The impact of organisational change on productivity. Sectoral evidence from the UK, 1995-2005

Working paper nr. 29

Kangasniemi, Mari and Catherine Robinson

EU KLEMS WORKING PAPER SERIES Product

The impact of organisational change on productivity. Sectoral evidence from the UK, 1995-2005

Working paper nr. 29

Kangasniemi, Mari and Catherine Robinson

EU KLEMS Project
Productivity in the European Union: A Comparative Industry Approach

August 2008

This project is funded by the European Commission, Research Directorate General as part of the 6th Framework Programme, Priority 8, "Policy Support and Anticipating Scientific and Technological Needs".

The impact of organisational change on productivity

Sectoral evidence from the UK, 1995-2005

Mari Kangasniemi and Catherine Robinson

National Institute of Economic and Social Research, UK

ABSTRACT

Investment in ICT has been slow to exhibit productivity gains and increasingly it is argued that modern organisational arrangements are crucial in unlocking productivity gains from general purpose technologies such as ICT. The relationship between organisational change, the labour market and technology is complex. In this paper, we explore in greater detail these relationships, specifically the impact that organisational change has on productivity, using EUKLEMS augmented with additional data on training and other workplace practices and structures from the Labour Force Survey and the Community Innovation Survey for the UK. Our findings show very little evidence of our chosen measures of organisational change affecting productivity at the industry level, with the exception of advanced workplace practices. We find also weak evidence that in higher skilled industries, organisational change is more positively associated with productivity gains.

1. Introduction

Since the widespread introduction of Fordist techniques in the 1940s and 1950s and the growth of production line systems it has been recognised that the way in which firms organise themselves has a fundamental impact on their productivity (See for example Tylecote and Vertova, 2004). Whilst this form of organisation was defined in terms of rigid hierarchies and mass low skilled employment, the early 1980s saw a move away from mass production towards flexible specialisation (Piore and Sabel, 1984) as a means of increasing value added in production. This move to smaller, more specialised production systems designed to be more responsive to consumers has, to some extent, been facilitated by technology improvements in relation to information and communications. As such, it is difficult to separate the importance of organisational change from that of technological changes in recent years. But the focus of this paper is the extent to which organisational changes are complementary in raising productivity is the focus of this paper.

Our primary data source with regards organisational change measures is the Labour Force Survey (LFS). A secondary source of information is the UK Community Innovation Surveys, which are firm based surveys of innovation practices, each of which covers a 2 year period. These surveys have been conducted approximately every 4 years since the early 1990s. Both data sources are aggregated on the basis of industries and these are linked to the EUKLEMS data, and our analysis covers the period 1995-2005. Variables include: the provision of training to workers, the flexibility of working time and place and the structure of organisations in each industry (measured by the proportions of employees at different levels of the organisation) and organisational innovation. Our variables have been selected

to reflect the aspects of organisational change first identified by Black and Lynch (1995).

It should be noted that as well as complications in the measurement of organisational change there are a number of other issues that it is necessary to consider. The impact of organisational change on productivity could potentially work in the opposite direction (i.e. productivity positively affecting the up-take of organisational change) since it is perfectly plausible to expect more productive industries to be more likely to engage in more training and provide more work flexibility. Thus, causality is likely to be an issue and we discuss ways in which this might be dealt with below.

Our paper is organised as follows: firstly, we consider the importance of complementary changes in the absorption of technology, the role of organisational change and crucially, its definition. In section 3 we provide details of our data sources, highlighting their strengths and weaknesses. Section 4 outlines the model adopted to evaluate the effect of organisational change on productivity growth in the UK. Our results are presented in section 5. Finally, we present the conclusions that we draw from our findings and suggest future avenues for research.

2. Organisational change, technology and productivity

Organisational capital is an intangible capital, distinct from the concepts of human or physical capital in the standard growth model. It is the organisational capability to enhance the productivity of workers and includes the organisational structure, task allocation, decision-making distributions, relations with suppliers and major customers, and the culture of the company. One strand of the literature treats organisational capital as

embodied in the firm's workers or in their matches to tasks within the firm, defining it as firm specific human capital. We take the view that organisational capital is a firm-specific capital good, jointly produced with output and embodied in the organisation itself (c.f. Brynjolfsson et al, 2002).

Organisational change, as distinct from organisational capital, is the process of organisational reform. Most recently, it has largely been instigated in order to complement the incorporation of ICT, switching from vertically centralised structures to more horizontal, knowledge-based work systems. We recognise that this is not a discrete or immediate transformation, nor is the scale of each instance of organisational change the same. However, due to the difficulties of measurement and the limited detail of data available it is necessarily treated as such.

There are two main ways through which organisational change is thought to raise productivity, firstly through improving the usage of new technology, which lends itself to more flexible management systems and a more horizontal enterprise structure, and secondly, through utilising skilled workers more effectively (Caroli and van Reenen, 2001). Giuri et al (2008) point to the 'direct and indirect effects of new technologies on labour demand' (p30), arguing that the indirect effects are driven by 'organisational co-inventions and product or service innovations that may produce an additional effect on the productivity of skilled labour'. Research into how far skills have been a necessary complementary asset to ICT capital investment has been explored extensively by analysing how far technological change is skill biased (Bresnahan et al, 2002; O'Mahony et al 2008). More recently, research has turned to the extent to which organisational change as a necessary complementary asset.

Less empirical work has been carried out directly linking organisational change to productivity gains, despite this often being cited as the reason why ICT benefits have been slow to materialise. In a paper which demonstrates the link between productivity and organisational changes associated with flexible specialisation, Black and Lynch (2001) use detailed firm level data for the US (the Educational Quality of the Workforce, National Employers Survey), matched into the US Longitudinal Respondents Database (LRD) to estimate cross sectional and panel production functions. These production functions incorporate measures of workplace practices and technology over the period 1987-1993. This is recognised as a period of rapid adoption of ICT particularly in the US and just before the resurgence of US productivity growth (O'Mahony and van Ark, 2003). Their findings highlight the importance of establishing the extent to which firms actually engage in new management practices, not simply whether they supposedly have systems in place.

A recent paper by Crespi, Criscuolo, and Haskel (2007) examines in detail the relationships between productivity growth, IT investment and organisational change using UK firm panel data for 1998 and 2000. Crespi et al (2007) find that IT capital and organisational change are complementary in raising productivity, but this relationship does not hold for non-IT capital, suggesting that organisational change is integrally linked to realising productivity gains from this new technology. Their measure of organisational change is derived from the CIS3 and matched into financial firm level data for the period 1998-2000. The study goes further and finds organisational change is affected by competition and that ownership affects the propensity to implement changes. In their conclusions, they speculate that the EU slowdown relative to the US is possibly a combination of later IT investment and less organisational change.

In a similar analysis Bloom et al (2006) cite two reasons for US productivity advantages; firstly they consider natural advantages, such as access to venture capital, better skills, larger markets, lower product and labour market regulation, etc. Secondly, they argue that the US has greater 'depth of organisational capital', which has enabled better exploitation of IT through the use of a more decentralised organisational structure (Acemoglu et al, 2007). Using firm level data for the UK, Bloom et al (2006) test this by considering the productivity of multinational US organisations based in the UK. They argue that it is possible to separate the natural advantages from the organisational advantages. Their findings suggest that part of the story relates to organisational capital, but also that US firms are 'leaner and meaner' and generally better equipped to deal with new technologies.

At the sector level, Basu et al (2003) focus on how far MFP growth can be explained by investment in organisational capital, which they argue is necessary to reap the benefits from a general purpose technology such as ICT. They use the growth in ICT investment as a proxy for the organisational capital and find a suggestion of an initial fall in TFP, in the UK before the benefits are realised in the longer run. Thus there is a view that the productivity gains from ICT are simply lagging the US although it could be argued that a more direct measure of organisational change is warranted if we are to understand the link between ICT investment, organisational change and productivity.

Organisational change is also likely to affect productivity indirectly by raising individual workers productivity, particularly the higher skilled workforce (Bresnahan, et al, 2002). Skill Biased Organisational Change is the hypothesis that organisational change increases the productivity of skilled workers relative to

unskilled workers since skilled workers are more able to handle information, have superior communication skills, are more receptive to retraining, and are more autonomous and as a result, organisational change measures are more cost effective to implement. In terms of empirical evidence supporting the existence of skill biased organisational change, Caroli and van Reenen (2001) compare and contrast evidence of skill biased organisational change in Britain and France. Using data from the UK WIRS and the French RESPONSE survey they find that organisational change leads to greater productivity increases in establishments with larger initial skill endowments. Caroli and van Reenen (2001) find too that technical change is complementary to human capital, but they assert that the effect of organisational change is not simply due to its correlation with technological change but has an independent role. What is clear from their paper is the multifaceted nature of organisational change.

Bresnahan (1999) argues that Skill-Biased Organisational Change (SBOC) and Skilled-Biased Technical Change (SBTC) are effectively the same phenomena viewed from different perspectives. This is supported by Giuri et al (2008) who find in their study of Italian manufacturing weak evidence of SBOC when measured alongside SBTC (for which they report strong evidence). This is consistent with the findings of Piva et al (2005) who find that upskilling is more a function of organisational change than a consequence of technological change alone. Some evidence of an additive effect of technological and organisational change on the skill composition of employment emerges, which they argue is consistent with the theoretical hypothesis of a co-evolution of technology and organisation.

Organisational change has been found to have a wider impact on the production process, not only productivity. Black, Lynch, and Krivelyova (2004) separate organisational change into different

practices and find that different measures result in varying levels of employment reductions and highlight the influence that unions can have on the employee fortunes post organisational change. They examine the US National Employers Survey, EQW from 1994-97, and find that employers do compensate a proportion of their workers for engaging in high performance workplace practices, but that these are the non-production workers.

It can be seen therefore that whilst there is general agreement that organisational change has an impact on the demand for labour (and thus, an indirect impact on productivity), there is mixed evidence of about the nature of the direct relationship with technology and productivity. This is partly due to the multi-faceted nature of organisational change and associated problems in measuring it. Most analysis has concentrated on firm level evidence of productivity impacts, however here we consider the role that organisational change is likely to have in affecting productivity growth at the sectoral level. It is clear, however, that organisational change, whilst hard to measure, has a number of channels through which it may raise productivity and is likely to be a significant part of the GPT/skills story of productivity over the past 20 years.

3. Data sources

The primary source of data is the UK component of the EUKLEMS productivity accounts database[1]which covers the period 1970-2005 and includes labour quantity and quality measures, capital services, both ICT and non-ICT capital, and output, as measured by gross value added. For our purposes, we

[1] EUKLEMS data are available from http://www.euklems.net. Whilst we use only UK data here, we gratefully acknowledge the substantial contribution of all members of the EUKLEMS consortium in acquiring and harmonising cross country comparable industry data, which we hope will allow for international comparisons in the longer term.

concentrate on the 1995-2005 period, given the timing of the phenomenon we wish to observe and data availability. Measures of organisational change are derived from two main sources. The UK Labour Force Survey (LFS), which draws a sample of individuals from the whole of the labour force, providing a convenient source of information which may be aggregated to the appropriate industry level, weighted to be population representative and consistent with input and output data available from EUKLEMS. The LFS is a widely used source of information on the labour market. Sample sizes at the level of disaggregation we are considering are relatively small. However, the LFS includes questions on training, working time arrangements, flexibility of the job like working from home and the use of managerial inputs.

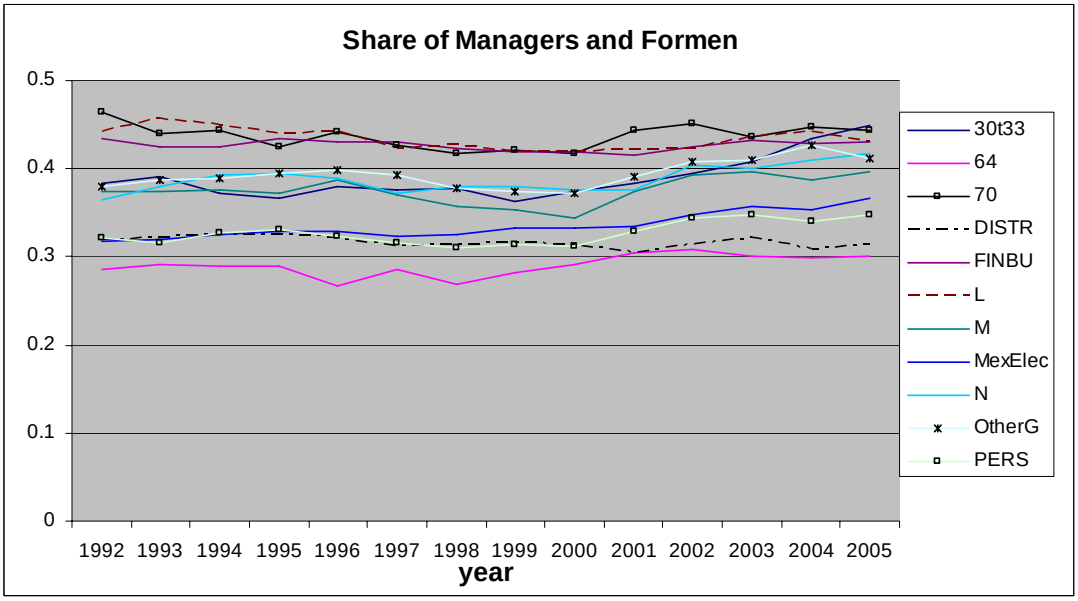
We construct four variables using the quarterly LFS (1992-2006)[2]. Firstly, we construct the share of managers and foremen in total employment. The LFS asks respondents about their managerial status since the spring of 1992. Thus, we use this variable to build a variable of manager/foreman share in each industry which we hope reflects the degree to which the organisation is hierarchical. Secondly, since 1993 there have been questions about employees' type of agreed work arrangement. We generate a dichotomous variable of whether any flexible working arrangements were used and calculate the share of positive responses in each industry. Thirdly, the LFS contains information on whether respondents have received training or education on the job in the last three months (from 1995) Finally, by industry, we extract the share of people working from home, although this is more difficult to identify, based on responses in the spring and autumn quarters.

[2] The access to the LFS micro data was granted by the UK Data Archive whose assistance is gratefully acknowledged. The original data creators, depositors or copyright holders, the funders of the Data Collections and the UK Data Archive bear no responsibility for their further analysis or interpretation. The LFS data are Crown copyright.

The question changed slightly in 1998 and only covers the spring quarter. However since we only use the share of people ever working from home, these changes should not affect our data.

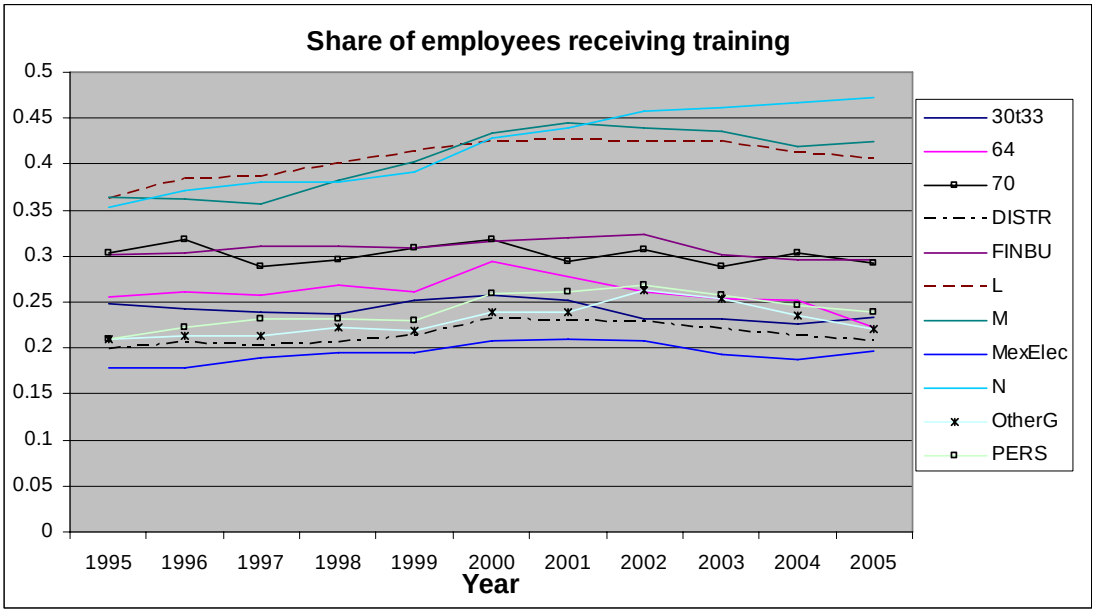
Figures 1 to 4 show the evolution of the four variables at an aggregate level. In terms of industry breakdowns, we use an aggregated EUKLEMS industrial classification, above the two digit level in a number of cases. This is to account for some small industry sample sizes which are likely to result in misleading findings. It can be seen that most variation is between industries and the variables change little over time. The same patterns are present in the data disaggregated to the lowest level and variation between industries is much larger than within them.

Figure 1:



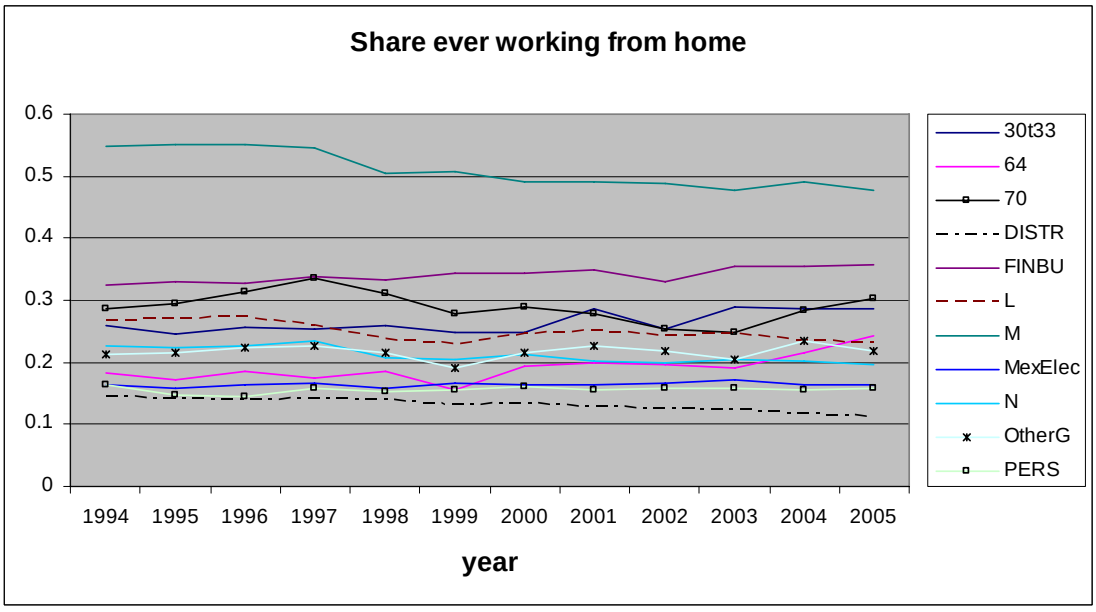
30t33=Electrical and optical equipment; 64=Post and telecommunications; 70=Real Estate Activties;DISTR=Distribution; FINBU=Finance and Business, except real estate; L=Public Administration and defence; compulsory social security; M=Education; MexElec=Metal manufacturing, excluding electrical; N=Health and social Work; OtherG=Other Production; PERS=Personal Services.

Figure 2:



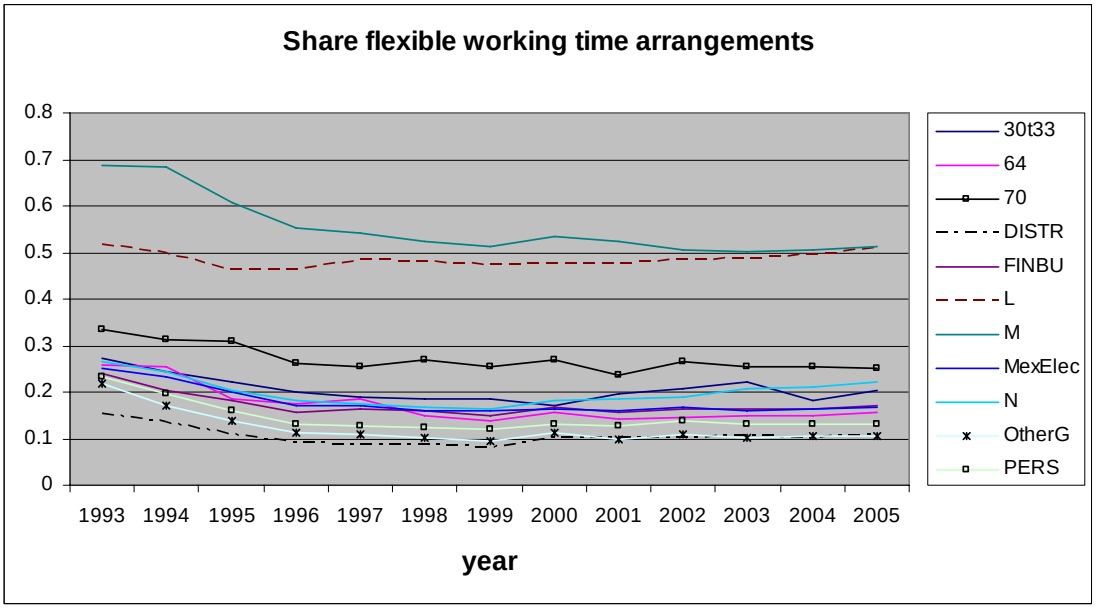
30t33=Electrical and optical equipment; 64=Post and telecommunications; 70=Real Estate Activties;DISTR=Distribution; FINBU=Finance and Business, except real estate; L=Public Administration and defence; compulsory social security; M=Education; MexElec=Metal manufacturing, excluding electrical; N=Health and social Work; OtherG=Other Production; PERS=Personal Services.

Figure 3:



30t33=Electrical and optical equipment; 64=Post and telecommunications; 70=Real Estate Activties;DISTR=Distribution; FINBU=Finance and Business, except real estate; L=Public Administration and defence; compulsory social security; M=Education; MexElec=Metal manufacturing, excluding electrical; N=Health and social Work; OtherG=Other Production; PERS=Personal Services.

Figure 4:



30t33=Electrical and optical equipment; 64=Post and telecommunications; 70=Real Estate Activties;DISTR=Distribution; FINBU=Finance and Business, except real estate; L=Public Administration and defence; compulsory social security; M=Education; MexElec=Metal manufacturing, excluding electrical; N=Health and social Work; OtherG=Other Production; PERS=Personal Services.

Correlations between these variables are presented in Table 1. All variables are statistically significantly correlated, in particular the share of individuals trained with the share of managers and foremen, and the share of flexible working time arrangements with the share of employees trained. Since our aim is to measure the holistic impact of organisational change, we expect these variables to be linked, however to include them separately in regression analysis is likely to lead to misleading results because of the high level of correlation. Therefore we condense the four variables by using principal components analysis and use the first principal component in our analysis. We use eigenvectors from the covariance matrix since the unit of measurement of each variable is the same, i.e. the proportion of employed individuals with each characteristic. The final column in Table 1 contains the eigenvector for the first principal component, which captures 61 per cent of the variation of the variables and can therefore be considered an adequate measure of organisational capital.

Table 1: Correlations between the LFS derived measures of Organisational Change

	share of formen and managers	share of employees received training	share ever work home	share flexible working time arrangements	Eigenvector of 1st principal component
share of formen and managers	1				0.3347
share of employees received training	0.668	1			0.5435
share ever work home	0.1739	0.4067	1		0.463
share flexible working time arrangments	0.3399	0.6567	0.5055	1	0.6149

* All correlations significant at the 1% level.

Given the multi-faceted nature of organisational change, our additional source data is the UK Community Innovation Survey (1994-2004). This is an enterprise based survey conducted by all EU countries since the mid 1990s to explore innovation activities in enterprises across Europe. It draws from a sample of enterprises with 10 or more employees and asks questions related to the type of innovation (if any) undertaken. There are four main categories of innovation (DTI, 2006) these include soft and wider innovation such as strategic changes to the organisation or business function, improving competitiveness through gains in efficiency or service improvements. Over time, there have been changes in the questions asked in the survey, and changes in sample coverage and size[3]. Given this, the development of a single measure of organisational change is not straightforward.

In the case of assessing the degree to which industries have engaged in organisational change, within the CIS3 and CIS4, there is a subsection of questions that considers 'wider innovation'. These include questions in relation to advanced management techniques, new corporate strategies and new organisational

[3] See Frenz (2002) for a detailed comparison of CIS2 and CIS3 and more recently Robson and Ortmanns (2006) for a discussion of how CIS4 differs from earlier survey formats,

structures. We included the three variables: "changes to organisational structure", "new corporate strategies", and "advanced management techniques". In CIS2 there were no questions on advanced management techniques or corporate strategies. Differences in questionnaires and in sample sizes meant that for the CIS2 period, we needed to construct a variable to measure changes in organisational structures. In CIS2, questions were asked in relation to an enterprise introducing specifically, JIT management, or similar planning system, a quality management system, or some other sort of change or technique. Enterprises were also specifically asked also if they undertook no changes or techniques during 1994-97. A composite variable measuring changes in organisation was constructed on the basis of all four questions. In order to get a series that covers the same period as the LFS data, CIS2 results were assumed to hold for 1995-1997, CIS3 1998-2001 and CIS4 2002-2005. It should also be pointed out that CIS3 does not include coverage of the sectors wholesale, retail or hotels and restaurants so the findings from CIS 4 results were assumed to hold for the earlier periods[4]. None of the CIS data includes agriculture, fishing or non-market services.

The correlations between the CIS variables are presented in Table 2, which shows they are heavily correlated with one another. The first principal component captures 91% of the variation and is used it in the analysis.

Table 2: Correlation between CIS derived measures of Organisational Change (CIS 2, 3 and 4)

	Changes to the Organisational Structure	New Corporate Strategies	Advanced Management Techniques	Eigenvector of 1st principal component
Changes to the Organisational Structure	1			0.5585

[4] For new corporate strategies and advanced management techniques the results from CIS3 were assumed to hold for the earliest period.

New Corporate Strategies	0.8349	1		0.5886
Advanced Management Techniques	0.8148	0.947	1	0.5844

* All correlations significant at the 1% level

To provide an overview of organisational change as it varies by industry and over time, Table 3 below contains percentages of enterprises engaging in the various forms of organisational change measured in the CIS. 2000 appears to be the point in the data when the majority of the organisational changes were taking place in enterprises. Where data are available from the CIS2, we see that, by and large, changes in organisational structure were closer to the order of magnitude in 2004 rather than the 2000 level. The percentage uptake of each form of organisational change is broadly similar across the variables, suggesting that there is considerable correlation between these variables. In terms of differences between industries, Table 3 shows that higher technology driven industries and those that are often reported to have experienced considerable growth in the UK (O'Mahony et al, 2007) appear to have been instigating organisational change – particularly evident when we consider the financial services sector and the higher technology production sectors such as electrical and optical equipment. These descriptive findings do perhaps point to a link between technology uptake and the uptake of more modern organisational arrangements within the enterprise.

Table 3: Percentage share of enterprises engaging in organisational change by broad sectoral breakdowns, 1996-2004

		% firms with New Corporate Strategy			% firms with Change in Organisational Structure			% firms with Advanced Management Techniques		
	CODE	**1996**	**2000**	**2004**	**1996**	**2000**	**2004**	**1996**	**2000**	**2004**
MARKET ECONOMY	MARKT	-	36.57	16.49	19.12	32.02	17.12	-	30.48	13.55
ELECTRICAL MACHINERY, POST AND COMMUNICATION SERVICES	ELECOM	-	48.68	27.11	44.56	42.19	29.04	-	43.10	17.69
Electrical and optical equipment	30t33	-	50.15	25.60	50.14	44.20	29.67	-	47.12	17.18
Post and telecommunications	64	-	43.68	29.56	12.84	35.36	28.03	-	29.45	18.51
Goods, producing excluding electrical	GOODS	-	33.94	15.62	24.82	29.84	16.95	-	29.62	14.12
Metal manufacturing, excluding electrical	MexElec	-	38.22	17.83	28.51	33.03	19.18	-	32.89	13.97
Consumer manufacturing	Mcons	-	32.24	16.70	17.41	30.63	18.32	-	30.46	12.38
Intermediate manufacturing	Minter	-	38.68	16.44	31.33	32.01	18.31	-	32.08	13.47
Investment goods, excluding high-tech	Minves	-	45.84	24.63	37.58	40.65	23.65	-	39.72	18.17
OTHER PRODUCTION	OtherG	-	24.30	11.22	12.97	22.65	12.49	-	22.28	14.40
MARKET SERVICES, EXCLUDING POST AND TELECOMMUNICATIONS	MSERV	-	37.95	16.24	13.92	33.15	16.47	-	29.93	13.03
DISTRIBUTION	DISTR	-	31.37	13.00	11.16	26.71	13.07	-	25.19	11.24
FINANCE AND BUSINESS, EXCEPT REAL ESTATE	FINBU	-	44.21	24.36	29.23	39.30	24.81	-	34.44	18.43
PERSONAL SERVICES	PERS	-	6.55	6.55	6.68	6.68	6.68	-	5.75	5.75
NON MARKET SERVICES	NONMAR	-	27.84	21.50	17.49	22.21	21.06	-	15.25	15.74
Total Economy	**TOT**	**-**	**36.31**	**16.64**	**19.09**	**31.73**	**17.24**	**-**	**30.02**	**13.61**

Source: CIS2, 3 and 4 (DTI), NIESR calculations.

4. Econometric model

In order to consider the impact organisational change has on productivity, we start by assuming a standard Cobb-Douglas production function in log form:

(1) $\ln Y_{it} = \ln A_{it} + \alpha_1 \ln KIT_{it} + \alpha_2 \ln KNIT_{it} + \beta \ln L_{it} + \varepsilon_{it}$

Where Y is value added, KIT a measure of IT capital, KNIT a measure of non-IT capital, L labour input and ε_{it} error term that may include industry specific effects. Organisational change is included into this specification as a vector of separate regressors O, derived from LFS and CIS as described above:

(2)

$$\ln Y_{it} = \ln A_{it} + \alpha_1 \ln KIT_{it} + \alpha_2 \ln KNIT_{it} + \beta \ln L_{it} + \gamma \ln O_{it} + \varepsilon_{it}$$

We estimate the equation in both levels form as above and in difference form:

(3)

$$\Delta \ln Y_{it} = \Delta \ln A_{it} + \alpha_1 \Delta \ln KIT_{it} + \alpha_2 \Delta \ln KNIT_{it} + \beta \Delta \ln L_{it} + \gamma \Delta \ln O_{it} + \Delta \varepsilon_{it}$$

The variables derived from CIS can only be used in the difference estimation in this specification as they measure how widespread organisational changes are in each industry but give no indication of the differences of the *level* of organisational development between industries. In our two stage estimation, however, we also examine the relationship between the average share of companies with organisational changes and levels of productivity. The interpretation of this link is naturally different from that of the level of organisational development and productivity.

Conceptually, we can assume that organisational change has a direct impact on total factor productivity or that organisational change enters production as a multiplicative factor increasing the productivity of labour and/or capital. Therefore, in addition to the standard specification we add interaction terms to the specification. These provide further information on the interaction effect of organisation with other inputs. A similar approach has been used for example by Bresnahan et al (2002) where they interact workplace organisation with skills and IT variables.

Input and output measures from the UK EUKLEMS database are used. For levels estimations the preferred input measures are capital and labour services which are calculated using levels for 1997 and service indices from UK EUKLEMS. These are, however only available for 26 industries[5]. Therefore, we also use capital stock measures and hours for levels estimations to be able to use all 31 industries and check that the inclusion of these industries does not essentially change the results. The capital (ICT and non ICT) and labour service indices reported in the UK EUKLEMS database are used in fixed effects and first differences estimations.

Firstly, each of organisational change variables are entered separately, to see if they have individual effects and we then adopt the composite variable obtained from principal component analysis. We interact the organisational change measures with IT capital and (in fixed effects and first difference estimations) with labour quality index from EUKLEMS. This is based on relative changes in shares of employed people in different gender, age and education groups. We also examine the impact of the interaction

[5] The missing industries are non-market industries, health, education and government, and real estate activities and private households with employed persons. The levels estimates for 1997 were provided by Mary O'Mahony.

of levels of organisational capital and the share of high skilled individuals in our two stage estimation.

Our initial results suggest that the small variation in the organisational variable does not allow efficient estimation of its impact on productivity in fixed effects and first differences estimations. Therefore we also follow an approach similar to that used by Black and Lynch (2001), estimating fixed effects by using capital and labour variables as explanatory variables. Then we extract the residuals, which are composed of fixed effects and the random error, and calculate average of these over the period:

$$(4)\quad \overline{\varepsilon}_i = \left(\sum_t \ln(Y_{it}) - (\hat{\alpha}_1 \ln KIT_{it} + \hat{\alpha}_2 \ln KNIT_{it} + \hat{\beta} \ln L_{it}) \right) \Big/ T$$

This new variable is then regressed on the industry averages of the organisational change variable.

Black and Lynch (2001) only have information on organisational practices for one year. We, however, in principle have organisational information for each year even though its variation is low. Therefore we also conduct similar estimation by adding the organisational change variable as an explanatory variable in the first stage of estimation in order to control for within industry variation. In this case the average error used in second stage does not include the short term changes correlated with changes taking place over the period of observation. The average errors which include fixed effects are then used as dependent variables in the second stage between groups regression.

We estimate the models specified above using OLS, fixed effects and first difference methods of estimation. These may suffer from the usual endogeneity problems associated with production

function estimation. Organisational changes may be a result of higher productivity rather than vice versa, since one would expect firms at the production frontier to be those most likely to adopt latest technologies and methods. This can be dealt with using instrumental variables, where such external instruments are available. This is however not the case for organisational change. Lagged differences of variables themselves can be used as instruments for levels and lagged levels for differences if the number of units observed is large enough (Arellano and Bond 1991 and Blundell and Bond 2000). In this dataset however, this is not the case. Lagged differences and levels may also be very weak instruments for current levels and differences. We experiment following Black and Lynch's (2001) approach using system GMM to estimate the impact of the other inputs[6] and generate average residual for each industry which is then used as the left hand side variable as in the case of fixed effects estimation but this does not seem to produce significantly improved results. In addition to too small number of units, we acknowledge that our data are also more likely have problems relating to their dynamic structures which the system GMM method does not solve.

5. Results

We find all measures of organisational change produce largely insignificant coefficients in all specifications (with the exception of working time arrangements in some specifications). Including interactions with IT capital, by and large results in the IT capital coefficient becoming insignificant and the interactions are not significant either, suggesting the interaction term merely waters down the ICT capital effect. In fixed effects estimations the interactions become significant but the actual capital input variables are reduced to very small values. Therefore, it seems likely that the interaction variables pick up the impact of capital

[6] Using Roodman's (2006) xtabond2 Stata command.

inputs, with which they are collinear. Similarly, the impact of the CIS variables separately in the first difference equation, are minimal. Therefore we only report the results from the specifications with the scores calculated from principal component analysis.

Results from the various value added specifications are reported in table 4. Different measures of capital and labour inputs, labour and capital services levels, capital stocks and unadjusted hours and capital and labour service indices, do not greatly differ between these specifications and so we report here labour and capital services levels results. The results concerning the other measures are presented in the Appendix.

In the levels estimations without interaction terms the score measure of organisational change is positive and significant at 5% (services) and 10% (capital stock and hours) level of significance. To address possible endogeneity we use lagged measures of organisational change since it is reasonable to suppose that organisational changes may feed through to affect productivity over time. Our findings, however, are much the same as when simultaneous values of explanatory and dependent variables are included in the OLS estimations[7]. In fixed effects and first differences estimations the coefficients are insignificant and in first difference where lagged organisational change is used the coefficient is negative. This may be largely due to the fact that there is little variation on the scores over time. The OLS coefficient is therefore mainly determined by between-industry variation. In OLS specifications with capital stock and unadjusted hours instead of the service levels (where non-market sectors are also included) the impact of organisational change is dampened but still significant at 10% level in the specification with the

[7] Results are available on request.

simultaneous organisational structure variable on the right hand side. In fixed effects and first differences estimations for capital stock and unadjusted hours and service volume indices the coefficients of organisational variable are not significant. The results further support the hypothesis that in these data organisational changes over time are not adequate to cause significant immediate changes in productivity.

Table 4: Regression results, determinants of value added (volume measures)

	OLS	FE	FD	
Dependent variable	LNVAVOL	LNVAVOL	D.LNVAVOL	D.LNVAVOL
Coefficient				
Ln (ICT capital services)	0.110**	0.107	0.107	0.0950
	(0.053)	(0.074)	(0.068)	(0.072)
Ln(Non-ICT capital services)	0.340***	0.149	0.291**	0.279**
	(0.079)	(0.25)	(0.12)	(0.12)
Ln(Labour services)	0.467***	0.573**	0.216**	0.242**
	(0.080)	(0.22)	(0.10)	(0.11)
Ln (organisation score)	0.555**	-0.276	0.0547	
	(0.22)	(0.17)	(0.066)	
L. Ln (organisation score)				-0.0351
				(0.042)
Constant	-0.862*	-0.687	-0.000195	-0.000540
	(0.46)	(0.75)	(0.0075)	(0.0093)
Observations	286	286	260	234
R-squared	0.94	0.62	0.25	0.25
Number of NR3		26		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When we include scores from CIS as explanatory variables to first difference estimation (results in the Appendix), we find that the coefficient is insignificant though positive throughout.

In order to explore complementarity between organisational change, ICT capital and skills we add interactions of the organisational change variable with ICT capital and labour quality (the latter only in fixed effects and first differences estimations since between industry variation of the index is not meaningful). These results are reported in the Appendix. Coefficients on the interaction terms between the organisational change score and IT capital and labour quality are insignificant in all estimations

except for the fixed effects for service levels specification where the interaction of ICT capital and organisational change is significantly positive. The coefficient of the organisational change variable, however, is more strongly negative than in the fixed effects regressions without interactions and the coefficients for ICT capital services are more strongly positive. The first difference results show coefficients for the ICT capital services and the organisational change score also change as a result of the inclusion of interaction variables but to a lesser extent. In the OLS specification the coefficient for ICT capital decreases after the inclusion of the interactions and the coefficient for organisational change increases but becomes less significant. Similarly the coefficients in the capital stock and hours and service indices estimations seem to change as a result of the inclusion of interaction terms. Including more variables which are strongly correlated with existing variables seems to add further randomness to the results, conflating the findings.

Finally, the results from the two stage approach are reported in table 5. In alternative specifications we include either only capital and labour inputs in the first stage, or also include the LFS organisation score or LFS and CIS scores in order to extract the within industry effect. The coefficient of the LFS based organisational change score is significant in all specifications at 1% level which suggests that higher levels of productivity are strongly linked to advanced workplace practices.

Table 5: First stage, Fixed effects

COEFFICIENT	(1)&(3) LNVAVOL	(2) LNVAVOL	(4) LNVAVOL
Ln (organisation score)		-0.276	-0.256
		(0.17)	(0.18)
Ln(CIS score of organisational change)			0.115
			(0.10)
Ln (ICT capital services)	0.128	0.107	0.122*
	(0.076)	(0.074)	(0.071)
Ln(Non-ICT capital services)	0.155	0.149	0.0572

	(0.26)	(0.25)	(0.26)
Ln(Labour services)	0.532**	0.573**	0.634***
	(0.23)	(0.22)	(0.20)
Constant	-0.368	-0.687	-0.308
	(0.73)	(0.75)	(0.93)
Observations	286	286	264
Number of NR3	26	26	24
R-squared	0.61	0.62	0.66

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 continued: Second stage

COEFFICIENT	(1) fixed	(2) fixed	(3) fixed	(4) fixed
Ln (avg organisation score)	0.867***	1.224***	1.173***	1.658***
	(0.22)	(0.22)	(0.27)	(0.32)
Ln(avg CIS score of organisational change)			-0.200	-0.310*
			(0.13)	(0.16)
Constant	0.776***	1.095***	0.885***	1.206***
	(0.20)	(0.20)	(0.20)	(0.24)
Observations	26	26	24	24
R-squared	0.40	0.57	0.51	0.58

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The inclusion of organisational practices in the first stage of estimation increases their coefficient in the second stage. This could be explained by the fact that changes in organisational change and productivity are unlikely to be simultaneous: there may be considerable delay in the effects of organisational change to pass through or organisational reforms can be used as a response to negative productivity shocks. The length of this panel, however, does not allow estimation of models with separate long and short term effects.

The coefficients of the CIS measure of organisational change in the second stage are negative but not particularly significant. Changes in organisational structures may be used in attempt to improve productivity. In the first stage the coefficient is slightly positive; this implies that within industries changes are carried out in periods when productivity is unusually high. However, this result is seriously weakened by the fact that we expand the CIS

measure collected in one point in time over several periods, so the timing of high values of CIS variable does not necessarily coincide with the actual events.

In order to examine the possible skill bias in the links between organisational change and productivity we conducted two stage estimations with interactions between average organisational variables and average share of highly skilled workers. The results are presented in table 6.

Table 6: Stage 1

COEFFICIENT	(1)&(2) LNVAVOLUME	(3) LNVAVOLUME	(4) LNVAVOLUME
Ln (ICT capital services)	0.128	0.107	0.122*
	(0.076)	(0.074)	(0.071)
Ln(Non-ICT capital services)	0.155	0.149	0.0572
	(0.26)	(0.25)	(0.26)
Ln(Labour services)	0.532**	0.573**	0.634***
	(0.23)	(0.22)	(0.20)
Ln (avg organisation score)		-0.276	-0.256
		(0.17)	(0.18)
Ln(avg CIS score of organisational change)			0.115
			(0.10)
Constant	-0.368	-0.687	-0.308
	(0.73)	(0.75)	(0.93)
Observations	286	286	264
Number of NR3	26	26	24
R-squared	0.61	0.62	0.66

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Stage 2

COEFFICIENT	(1) Fixed	(2) Fixed	(3) Fixed	(4) fixed
Ln (avg organisation score)	0.580**	-0.992	0.974***	-0.940
	(0.28)	(1.00)	(0.28)	(1.19)
Ln (avg organisation score)*ln(average share of highly skilled individuals)	0.231	1.008**	0.200	1.201**
	(0.14)	(0.45)	(0.15)	(0.54)
Ln(avg CIS score of organisational change)		1.721*		2.088*
		(0.88)		(1.04)
Ln(avg CIS score of organisational change)*ln(average share of highly skilled individuals)		-0.959**		-1.213**
		(0.44)		(0.52)

Constant	0.978***	0.832***	1.271***	1.090***
	(0.23)	(0.22)	(0.24)	(0.26)
Observations	26	24	26	24
R-squared	0.46	0.61	0.60	0.67

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Without controls for the CIS measures of organisational change the interaction variable for the LFS measure of organisational change is positive (but not significant), i.e. higher levels of skill in an industry also mean that advanced organisation is more beneficial for productivity. Adding CIS scores and their interaction with skill level results in the coefficient for the LFS score becoming negative and, unlike in estimations without interactions, the CIS score coefficient in the second stage is positive. The interaction of skills with CIS score has a strongly negative coefficient whereas the interaction with the LFS measure has an even stronger positive coefficient than without the CIS variables. There is clearly a high degree of collinearity. However, these results suggest that the positive effects of the organisational status may be stronger in higher skilled industries.

6. Conclusions and policy implications

From the results presented in Section 5, it is difficult to establish causality but clearly certain workplace practices are linked to higher productivity. Further steps in this research are to refine our measures of organisational change. What is clear from our extensive analysis so far is that it is difficult to measure organisational change – as Lynch (2007) points out, it is not just a case of having such management practices in place, it is whether or not they are carried out in the day to day running of the establishment. Ensuring that our measure manages to capture the reality of change is perhaps our first step.

The results suggest that at the industry level a link is to be found between high levels of productivity and use of more advanced

organisation as measured by the variable derived from the LFS. There is a less clear link between organisational changes as measured in the CIS and productivity. There is also some weak evidence that the positive effect of advanced organisation is stronger in industries with high skill levels. It remains unclear, however, whether this link is indicative of advanced organisational practices actually increasing productivity.

It should be pointed out that our findings are not dissimilar to those of Basu et al (2003) who also struggled to find much evidence that organisational change was positively related to productivity gains in the UK. This may in part be due to the fact that industry level analysis for this firm level factor is an inappropriate unit to consider. Whilst we would like to think that effects would be manifest at the industry level, it appears that by averaging effects across firms within sectors, much of the heterogeneity is lost (weakening relationships econometrically), and the ability to link changes to performance gains is hindered. Thus, what our analysis really points to is a need to refine our measure at the industry level if indeed industry level analysis is meaningful. Thus, in terms of policy conclusions to be drawn from our findings, perhaps the most obvious is that organisational change has to be better measured. Finally, it is clear from aspects of our analysis that the length of the analysed panel is not sufficient to capture or analyse long term effects, specifically in relation to certain industries and for certain organisational changes.

References

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen and F. Zilibotti (2007) 'Technology information and the decentralisation of the firm', *Quarterly Journal of Economics*, **122**(4), 1759-1799.

Arellano, M. and S. Bond (1991) 'Some tests of specification for panel data. Monte Carlo evidence and an application to employment equations', *Review of Economic Studies*, **58**(2), 277-297.

Basu, S., J. G. Fernald, N. Oulton and S. Srinivasan (2003) 'The case of the missing productivity growth; or why has productivity accelerated in the US but not in the UK' NBER Working Paper 10010.

Black, S. and L. Lynch (1995) 'Beyond the incidence of training: evidence from a National Employers Survey', NBER Working Paper 5231.

Black, S. and L. Lynch (2001) 'How to Compete. The impact of Workplace Practices and Information Technology on Productivity', *Review of Economics and Statistics*, **83**(3), 434-445.

Black, S. and L. Lynch (2005) 'Measuring Organisational Capital in the New Economy', IZA Discussion Paper 1524.

Black, S., L. Lynch and Krivelyova (2004) 'How workers fare when Employers Innovate', *Industrial Relations*, **43**(1), 44-66.

Blundell, R. And S. Bond (2000) 'GMM Estimation with Persistent Panel Data: An Application to Production Function', *Econometrics Review*, **19**(3), 321-340.

Bloom, N., R. Sadun and J. van Reenen (2006) 'It ain't what you do, it's the way that you do I.T. Investigating the productivity miracle using the overseas activities of US multinationals' mimeograph, Centre for Economic Performance, LSE.

Bresnahan, T., Brynjolfsson, E. and Hitt, L (2002), 'Information Technology, workplace organization and the demand for skilled labour: firm level evidence', *Quarterly Journal of Economics*, **117** (1), 339-376.

Bresnahan, T. (1999) 'Computerisation and wage dispersion: An analytical reinterpretation', *Economic Journal*, **CIX**, 390-415.

Brynjolfsson, E., L. M. Hitt and S Yang (2002) 'Intangible Assets: Computers and Organisational Activity', Brookings Papers on Economic Activity

Caroli, E. And J. Van Reenen (2001) 'Skill Biased Organisational Change? Evidence from British and French Establishments', *Quarterly Journal of Economics*, **CXVI**(4), 1449-1492.

Crespi, G. C. Criscuolo and J. Haskel (2007) Information Technology, Organisational Change and Productivity Growth: Evidence from UK Firms, CEP Discussion Paper, 783.

DTI (2006) Innovation in the UK: Indicators and Insights, Occasional Paper No. 6, July 2006.

Frenz, M. (2002) 'A Comparison of the Second and Third UK Community Innovation Survey', Mimeograph.

Giuri, P. S. Torrisi and N. Zinovyeva (2008) 'ICT, skills and organisational change: evidence from Italian manufacturing firms', *Industrial and Coroporate Change*, **17** (1), 29-64.

Lucking, B. (2004) International Comparisons of the Third Community Innovation Survey, DTI Mimeograph.

Lynch, L. (2007) 'The Adoption and Diffusion of Organisational Innovation. Evidence for the US Economy', IZA Discussion Paper 2819.

Office for National Statistics. Social and Vital Statistics Division and Northern Ireland Statistics and Research Agency. Central Survey Unit, *Quarterly Labour Force Survey files, 1992-2006* [computer files]. Colchester, Essex: UK Data Archive [distributor].

O'Mahony, M. and B. van Ark (2003) Eds., *'EU Productivity and Competitiveness – An Industry Perspective: Can Europe resume the Catching-up Process'*, European Commission Publication.

O'Mahony, M. A. Rincon-Aznar and C. Robinson (2007) 'Productivity growth in the US and the EU: A Sectoral Analysis', NIESR Discussion Paper 307.

O'Mahony, M., C. Robinson and M. Vecchi (2008), 'The Impact of ICT on the Demand for Skilled Labour: A Cross-Country Comparison', forthcoming in *Labour Economics*

Piore, M. and C. Sabel (1984) *The Second Industrial Divide: Possibilities for Prosperity*, New York: Basic Books.

Piva, M., E. Santarelli and M. Vivarelli (2005) 'The Skill Bias Effect of Technological and Organisational Change: Evidence and Policy Implications', *Research Policy*, **34**(2), 141-157.

Tylecote, A. and G. Vertova (2004) 'The Rise and Decline of Fordism and the Sea-Change in the Technological

Advantage of Nations', Sheffield University Management School Discussion Paper 2004.05.

Robson, S. and L. Ortmans (2006) First findings from the UK Innovation Survey, 2005, *Economic Trends* **628**, 58-64.

Roodman, D., (2006) "How to Do xtabond2: An Introduction to "Difference" and "System" GMM in Stata," Center for Global Development Working Paper **103**.

APPENDIX

Table A1: Regression results, determinants of value added (capital stock and unadjusted hours)

	OLS	FE	FD	
Dependent variable	LNVAVOL	LNVAVOL	D.LNVAVOL	D.LNVAVOL
Coefficient				
Ln(ICT capital stock)	0.159***	0.116*	0.104*	0.0924
	(0.034)	(0.063)	(0.054)	(0.056)
Ln(Non-ICT capital stock)	0.306***	0.283	0.310***	0.319***
	(0.051)	(0.18)	(0.11)	(0.10)
Ln(hours)	0.400***	0.359*	0.190**	0.199**
	(0.066)	(0.18)	(0.083)	(0.089)
Ln (organisation score)	0.311*	-0.155	0.0367	
	(0.18)	(0.19)	(0.060)	
L.Ln (organisation score)				-0.0278
				(0.044)
Constant	-1.582***	-1.142	0.00131	0.000806
	(0.42)	(1.16)	(0.0062)	(0.0080)
Observations	330	330	300	270
R-squared	0.92	0.57	0.24	0.24
Number of NR3		30		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: continued: Regression results, determinants of value added (quantity indices)

	FE	FD	
Dependent variable	LNVA_QI	D.LNVA_QI	D.LNVA_QI
Coefficient			
Ln(index of ICT capital services)	0.149*	0.114*	0.107
	(0.081)	(0.061)	(0.065)
Ln(index of NonICT capital services)	0.192	0.238**	0.223*
	(0.23)	(0.11)	(0.11)
Ln(index of labour services)	0.375*	0.198**	0.217**
	(0.21)	(0.089)	(0.097)
Ln(organisation score)	-0.0666	0.0514	
	(0.21)	(0.063)	
L.Ln(organisation score)			-0.0212
			(0.043)
Constant	1.256**	-0.00106	-0.000979
	(0.60)	(0.0067)	(0.0082)
Observations	330	300	270
Number of NR3	30		
R-squared	0.57	0.24	0.24

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3: Regression results determinants of value added (incorporating CIS measures of OC)

		FD	
COEFFICIENT	D.LNVAVOL	D.LNVA_QI	D.LNVAVOL
Ln(ICT capital stock)	0.137**		
	(0.058)		
Ln(Non-ICT capital stock)	0.325**		
	(0.13)		
Ln(hours)	0.205*		
	(0.10)		
Ln(index of ICT capital services)		0.147**	
		(0.066)	
Ln(index of NonICT capital services)		0.307***	
		(0.11)	
Ln(index of labour services)		0.197*	
		(0.11)	
Ln (ICT capital services)			0.142*
			(0.071)
Ln(Non-ICT capital services)			0.310**
			(0.12)
Ln(Labour services)			0.231**
			(0.11)
Ln (organisation score)	0.0223	0.0392	0.0453
	(0.064)	(0.067)	(0.070)
Ln(CIS score of organisational change)	0.00558	0.00591	0.00612
	(0.0085)	(0.0071)	(0.0068)
Constant	0.000852	-0.00258	-0.00132

	(0.0096)	(0.0089)	(0.0091)
Observations	250	250	240
R-squared	0.28	0.29	0.30

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4. Regression results: interactions of organisation with ICT and labour quality.
Capital and labour services.

	OLS	FE		FD	
CIENT	LNVAVOLUME	LNVAVOLUME	LNVAVOLUME	D.LNVAVOLUME	D.LNVAVOLUME
capital services)	0.0806	0.238**	0.239**	0.101	0.0932
	(0.11)	(0.11)	(0.10)	(0.079)	(0.081)
ICT capital services)	0.338***	0.153	0.158	0.292**	0.286**
	(0.079)	(0.25)	(0.26)	(0.12)	(0.12)
ur services)	0.472***	0.520**	0.519**	0.217**	0.232**
	(0.083)	(0.21)	(0.22)	(0.10)	(0.10)
	0.774	-1.012**	-0.810	0.0956	-0.382
	(0.71)	(0.40)	(1.13)	(0.27)	(0.31)
capital services)*	-0.0319	0.132*	0.136**	-0.00704	-0.0118
isation score)					
	(0.088)	(0.068)	(0.060)	(0.041)	(0.032)
our composition index)*			-0.0889		0.205
isation score)					
			(0.38)		(0.13)
	-0.666	-1.152	-1.169	-0.000102	-0.000492
	(0.74)	(0.72)	(0.73)	(0.0075)	(0.0082)
ions	286	286	286	260	260
d	0.94	0.64	0.64	0.25	0.26
of NR3		26	26		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4: continued Regression results: interactions of organisation with ICT and labour quality. Capital stock and unadjusted hours.

	OLS	FE		FD	
COEFFICIENT	LNVAVOLUME	LNVAVOLUME	LNVAVOLUME	D.LNVAVOLUME	D.LNVAVOLUME
Ln(ICT capital stock)	0.0373	0.104	0.0953	0.0701	0.0692
	(0.11)	(0.081)	(0.069)	(0.056)	(0.058)
Ln(Non-ICT capital stock)	0.306***	0.279	0.334*	0.312***	0.303**
	(0.050)	(0.18)	(0.19)	(0.11)	(0.12)
Ln(hours)	0.417***	0.370*	0.361*	0.203**	0.210**
	(0.065)	(0.19)	(0.19)	(0.080)	(0.082)
Ln(organisation score)	1.343*	-0.0838	0.871	0.303	-0.0786
	(0.79)	(0.45)	(0.78)	(0.26)	(0.31)
Ln (ICT capital stock)* Ln(organisation score)	-0.137	-0.0118	0.00428	-0.0417	-0.0417
	(0.11)	(0.063)	(0.061)	(0.035)	(0.027)
Ln (Labour composition index)* Ln(organisation score)			-0.424		0.155
			(0.26)		(0.11)
Constant	-0.764	-1.103	-1.470	0.00172	0.00146
	(0.73)	(1.22)	(1.20)	(0.0063)	(0.0067)
Observations	330	330	330	300	300
R-squared	0.93	0.57	0.58	0.24	0.25
Number of NR3		30	30		

Table A5. Continued... Regression results: interactions of organisation with ICT and labour quality. Capital and labour services indices.

	FE		FD	
COEFFICIENT	LNVA_QI	LNVA_QI	D.LNVA_QI	D.LNVA_QI
Ln(index of ICT capital services)	0.178	0.177	0.165*	0.166*
	(0.11)	(0.11)	(0.090)	(0.093)
Ln(index of NonICT capital services)	0.201	0.195	0.227**	0.223**
	(0.25)	(0.24)	(0.11)	(0.11)
Ln(index of labour services)	0.355	0.356	0.190**	0.200**
	(0.22)	(0.22)	(0.089)	(0.090)
Ln(organisation score)	0.118	-0.180	-0.232	-0.722*
	(0.96)	(0.53)	(0.40)	(0.42)
Ln(index of ICT capital services)* Ln(organisation score)	0.0308	0.0248	0.0540	0.0579
	(0.090)	(0.092)	(0.071)	(0.069)
Ln (Labour composition index)* Ln(organisation score)	-0.130			0.191
	(0.34)			(0.14)
Constant	1.190	1.199	-0.00254	-0.00293
	(0.72)	(0.71)	(0.0068)	(0.0073)
Observations	330	330	300	300
Number of NR3	30	30		
R-squared	0.57	0.57	0.24	0.25

EU KLEMS WORKING PAPER SERIES