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WAGES, EFFORT AND PRODUCTIVITY

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ABSTRACT

Empirical analyses of longitudinal data on some 66 manufacturing companies in Britain lead us to the following three conclusions. First, agreed reductions in restrictive work practices lead to increases in productivity. Second, controlling for such agreed reductions, there is some weak evidence that both relative pay and aggregate labour market slack have some positive impact on productivity. Third, falls in market share or declines in the financial health of companies lead to both lower pay rises and reductions in restrictive practices.

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Introduction

Many people believe that companies which are doing well pay their workers more than companies which are doing badly. Another commonplace belief is that paying workers well motivates them to work harder, and thus enables the company which employs them to improve its performance. It is clear from this that the causal relationships between pay, effort and company performance are nothing if not complex.

In the market for labour, the forces of competition will generally ensure that individuals who are consistently hard-working will obtain higher wages. Aside from this, what other forces might be at work? Suppose, for example, that pay results from a firm-union bargain. Suppose further that the union side is concerned with both wages and job security. Then any exogenous factor which generates a *ceteris paribus* improvement in job security leads to the union achieving higher wages in the bargain. Examples of such factors include an increase in the market power of the company or an improvement in its financial position.[1] So this implies a direct causal link between the improvement in company performance and the subsequent increase in pay. This link can also apply in non-union firms if the improvement in performance is associated with an increase in product market rents or free cash flow which is then shared with the employees.

Where might employee effort enter this story? In the majority of union plants in Britain, bargaining takes place over effort as well as pay.[2] In this case if an improvement in the financial position of a company, for example, leads to the union obtaining a bigger pay increase, such an improvement will also enable it to bargain for lower effort. So in this context, we might expect to observe an improvement in company performance generating both an increase in pay and a reduction in effort. We could, therefore, observe a negative relation between effort and pay in response to certain types of shock.

Where does this leave the motivation argument noted at the beginning of this section? The use of pay to motivate workers is a standard idea in the literature on human resource management, and comes in very direct forms such as piece rates or performance related bonuses. The efficiency wage literature has generated a more subtle notion in the form of the shirking model (see Shapiro and Stiglitz, 1984). The difference here is that while performance pay relates wages to readily observed outcomes, the shirking model generates a positive relationship between effort and pay in situations where individual effort is not readily observed. The idea here is that higher pay leads to a reduction in shirking because the penalty for being caught shirking, namely job loss, is more serious if wages are higher.

Our purpose in what follows is to try and shed some light on these issues using longitudinal data on a group of UK manufacturing companies, including some information on changes in observed effort. We shall investigate a number of questions. First, can we detect a relationship between our measure of observed effort and company productivity? Second, controlling for observed effort, can we detect any efficiency wage effects on productivity? Third, do increases in market power or improvements in the financial position of companies lead to higher pay rises and reductions in effort? Our main focus will be on the first and third questions. The second we see as a more speculative endeavour because the detection of efficiency wage effects in a production function framework is fraught with problems.

1. The Analytical Framework

In this section we consider the theoretical and empirical background to the determination of productivity and to the determinants of wages and effort in a bargaining framework.

The determinants of productivity

The basis of our analysis is the production function. Output is a function of labour, capital, working hours plus the "effort" of both operatives and managers. Here we use the term "effort" in a broad sense to cover anything that workers and managers do to improve company productivity which raises the disutility of work. Increased effort will raise measured efficiency (the level of productivity) and, particularly in the case of managerial effort, it may also raise productivity growth as managers continuously search harder for better ways of doing things.

First, consider these growth effects. An interesting hypothesis, which is extensively analysed in Nickell (1993), is that managerial effort is influenced by the extent of product market competition. That is, competition acts as a spur to managers, leading to a higher rate of productivity growth. This idea will be investigated in what follows but will not be our main focus. Here we concentrate on level effects, particularly the role of efficiency wages.

As we have already noted, it is important to recognise that efficiency wage effects operate via unobserved effort. In the standard shirking model of Shapiro and Stiglitz (1984), shirking is not readily observed and higher (unobserved) effort is induced by paying wages in excess of outside opportunities. This works because the firm undertakes some limited monitoring of workers and if they are caught shirking, they lose their jobs. The higher the wage relative to outside opportunities, the greater the cost of job loss and the greater the incentive not to shirk at given levels of monitoring. If worker effort is readily observed, the uniformly higher wages are unnecessary because workers can be paid directly in relation to their effort.

In reality, of course, there are both observed and unobserved aspects to individual effort and it is only the latter to which efficiency wage arguments apply. For example, observed effort includes, most obviously, hours of work, and also manning ratios on machines and the flexibility of working practices.[3] Less readily observed aspects of effort relate to intensity of work, care taken over quality, and the like.

In order to capture these effects, we use a constant returns log-linear production function of the form

$$\beta_i + \beta_t + \alpha_i n_{it} + (1-\alpha_i) k_{it} + \alpha_1 h_{it} + e_{oit} + e_{uit} + g_i \quad \textbf{(1)}$$

where y = output, n = employment, k = capital stock, h = working hours, e_o = observed effort, e_u = unobserved effort, g = productivity growth and ε = all other factors. i is the firm index, t is the time index, β_i is an unobserved firm effect and β_t is a time effect. The latter two variables capture all time invariant firm specific factors and all time varying factors common to all firms. In our empirical work, the most important purpose served by this model is to check that our measure of observed effort really does influence productivity. We shall also, however, investigate competition effects on productivity growth by supposing that

$$g_i = \underset{+}{g}(\text{competition}_i) \quad (2)$$

and efficiency wage effects via unobserved effort by specifying

$$e_{uit} = e_u(\underset{+}{W_{it}/W_t}, \underset{+}{u_{jt}}), \quad (3)$$

where W_i/W = relative wages and u_j = the industry unemployment rate.

What do we know about these effects? On the efficiency wage front, we have some direct firm level production function evidence that wages influence productivity (see Wadhwani and Wall, 1991 and Levine, 1992). Unfortunately neither of these studies control for <u>observed</u> effort and the former does not control wages for skill-mix either. These omissions naturally create a potential correlation between productivity and wages which can corrupt the relationship we are looking for. Other production studies tend to use more aggregative data and generally find a positive unemployment effect on productivity. (See Oster, 1980; Rebitzer, 1988 or Green and Weisskopf, 1990, for example).

Concerning competition and productivity growth, Geroski (1990) finds clear evidence that increases in monopoly power tend to <u>reduce</u> the rate of innovation and hence productivity growth.[4] Nickell (1993) finds evidence that firms with a large number of competitors tend to have higher (total factor) productivity growth than those facing less competition. Otherwise there is little evidence available.

The determination of observed effort and wages

Since this is to be the main focus of our empirical investigation, it helps if we can pin down rather precisely the implications of a simple theory. Here we suppose that firms and unions bargain over wages and effort, and then, output, employment and prices are determined via a Cournot-Nash equilibrium. The industry setting is that described in Nickell (1993). There are n firms producing a homogeneous good. Firm i has technology

$$Y_i = \phi_i (E_i N_i)^{\alpha}, \ \alpha<1 \tag{4}$$

where Y is output, N is employment, E is observed effort and ϕ reflects other factors influencing firm productivity. Industry price P satisfies

$$P = [\Sigma Y_i / Y_d]^{-1/\eta} \tag{5}$$

where Y_d is a demand index and η is the industry demand elasticity.

The sequence of events is as follows. First firm and union pairs bargain independently about effort, E_i, and the wage, W_i. Then firms in the industry set output and employment at the Cournot-Nash equilibrium. At the second stage, we can show that employment in firm i satisfies

$$N_i = (W_i/\phi_i E_i^{\alpha} P \alpha \kappa_i)^{-1/(1-\alpha)} \ ; \ \kappa_i = 1 - MS_i / r \tag{6}$$

where $MS_i = Y_i / \Sigma Y_k$, the market share of firm i. Using this and (4), (5), we can show that the market price P satisfies

$$P = \left[\frac{1}{Y_d} \sum_i \phi_i^{\frac{1}{1-\alpha}} (\alpha \kappa_i E_i \ / W_i)^{\frac{\alpha}{(1-\alpha)}} \right]^{-\frac{(1-\alpha)}{\alpha+\eta(1-\alpha)}}$$

This enables us to show that

$$\frac{N_i}{W_i} = -\frac{1}{1-\alpha}\left(1-\frac{\partial \log P}{\partial \log W_i}\right) = -\frac{1}{1-\alpha}\left(1-\frac{\alpha M}{\alpha+\eta (}\right. \tag{7}$$

$$\frac{\partial \log N_i}{\partial \log E_i} = \frac{\alpha}{1-\alpha}\left(1-\frac{MS_i}{\alpha+\eta(1-\alpha)}\right) \tag{8}$$

and that profit, π_i, is

$$\pi_i = \frac{1-\alpha\kappa_i}{\alpha\kappa_i} W_i N_i \tag{9}$$

Turning to the first stage, we use the generalised Nash bargaining framework. The union contribution to the Nash bargain we specify as $[W_i g(E_i)-\bar{U}]N_i$, which is consistent with a utilitarian union objective. $W_i g(E_i)$ is the utility of a representative union member and $\bar{U}$ is the utility which the union member can obtain outside the firm. The contribution of effort to utility, $g(E_i)$, is assumed to be decreasing in effort at an increasing rate ($g' < 0$, $g'' < 0$). Taking the firm's contribution to the Nash bargain to be its profit, the Nash objective has the form

$$\Omega = [(W_i g(E_i)-\bar{U})N_i]^{\beta_i}\pi_i \tag{10}$$

where β_i reflects the power of the union in the bargain.

In order to introduce financial pressures on the firm arising from high levels of debt, say, we simply constrain the firm to make a profit greater than some fixed amount $\hat{\pi}_i$, in order to cover debt servicing, for example. So wages and effort are determined by solving

$$\max_{W_i, E_i} \Omega \text{ subject to } \pi_i - \hat{\pi}_i \geq 0 .$$

The Lagrangian for this problem is given by

$$\beta_i \log(W_i g(E_i)-\bar{U}) + \beta_i \log N_i + (1+\lambda_i)\log\pi_i - \lambda_i \log\hat{\pi}_i$$

and, using (9), the Nash bargain reduces to solving

$$\max_{W_i, E_i} \beta_i \log(W_i g(E_i)-\bar{U}) + (\beta_i+\lambda_i+1)\log N_i + (1+\lambda_i)\log W_i .$$

The first order conditions are

$$\frac{\beta_i W_i g(E_i)}{W_i g(E_i)-\bar{\bar{U}}} = \frac{\beta_i+(1+\lambda_i)\alpha - Z}{(1-\alpha)} \tag{11}$$

$$\frac{\beta_i W_i |E_i g'(E_i)|}{W_i g(E_i) - \bar{\bar{U}}} = \frac{\beta_i \alpha+(1+\lambda_i)\alpha - Z}{1 - \alpha} \tag{12}$$

where

$$Z = \frac{(1+\beta_i+\lambda_i)\alpha MS_i}{\alpha + \eta(1-\alpha)} \quad . \tag{13}$$

Furthermore, there is the usual complementary slackness condition,

$$\lambda_i \geq 0, \; \lambda_i(\log\pi_i - \log\hat{\pi}_i) = 0 \; . \tag{14}$$

Some elementary manipulation then yields

$$\left|\frac{E_i g'(E_i)}{g(E_i)}\right| = \frac{\alpha\beta_i + \alpha(1+\lambda_i) - Z}{\beta_i + \alpha(1+\lambda_i) - Z} \tag{15}$$

$$W_i|E_i g'(E_i)| = \overline{U} \tag{16}$$

For our purposes, the relevant comparative static results are

$$\partial E_i/\partial\lambda_i > 0 \; , \; \partial E_i/\partial MS_i < 0 \; , \; \partial E_i/\partial\overline{U} = 0 \tag{17}$$

$$\partial W_i/\partial\lambda_i < 0 \; , \; \partial W_i/\partial MS_i > 0 \; , \; \partial W_i/\partial\overline{U} > 0 \; . \tag{18}$$

Since λ_i is non-decreasing in the profit constraint, $\hat{\pi}_i$, these results indicate that an increase in financial pressure or a reduction in market power (fall in market share) will lead to an increase in bargained effort and a reduction in wages. The utility available outside the firm, $\overline{U}$, is a function of outside opportunities. In particular it will depend positively on outside wages and negatively on aggregate unemployment. Changes in these variables will influence wages but not effort in this simple framework. Finally it is worth noting that (16) implies that for a given state of the outside labour market, wages and effort move in opposite directions. It is our purpose to investigate all these hypotheses with our company data set.

Evidence on the impact of market power and financial pressure on wages is now readily available. For example, Nickell and Wadhwani (1990) and Carruth and Oswald (1989) provide clear evidence that financial pressure lowers pay, and the role of market power in enabling managers to pay higher wages is clearly demonstrated in Veugelers (1989), Stewart (1990), Konings and Walsh (1993) or Nickell et al. (1992). However, there is not direct evidence that these same forces shift effort in the opposite direction. It is our investigation of this issue which is our main claim to originality.

2. The Empirical Formulation

We shall use panel data on UK manufacturing companies to investigate the various hypotheses discussed in the previous section. Our basic data source is the published accounts of 66 UK manufacturing companies over the period 1979-86. All the companies are unionised. Added to these data is information from the annual Confederation of British Industries (CBI) Survey of wage settlements which has been matched to the accounting data.[5] We shall discuss some of the data definitions here because they have important implications for the interpretation of the results. Complete definitions may be found in the appendix.

The productivity equation

This is based on the model set out in the previous section in equations (1), (2), (3). The following variables are of particular interest.

Employment elasticity, α_i. This coefficient is equal to $\mu_i s_i$, where μ_i is the mark-up of price on marginal cost and s_i is the share of labour (see Hall, 1986, for example). Since we have no accurate measures of μ_i, we either treat α_i as a constant or suppose it to be a linear function of the (average) share of labour for each firm.

Hours, h_{it}. We follow Muellbauer (1984) and use $\alpha_{11}(H_{ojt}/H_{njt}) + \alpha_{12}(H_{ojt}/H_{njt})^{-1}$ where H_{oj} measures overtime hours per worker in industry j and H_{nj} measures standard hours per worker. This captures the asymmetry arising from the fact that measured hours tend to overstate actual hours worked in slumps.

Observed effort, e_{oit}. The only variable available is from the CBI data set and measures a change in observed effort. It is a dummy variable which takes the value 1 if the annual wage settlement includes an agreement by workers on the removal of restrictive practices. These include the elimination of inefficient work practices, the removal of demarcation rules about which sorts of workers are allowed to undertake which sorts of jobs, and generally involve an increase in the flexibility of the workforce. This typically reflects an increase in "effort" on the part of workers, both in the literal sense and in the sense that eliminating restrictive practices raises the disutility of work.

Unobserved effort, e_{uit}. Here we simply follow the standard efficiency wage formulation (equation (3)) and utilise relative wages and industry unemployment. Aggregate unemployment effects are absorbed in the time dummies.

Competition$_i$. The variables we have available here include the average market share at the firm level, the average concentration ratio and import penetration in the industry in which the firm is located, and a firm based measure of rents. Our measure of market share is not satisfactory as a relative or cross-section indicator of market power because the denominator refers to (3 digit) industry sales, which is simply not the correct `market'. Furthermore, its relationship to the correct market will vary systematically across industries. So, while time series fluctuations in this variable may well capture quite accurately variations in the true variable over time, as a cross-section variable it is useless. The industry variables may be of some value, but in our view, the rents variable is the most promising. We have computed for each firm a measure of rents normalised on value added averaged over a ten year period. Rents are defined as pre-tax profits plus interest payments and depreciation less the product of the cost of capital and the capital stock at current replacement cost. The idea is that firms facing less competition will generate higher rents in the long run. Of course, what we really require are potential rents since part of our basic argument is that these are dissipated in the form of lower effort or captured in the form of higher wages. So what we have is a measure of the rents that the shareholders obtain. Insofar as these are roughly proportional to potential rents, this variable is satisfactory.

So the equation which serves as the basis of our investigation of company productivity has the form

$$(y_{it}-k_{it}) = \beta_i + \beta_t + \lambda(y_{it-1}-k_{it}) + (1-\lambda)\alpha(n_{it}-k_{it}$$

$$+ \alpha_{11}(H_{ojt}/H_{njt}) + \alpha_{12}(H_{ojt}/H_{njt})^{-1} + \alpha_2(mksh_i.)t$$

$$+ \alpha_3(conc_j.)t + \alpha_4(imp_j.)t + \alpha_5(rents_i.)t + (\Sigma\alpha_6^i d_j$$

$$+ \alpha_7 RRP_{it-1} + \alpha_8(w_{it-1}-w_{t-1}) + \alpha_9 lnu_{jt-1}$$

$$\varepsilon_{it} \qquad (19)$$

where y_i = output, n_i = employment, k_i = capital stock, H_{oj} = overtime hours, H_{nj} = standard hours, $mkshi_i.$ = average market share, $conc_j.$ = average 5 firm industry concentration ratio (3 digit), $imp_j.$ = average industry import penetration (3 digit), $rents_i.$ = average rents per unit of value added, d_j = two digit industry dummies, RRP_i = reduced restrictive practices, (i.e. if RRP is high, the level of restrictive practices is low and effort is high) w_i - w = relative wage, u_j = industry unemployment, i = firm, j = industry. We have allowed simple dynamics in the equation in the form of a lagged dependent variable, to capture the possibility that whenever a factor of production is changed, it takes some time for output to reach its new long-run level. The key variable influencing productivity growth is that capturing product market power in the form of rents, namely $rents_i.$. The other variables, namely market share, concentration, import penetration and industry dummies (d_j) are included simply as controls. We have already noted that our measure of market share is not adequate in a cross-section context. Concerning productivity levels, we have lower levels of restrictive practices (RRP) capturing observed effort, and relative wages and industry unemployment to pick up efficiency wage effects. These are all lagged one period in order to allow them time to influence productivity, and to try and eliminate reverse causality effects.

In order to estimate the parameters of (19), we eliminate the firm effects (β_i) by taking first differences to obtain

$$\Delta(y_{it}-k_{it} = \Delta\beta_t + \lambda\Delta(y_{it-1}-k_{it}) + (1-\lambda)\alpha\Delta(n_{it}-k_{it})$$

$$+ \alpha_{11}\Delta(H_{ojt}/H_{njt})$$

$$+ \alpha_{12}\Delta(H_{ojt}/H_{njt})^{-1} + \alpha_2 mksh_{i.}$$

$$+ \alpha_3 conc_{j.} + \alpha_4 imp_{j.}$$

$$+ \alpha_5 rents_{i.} + \Sigma\alpha_6^i d_j + \alpha_7\Delta RRP_{it-1}$$

$$+ \alpha_8\Delta(w_{it-1}-w_{t-1})$$

$$+ \alpha_9\Delta lnu_{jt-1} + \Delta\varepsilon_{it} \qquad (20)$$

This has certain implications. First, the error term will contain productivity shocks associated with both employment composition and intensity of factor use. So we must treat both current employment and capital as endogenous. Furthermore, after differencing, y_{it-1} is also correlated with the equation error. However, so long as the basic error, ϵ_{it} , is serially uncorrelated, then all lags on y, n and k beyond t-2 are valid instruments. IV estimators based on this fact have been proposed by Arrelano and Bond (1991) and are used here. Second, it is worth noting that our data on restrictive practices and company wages come in first difference form. For the former, we know when restrictive practices are reduced (i.e. ΔRRP takes the value 1 if restrictive practices are reduced, zero otherwise). For the latter, we have information on the percentage pay rise for a particular manual group in the pay settlement. For present purposes, this is particularly valuable because it cuts out both hours effects and skill composition effects, both of which generate natural positive correlations between average earnings and productivity. However, there is still the danger of reverse causality for both restrictive practice and efficiency wage variables (i.e. firm does badly and so removes restrictive practices, firm does well and pays higher wages), so as well as lagging, we treat all these variables as endogenous.

The wage/effort model

This is based on the theoretical model set out in the previous section. The results in (17) and (18) indicate that both wages and effort are functions of market power and financial pressure, but only the former is influenced by external labour market factors, notably outside wages and unemployment. Our measure of market power is simply the market share of the company concerned, but as indicators of financial pressure we use three variables, namely profits per employee, π/N, a flow measure of the pressure of debt, br, and a variable which captures the extent of the shock hitting the company in the recession of 1979-81 (shock). To be more precise, π/N measures pre-tax profits per employee, br is a flow borrowing ratio measured by interest payments as a proportion of pre-tax profits plus interest payments and depreciation, and "shock" is equal to the proportional fall in employment from 1979-81 for the years 1982 to 1984 and takes the value zero for other years. So this last variable is only allowed to affect the firm for three years after the end of the recession. The idea behind these variables is that the firm is under more financial pressure, the lower are profits per employee, the higher are interest payments as a proportion of total available cash flow and the greater the shock generated by the 1979-81 recession. The first two should be lagged, since current financial pressure is determined by past financial performance.

The wage equation is based on the notion that nominal wages are influenced by outside nominal wages and nominal profits per employee (lagged) plus other factors. To preserve homogeneity, we thus have

$$W_{it} = (1-\lambda)W_t + \lambda(\pi_i / N_i)_{t-j} + ...$$

We cannot use $\ln(\pi / N)$ because π is sometimes negative, so we proceed as follows. Taking differences yields

$$\Delta W_{it} = (1-\lambda)\Delta W_t + \lambda\Delta(\pi_i / N_i)_{t-j} + ...$$

or

$$\frac{\Delta W_{it}}{W_{it}} \simeq (1-\lambda)\frac{\Delta W_t}{W_t} + \lambda\frac{\Delta(\pi_i/N_i)_{t-j}}{W_t} \; ....$$

or

$$\Delta w_{it} \simeq (1-\lambda)\Delta w_t + \lambda\frac{\Delta(\pi_i/N_i)_{t-j}}{W_t} \; ....$$

Adding in the other variables and including a lagged dependent variable to pick-up contract related persistence, we have

$$\Delta w_{it} = \mu_0 + \mu\Delta w_{it-1} + (1-\mu)\lambda \frac{\Delta(\pi_i/N_i)_{t-j}}{W_t} - \gamma_1\Delta br_{it-j}$$

$$+ \gamma_2\Delta mksh_{it-j} - \gamma_3 Shock_{it}$$

$$+ (1-\mu)(1-\lambda)(\Delta w_t - \gamma_4\Delta \ln u_t) \; , \tag{21}$$

where π_i / N_i = nominal annual profit per employee; W = annual aggregate pay; br = flow borrowing ratio; mksh = market share; Shock = 1979-81 proportional fall in employment for the years 1982-84, zero otherwise; u = aggregate unemployment rate. Note that we have arranged the equation so that the first bracket contains the firm specific factors arising from market power and financial pressure, whereas the second bracket captures the impact of the external labour market. The difference form ensures that stable firm specific factors influencing the level of wages are already eliminated. To impose homogeneity, we rewrite (21) as

$$w_{it}-w_{t}) = \mu_{0}+\mu\Delta(w_{it-1}-w_{t})+(1-\mu)\lambda\left[\left(\frac{\Delta(\pi_{i}/N_{i})_{t-j}}{W_{t}} - \Delta w_{t}\right.\right.$$

$$\left.- \gamma_{1}\Delta br_{it-j}+ \gamma_{2}\Delta mksh_{it-j}- \gamma_{3}Shock_{it}\right]$$

$$- (1-\mu)(1-\lambda)\gamma_{4}\Delta lnu_{t} \;. \qquad (22)$$

Corresponding to this equation is the effort model, where the dependent variable is ΔRRP which takes the value 1 if the wage settlement involves an agreed reduction in restrictive practices and zero otherwise.[6] In case there are systematic industry variations in this variable because of industry based technological or industrial relations variables, we include industry dummies (d_j) as well as the variables in (22). Normalising profits per employee on the aggregate price level, we specify the equation as

$$\Delta RRP_{it} = \delta - \delta_0 \Delta(\pi_i / PN_i)_{t-j} + \delta_1 \Delta br_{it-j} - \delta_2 \Delta mksh_{it-j}$$

$$+ \delta_3 Shock_{it} + \delta_4 \Delta lnu_t + \Sigma \delta_5^j d_j \;. \qquad (23)$$

The key hypotheses are that the firm specific factors which influence wages have the opposite effect on effort and that aggregate variables, notably unemployment, have no impact on effort at all ($\delta_4 = 0$). An alternative way of investigating these hypotheses is simply to estimate an equation based on (16), where we see that wages and effort have a stable negative relationship at given levels of outside variables. This suggests we estimate a simple dynamic equation of the form

$$\Delta(w_{it} - w_t) = \omega_t + \omega_1 \Delta(w_{it-1} - w_t) - \omega_2 \Delta RRP_{it} \qquad (24)$$

using the lagged firm specific variables in (23) as instruments for ΔRRP. The time effects ω_t capture all the relevant aggregate variables and so we are simply looking for a negative coefficient on the effort term.

3. Results

We shall first briefly consider the productivity results and then turn to our main matters of interest, namely the impact of market power and financial pressure on wages and effort.

Productivity results

The parameter estimates of the production function model (equation 19) are set out in table 1. We have a basic constant returns Cobb-Douglas equation in column 1, followed by a CES version in column 2. If we relax constant returns, we find a production function which exhibits diminishing returns and which is not significantly different from the equation in column 1 (t=1.2). If we include the share of labour interacted with the employment term, in addition to the existing terms, the extra variable is completely insignificant.

Three results are of interest. First, and most important, lower levels of restrictive practices lead to significantly higher levels of productivity.[7] So treating this as an observed effort variable seems quite sensible. Second, firms with higher average rents per unit of value added have lower levels of productivity growth. Note this variable maintains its coefficient when average firm size is allowed to influence productivity growth (column 3) whereas the positive market share effect simply disappears, emphasising its lack of value in a cross-section context. So this provides evidence that market power; as measured by rents accruing to shareholders, is bad for productivity growth at the firm level.

Finally, the efficiency wage terms are correctly signed and either significant or close to significance. So this is weak evidence in favour of such effects. Furthermore it is worth noting that if we drop observed effort (RRP) from equation 1, the coefficient on relative wages rises by around 40% with a t ratio of 2.9. This indicates how important it is to control for observed effort if we are to identify efficiency wage effects using the production function model.

Wages and effort

The theory of wage and effort bargaining indicates that in response to an adverse internal shock, bargained wages will tend to fall and bargained effort to rise, holding constant general labour market conditions. To see if this holds in practice, we estimate equation (24), the results being set out in table 2. These indicate a strong negative relationship between wages and effort in response to adverse internal shocks (which are used as instruments), holding aggregate conditions constant (via the use of time dummies). Thus following an increase in financial pressure, for example, firms have lower than usual pay rises and are more likely to gain union agreement to a reduction in restrictive practices.

In table 3, we present both wage change and effort change equations which make clear what is going on. The key internal shock variables are captured by changes in market share (mksh),[8] profit per employee (π / N), the burden of interest payments (br) and the proportional fall in employment during the 1979 to 1981 recession (shock). The first two are favourable shocks and therefore have a positive effect on wages and a negative impact on effort whereas the latter two variables are unfavourable and act in precisely the opposite direction. The parameter estimates in table 3 are completely consistent with this story. Not all the parameters are significant but the overall picture is compelling. Furthermore, it is clear that aggregate conditions in the labour market have a strong impact on wages but no effect on effort, exactly as predicted by the theoretical comparative static results (17, 18).

Conclusions

In the introduction we posed three questions. Our answers, based on an analysis of longitudinal data for some 66 manufacturing companies in Britain, are as follows. First, our measure of increases in observed effort, namely agreed reductions in restrictive work practices, do lead to subsequent increases in productivity. Second, controlling for observed effort, there is some weak evidence that both relative pay and aggregate labour market slack have some positive impact on productivity. This is consistent with an efficiency wage story. Third, falls in market power or declines in the financial health of companies lead to both lower pay rises and increases in effort (higher chances of reductions in restrictive work practices). This last we see as our most robust and important result.

ENDNOTES

1. For example, an improvement in the financial position of a company will reduce the risk of bankruptcy and hence improve job security. For evidence on the impact of financial position on employment, see Nickell and Wadhwani (1991).

2. For example, in 1980 bargaining took place over manning levels (i.e. workers per machine) as well as pay in some 80% of union establishments (see Daniel and Millward, 1983, pp.197 and 182). However, it is worth noting that bargaining over employment is very rare (Oswald and Turnbull, 1985).

3. Flexibility of working practices include, for example, operatives undertaking minor maintenance on their machines rather than waiting for a maintenance engineer to turn up. A blatant example of inflexibility is the requirement that a "qualified" electrician is required to change a light bulb. Thus, for example, it has been noted that in some UK hospitals, the involvement of no less than six employees is required in order for a light bulb to be replaced.

4. There are, of course, numerous studies measuring cross-section correlations between market structure and R and D intensity, for example, but these are not informative on the main point at issue because they fail to control for the variation in technological opportunities across industries. Geroski (1990) uses panel data and controls for the latter variable by including industry dummies, thereby generating reliable results.

5. We were only able to match 66 companies which had adequate time series data on settlements.

6. This is not quite correct because we adjust this variable so that it matches the calendar year. This may involve it taking the value ϕ, say, in one year and $1-\phi$ in the next (see data appendix for details). This rules out the use of discrete variable models (e.g. probit).

7. Note that the equation in estimated in first differences, so an agreement to reduce restrictive practices is followed by a significant increase in total factor productivity in the following year.

8. Recall that the denominator of our market share variable reflects 3-digit industry sales and is not, therefore, congruent with the appropriate market. This makes the variable unsuitable for cross-section work but so long as 3-digit industry sales are roughly proportional to the sales in the true market over time, then it is perfectly adequate for time series analysis. Since we are taking differences of market share here, the results are essentially based on the time series variation in the data.

DATA APPENDIX

The dataset consists of longitudinal data on 66 companies for which we can merge information from the EXSTAT company database and the Confederation of British Industries (CBI) Pay Databank. The CBI data are available for 1979-86 and of our 66 firms, 10 are present for 5 consecutive years, 7 for 6, 8 for 7 and 41 for 8. So the panel is unbalanced. The CBI data provide information on pay increases and reductions in restrictive practices. All the other firm specific data come from the EXSTAT database.

Firm specific variables

Output (y_i). Sales (EXSTAT item C31). This is normalised on an industry specific price index. See below.

Employment (n_i). Total employment (C19). For a small number of firms (4), it is impossible to construct a consistent *total* employment series and we then use domestic employment.

Capital stock (k_i). This is based on transforming net tangible assets at historic cost into the same variable at current replacement cost and then normalising on the price index for plant and machinery. Details of the method are provided in S. Wadhwani and M. Wall (1986).

Market share ($mksh_i$). Total sales in each industry (TSALS) is calculated as:

$$TSALS_{jt} = N_j\, AVSALS_{jt}$$

where $AVSALS_{jt}$ = average sales of a firm in industry j at year t
N_j = number of firms in industry j in a chosen base year (1980)

The number of firms is kept constant over years to correct for the changing firm base of our sample. (The sample used to obtain these data includes about 1200 firms including all the major quoted companies in the industry.) The market share is obtained as Sales in firm in year t (EXSTAT item C31) ÷ $TSALS_{jt}$.

Rent per unit of value-added ($rents_i$). The numerator is defined as Profits before tax (C34) + Depreciation (C51) + Interest Payments (C53+C54) - Capital Stock x (Real interest rate + depreciation rate + risk premium). The real interest rate we take to be 0.02812 which is the average 1981 value of the real gross redemption yield on 2% index-linked stock (1996). The depreciation rate + the risk premium we take to be 4%.

The denominator is Profits before tax (C34) + Depreciation (C51) + Interest Payments (C53+C54) + Staff Costs (C63) + Amounts payable from Profit Sharing Schemes (C72). For 1982 and after, staff costs refer to total employment and include social security and pension costs. Prior to 1982 staff costs refer to domestic wages and salaries only. We have adjusted these to make them comparable to the post 1982 data.

Wage increase (Δw_i). The CBI pay databank includes pay rise information for each of up to three bargaining groups. We use data on a manual bargaining group. For this bargaining group, the databank provides some information on (i) the month of the pay settlement, (ii) a manager's estimate of the impact of the settlement on the increase in gross average earnings in the coming calendar year and (iii) the actual agreed pay increase. In many cases (iii) is missing. However, when both (ii) and (iii) are available, they are nearly always the same. So we take (ii) as our percentage pay increase and then use (i) to allocate it over the two calendar years to which it typically refers (the agreement is nearly always for 12 months).

Reduction in restrictive practices (ΔRRP_i). In the CBI survey of pay settlements, managers are asked whether a pay settlement also involved the removal of restrictive practices. The variable is a dummy which takes the value 1 if they respond in the affirmative. However, the settlement date is then used to allocate this variable across the relevant two calendar years. This is done because the removal of restrictive practices is typically a process lasting for at least the period of the pay agreement, not a one-off event taking place on the settlement date. Around 38% of firms in the sample removed restrictive practices at some point in the period 1980-86.

Profits (π_i). Profit before tax (C34).

Borrowing ratio (br_i). This is a flow concept defined as Interest Payments (C53+C54) ÷ [Profits before tax (C34) + Depreciation (C51) + Interest Payments (C53+C54) + Constant]. The constant is set to be large enough to ensure the denominator is always positive. We also experimented with a stock version of the borrowing ratio, essentially debt/debt + equity), but found that the flow version performed slightly better.

Shock$_i$. This is defined as -(n(1981)-n(1979)) for the years 1982-84, zero otherwise.

Industry level variables

Unemployment rate (u_j). Source: <u>Employment Gazette</u>.

Concentration ratio (cr_i). Source: Annual <u>Census of Production</u>, PA 1002, table 13.

Import penetration (imp_j). Defined as imports ÷ home demand (sales + imports - exports). Source: <u>Business Monitor</u> MQ12 (collected by S. Machin).

Overtime hours (H_{oj}). Weekly overtime hours per operative on overtime x fraction of operatives on overtime. Source: <u>Employment Gazette</u>.

Standard hours (H_{nj}). Normal weekly hours. Source: <u>Employment Gazette</u>.

Producer price index (P_j). Source: <u>British Business</u> and unpublished data from the Business Statistics Office. Used to normalise the sales data.

Aggregate variables

Unemployment rate (u). Male unemployment rate. Source: <u>Employment Gazette</u>.

Aggregate wage (w). Source: S. Savouri (1989) Regional Data 1967-87, CLE Working Paper 1135, London School of Economics.

TABLE 1

Production Function 1982-86 (equation 19)
Dependent Variable: $(y_{it}-k_{it})$

Independent variables	Equation description: Basic equation (1)		Add CES term (2)	
$*(y_{it}-k_{it})$	0.36	(4.3)	0.30	(2.7)
$*(n_{it}-k_{it})$	0.70	(8.7)	0.18	(1.1)
H_{ojt} / H_{njt}	2.24	(2.5)	1.26	(1.2)
$10^{-3}(H_{ojt} / H_{njt})^{-1}$	0.22	(1.0)	0.22	(0.8)
$*(w_{it-1}-w_{t-1})$	0.54	(1.0)	1.27	(2.4)
$\ln u_{jt-1}$	0.11	(2.7)	0.081	(2.1)
$*R_{it-1}$	-0.17	(3.0)	-0.15	(2.7)
$*(n_{it}-k_{it})^2$			-0.12	(2.9)
Serial correlation (N(0,1))	-0.23		-0.68	
Instrument validity	$\chi^2(26)=29.2$		$\chi^2(25)=25.4$	

Notes

(i) The number of firms is 66 and the number of observations is 225. Absolute asymptotic t ratios in parentheses.

(ii) The dependent variable is (log real sales - log real capital stock). All equations are estimated in first differences and include both time dummies and 2 digit industry dummies.

(iii) Starred variables are treated as endogenous. Instruments include $y_i(t-2,t-3,...)$, $k_i(t-2,t-3,...)$, $n_i(t-2,t-3,...)$.

(iv) The equations are estimated in first differences using the Dynamic Panel Data Package (DPD), written by M. Arrellano and S. Bond and described in Arellano and Bond (1991). The standard errors are robust to heteroskedasticity of general form.

(v) y = output, n = employment, k = capital, H_o = overtime hours, H_n = standard hours, w = wages, u = industry unemployment rate, R = level of restrictive practices.

TABLE 2

Structural Relationship Between Wages and Restrictive Practices 1981-86
(equation 24)

Dependent Variable: $\Delta(w_{it}-w_t)$

Independent variables		
$*\Delta(w_{it-1})-w_t)$	0.68	(17.6)
$*\Delta r_{it}$	0.021	(3.7)
Serial correlation (N(0,1))	0.29	
Instrument validity	$\chi^2(28)$ =	22.6

Notes

(i) Number of firms is 66, number of observations is 231. Asymptotic t ratios in parentheses.

(ii) The equation includes time dummies.

(iii) Starred variables are treated as endogenous. Instruments include n_i(t-2,t-3,...), $\Delta mkshi_{it-2}$, Δbr_{it-2}, $\Delta(\pi/N)_{it-2}$, $shock_{it}$, 2 digit industry dummies.

(iv) As table 1, note (iv).

TABLE 3

Wage and Effort Reduced Form Equations, 1981-86
(equations 22, 23)

Dependent variable	$\Delta(w_{it}-w_t)$ 1		$\Delta(w_{it}-w_t)$ 2		ΔRRP_{it} 3		ΔRRP_{it} 4	
Independent variable								
$^*\Delta(w_{it-1}-w_t)$	0.67	(16.5)	0.64	(9.3)				
$\Delta \ln u_t$	-0.12	(12.3)			0.056	(0.3)		
$\Delta conc_{jt-2}$	-0.0087	(0.4)	-0.020	(0.6)	0.093	(0.2)	-0.10	(0.2)
$\Delta mksh_{it-2}$	0.55	(2.0)	0.55	(1.1)	-3.23	(1.0)	-4.76	(1.5)
$\frac{\Delta(\pi_{it-2}/N_{it-2})}{W_t} - \Delta w_t$	0.024	(4.6)	0.017	(2.1)	$\Delta(\pi_i/P_jN_i)_{t-2}$ -0.021	(2.0)	-0.022	(2.0)
$^*\Delta br_{it-1}$	-0.23	(3.3)	-0.20	(2.5)	0.71	(1.9)	0.67	(1.6)
$10^{-2}Shock_{it}$	-1.26	(2.4)	-0.51	(0.6)	0.26	(1.8)	0.27	(1.8)
Serial correlation (N(0,1))	0.075		0.28		-0.36		-0.024	
Instrument validity	$\chi^2(23)=26.8$		$\chi^2(23)=25.5$					
Time dummies	x		√		x		√	
Industry dummies	x		x		√		√	

Notes

(i) Number of firms is 66, number of observations is 231. Asymptotic t ratios in parentheses.

(ii) In columns 1, 2, the starred variables are treated as endogenous. Instruments include n_i(t-2, t-3,...), w_{it-2}, two digit industry dummies.

(iii) Equations in columns 1, 2 are estimated by IV using DPD. In columns 3, 4, they are OLS estimates. In all cases, the standard errors are robust to general heteroskedasticity.

(iv) Δw_i = proportion pay increase; ΔRRP_i = 1 if restrictive practices are removed, = 0 otherwise; ln u = log aggregate unemployment rate; $conc_j$ = industry concentration ratio; $mkshi_i$ = market share; π_i / N_i = pre-tax profit per employee; br_i = flow borrowing ratio; $shock_i$ = proportional fall in employment 1989-91 for the years 1982 to 1984, zero otherwise; P_j = producer price index.

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