L)$_i$	0.244	0.371	0.351	0.338	0.321	0.341	0.324	0.335
Labour	(0.011)**	(0.005)**	(0.018)**	(0.005)**	(0.008)**	(0.006)**		
ln (K)$_i$	0.244	0.194	0.264	0.205	0.185	0.217	0.198	0.202
Capital	(0.012)**	(0.005)**	(0.019)**	(0.005)**	(0.008)**	(0.007)**		
ln (S)$_i$	0.148	0.212	0.177	0.181	0.164	0.178	0.176	0.170
Purchased Services	(0.011)**	(0.005)**	(0.025)**	(0.005)**	(0.009)**	(0.007)**		
ln (G)$_i$	0.322	0.208	0.179	0.260	0.317	0.238	0.272	0.322
Purchased Goods	(0.009)**	(0.005)**	(0.013)**	(0.005)**	(0.010)**	(0.005)**		
ln (ICT)$_i$	0.022	0.021	0.026	0.019	0.017	0.022	0.020	0.017
ICT	(0.004)**	(0.002)**	(0.004)**	(0.002)**	(0.002)**	(0.002)**		
ln (ICT)$_i$ *	0.005	0.006	0.007	0.005	0.005	0.006	0.004	0.002
ln (Services)$_i$	(0.001)**	(0.000)**	(0.001)**	(0.000)**	(0.001)**	(0.001)**		
US$_i$	0.182	0.148	0.175	0.157	0.120	0.196	0.143	0.140
	(0.028)**	(0.016)**	(0.022)**	(0.018)**	(0.013)**	(0.027)**		
MNE$_i$	0.137	0.092	0.101	0.112	0.061	0.154	0.088	0.083
	(0.016)**	(0.009)**	(0.017)**	(0.009)**	(0.008)**	(0.014)**		
Observations	15,697	54,347	9,015	61,029	20,785	44,539		

Source: Authors' calculations using the ABI-ARD for years 2000-2003.

Note: Robust standard errors are in parentheses, clustered at the enterprise group level. * significant at 5%; ** significant at 1%. Variables are transformed as deviations from the log of the mean 4-digit industry level for each variable. All regressions include region dummies, year and 4-digit industry dummies, establishment's age, whether it is part of a group, and whether it answered the long form questionnaire. R-squared is over 0.93. Industries are classified as high labour productivity (average wage) if their average labour productivity (average wage) is higher than the average for business services (2-digit SIC codes: 71, 72, 73 and 74), using aggregate data for 2001 from the Annual Business Inquiry. We use all the industries listed in Table A2. Of these industries the following ones are classified as high labour productivity: 23; 24; 35; 40; 41; 51; 61; 62; 64; 71; 72 and the following ones with high average wage: 21; 23; 24; 27; 30; 32; 34; 35; 40; 61; 62; 64; 72; 73.

Table 4: Production function estimates controlling for average skill levels

Dependant variable: ln (Gross output) i	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
ln $(L)_i$	0.338	0.339	0.337	0.337	0.279
Labour	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.008)**
ln $(K)_i$	0.211	0.211	0.215	0.214	0.233
Capital	(0.006)**	(0.006)**	(0.006)**	(0.006)**	(0.008)**
ln $(S)_i$	0.172	0.171	0.190	0.189	0.219
Services	(0.006)**	(0.006)**	(0.006)**	(0.006)**	(0.008)**
ln $(G)_i$	0.241	0.242	0.242	0.242	0.236
Goods	(0.005)**	(0.005)**	(0.005)**	(0.005)**	(0.007)**
ln $(ICT)_i$	0.010	0.026	0.021	0.035	0.037
ICT	(0.002)**	(0.004)**	(0.002)**	(0.004)**	(0.004)**
ln $(ICT)_i$ *ln $(Services)_i$			0.006	0.006	0.016
			(0.000)**	(0.000)**	(0.002)**
ln(SK)	0.075	0.101	0.072	0.094	0.096
Skills	(0.008)**	(0.010)**	(0.008)**	(0.010)**	(0.010)**
$ln(ICT)_{i*}$ Ln(SK)		0.009		0.007	0.008
		(0.002)**		(0.002)**	(0.002)**
ln $(ICT)_i$ *ln $(Labour)_i$					-0.021
					(0.002)**
ln $(ICT)_i$ *ln $(Capital)_i$					0.008
					(0.002)**
ln $(ICT)_i$ *ln $(Goods)_i$					-0.004
					(0.002)
US_i	0.195	0.191	0.175	0.171	0.175
	(0.016)**	(0.016)**	(0.016)**	(0.016)**	(0.015)**
MNE_i	0.134	0.133	0.117	0.116	0.117
	(0.009)**	(0.009)**	(0.009)**	(0.009)**	(0.009)**

Source: Authors' calculations using the ABI-ARD for years 2000-2003.
Note: Sample includes 61,135 observations. Robust standard errors are in parentheses, clustered at the region level; * significant at 5%; ** significant at 1%. All regressions include year dummies; 4-digit industry dummies; establishment's age, whether it is part of a group, and whether it answered the long form questionnaire. The variable Skills (SK) is the average proportion of working population holding a degree at the region and 2-digit industry level in the year 2000, hence variables are not transformed as deviations from log of the mean at 4-digit industry level and region dummies are not included. R-squared is over 0.94 in all columns.

Table 5: Production function estimates using an alternative measure of ICT

Dependant variable: ln (Gross output)$_i$	*(1)*	*(2)*
ln $(L)_i$	0.351	0.351
Labour	(0.006)**	(0.006)**
ln $(K)_i$	0.224	0.222
Capital	(0.006)**	(0.006)**
ln $(S)_i$	0.162	0.139
Services	(0.006)**	(0.006)**
ln $(G)_i$	0.238	0.238
Goods	(0.006)**	(0.005)**
ln(PCINT)	0.010	-0.029
PC per employee	(0.003)**	(0.008)**
ln(PCINT) *ln(Services)$_i$		0.007
		(0.001)**

Source: Authors' calculations using the ABI-ARD for years 2000-2003 and E-Commerce Survey.
Note: Sample includes 51,692 observations. Robust standard errors are in parentheses, clustered at the size band and industry level; * significant at 5%; ** significant at 1%. All regressions include region dummies; year dummies; 4-digit industry dummies; establishment's age, whether it is part of a group, owner by a multinational US firm or other multinational firm; whether it answered the long form questionnaire. The variable PCINT is at the employment 5-size band and 5-digit industry level; hence variables are not transformed as deviations from log of the mean at 4-digit industry level. R-squared is 0.95.

Table A1: Samples description

	N	*Turnover/revenue (£ 0,000)*	*Employment (People employed)*	*Turnover per employee (£0,000 per worker)*	*VA per employee (£0,000 per worker)*	*Capital per employee (£0,000 per worker)*
All establishments 2000-2003	177,750	23,248	173	417	69	172
+ w/ positive turnover	175,905	23,492	174	421	91	157
+ w/ positive employment	175,760	23,477	175	421	91	157
+ w/positive total intermediate purchases	170,367	24,005	179	402	62	160
+w/costs<turnover	150,270	22,851	176	314	137	105
+ w/positive total capital stock	128,483	26,123	200	352	151	124
+ w/positive purchases of services and goods	125,622	26,618	204	320	131	119
+w/ software capital stock = Main sample	70,044	36,418	288	213	96	132
Long form	24,333	93,545	740	383	183	232
Short form	45,711	6,008	48	123	49	79

Source: ONS, ARD-ABI. Descriptive statistics are for years 2000 to 2003.

Table A2.Industries included in the analysis

SIC code	Description	Sample size
Manufacturing		
15	Food Products and Beverages	2,374
17	Textiles	879
18	Wearing Apparel; Dressing and Dyeing of Fur	454
19	Tanning and Dressing of Leather	384
20	Wood And Products of Wood	919
21	Pulp, Paperand Paper Products	1,767
22	Publishing, Printing and Reproduction of Recorded Media	1,544
23	Coke, Refined Petroleum Products and Nuclear Fuel	1,357
24	Chemicals and Chemical Products	880
25	Rubber and Plastic Products	780
26	Other Non-metallic Mineral Products	1,998
27	Basic Metals	2,091
28	Fabricated Metal Products, Except Machinery and Equipment	240
29	Machinery and Equipment Not Elsewhere Classified	980
30	Office Machinery and Computers	608
31	Electrical Machinery and Apparatus Not Elsewhere Classified	832
32	Radio, Television and Communication Equipment	814
33	Medical, Precision and Optical Instruments	565
34	Motor Vehicles, Trailers and Semi-trailers	1,319
35	Other Transport Equipment	2,374
36	Furniture; Manufacturing Not Elsewhere Classified	879
	Total	20,785
Services		
50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles;	3,768
51	Wholesale	9,449
52	Retail	6,680
55	Hotels and Restaurants	4,798
60	Land Transport; Transport Via Pipelines	2,259
61	Water Transport	258
63	Supporting And Auxiliary Transport Activities; Activities Of Travel Agencies	1,628
64	Post and Telecommunications	581
71	Renting of Machinery and Equipment Without Operator and of Personal and Household Goods	878
72	Computer and Related Activities	2,259
73	Research and Development	284
74	Other Business Activities	11,697
	Total	44,539
Other		
40	Electricity, Gas, Steam and Hot Water Supply	163
45	Construction	4,557
	Total	4,720

Notes: ONS, ARD-ABI. Sample sizes are for years 2000-2003. We pool some 2-digit industries together in cases where sample sizes where not big enough to control for industry fixed effects or to conduct analysis at the 2-digit industry level. Industry 15 includes industry 16; industry 18 includes industry 19; industry 23 includes industry 24; industry 36 includes industry 37; industry 40 includes industry 41; and industry 61 includes industry 62.

Table A3: Descriptive statistics for manufacturing and services

		Manufacturing		*Services*	
Variable		*Mean*	*Sd*	*Mean*	*Sd*
Gross output	Y	38,408	205,802	35,070	341,251
Number of employees	L	255	585	312	2,685
	L/Y	0.015	0.013	0.023	0.042
Employment cost	L cost	6,454	18,246	5,957	54,301
	L cost /Y	0.278	0.138	0.268	0.211
Capital stock	K	29,239	135,993	20,669	292,756
	K/Y	0.942	1.210	0.938	40.500
Intermediate purchases	M	22,201	107,144	21,031	221,687
	M/Y	0.570	0.200	0.524	0.274
Services purchased	S	4,554	19,582	6,088	82,818
	S/Y	0.123	0.079	0.163	0.157
Goods purchased	G	17,647	93,788	14,943	187,136
	G/Y	0.447	0.184	0.361	0.285
Software capital stock	ICT	155	1,088	349	7,619
	ICT/Y	0.006	0.025	0.016	0.199
Proportion of employees with PC and internet access (%)	PCINT	27.4	21.3	39.8	28.8
Skills (% of employees with university degree)	SK	19.80	10.60	22.40	15.30
Age	Age	18	11	8	5
UK single	UK single	0.444	0.497	0.65	0.48
UK group	UK group	0.197	0.398	0.15	0.36
UK multi	UK multi	0.147	0.354	0.08	0.27
US	US	0.080	0.271	0.04	0.20
Other foreign	Other foreign	0.133	0.339	0.08	0.27
Observations		20,785		44,539	

Source: ONS, ARD-ABI. All nominal variables are in thousands of pounds. Descriptive statistics are for years 2000- 2003.