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Skill Biased Organizational Change? Evidence from a panel of British and French establishments[1]

Eve Caroli[2] and John Van Reenen[3]

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[2] INRA-LEA and Cepremap. Correspondence: INRA-LEA, 48 Bd Jourdan - 75014 Paris - France. caroli@java.ens.fr

[3] Institute for Fiscal Studies, University College London and CEPR. Correspondence: IFS, 7 Ridgmount Street, London WC1E 7AE jvanreenen@ifs.org.uk

Changement Organisationnel Biaisé ? Evidence à partir d'un panel d'établissements britanniques et français.

Dans cet article, nous cherchons à déterminer si les changements organisationnels en cours sont ou non "biaisés" vers les qualifications de niveau élevé. Par changements organisationnels, on entend la décentralisation de l'autorité, la réduction du nombre de niveaux hiérarchiques et l'accroissement de la variété des tâches réalisées par les agents. Nous utilisons plusieurs sources de données de panel relatives aux étalissements britanniques et français. Trois résultats sont mis en évidence : (i) le changement organisationnel diminue la demande de travailleurs non qualifiés dans les deux pays ; (ii) le changement organisationnel est d'autant moins rapide que le salaire relatif des qualifiés est le plus élevé dans la région où se situe l'établissement (traduisant ainsi une pénurie relative de l'offre de travail qualifié) ; (iii) le changement organisationnel accroît la productivité dans les établissements disposant d'une proportion élevée de main-d'oeuvre qualifiée. Nous concluons que les changements organisationnels et technologiques ainsi que le capital humain sont des actifs complémentaires au sein de l'entreprise. Le développement des nouvelles formes d'organisation du travail est ainsi susceptible d'avoir joué un rôle important dans le déclin de la demande de travail peu qualifié dans les économies de l'OCDE.

Mots clés : changement organisationnel - qualifications - technologie - données de panel

Skill Biased Organizational Change? Evidence from a panel of British and French establishments

In this paper we investigate evidence for the 'skill bias' of organizational change (OC). These include the decentralization of authority, delayering of managerial functions and increased multi-tasking. We use several sources of panel data on British and French establishments. Three findings emerge: (i) organizational change tends to reduce the demand for unskilled workers in both countries; (ii) OC is retarded by increases in regional skill price differentials (a measure of the relative supply of skill); (iii) OC leads to greater productivity increases in establishments with larger initial skill endowments. We argue that OC, technology and human capital are complementary assets of the modern enterprise. The widespread introduction of new organizational forms may be an important factor in the declining demand for less skilled workers in OECD countries.

Key words: organizational change, skills, technology, panel data change

JEL classification: L2, J3, O3

1. Introduction

For several decades now, the organization of work inside firms has experienced dramatic changes in most industrialized countries. Generally, there has been a trend towards less hierarchy and more flexible organizational forms. This move encompasses more autonomy and responsibility being awarded to workers and their performing a wider range of tasks[4]. As pointed out by management specialists, organizational change has led to more *decentralization* in work organization. It is generally believed that these changes require a higher level of human capital from individual workers since they need to deal effectively with increased uncertainty and responsibility. Although there are a wealth of case studies on organizational change, there is little quantitative evidence across a broad range of establishments. The main purpose of this paper is to provide some econometric evidence on what we term 'skill biased organizational change' - the hypothesis that modern organizational changes are complementary with skilled workers. This implies that organizational change will increase the demand for skills within firms; that relative shortages of human capital can retard organizational innovation and that firm productivity is enhanced by the combination of decentralization with deepening human capital.

Traditionally economics has tended to treat the internal organization of the firm as a 'black box'[5]. Yet recently there has been an upsurge of interest into peering into the void. This has appeared in several related literatures. Most influentially, Milgrom and Roberts (1990) provide a systematic theoretical treatment of complementarity in organizations which leads to the clustering of practices. Other theorists argue that organizational change may be an important driving force behind the upskilling of within-firm occupational structure and rising wage

[4]For an overview on work restructuring in Europe see European Foundation (1998). For the developed countries OECD (1999) or Caroli (1999) have surveys. For quantitative evidence see Osterman (1994) for the USA, NUTEK (1999) in the Nordic countries.

[5]Of course the classical tradition of such diverse economists as Adam Smith and Karl Marx placed a great emphasis on organizational matters. Alfred Chandler revived interest in the 1960s. The classical tradition survived in the sociology of organisations, as well as institutional and evolutionary economics.

inequality[6]. One stream of work [7] argues that current changes in organization lead to segregated equilibria in which skilled and unskilled workers are no longer employed in the same firms. Hence, firms skill structure tends to become more homogenous. Another emphasizes that not only does organizational change lead to more homogeneity of skills inside firms, but that it also shifts overall demand in favor of skilled workers. Thus doing, it contributes to worsen the employment and wage prospects of least skilled employees[8].

On the empirical side, the stimulus has come from investigations of the effects of technical change on skills and productivity. A host of studies have found evidence for skill biased technical change, although there is fierce argument over the extent to which the decline in the wage and employment prospects of less skilled workers is due to recent advances in information technologies (e.g. Autor, Katz and Krueger (1998))[9] The idea that organizational change might be skill-biased has been taken up lately in the empirical literature. Machin and Van Reenen (1998) find evidence of complementarity between technical change and skills for seven countries, but argue that technology accounts for a smaller fraction of the changes in the skill structure in the two countries with the fastest growth of wage inequality (Britain and the US). They speculate that rapid organizational changes in these countries may be responsible for the large residual. Similarly, Dunne, Haltiwanger and Troske (1996) in their detailed analysis of the change in the skill structure of over 11,000 US plants over 15 years, conclude that unobserved factors play a large role and "one label to put on the factors generating these patterns of plant level changes is *organizational capital*" [P.42, our italics]. Aguirregabiria and Alonso-Borrego (1998) also emphasize the importance of organizational restructuring in their analysis of skill biased technical change in a panel of Spanish firms.

A second important empirical literature relates to the so-called 'productivity paradox'. A commonly cited reason for the apparent failure of huge investments

[6] See Aghion, Caroli and Garcia-Peñalosa (1999).

[7] See Kremer and Maskin (1996), Acemoglu (1999), Kramarz, Lovillier and Pele (1996).

[8] See Thesmar and Thoenig (1999)

[9] Other studies have emphasized the role of trade and labor market institutions (see , Wood, 1996, and DiNardo, Fortin and Lemieux, 1996, for examples of these alternative perspectives).

in computers to result in significant increases in productivity[10] is that companies lack the necessary organizational structures that facilitate the introduction of new technologies. Without the organizational and skills infrastructure, technology alone is not enough.

Despite these conjectures, there is very little empirical evidence regarding the determinants and consequences of organizational change. The reason for this lack of attention is mainly practical as it is extremely difficult to empirically proxy organizational change. A few papers attempt to analyze correlation patterns of "reorganized" enterprises putting forward a series of common features such as: size, product market conditions, quality strategy, technical intensity, and human resource policies[11]. Some others have also focused on the consequences of organizational change for productivity[12] but there have been very few attempts to focus directly on skills. Recent exceptions are Greenan (1996a-1996b) who examines French firms and Bresnahan, Brynjolfsson and Hitt (1998) who examine US firms. Both papers argue for some complementarity between technical change, organizational change and skills. Unfortunately neither paper has access to data where it is possible to follow the impact of past incidents of organizational change on future employment and productivity outcomes over a number of years. This is one of the main contributions of the current paper.

This paper aims at providing empirical evidence regarding the relationships between organizational change and skills. We argue that the existence of complementarities between organizational change and skills leads to three empirical predictions:

1. Organizational change should be followed by a declining demand for less skilled labor

2. Falls in the relative cost of skills should increase the probability of organizational change

[10] See Brynjolfsson and Yang, 1996, for a recent survey. It may be that the productivity growth of the US economy in the last few years has resolved the paradox, although the jury is still out.

[11] Osterman (1994) on US data; Machin and Wadhwani (1991) and Nickell and Nicolistas (1996),on British data; Greenan and Guellec (1994) and Coutrot (1996) on French data.

[12] Some examples are Ichinowski, Shaw and Prennushi (1997), Boning et al (1998), Askenazy (1998).

3. Organizational changes should have a larger impact on productivity in workplaces with higher levels of skills

We test (and find support for) each of these predictions in our econometric analysis.

The paper is organized as follows. Section 2 presents some theoretical considerations. Section 3 outlines the econometric model. Section 4 discusses the data paying particular attention to how we measure organizational change. The results are presented and discussed in Section 5 and some concluding comments are offered in Section 6.

2. Theoretical Considerations

The idea that complementarities in organizations may generate some clustering of practices and some discontinuities in organizational change was first formalized by Milgrom and Roberts (1990). They develop a simple model based on supermodularity properties of the profit function. A number of activities carried out inside firms are assumed to be complementary in the sense that doing more of one of them raises the marginal return in terms of profit to doing more of the others. Milgrom and Roberts show that, in this context, following a change in parameters values, only coordinated changes in all variables will allow firms to achieve the new optimal organization.

Using the same formal framework, Athey and Schmutzler (1995) build up a model of firm's choice of technological innovation. They show that, if firms organizational flexibility is complementary to the implementation of technological innovation, any decrease in the cost of flexibility or in that of investing in research capabilities (thus enhancing the return to implementation) will induce firms to shift to a new equilibrium characterized by more implementation of technological innovation, more organizational flexibility and a higher productivity. Milgrom and Roberts (1995) extend the analysis to the role of skills and training. The level of training of the workforce is assumed to be complementary with product and process innovation. This is, in turn, complementary with equipment and design flexibility, organizational change directed towards greater flexibility and

new forms of human resource management. As a consequence, any decrease in the cost of equipment and design flexibility is likely to bring about a change in the clustering of practices characterized by more implementation of product and process innovation, more flexibility in organization and a higher skill level of the workforce.

So, according to the supermodularity literature some complementarities do exist between technical change, organizational change and skills. A first attempt to examine the complementarity between skills and organizational forms is to be found in Kremer and Maskin (1996) and Acemoglu (1999). Both papers argue that as the supply of skills increases in the economy, the nature of the match at work inside firms changes, inducing a shift towards a greater homogeneity of the skill structure. Acemoglu models an economy in which firms choose their capital stock before hiring workers and where the matching technology is random. When the relative supply of skilled workers is low, the probability of meeting one of them is low too, so that all firms choose the same level of capital and employ all types of workers: the economy is in a pooling equilibrium. As skilled labor becomes more abundant the probability of meeting one of them goes up and firms can afford to "specialize". The economy moves to a separating equilibrium in which firms open either high or low capital jobs and employ only skilled (respectively unskilled) workers. As a consequence, skill heterogeneity rises across firms while skill homogeneity increases inside each of them. Kremer and Maskin (1996) display a similar result although the match of interest is no longer between capital and labor but between skilled and unskilled workers directly. In their economy, production requires two tasks. These are complementary and unequally sensitive to skills. Accordingly, both types of workers are imperfect substitutes in both tasks. When skill dispersion across groups is low, skilled and unskilled workers are employed in the same firms: the asymmetry of tasks that militates in favor of cross-matching overweighs the complementarity that militates in favor of assortative matching. As human capital accumulates assortative matching finally dominates. A separating equilibrium thus prevails, which is again characterized by homogeneity of skills inside firms.

As the relative supply of skills increases in the economy, the type of match

at work inside firms thus changes, leading to a greater homogeneity of skills. To the extent that the nature of the match is an indicator of firms' organizational structure, these results imply that an increase in the supply of skilled workers induces some organizational change which leads, in turn, to a greater homogeneity of firms' skill structure. Work more directly focused on organizational change confirm that the complementarity between skills and changes in organization takes the form of a two-direction relationship.

First, an increase in the supply of skills in firms' environment raises the incentives for firms to reorganize. Lindbeck and Snower (1996) consider a move from a "Tayloristic" organization in which each worker is specialized in one task to a "Holistic" organization in which each worker participates in two tasks. There exist both returns to specialization and returns to task diversification. If technological change or human capital accumulation makes workers more flexible, all other things being equal, returns to diversification increase, thus enhancing organizational change. Caroli et al. (1997) model a similar idea though considering explicitly the impact of a rising supply of skilled labor in the economy. Organizational change takes the form of a shift from a centralized organization in which each worker participates in one single task, to a decentralized organization characterized by task diversification. The production process requires both conception activities, in which skilled workers have a comparative advantage, and execution activities. When skilled labor is scarce, in accordance with the full exploitation of comparative advantages, all firms in the economy are centralized, with skilled workers allocated to conception activities and unskilled workers allocated to execution activities. As the proportion of skilled workers increases in the economy, initial comparative advantages are overcome by decreasing returns to conception. A decentralized sector thus develops where skilled workers participate both in conception and execution activities. Organizational change is associated with the move towards decentralization.

A second direction for complementarity is suggested by Thesmar and Thoenig (1999). Organizational change would raise the proportion of skilled workers employed inside firms, thus inducing some segregation in the form of higher homogeneity of firms' skill structure. In this model, organizational change is defined

as a move from a "mechanistic" to an "organic" organization. In the former, new innovations can be implemented only after payment of a sunk cost and productivity is then high. In the latter, on the contrary, no sunk cost is born by firms and productivity is lower. As the relative supply of skilled workers increases in the economy, the R&D (skill-intensive) sector expands, accelerating the arrival of new innovations. Creative destruction is then speeded up which creates an incentive for firms to shift to an organic organization in which no fixed cost is incurred. As a consequence, the value of innovation rises and the R&D sector develops further at the expense of production activities. Overall, the proportion of skilled workers employed by firms goes up and their skill structure tends to become more homogenous.

The econometric work carried out in this paper seeks to examine some implications of these theories. We examine skill-share equations (is there skill upgrading following organizational change?), organizational change equation (do increases in the relative market price of skills affect organizational form?) and productivity growth (does organizational change combined with skills have a particularly strong effect on productivity?).

3. Econometric Modelling Strategy

We have constructed two datasets in Britain and France combining information on individuals' skill characteristics and on plant organization. The advantage of using two countries is that if any robust results can be generated in both nations then they are more likely to arise from economic fundamentals than from specific institutional features or peculiarities of one dataset.

3.1. The demand for skills and organizational change

To put these issues in a more familiar setting we choose a fairly general description of the firm's decision problem. Consider a short-run variable cost (VC) function (see Brown and Christensen, 1981). The firm will choose different variable factors to minimize costs subject to an output constraint. We assume that the only variable costs are different types of labor (indexed by skill group f). We assume that there is a factor, K, which will be denoted as 'organizational capital' (we

discuss the introduction of other types of capital below) and that it is fixed in the short run (i.e. we will condition on the quantities of capital in the factor demand equations). In other words, we assume that there are no adjustment costs for labor over the period considered and do not explicitly model any adjustment costs for capital[13]. Approximating the variable cost function as a translog implies

$$\begin{aligned}\ln VC &= \beta_0 + \sum_f \beta_f \ln W_f + \beta_K \ln K + \beta_Y \ln Y \\ &+ \frac{1}{2}\sum_f \beta_{ff}(\ln W_f)^2 + \beta_{KK}(\ln K)^2 + \beta_{YY}(\ln Y)^2 \\ &+ \sum_{f,g,f\neq g} \beta_{fg} \ln W_f \ln W_g + \sum_f \beta_{fK} \ln W_f \ln K \\ &+ \sum_f \beta_{fY} \ln W_f \ln Y + \beta_{KY}(\ln K \ln Y) \end{aligned} \tag{3.1}$$

Where Y = output and W is the wage rate of each factor f.

Using Shepherd's Lemma generates a series of f variable cost share equations of the familiar form:

$$S_f = \beta_f + \beta_{ff} \ln W_f + \sum_{g,f\neq g} \beta_{fg} \ln W_g + \beta_{fK} \ln K + \beta_{fY} \ln Y \tag{3.2}$$

Where $S_f = \frac{\partial \ln VC}{\partial \ln W_f}$ = wage bill share of skill f. The hypothesis that a skill group is complementary with 'organizational capital' is essentially a test that $\beta_{fK} > 0$. Constant returns implies $\beta_{fK} = -\beta_{fY}$.

There are a large number of econometric problems with estimating equation (3.2). First, unobserved heterogeneity is likely to be a major problem. For this reason we estimate the cost share equations in (long) differenced form to remove the correlated fixed effects.

$$\Delta S_f = \beta_{ff} \Delta \ln W_f + \sum_{g,f\neq g} \beta_{fg} \Delta \ln W_g + \beta_{fK} \Delta \ln K + \beta_{fY} \Delta \ln Y \tag{3.3}$$

where Δ is the long difference operator.

[13]This is forced upon us by the data as we do not have enough time series in the panel to properly tackle the adjustment dynamics.

Secondly, organization is not the only form of capital of influence on cost shares. Technological change, such as the introduction of computerization ($COMP$) and other forms of information technology are a particular concern. K could be considered as a vector $(K_1, K_2, ...,)$ of different quasi-fixed factors. In Britain we do not have good measures of changes in output or the physical capital stock so we have to assume that after taking out the fixed effects and time dummies these are proxied by changes in total employment and industry dummies (IND_j). In France we measure firm level capital and value added. We also consider other variables (x) such as the establishment size, ownership status (public sector, foreign-owned), union power and demand conditions[14]. Thirdly, we have to accept that identification of the wage effects may be very difficult due to the fact that movements in wages reflect not only exogenous movements in the price of labor, but also changes in the unobserved (to the econometrician) quality mix of workers. Thus we will estimate equations both with and without the regional wage terms. We also compare the wage bill share equations with employment share equations to check that results are being driven by changes in the quantities rather than the factor prices. A fourth problem is that changes in many of the variables and in particular organizational and technological capital are not observed as continuous variables but rather as qualitative indicators (OC). We treat this as a measurement issue (i.e. OC=1 if there is an organizational change), but of course there is a deeper issue of whether discreteness is inherent to these forms of 'capital' where marginal changes are not possible.

Fifthly, and perhaps most importantly, OC is likely to be endogenous[15]. For example, if the skill structure and modern organizations are complementary then shocks to a plant's skill structure will increase the likelihood of OC. It may also be that a third factor (such as an unfavorable demand shock) induces a firm to simultaneously lay-off unskilled workers and re-organize the company. To try to mitigate these problems we focus on using lagged values of organizational change. In Britain we have information on the change in skill shares between 1984 and 1990 and we regress these on organizational changes introduced between 1981 and

[14] We also experimented with measures of plant age, pay incentive schemes, gender composition, whether the plant was stand alone or part of a larger group and many others.

[15] This is one of the main points stressed by Athey and Stern (1998).

1984. In France we have information on changes in the skill shares between 1992 and 1996 and we regress these against organizational changes occurring between 1989 and 1992. If anything, this should bias us against finding any significant effects of OC. Since there are similar issues for the other controls we also use lagged values of the controls. The shortness of the panel makes it difficult to deal with endogeneity biases using longer lags as instruments, but we report a series of experiments checking the sensitivity of the findings to alternative specifications. Our basic skill share equations are essentially:

$$\begin{aligned}\Delta S_{fit} &= \beta_{fK} OC_{it-1} + \alpha_1 COMP_{it-1} + \beta_{ff} \Delta \ln W_{ft} + \sum_{g,f \neq g} \beta_{fg} \Delta \ln W_{gt} + \\ &+ \beta_{fK} \Delta \ln K_{it} + \beta_{fY} \Delta \ln Y_{it} + \alpha_2' x_{it-1} + \gamma_1' IND_j + u_{ijt} \end{aligned} \tag{3.4}$$

3.2. The Determinants of Organizational Change

A second equation of considerable interest is the determinants of organizational change (OC). The theories discussed in Section 2 argue that key factors driving OC are the supply of skills and technology. To capture this we have to consider the long-run determination of all the capitals in equation (3.1). Direct estimation of the long-run factor demands is not possible, but we will attempt a simpler approach. The factor demand equations for the quasi-fixed factors will be a function of, inter alia, changes in the prices of other factors. In particular, if skills are complementary to organizational design, then increases in the relative cost of skilled workers should make it less likely that an establishment will introduce organizational changes. To investigate these ideas we estimate 'organizational change' probits of the form:

$$y_{it}^* = \alpha ln(W^{HIGH}/W^{LOW})_{kt} + \beta' x_{it} + \gamma_1' IND_j + u_{it} \tag{3.5}$$

where

$$\begin{aligned} OC_i &= 1 \text{ if } y_i^* > 0 \\ OC_i &= 0 \text{ otherwise} \end{aligned}$$

$ln(W^{HIGH}/W^{LOW})$ refers to hourly wage differentials by educational groups ('A' level or above in the UK, Baccalaureate or above in France) in the region where the establishment is located. The establishment characteristics, x_i and industry dummies, IND_j, are the same as in the skill share equation.

Grouping the wage differentials by region is natural. Within European countries there are distinct local labor markets due to costs of geographical mobility[16]. The correlation of relative wages with the relative proportion of educated workers in a region is -0.194 in France and -0.134 in the UK. There are, of course, issues of endogeneity of the skill price variables. A shock which increases the proportion of plants in a region introducing organizational change may drive up the wages of skilled workers, pushing the coefficient of interest, α , in a positive direction. Also, if a region has skilled workers of above average ability measured wage differentials will be higher and organizational change more likely. This will again bias our estimated α . Since we believe the true value of the coefficient to be negative both of these endogeneity problems will cause a bias towards zero, making it harder to reject the hypothesis that 'cheap skills' have no effect on organizational change. The empirical section will consider a variety of approaches to dealing with this problem including the use of changes in wage premia, exogenous instruments (regional unionization rates) and alternative measures of relative supply (total numbers of educated individuals in region).

3.3. Productivity and organizational change

In addition to the wage share equations and the OC equation there are several other equations that could be added to the system[17]. Of more interest is direct evidence of complementarity from 'performance equations'. For example, one could add direct estimation of the cost function (3.1). We would be most interested in the interactions between technological and organizational change, and skills and organizational change. This is a tough task due to the highly non-linear nature of the model and the fact that much of the necessary data are missing in the UK.

[16] About 3% of US households change their region of residence in a year, compared to 1% in UK, France and Germany (OECD, 1990, Table 3.3).

[17] The technology choice equation has been analyzed in the UK in some detail in previous work (e.g. Chennells and Van Reenen, 1997).

As a preliminary step we have estimated simpler 'performance equations'. In particular for France we estimate long-differenced production functions (1996-1992) of the form

$$\begin{aligned}\Delta \ln Y_{it} &= \lambda_1' \Delta \ln X_{it} + \lambda_2 OC_{it-1} + \lambda_2 SKILLS_{it-1} + \lambda_3 COMP_{it-1} + \lambda_4 (OC * SKILLS)_{it-1} \\ &\quad + \lambda_5 (SKILLS * COMP)_{it-1} + \lambda_6' z_{it-1} + u_{it} \end{aligned} \tag{3.6}$$

where X_{it} is a vector of factor inputs including capital and labor (by skill group) and z_{it-1} a set of other lagged controls. We are particularly interested in the signs of the interaction terms. For example, if OC is more productive when introduced in skill-rich plants we expect $\lambda_4 > 0$, skill biased technical change implies $\lambda_5 > 0$. We also present models where we estimate separate production functions for the plants exhibiting organizational change allowing all the coefficients in (3.6) to differ with OC status. In Britain we have some qualitative indicators of performance in WIRS which we experiment with, but the measurement of these is much less satisfactory than the French data.

4. Data

4.1. British Data

The data that we use come from several databases as it is necessary to combine information on organizational change, establishment characteristics and skills. Information on organizational practices are very rare. One rich source of detailed establishment level data is the British Workplace Industrial Relations Survey (WIRS). It consists in a cross section of over 2,000 British establishments in 1980, 1984 and 1990. This has been extensively used by labor economists to examine the effects of the structure of industrial relations on economic outcomes (see Millward, 1993 for a survey), such as the size of the union wage mark-up (e.g. Stewart, 1987). There are a whole host of questions in WIRS which relate to organizational change in 1984 and a limited follow up in 1990 which asks more basic information. In both surveys, senior managers have been asked the following question: *Would you look at this card and tell me which, if any, of these changes*

you have made during the last three years directly affected the jobs or working practices of the manual workforce.

A. The introduction of new plant, machinery or equipment that includes new micro-electronic technology (AC)

B. The introduction of new plant, machinery or equipment not *including new micro-electronic technology (CC)*

C. Substantial changes in work organization or working practices not *involving new plant, machinery or equipment (OC)*

[emphasis in original]

If managers answered 'yes' to C. (they could answer yes to any or all of A., B. or C.) the establishment was coded to have OCMAN=1. An almost identical question was asked for non-manual workers[18] (OCNMAN). We created the variable OC = 1 if there was either manual or non-manual organizational change. In 1990 the OCMAN question was identical. For non-manual workers the question was phrased slightly differently to 1984 as it applied to 'office workers' whereas in 1984 it applied to any non-manual employees (for more details see the Data Appendix).

There are two main advantages of using these data. First, organizational change is clearly distinguished from technical change (question A) and physical investment (question B). Second, there is a time series element to the data including both a repeated cross section, and a panel for a sub-sample of the firms. On the negative side, the WIRS questions are asked to a very specific group of employees - senior managers. This could generate a bias with managers being, for example, over-optimistic about the performance of the firm. However, detailed comparisons between their answers and those given by a workers' representative to identical questions in WIRS have revealed substantial agreement as to the occurrence of an organizational change (Millward, 1990).

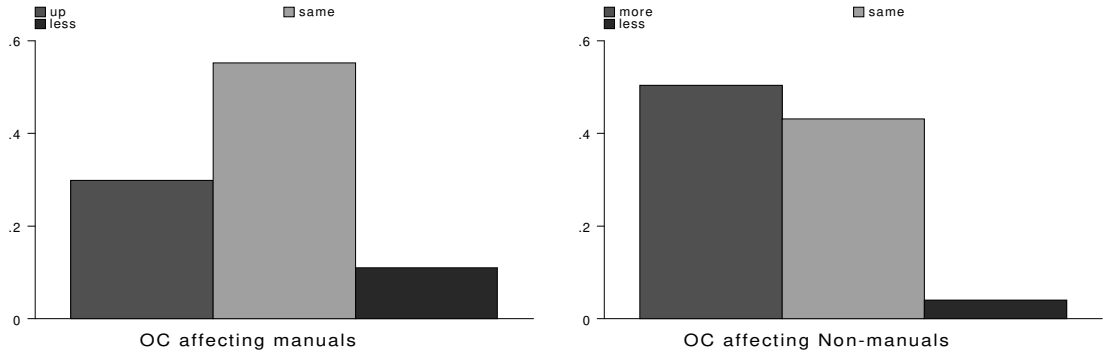
A second source of measurement difficulty regards the nature of organizational change. The theories discussed in section 2 generally assume that organizational change takes the form of workers having more responsibility and performing a wider range of tasks. Is our measure broadly capturing these notions? Fortu-

[18] A 'manual worker' is a production worker and a 'non-manual' a non-production worker.

nately, in 1984 managers were asked in more detail what the change actually involved. The answers are tabulated in Table 1. Although in many cases the change in organization did not involve any change in responsibility, when it did so a substantial fraction of organizational changes lead to more responsibility (almost half of all incidents for non-manuals and about a third for manuals). There were practically no examples of OC leading to decreases in responsibility. Reading down the table, it also appears that organizational change is more likely to be associated with a widening of the range of tasks performed by workers. This effect, broadly speaking, is stronger for non-manual than for manual workers. Downsizing (employment falls) generally follows organizational change, and this is more likely to follow from OCMAN (46% of cases) than from OCNMAN (34.6%). Overall then, although the measure is far from perfect it does seem to broadly capture the type of organizational changes that we consider important from a theoretical perspective. As displayed in Appendix Table A1, organizational change does affect an important proportion of firms in our sample. Over 1981-1984, 30.2% of firms have introduced changes in work organization regarding manual workers and 26.4% changes regarding non-manuals. These figures are even higher for the 1987-1990 period (47% and 42% respectively) indicating that there has been an acceleration of organizational change, at least in the 1980s. Perhaps the most relevant part of Table 1 however, is the question relating directly to the effect of organizational change on the skill level in the establishment (row B). Figure 4.1 graphs the results in this row which clearly show that managers were far more likely to state that organizational change increased, rather than decreased, the level of skill requirements[19].

The panel element of WIRS follows a subset of 537 of the plants sampled in 1984 through to 1990. Since the occupational proportions are asked to managers in both these years we can observe the changing skill structure of establishments (this is the only publicly available data in the UK containing the plant level

[19] It should be noted that these results are not driven by the fact that some plants experiencing organizational change also experienced technical change. Conditioning on the establishments which had organizational but no technical change we find that 56% (25%) increased responsibility compared to 3% (2%) who decreased following non-manual (manual) OC. The equivalent figures for skills are 38%(22%) increase vs. 5%(6%) decrease; for range of tasks: 63% (37%) wider vs. 5%(10%) narrower; for manning levels 16%(11%) more vs. 35%(28%) less



Senior Manager's estimate of effect of OC on skills - UK

Figure 4.1:

evolution of the skill structure). All the other questions available in the cross section can be used. To mitigate endogeneity problems we use OC in 1981-1984 as the key variable of interest to explain the 1984-1990 change in employment. Figure 4.2 presents the distribution of the change in unskilled manual proportions (the least skilled group) broken down between plants experiencing OC and those who did not. Immediately we see that the plants with OC tended to reduce the proportion of their unskilled workers at a faster rate than those who did not introduce organizational changes. The econometric section attempts to gauge whether these correlations are significant even when one controls for other factors.

[Table 1 about here]

A variety of indicators are used to control for technical change. First we use the question on advanced technical change (AC) asked at the same time as the

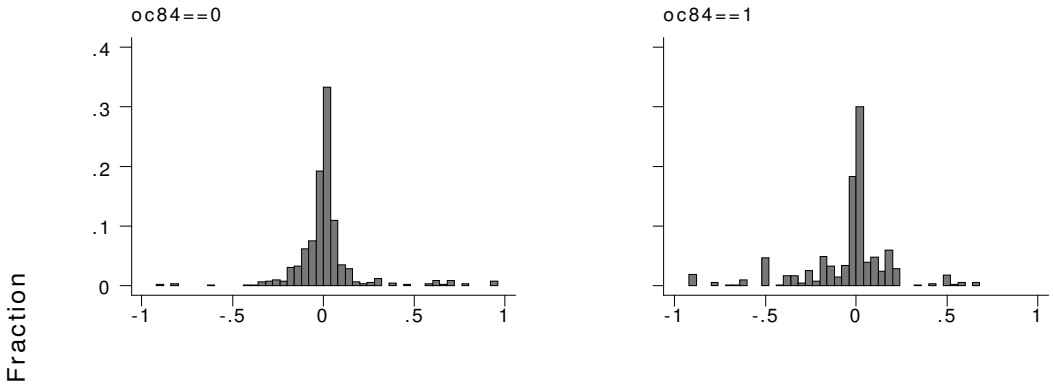

oc84==0
oc84==1
Fraction
0
.1
.2
.3
.4
-1
-.5
0
.5
1
Change in % Unskilled Manuals
Effect of OC 1981-84 on plant skills 1984-1990 in UK

Figure 4.2:

OC question. There is also information on the proportions of workers who were using micro-electronic technologies in the plant if major technical change occurred ($\%COMP_{84-81}$). In addition to this we aggregate individual information from the British Social Attitudes Survey on the proportions of workers using new technologies at work in 1985, 1987 and 1990. This is at the two digit level ($\%COMP^{ind}$). Finally, because we have a panel we can also calculate whether plants introduced computerized technologies in the 1990-1984 period ($COMP_{90-84}$).

The second datasource we use is the GHS (General Household Survey). This contains information on earnings as well as education and occupation. It is the closest equivalent in the UK to the US Current Population Survey and is the only UK dataset containing information on wages, education and occupation since the mid-1970s. Using the GHS we calculated the region-specific weekly earnings for each of the six occupational skill groups used in the analysis and used these to calculate the wage bill shares. We also calculated mean wages by education group focusing on two groups - highly educated people with college degrees or 'A' levels and low educated people being all others (roughly, 'O' levels/GCSEs and below). Finally, we use the UK Labor Force Survey (LFS) to measure the total supply of skills (the sample is much larger than the GHS, but there is no wage information until 1992).

4.2. French Data

Information about organizational changes is more abundant for France than for the UK [20]. We use the REPONSE (Relations Professionnelles et Négociations d'Entreprise) survey which has been explicitly devised with reference to the British WIRS. 2500 establishments were surveyed with senior managers being asked questions about industrial relations and organization in 1992. The question on work organization related to the previous three years.

For any of the organizational methods I will mention, would you tell me whether it is already implemented, in the process of being so, being considered

[20] Among them: "TOTTO" dealing with work organization and technique, conducted by the French Statistical Institute INSEE in 1987 and the survey entitled "Changements Organisationnels dans la Production" conducted by the Ministry of Industry in 1993 and focusing on organizational change.

or not even thought of, in your establishment?

One of these methods is specifically *delayering*[21] - removing one or more managerial levels, which is very close to the theoretical concept we are trying to measure. Whenever the manager answered that delayering was already implemented or in the process of being so, the establishment was coded as having $OC = 1$ for this method. The main advantage of using this data is obviously due to the similarity of the WIRS and REPONSE surveys. Both are establishment based, designed to be nationally representative and contain similar control variables that can be introduced in the regressions. A detailed study carried out by Coutrot (1996) shows that delayering leads to more autonomy being awarded to workers. We also consider some of the other organizational variables - Just In Time, Quality Circles and Total Quality Management. The main technology variable is the proportion of workers using computers or other micro-electronic technologies ($\%COMP$).

REPONSE also asks many questions about changes in the workforce. Managers are questioned about whether there had been increases or decreases in net employment of three groups of workers (managers, intermediate workers and operatives). Figure 4.3 plots out the proportion of managers reporting increases in net employment by their OC status. For the most skilled group, there is hardly any difference in the height of the bars - increases in managerial employment appear uncorrelated with the presence of OC. For the less skilled groups, however, there is a clear difference. Establishments with OC were much less likely to expand their employment of manual workers than those without OC.

Senior Managers were also asked about changes in their human resource policies towards seven different levels of skilled workers (managers, supervisors, technicians, sales staff, clerks, skilled manuals and unskilled manuals). The question was:

Over the past 3 years ... have you i) fired workers ii) encouraged quitting iii) hired workers iv) trained workers aiming at specialization v) trained workers aiming at multiskilling?

We use the answers to these questions to extract further information on the

[21] Raccourcissement de ligne hiérarchique (c'est-à-dire suppression d'un niveau hiérarchique intermédiaire).

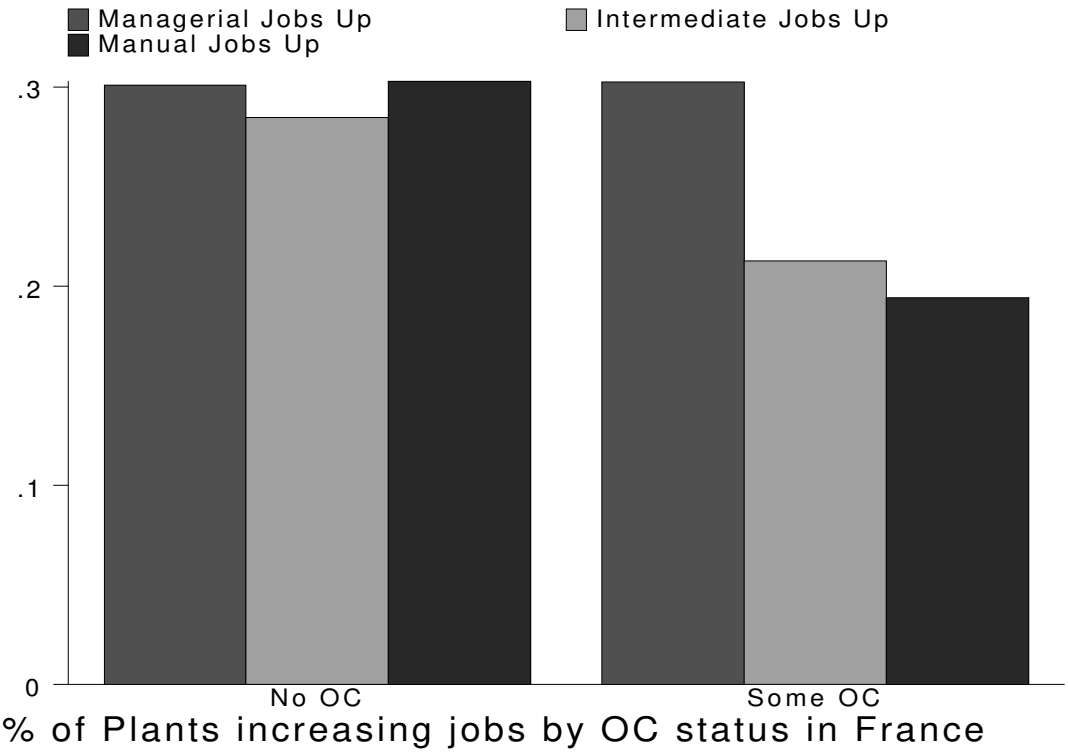

Managerial Jobs Up
Intermediate Jobs Up
Manual Jobs Up
.3
.2
.1
0
No OC
Some OC
% of Plants increasing jobs by OC status in France

Figure 4.3:

effects of organizational change. The training question is particularly interesting as the theoretical section assumes that organizational change should be associated with increases in the training of workers in general skills to help them cope with the greater responsibilities of decentralized organizations.

The Enquête REPONSE does not include data on occupational structure. In order to examine employment changes over time we drew on another survey of employment structure in France, the ESE, which is a stratified random sample of French establishments. About half of the REPONSE establishments which continuously existed between 1992 and 1996 were matched to the ESE (1360 plants)[22]. The ESE breaks the workforce down into 5 occupational categories (unskilled manuals, skilled manuals, clerical, middle managers and senior managers). Figure 4.4 for France is analogous to Figure 4.2 for the UK. We plot the histogram of the change in the share of the least skilled group (unskilled manuals) between 1996 and 1992 broken down by whether the plant experienced any organizational change in the 1989-92 period. Although less stark than in the UK, there is a longer tail of negative changes for the 'some OC' plants and in particular a smaller proportion of small positive changes.

The third French dataset is the Enquête Emploi (EE), an annual survey of individuals conducted by the French National Statistical Agency, INSEE. The EE is a 1/300 sample of the French population based on a three year rotating panel containing information about education levels, occupations, wages, region, industry and employment status. We define as educated those workers with a college degree or any baccalaureate. All others (with BEP, CAP and below) are considered as low educated. As for British data, we compute region-specific hourly wages for 5 occupational groups which we use to calculate wage bill shares. We also compute relative wages of the top to the bottom educational group at the level of 21 regional cells. We also measured the total supply of skills (proportion of workers with a baccalaureate or college degree) at the regional level.

Finally, we needed to obtain data on capital stock and value added. This comes from the BIC, a firm level database with information on the historical value of the capital stock, value added and other information[23]. It is a major advantage

[22] Failed matches are due to incomplete sampling and closures between 1992 and 1996.

[23] Since BIC relates to firm level information rather than plant level information we aggregate

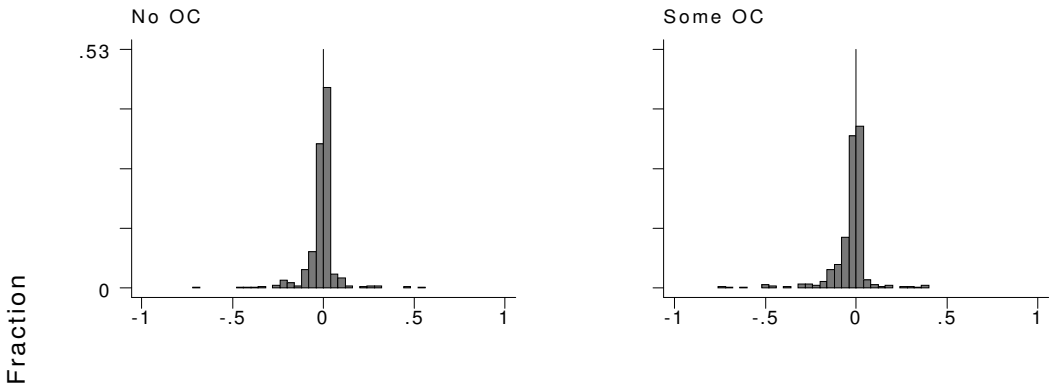


Figure 4.4:

having a panel of quantitative measures of firm production activities matched with detailed information on organization in all sectors of the economy. There are very few data sets with this property (examples focused on manufacturing include Black and Lynch, 1998, for the US and Nickell et al, 1992, 1996 for the UK).

5. Results

5.1. Organizational Change and changes in skill structure

5.1.1. British Results

Considerable recent effort has been directed at examining the effect of technology on enterprise skill structure (e.g. Doms et al, 1997). In this section we examine

over the plants when running the production functions, (weighting by total employment in 1992). There are very few firms that have more than one plant in Reponse - only about 8 in the final sample.

the impact of organizational changes in the 1984-1981 period on the subsequent evolution of skill structures in the 1990-1984 period within the same establishments. Table 2 reports the results using the WIRS panel to estimate the effects of OC between 1984-1981 on the change in the wage bill shares. The first panel presents the correlation between OC and the change in skill proportions (each column summarizes the results from a separate OLS regression). The only additional controls are the change in total firm size (change in log employment 1990-1984), the initial proportion of the skill groups in 1984[24] and a set of regional and industry dummies. The second panel includes the technology variables and the third panel includes a full set of conditioning variables.

[Tables 2 and 3 about here]

It is clear that OC is associated with a significant shake-out of the least skilled group - unskilled manual workers. Across all specifications there is a negative effect of past organizational change on the change in the wage bill share of unskilled manuals. It is less clear, however, which other groups are increasing their proportions at the expense of the least skilled. It appears, in general, that the middle layers of the occupational hierarchy expand rather than simply the middle and upper managers.

Panel B includes the three controls for technical change. Unsurprisingly, we find evidence for skill biased technical change, the computerization variables (especially the 1990-1984 computer introduction variable) have strong positive effects on the most skilled group (managers and technicians). The introduction of computers in the plant is also associated with a fall in the proportion of unskilled manuals. The OC effect on the least skilled persists conditional on these variables. Panel C saturates the model by including an extensive list of establishment level controls including financial performance, ownership and demand variables. The negative effect of OC is quite robust to these controls.

Table 3 considers various robustness tests. An important criticism of the results is that managers may interpret large employment changes as organizational

[24] This was to control for the fact that organizational change may be less likely in plants with many skilled workers and these establishments could have shrunk more rapidly over this period. The OC effects are quite robust to the exclusion of these initial conditions.

change. Since many of the employment shifts over this period were to reduce unskilled workers it could be argued that we are merely picking up an identity with the regressions. The force of this criticism is mitigated by our use of lagged OC and also by the fact that managers seemed to understand the difference between employment changes and organizational changes (see Table 1). Nevertheless, we attempted to address the problem empirically in two different ways. First, we used the fact that managers were asked to distinguish between organizational changes primarily affecting manual workers (OCMAN) and non-manual workers (OCNMAN). If we are merely picking up some kind of identity then one would expect the downward bias in the unskilled manual equation to be much larger for OCMAN than OCNMAN. In Table 3 we therefore repeat the specifications using OCNMAN and OCMAN as explanatory variables in separate regressions (they are quite highly correlated so including them together in the same equation results in collinearity problems). It is quite clear from the three panels that OCNMAN has the strongest negative effect on the demand for unskilled workers and not OCMAN, as would be the case if we were picking up some form of identity. A second way of checking the results is to use another question in WIRS which directly asks managers whether they have made any changes to increase employee involvement[25]. The pattern of results using this question instead of the OC question were reasonably similar (e.g. the coefficient of the variable in the unskilled workers equation was -0.031 with a standard error of 0.16 in panel C of Table 3, and insignificant in all other skill share equations).

We regard both OCMAN and OCNMAN as noisy signals of the fact that firms have introduced organizational changes and reject the view that managers are not distinguishing between organizational changes and changes to employment structure.

Although the theoretical model suggests that wage effects should be included in the regressions, the six wage variables were generally insignificant[26]. The disappointing results could be due to several reasons. There is a kind of division bias in operation since the wage (right hand side variable) is also used to calculate the

[25] "Has the management made any changes in the last 4 years with the aim of increasing employees' involvement in the operation of the establishment?". 43 per cent answered 'yes'.

[26] We obviously drop the regional dummies when including the regional hourly wage terms.

wage bill share (left hand side variable). Also there is the problem that wage differentials reflect both exogenous differences in the price of labor and unobserved differences in labor quality across regions. Nevertheless, the effects of OC were quite robust to the inclusion of these extra hourly wages variables - this is shown in Panel D of Table 3. We found that the calculations of the own-price elasticities of employment with respect to wages were reasonably sensible being stronger for the manual workers than non-manual workers. The cross price elasticities were very poor on economic and statistical grounds. The own price elasticities were -0.96, -2.53, -2.36, -0.51, -2.22, -0.63 for unskilled, semi-skilled, skilled, clerical, supervisors and managers respectively[27].

The impact of OC appears to be mainly driven by employment shifts rather than wage changes as we would expect from theory. This is illustrated for the most general model in the final panel (E) of Table 3. There has been a move in the UK towards outsourcing many less skilled jobs (e.g. cleaning). It may be the case that, although such workers are no longer directly counted as employees, the structure of employment has not fundamentally changed. To test for whether OC is just a re-labelling of outsourced workers we included a variable measuring the increase in the number of sub-contracted workers (normalized on total employment). Although the variable was correctly signed and marginally significant in some specifications the effect of OC on unskilled workers was robust[28]. All results were robust to including a larger number of industry dummies. For example including 47 two digit dummies (instead of the 9 one digit dummies) changed the coefficient on OC in the most general specification to -0.079 (0.022).

5.2. French Results

Table 4 holds the results on the effects of organizational change on wage bill shares for France. The table is similar in structure to the UK results in Table 3 panels

[27] These were calculated using the formula that the price elasticity $= \frac{\widehat{\beta_{ff}} + S_f^2 - S_f}{S_f}$. The wage bill shares of the skill groups (in 1984) were 0.12 (unskilled manual), 0.12(semi-skilled manual), 0.15(skilled manual), 0.23 (clerical),
0.06(supervisors), 0.33(managers).

[28] For example, in the context of the unskilled manual worker's equation, column (1) in Panel C., the sub-contracting variable has a coefficient (standard error) of -0.143(0.096) and the coefficient on OC falls to -0.048(0.018).

A through C except we only have 5 occupational groups for France as opposed to six for Britain[29]. It is remarkable that across all three specifications we also identify a significant and negative effect of OC on the change in the employment share of unskilled manuals as we found in the UK. The strongest positive effect of managerial delayering appears to be on the skilled manual workers, a pattern that was not so clearly present in the UK (the signs were generally positive but insignificant in Britain). Another difference is that we cannot identify any significant effects for the technology variables in France (although the sign is negative for the least skilled). The technology variables are more crudely measured for France than in the UK (we have only cross sectional information). Nevertheless other authors have argued that the evidence for skill biased technical change is weaker for France than for other countries(e.g. Goux and Maurin, 1995).

For France we also have information on changes in capital intensity that we include in panel E. There is some evidence that establishments which increase their capital intensity also tend to increase their skill intensity. There is a significant and positive coefficient on capital intensity in the equation for most skilled group and a negative but insignificant association for the least skilled group. Most importantly for our purposes, the OC effect is robust to this extra control[30]. As with the UK, the regional wage terms were not significant and we have difficulty in pinning down the size of the wage elasticities for any group except the unskilled manuals[31].

The criticism that the results are merely reflecting the fact that delayering is the same as reduction of the least skilled is highly unlikely as the delayering question refers to changes in management functions. Thus any measurement biases are likely to result in underestimating the effects of organizational change on reducing the demand for the least skilled.

[Tables 4 and 5 about here]

[29]The covariate set in the 'extended' model differs slightly due to data availability. For example there are no questions on foreign ownership and financial performance in REPONSE.

[30]These are robust to including the growth in value added as an additional variable.

[31]The own factor price elasticity for unskilled manuals was -1.325. The others were +0.41, +0.29, +1.11, -0.78 For skilled manuals, clericals, middle managers and senior managers repsectively.

As a further test of our interpretation of the correlation of the skills structure with organizational change we estimated simple probits of whether different groups of workers had received training in general skills (Table 5 Panel A) or specific skills (Table 5 Panel B). The finding that stands out from this table is that plants who delayer have a significantly higher propensity to train their workers in general skills. The correlation seems particularly strong for the least skilled employees. By contrast, unskilled manuals are significantly *less* likely to receive firm-specific training when delayering is introduced. This suggests that delayering demands the greater flexibility and general skills associated with more skilled workers. Unskilled workers are more likely to lose their jobs and the (presumably high ability) ones who remain need to be trained in general skills to perform the tasks previously only done by more skilled workers.

The French results on changes in the skill structure appear to broadly corroborate the UK results, despite covering a more recent time period, being a larger sample and having a rather different measure of organizational change.

5.3. The determination of organizational change

The next equation of interest is the organizational design equation. Table 6 summarizes the results for the UK and France. In the UK we pool the two cross sections in 1984 and 1990 and include a full set of covariates[32]. Column (1) has the results for manual OC and column (2) for non-manual OC. Clearly, larger plants and those with more technology have a higher probability of organizational change. Surprisingly, plants which faced large rises *or* large falls of demand in the previous year were significantly more likely to experience OC than those which had stable demand. Unionization and public sector status is positively correlated with organizational change.

Turning to the variable of interest, wage inequality appears to be associated with a lower probability of organizational change. Our interpretation of this is that cheap skills are beneficial to the introduction of organizational change. A relative shortage of educated workers in the local labor market drives up relative

[32]This restriction was not statistically rejected by the data. For OCMAN a joint test of the interactions had a p-value of 0.23 and for OCNMAN a p-value of 0.471.

wages and makes the introduction of organizational change (which is skilled labor intensive) more expensive[33].

The next columns in Table 6 examine the organizational change equation for France. As with Britain, high tech and larger plants are more likely to introduce organizational change. Union strength and being in the public sector appear to have a negative correlation with OC, however. This difference is probably because of the substantial changes in the unionized and public sectors stimulated by deregulation in the 1980s in the UK under Mrs. Thatcher (see Machin and Wadhwani, 1991, for example). Being unionized or state owned generally retards the probability of organizational change, but when incumbents in these plants are being weakened by legislative changes (as in the 1980s in the UK) these plants can experience the most dramatic restructuring.

Most importantly, relative wages also exhibit a negative and significant correlation with OC in France even after controlling for these other variables. We add firm capital and value added as additional controls in the final column. Although positive, capital intensity is insignificant and the coefficient on relative wages remains robust.

Table 7 presents a variety of checks on the main results. First, we constructed an alternative measure of the supply of skills from the Labor Force Surveys in each country. For each region we calculated the proportion of individuals in the labor force (not just workers) who had high levels of education. this was then used as an alternative to the relative wage terms. Regions with greater proportions of educated workers were significantly more likely to have experienced organizational change, although the correlation is only significant at the 10% level in the UK .

We are sensitive to the fact that there may be other region-specific variables driving the relative wage-OC correlation. First, in Row 3 we include the *change* in the regional wage differentials rather than the level, for the UK. For both types of OC there is a negative marginal effect, although the magnitude is about half the size of that in Table 6. It is well known that measurement error will be exacerbated by differencing data and this may be the problem here. As an alternative strategy,

[33]The effects of relative wages are robust to a several of specification checks. Dropping suspected endogenous variables such as computer use changed the coefficient on relative wages to -1.106(0.404). The skills effect is stronger in 1984 (-1.673(0.617)) than in 1990 (-0.878(0.558)).

a possible instrument for relative wages is regional unionization as it is well known that unions compress wage differentials. We constructed the average proportion of establishments in the region with a recognized union and used this to instrument the regional relative wage in Row 4 (note that plant level unionization rates are already controlled for). In the reduced form unionization is a strong predictor of wage compression. The marginal effect of relative wages is actually larger for manual OC, although smaller for non-manual OC. In France, there is no significant effect in the differenced specifications. This is likely to be because the French wage structure was relatively stable over the period (compared to the UK and US) so time series changes are dominated by sampling error. Rows 6 and 7 repeat the baseline specifications for two other measures of organizational change in France (JIT and quality circles). Relative wages have a negative effect on both of them, although the effect is only significant for 'Just in Time'[34].

A large number of other specification tests were also performed on the OC equations. Firstly, it may be that wage relativities are low in some regions not because of skill abundance, but because of institutional constraints on the wages of less skilled workers (e.g. the French minimum wage was high over this period). Consequently we included relative unemployment rates in some specifications - these were always insignificant. Secondly, it may be that the standard errors on the education variables are underestimated due to common group errors within a cell (Moulton, 1986; Borjas and Sueyoshi, 1994). Diagnostic tests did not reveal much evidence of this however. Although Bruesch-Pagan LM tests rejected when we do not control for the different industry composition of regions, the industry dummies appear to deal adequately with the problem. Finally, several other measures of product market competition were included to examine whether product market competition stimulated organizational innovation[35]. Mostly these were uninformative. There was some evidence that falling prices (in the plant's 3 digit industry) stimulated more OC in the early 1980s in the UK (when the economy experienced a major recession), but there were no significant effects in the late 1980s or in France. In all cases the effects of regional wages were robust to the

[34] Neither of these were ever significant in Table 4, the skill share equations.

[35] Measures included import prices, concentration indices and the manager's assessment of the number of competitiors faced by the establishment.

inclusion of these additional controls.

5.4. Organizational change and plant performance

The third implication of the hypothesis that skills and OC are complementary relates to firm performance. Table 8 contains estimates of production functions for France. The dependent variable is the growth of annualized value added between 1996 and 1992. In the first column we simply include our measure of OC, the 1992 proportion of unskilled manuals[36] and the interaction between the skills and OC variable. Consistent with the evidence previously presented, in establishments with no unskilled manual workers, introducing organizational changes in the late 1980s was associated with growth in value added of 3.5% a year. The less skill intensive plants were significantly less likely to benefit from organizational changes, however, as the interaction term is negative and significant. For plants with more than 27% of unskilled workers there is actually a negative effect of OC (the median proportion of unskilled manual workers is 4.3%). Column (2) includes the growth rates of capital and labor as additional controls. Their coefficients are close to their share in value added, which is reassuring, especially as differencing is likely to exacerbate measurement error (Griliches and Mairesse, 1997). The third column includes the technology variables and interactions with OC and initial skills. The COMP*UNSKILLED interaction is negative, consistent with skill biased technical change, but is insignificant. One variable that does matter, however, is another type of organizational innovation: quality circles. This has a robust and positive effect (although we could find no role for additional interactions).

The fourth column changes the dependent variable to TFP (using the observed factor shares as weights for labor and capital). This specification imposes constant returns - a restriction that cannot be rejected on the basis of column (3). It is attractive because the possibly endogenous inputs of labor and capital are no longer in the covariate set. The fifth column includes a set of other lagged controls (unions, public sector, demand changes and regional and industry dummies). In both of these columns the interaction between skills and OC remains

[36] We focus on this group because of the evidence from the skill share equation that this group suffered the most from organisational change.

significant[37]. It is possible that OC is introduced in plants which have higher trend in productivity growth (cf. Ichinowski et al, 1994), so to control for this we included the 1989-92 growth in value added (instrumented with the level of value added in 1989). The variable was insignificant (-0.046 with a standard error of 0.102) and did not change the OC interactions.

Finally, in the sixth column we estimate the most general model, allowing all the coefficients to vary by OC status. The unskilled proportion is negative and (weakly) significant for plants who experienced OC and positive (but insignificant) for plants who did not experience OC.

A similar exercise is not possible in the UK because WIRS lacks information on value added and investment. We did examine the part of the 1984-1990 panel which includes the firms who closed down before 1990. This is a rather extreme measure of plant performance. There does not appear to be a significant relationship between organizational change, skills or their interactions and the probability of plant closure (the strongest predictor is actually establishment size: larger plants are far more likely to survive than smaller plants). This does not give support to the idea of a complementarity between the two types of changes and a rather extreme measure of performance. On the positive side, it does mean that survivor bias is unlikely to be a major problem with our results.

6. Conclusions

This paper has examined the relationship between skills and organizational change. This is a subject which is the object of much speculation, but where there is a dearth of econometric analyses. Our results are easy to summarize. First, British and French establishments which introduce organizational changes are significantly more likely to reduce their demand for unskilled workers than those who do not. Secondly, the probability of introducing changes in organization, such as delayering of hierarchies, is depressed by shortages of skilled workers as proxied by educational wage differentials. Thirdly, in France at least, the introduction of organizational change in skill intensive firms leads to significantly faster produc-

[37]We experimented with also including the changes in the skill shares, but they were not significant (e.g. when included in column (5) F-Test = 0.68).

tivity growth than the introduction of organizational change in unskilled firms. Taken together, these findings do suggest that there is something in the notion of "skill biased organizational change".

The results presented here are part of a small but growing literature which tries to econometrically examine the relationship between skills, organization and technology. Using enterprize-level panel data from different countries is, we believe, an advance over existing work.

Where do we go from here? One issue that we would like to focus on in more detail is the role of product market competition in stimulating organizational change. We have some preliminary results suggesting that downward price shocks and larger market size stimulate organizational innovation. To the extent that there are some exogenous changes in the competitive environment facing firms, we may be able to identify more closely the link between competition and productivity growth stressed by many authors (Nickell, 1996; Porter, 1990). Another important issue is whether organizational factors really do have an independent influence on firm's productivity and demand or whether they are just part of the transmission mechanism between technological change and outcomes. If we had better measures of technical progress then organizational factors, per se, may be unimportant. Our prejudice is that this is not the case and managers do face real choices in what organizational strategies to pursue. Nevertheless, the usual call for improved data is certainly true in the area of technology and organization. The development of panel databases with repeated questions on the structure and change in organizational forms would be particularly beneficial.

Finally, the debate over the deteriorating position of low paid workers has tended to stress the role of technological factors and trade. We would emphasize that understanding the changing wage and employment position of the less skilled is intimately tied with the evolution of organizational forms. An important avenue for future research is to tie down the extent to which the declining fortunes of the unskilled are really linked to managerial innovations in the organization of work.

Table 1
What is Organizational Change in the UK?

OC-Non Manual				OC-Manual			
A. Have more or less Responsibility?							
More	Same	Less	D/K	More	Same	Less	D/K
0.462	0.465	0.029	0.045	0.328	0.571	0.064	0.036
B. Have to work at a more skilled or unskilled level?							
More	Same	Less	D/K	More	Same	Less	D/K
0.504	0.431	0.039	0.026	0.298	0.551	0.110	0.042
C. Effect on range of tasks							
Wider	Same	Narrower	D/K	Wider	Same	Narrower	D/K
0.625	0.281	0.058	0.03	0.395	0.450	0.133	0.020
D. Are subject to more or less supervision?							
More	Same	Less	D/K	More	Same	Less	D/K
0.126	0.608	0.242	0.025	0.195	0.610	0.177	0.018
E. Have more interesting or less interesting jobs to do?							
More	Same	Less	D/K	More	Same	Less	D/K
0.639	0.235	0.058	0.070	0.369	0.473	0.101	0.057
F. What happened to staffing or manning levels?							
More	Same	Less	D/K	More	Same	Less	D/K
0.092	0.554	0.346	0.007	0.112	0.417	0.461	0.009

Notes to Table 1: These are cell means relating to senior managers' responses to various questions on the effects of organisational change; D/K=don't know or not answered; there are 413 (436) observations for the non manual (manual) responses

Table 2
Changes in Wage bill Shares in the UK:
Effects of Organizational and Technological Change

1990-1984 Change in wage bill share of:	Unskilled manuals equation	Semi-skilled manuals equation	Skilled manuals equation	Clerical workers equation	Supervisors & foremen equation	Managers & technical staff equation
A. Basic controls						
OC_{81-84}	-0.048	0.004	0.006	0.023	0.016	-0.001
	0.017	*0.018*	*0.016*	*0.018*	*0.008*	*0.020*
B. Include technology						
OC_{81-84}	-0.049	0.004	0.020	0.024	0.014	-0.013
	0.018	*0.018*	*0.016*	*0.019*	*0.008*	*0.021*
$\%COMP_{81-84}$	0.031	-0.020	-0.057	-0.059	-0.002	0.107
	0.037	*0.039*	*0.034*	*0.040*	*0.017*	*0.044*
$COMP_{84-90}$	-0.027	0.005	-0.013	-0.016	0.011	0.040
	0.015	*0.015*	*0.013*	*0.016*	*0.007*	*0.017*
$\%COMP^{ind}_{84-90}$	-0.032	-0.003	-0.072	0.038	0.057	0.013
	0.048	*0.051*	*0.044*	*0.052*	*0.022*	*0.057*
C. Extended controls						
OC_{81-84}	-0.057	0.000	0.027	0.029	0.010	-0.001
	0.019	*0.020*	*0.017*	*0.020*	*0.008*	*0.022*
$\%COMP_{81-84}$	0.041	-0.033	-0.049	-0.064	-0.004	0.109
	0.039	*0.041*	*0.036*	*0.042*	*0.018*	*0.045*
$COMP_{84-90}$	-0.021	0.004	-0.015	-0.020	0.011	0.041
	0.015	*0.016*	*0.014*	*0.016*	*0.007*	*0.018*
$\%COMP^{ind}_{84-90}$	-0.004	-0.010	-0.080	0.021	0.052	0.021
	0.050	*0.053*	*0.046*	*0.053*	*0.022*	*0.058*

Notes to Table 2: 'Basic' controls include 11 regional and 9 industry dummies, growth in total log(employment) 1990-1984, 1984 skill shares (5). 'Extended' controls include basic plus 1984 values of union recognition, financial performance above/below average, UK ownership, presence of joint consultative committee. The number of observations is 401, 394 and 381 in panels A,B,C respectively.

Table 3
Changes in Wage bill Shares in the UK:
Robustness tests

1990-1984 Change in wage bill share of:	Unskilled manuals equation	Semi-skilled manuals equation	Skilled manuals equation	Clerical workers equation	Supervisors & foremen equation	Managers & technical staff equation
A. Basic controls						
$OCNMAN_{81-84}$	-0.064	-0.023	0.032	0.028	0.014	0.014
	0.019	*0.021*	*0.018*	*0.021*	*0.009*	*0.023*
$OCMAN_{81-84}$	-0.035	0.033	-0.015	0.031	0.004	-0.019
	0.022	*0.022*	*0.020*	*0.020*	*0.009*	*0.022*
B. Basic + computers						
$OCNMAN_{81-84}$	-0.067	0.023	0.045	0.029	0.014	0.003
	0.020	*0.021*	*0.018*	*0.022*	*0.009*	*0.023*
$OCMAN_{81-84}$	-0.044	0.031	-0.004	0.033	0.003	-0.029
	0.024	*0.023*	*0.020*	*0.020*	*0.009*	*0.022*
C. Extended controls						
$OCNMAN_{81-84}$	-0.075	-0.028	0.046	0.028	0.009	0.019
	0.021	*0.022*	*0.019*	*0.023*	*0.010*	*0.025*
$OCMAN_{81-84}$	-0.037	0.024	-0.003	0.040	-0.004	-0.027
	0.023	*0.025*	*0.026*	*0.021*	*0.009*	*0.023*
D. Extended + hourly wages						
OC_{81-84}	-0.047	-0.003	0.020	0.018	0.014	-0.002
	0.018	*0.019*	*0.017*	*0.020*	*0.008*	*0.021*
E. Change in employment share Extended controls						
OC_{81-84}	-0.075	0.011	0.028	0.026	0.010	-0.001
	0.024	*0.023*	*0.019*	*0.019*	*0.007*	*0.023*

Notes to Table: Same as Table 2. Note that row D. includes 4 relative hourly wage terms.

Table 4
Changes in Wage Bill Shares in France:
Effects of organizational change (delayering)

1996-1992 Change in wage bill share of:	Unskilled manuals equation	Skilled manuals equation	Clerical workers equation	Middle Managers equation	Senior Managers equation
A. Basic Controls					
OC_{89-92}	-0.012	0.014	-0.006	-0.003	0.005
	0.005	*0.006*	*0.004*	*0.005*	*0.003*
B. Basic Controls+Technology					
OC_{89-92}	-0.013	0.017	-0.005	-0.004	0.005
	0.005	*0.007*	*0.004*	*0.005*	*0.003*
$COMP_{92}$	0.003	-0.016	-0.002	0.008	-0.002
	0.006	*0.007*	*0.004*	*0.005*	*0.003*
C. Extended Controls					
OC_{89-92}	-0.014	0.013	-0.007	-0.001	0.007
	0.005	*0.007*	*0.004*	*0.005*	*0.004*
$COMP_{89}$	-0.000	-0.009	0.002	-0.004	0.003
	0.006	*0.008*	*0.005*	*0.006*	*0.004*
D. Extended + hourly wages					
OC_{89-92}	-0.014	0.015	-0.007	0.001	0.005
	0.005	*0.007*	*0.004*	*0.005*	*0.004*
E. Extended + Capital/VA					
OC_{89-92}	-0.014	0.018	-0.003	0.003	-0.007
	0.007	*0.009*	*0.004*	*0.006*	*0.004*
$\Delta \log(K/VA)$	-0.037	0.032	-0.016	-0.012	0.035
	0.030	*0.040*	*0.016*	*0.023*	*0.014*
F. Change in Employment Shares - Extended Controls					
OC_{89-92}	-0.015	0.015	-0.008	0.001	0.007
	0.005	*0.007*	*0.005*	*0.005*	*0.004*

Notes to Table 4
All regressions include industry (14) , regional (11) dummies, a dummy for vicinity to the German border, the initial proportion of skill group and change in total log(employment). Panel C also includes 1989 values of plant size, demand conditions, computers and a public sector dummy. Panel D. adds changes in log hourly wages of all skill groups. Panel E. includes changes in log(capital/VA). Estima-tion by weighted OLS; 1125 observations in panel A, 1123 in panel B 863 in panels C, D and F, 514 in column E.

Table 5
Organizational Change and Training in France (1992)

Training of:	Managers	Supervisors Foremen	Technicians	Salesmen	Clerical	Skilled Manuals	Unskilled Manuals
Panel A: General Training							
Delayering	0.057	0.090	0.076	0.067	0.053	0.079	0.121
(basic)	*0.023*	*0.024*	*0.025*	*0.023*	*0.024*	*0.028*	*0.029*
Observations	1604	1604	1360	1131	1751	1277	1198
Pseudo-R^2	0.003	0.007	0.006	0.007	0.002	0.004	0.011
Delayering	0.055	0.084	0.069	0.068	0.052	0.032	0.093
(basic)	*0.024*	*0.025*	*0.026*	*0.024*	*0.025*	*0.030*	*0.030*
computer	0.009	0.020	0.031	-0.014	0.004	0.161	0.099
	0.025	*0.026*	*0.028*	*0.025*	*0.025*	*0.031*	*0.032*
Observations	1502	1600	1355	1127	1744	1271	1194
Pseudo-R^2	0.003	0.007	0.006	0.007	0.002	0.020	0.016
Delayering	0.034	0.070	0.044	0.062	-0.023	-0.026	0.095
(extended)	*0.036*	*0.041*	*0.041*	*0.035*	*0.039*	*0.046*	*0.048*
computer	0.085	-0.019	0.015	0.065	0.085	0.179	0.081
	0.040	*0.046*	*0.048*	*0.039*	*0.043*	*0.056*	*0.058*
Observations	739	768	673	534	853	617	579
Pseudo-R^2	0.058	0.102	0.098	0.087	0.081	0.111	0.076
Panel B: Specific Training							
Delayering	0.051	0.043	0.047	0.039	0.033	0.055	-0.085
(basic)	*0.025*	*0.025*	*0.027*	*0.030*	*0.024*	*0.028*	*0.028*
Observations	1508	1604	1360	1131	1751	1277	1198
Pseudo-R^2	0.002	0.001	0.002	0.001	0.001	0.002	0.006
Delayering	0.036	0.027	0.037	0.054	0.031	0.046	-0.098
(basic)	*0.026*	*0.026*	*0.028*	*0.030*	*0.025*	*0.029*	*0.030*
computer	0.064	0.066	0.052	-0.071	0.008	0.039	0.047
	0.027	*0.027*	*0.030*	*0.031*	*0.025*	*0.031*	*0.031*
Observations	1502	1600	1355	1127	1744	1271	1194
Pseudo-R^2	0.005	0.004	0.003	0.005	0.001	0.003	0.007
Delayering	0.047	-0.022	0.032	-0.002	-0.006	0.073	-0.105
(extended)	*0.041*	*0.041*	*0.043*	*0.049*	*0.038*	*0.045*	*0.046*
computer	0.035	0.046	-0.001	-0.075	-0.062	-0.060	0.059
	0.046	*0.046*	*0.051*	*0.054*	*0.042*	*0.055*	*0.055*
Observations	739	768	673	546	853	617	577
Pseudo-R^2	0.084	0.044	0.049	0.130	0.053	0.031	0.090

Notes to Table: Basic regressions do not include any controls. Extended regressions include: size of establishment, public/private firms, union recognition and density, demand rise or fall over the past five years and industry and regional dummies; estimation by Probit (any training for a skill group)

Table 6
Determinants of Organizational Change

	UK		France	
	OCMAN	OCNMAN	OC-delayer	
Regional relative wage	-1.214	-0.759	-1.166	-1.218
(high-low education)	*0.316*	*0.313*	*0.497*	*0.498*
Computer	0.277	0.174	0.215	0.199
	0.030	*0.027*	*0.038*	*0.039*
Size_{t-3} $*10^{-4}$	0.623	0.499	-0.055	-0.125
	0.161	*0.119*	*0.109*	*0.113*
Demand Rise	0.077	0.048	-0.073	-0.061
	0.033	*0.032*	*0.042*	*0.042*
Demand Fall	0.062	0.070	0.010	0.024
	0.049	*0.051*	*0.049*	*0.050*
Public	0.232	0.074	-0.032	-0.072
	0.067	*0.068*	*0.054*	*0.057*
Union	0.085	0.106	0.028	0.001
	0.036	*0.030*	*0.043*	*0.044*
Union Density			-0.215	-0.219
			0.098	*0.099*
Foreign Owned	-0.032	0.027		
	0.042	*0.040*		
log(Capital)				0.029
				0.018
log(Value added)				0.007
				0.023
Industry Dummies (9)	yes	yes	yes	yes
Time dummies (1)	yes	yes		
Observations	1353	1306	1007	1007
Log Likelihood	-742.4	-719.4	-611.8	-604.7
Pseudo R^2	0.176	0.123	0.119	0.129

Notes to Table: These are the marginal effects (and associated standard errors) from a probit ML regression

Table 7 - Robustness of OC Equations

Row	Equation	Experiment	marginal effect (s.e)
1.	OC, 1984 and 1990 pooled,UK	Proportion of educated instead of relative wage	0.747(0.438)
2.	OC, 1992, France	Proportion of educated instead of relative wage	1.081(0.493)
3.	OC, 1984 and 1990, pooled UK	Change in regional relative wage 1984-1981 and 1990-1987	
	OCMAN		-0.586 (0.213)
	OCNMAN		-0.307 (0.206)
4.	OC 1984 and 1990 pooled, UK	Instrument regional relative wages with regional unionisation	
	OCMAN		-1.516 (0.933[a])
	OCNMAN		-0.544(0.888[a])
5.	OC, 1992, France	Change in regional relative wage 1990-1992	0.049(0.361)
6.	Just-in-Time, France	Regional Relative wages	-1.477(0.452)
7.	Quality Circles, France	Regional Relative wages	0.211(0.414)

Notes to Table
These are specifications identical to those in Table 6, including all the additional controls.
[a] *Standard error on predicted variable (uncorrected)*

Table 8
Firm level Production Functions for France

	$\Delta \ln(Value\ Added)^{96-92}$			ΔTFP^{96-92}	$\Delta \ln(VA)^{96-92}$		
						$OC=1$	$OC=0$
	(1)	(2)	(3)	(4)	(5)	(6)	
$\Delta \ln(Capital)^{96-92}$		0.188	0.181		0.220	0.263	0.222
		0.046	*0.046*		*0.082*	*0.142*	*0.092*
$\Delta \ln(Labour)^{96-92}$		0.830	0.850		0.910	0.791	0.824
		0.060	*0.062*		*0.101*	*0.156*	*0.129*
Lagged variables (REPONSE)							
OC	0.035	0.023	0.022	0.034	0.035		
	0.014	*0.011*	*0.011*	*0.020*	*0.017*		
OC*%Unskilled	-0.133	-0.096	-0.078	-0.074	-0.137		
	0.050	*0.038*	*0.040*	*0.034*	*0.057*		
%Unskilled	-0.019	0.015	0.037	0.031	0.107	-0.102	0.018
	0.036	*0.030*	*0.032*	*0.030*	*0.056*	*0.057*	*0.038*
%COMP			0.016	0.012	0.003	0.017	-0.037
			0.018	*0.015*	*0.028*	*0.043*	*0.027*
%COMP*%Unskilled			-0.111	-0.054	-0.148		
			0.067	*0.056*	*0.095*		
Quality Circles			0.023	0.019	0.016	0.017	0.024
			0.010	*0.009*	*0.015*	*0.028*	*0.015*
Industry Dummies (9)	no	no	no	no	yes	yes	
Regional Dummies (11)	no	no	no	no	yes	yes	
Other controls	no	no	no	no	yes	yes	
Observations	551	523	523	289	289	141	148
R-Square	0.023	0.461	0.464	0.034	0.541	0.620	0.554

Notes
These are long-differenced specifications. Value added, capital and labour are annualised changes 1996-1992. Other variables from Reponse in 1992.
Other controls are: demand changes, public sector, union status, German border.

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Table A1
Descriptive Statistics - UK and France

Variable	UK - 1984 Mean	UK - 1984 Standard Deviation	UK - 1990 Mean	UK - 1990 Std Dev.	France - 1992 Mean	France - 1992 Std Dev.
Organisational Change						
OC -Delayering	-	-	-	-	0.542	0.498
OC-manual	0.302	0.459	0.474	*0.500*	-	-
OC-non manual	0.264	0.441	0.421	*0.494*	-	-
OC-either	0.380	0.485	0.506	*0.500*		
Educational structure of the Working Population:						
% High Educated (Degrees+A-level or Bac)	0.359	*0.099*	0.398	*0.110*	0.261	*0.125*
% Degrees	0.066	*0.049*	0.063	*0.046*	0.134	*0.080*
% A-levels/Bac	0.293	*0.080*	0.335	*0.092*	0.126	*0.061*
% O-levels/BEPC+CAP	0.214	*0.059*	0.281	*0.071*	0.413	*0.060*
% No qualification	0.427	*0.094*	0.320	*0.078*	0.326	*0.107*
Union Recognition	0.500	*0.501*	0.459	*0.499*		
Union density	-	-	-	-	0.150	*0.191*
Size (total employees)	127.56	*280.16*	130.22	*260.68*	105.24	*282.80*
Demand Rise	0.617	*0.486*	0.545	*0.498*	0.516	*0.500*
Demand Fall	0.095	*0.293*	0.168	*0.374*	0.244	*0.430*
Foreign Ownership	0.090	*0.287*	0.172	*0.378*	-	-
Public Firm	0.153	*0.360*	0.066	*0.249*	0.190	*0.393*

Notes to Table A1: All variables are weighted by WIRS/REPONSE sampling weights and plant employment (except size variable)

Table A1 continued
Descriptive Statistics- Means of OC

United Kingdom	1984 (mean)	1990 (mean)	France	1992 (mean)
Industries			Industries	
			Food Processing	0.048
Energy	0.068	0.033	Energy	0.032
Minerals and Chemicals	0.105	0.107	Intermediate goods	0.176
Metal and Engineering	0.218	0.260	Engineering	0.218
Other Manufacturing	0.227	0.239	Consumption	0.075
Construction	0.033	0.021	Construction	0.033
Distribution	0.144	0.168	Distribution	0.098
Transport and Communication	0.102	0.109	Transport and Communication	0.082
Banking and Finance	0.039	0.030	Traded services	0.145
Other Services	0.063	0.032	Real Estate	0.005
			Insurance	0.0198
			Banking and Finance	0.065
			Other Services	0.004
Regions			Regions	
North	0.055	0.065	Nord-Pas de Calais+Picardie	0.092
Yorks	0.078	0.116	Basse+Haute Normandie	0.081
East-Midlands	0.089	0.081	Alsace+Lorraine	0.113
East-Anglia	0.050	0.033	Bretagne+Pays de Loire	0.072
London	0.124	0.093	Champagne-Ardenne	
			+Franche-Comte	0.048
South-East	0.196	0.156	Centre+Poitou-Charentes	0.044
South-West	0.084	0.073	Bourgogne+Rhone-Alpes	0.173
West-Midlands	0.112	0.091	Auvergne+Limousin	0.031
North-West	0.124	0.143	Aquitaine+Midi-Pyrennees	0.094
Wales	0.026	0.039	Laguedoc-Roussillon+PACA	0.075
Scotland	0.062	0.108	Ile de France	0.179

Table A1 - Continued

UK: Skill Shares in panel, 1990-1984

	% of wage bill in 1984	Change 1990-1984
Unskilled manuals	0.12	-0.012
Semi-skilled manuals	0.12	-0.001
Skilled manuals	0.15	-0.014
Clerical workers	0.23	-0.003
Supervisors	0.06	-0.005
Managers	0.33	0.035

France: Skill Shares in panel, 1996-1992

	% of wage bill in 1992	Change 1996-1992
Unskilled manuals	0.128	-0.023
Skilled manuals	0.322	0.002
Clerical workers	0.214	-0.012
Middle managers	0.237	0.022
Senior Managers	0.100	0.012

6.1. Data Appendix

Britain

The Workplace Industrial Relations Survey (WIRS) is a survey covering a stratified random sample of over 2,000 British establishments with at least 25 employees. It has been conducted in 1980, 1984, 1990 and 1997. There is a panel element of 537 establishments between 1984 and 1990. The main survey is answered by a Senior Manager but a large sample of the questions are also answered by a Workers Representative (e.g. a union shop steward). In 1984 a Personnel Manager was asked some further questions relating to Human Resource policies and in1990 a financial manager was also asked some specific questions relating to economic performance.

The General Household Survey (GHS) has been conduced since 1971. There are about 20,000 individuals in the survey in each year. The earnings question in GHS is asked consistently from 1979 onwards and relates to usual gross earnings. The earnings and hours question excludes overtime, but regional trends are very similar to those in the FES and NES. It contains the 3 digit Classification of Occupations (1980) which we use to create occupational categories matched to the 6 WIRS skill groups (see Chennells and Van Reenen, 1997, for details). GHS also contains detailed information on highest educational qualification which we use to construct two groups. Highly educated individuals are all those who have at least one 'A' level or higher qualification (e.g. college degree). All others are in the 'low' group.

The Labour Force Survey (LFS) covers about 80,000 individuals per quarter and is the main source of data for labor market statistic in the UK. Qualifications are similar to the GHS so we can construct proportions of educated workers by region in the same way. Unfortunately information on wages was not available until 1992.

France

Relations Professionnelles et Negociations d'Entreprise (REPONSE) was carried out in 1992 and was modelled on the UK WIRS (see Coutrot and Malan, 1996). 2500 establishments were surveyed with senior managers being asked questions about industrial relations and organization in 1992.

Enquête Structure des Emplois (ESE) is a stratified random sample of French establishments. About half of the Reponse establishments which continuously existed between 1992 and 1996 were matched to the ESE (1360 plants). Failed matches are due to incomplete sampling and closures between 1992 and 1996. The ESE breaks the workforce down into 5 occupational categories (unskilled manual, skilled manual, clerical, middle managers and senior managers).

Enquête Emploi (EE) is an annual survey of individuals conducted by the French National Statistical Agency, INSEE. The EE is a 1/300 sample of the French working population (about 60,000 households) based on a three year rotating panel containing information about education levels, region, industry and employment status. We define as educated those workers with a college degree or any baccalaureate. All others (with BEP, CAP and below) are considered as low educated. As for British data, we compute the supply of skills at the level of regional cells, although unlike WIRS we can disaggregate further into 21 regions. In order to get a comparable number of cells in France and in the UK we also reaggregate regions into 11 "zones". We do so on a geographical basis so that Nord-Pas de Calais is matched with Picardie, Aquitaine with Midi-Pyrénnées, Auvergne with Limousin. The only region which is not reaggregated to a higher level is Ile de France.

The BIC is a firm level database with information on the historical value of the capital stock, value added, total wages and other information[38]. It is a major advantage having a panel of quantitative measures of firm production activities matched with detailed information on organization in all sectors of the economy. There are very data sets with this property (examples focused on manufacturing include Black and Lynch, 1998, for the US and Nickell et al, 1992, 1996 for the UK).

[38]Since ESE relates to firm level information rather than plant level information we aggregate over the plants when running the production functions ans weighting by total employment in 1992. There are very few firms that have more than one plant in reponse - only about 8 in the final sample.