CENTRE FOR ECONOMIC RESEARCH

Productivity and Trade Unions in British Manufacturing Industry

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Working Paper Number 93/10

May 1993

UNIVERSITY COLLEGE DUBLIN

Department of Economics

BELFIELD, DUBLIN 4, IRELAND

Productivity and Trade Unions in British Manufacturing Industry 1973-1985 [1]

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This paper uses panel data on British manufacturing industries between 1973 and 1985 to examine the relationship between productivity and labour organisation. It is shown that the precise relationship between unions and productivity levels is difficult to pin down. There is some evidence of a negative relationship but it is far from robust. Allowing for the early 1980's recession weakens this relationship further as does controlling for endogeneity. We also find some evidence that industrial concentration is associated with higher levels of measured productivity.

JEL Classification D24 J51

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I Introduction:

There has been a great deal of debate about British economic performance in recent years with much of the attention focused on why Britain's productivity growth appeared to fall behind its major trading partners in the 1970's and why it subsequently appeared to make such a good recovery in the 1980's after the recession of 1980/81. A large number of possible explanations have been offered for these trends [see Muellbauer(1986)] and much attention has focused on the role of Trade Unions in influencing economic performance especially the level of productivity. Much of the literature suggested negative Union effects on productivity[1] . However a robust defence of Trade Unions was provided by Freeman and Medoff(1984) who argued that the mainly American evidence implied a far from damning criticism of organised labour.

Although there appears to be much anecdotal evidence concerning the impact of trade unions on the efficiency of the private sector in Britain the evidence from formal quantitative studies is very limited. A recently published study of a group of engineering firms, Machin(1991), found that there was evidence of a negative effect of union status on productivity in larger firms but not amongst the firms in general. Other studies include Nickell, Wadhwani & Wall(1992) who use company accounts data and Bean and Symons(1990) who use more aggregated data[2].

Nickell *et al*(1992), considering the period 1974-1986, conclude that higher unionisation was associated with higher Total Factor Productivity Growth during 1980-1984 but that there was no such relationship in the other years. This could arise if unionised firms had the greater capacity for improved growth arising from their exhibiting more extensive restrictive practices in the first place. That is they has more to catch up on. However they present no evidence that unions consistently lowered either the level or growth of productivity. Oulton(1990) also considers the impact of labour market

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1 For a useful survey see Hirsch & Addison (1986).

2 See also Wadhwani(1989), Wadhwani & Brown(1990) and Metcalf(1989) for discussions of the recent literature.

characteristics on productivity growth. However since the union data is for one year only (1973) it is difficult to simultaneously control for unobservable fixed effects.

Bean and Symons estimate a reduced form productivity growth equation for 19 OECD countries from 1950 to 1980. Using Union Density as a proxy for the power of trade unions they find that it has a numerically small and statistically insignificant effect. This is not entirely surprising. Aggregate union density may not be a particularly good guide to union power and moreover is often badly measured. Of course productivity is not the only yardstick by which economic performance should be judged and recently a number of authors have analysed other dimensions. Machin and Wadhwani(1991), using the Workplace Industrial Relations Surveys, find that plants with recognized unions were more likely to experience organisational change which they associate with the removal of restrictive practices. Denny and Nickell(1992), on the other hand, demonstrate a negative relationship between unionisation and the level of investment by industry.

This paper uses panel data on UK manufacturing industry for the period 1973-1985 to analyse the impact of trade unions on productivity. In the next section we outline the model utilised in the empirical work. Section 3 outlines the empirical results and section 4 concludes. More detail on the data used is provided in the Appendix.

2 Modelling Trade Unions and Productivity

Before proceeding to the empirical work it is necessary to develop a framework in which Trade Unions may be considered to influence the level of productivity of a firm or industry. The approach taken here is fairly standard amongst labour economists. It is not, however, beyond criticism, and some authors have argued that the simplistic approach typically by economists in this field is fundamentally misleading.

Such criticisms may take the form of pointing out, perfectly reasonably, that while the performance of a firm can depend on the state of industrial relations , this cannot be attributed entirely to organised labour. Hence ignoring the role of management and how it interacts with employees may give a very jaundiced view of productivity. Since the management is ultimately responsible for the organisation of a firm it seems odd that their influence should be ignored. Ironically, in the econometric literature discussing the advantages of Panel Data, management is often cited as a typical "fixed effect" to be controlled for. Perhaps the main reason for this trend in the literature is simply the absence of any good measures of the quality of management and the way in which they interact with their employees. Trade Unions, on the other hand, lend themselves to measurement, rather more easily . Either by counting the proportion of workers that are unionised or noting the existence of a recognized union in a plant or firm one can use this a a measure of "Union Power". Note that this emphasises the numerical strength of unions but ignores the *processes* by which they operate.

Denny and Muellbauer(1988) demonstrate that, data permitting, it is possible to answer these sort of criticisms while retaining essentially the same methodology as the existing literature. However this depends crucially on having information which is extremely rare indeed. Clearly the absence of the ideal dataset should not prevent one from studying the existing data. However it does imply some caution in interpreting it. In particular, one should be very careful in arguing for legislative reforms on the basis of very limited information.

We start with the assumption that the firms output is determined by a well behaved Neo Classical production function :

$$Y = f(X_1, X_2, X_3..) \qquad (1)$$

Y is a measure of the firms output. The variables on the right hand side represent *flows* of input services. To implement this approach it is necessary to choose a functional form for (1) . We choose Value Added as the dependent variable so we can omit Intermediate Inputs from the right hand side . The independent variables are the levels of manual and nonmanual employment and the stock of capital (L,N and K respectively). We assume that the production function is of the Cobb Douglas variety :

$$Y = A \cdot L^{\alpha_1} N^{\alpha_2} K^{\alpha_3} \qquad (2)$$

The influential study of Brown and Medoff(1978) allowed the quality of the labour input to depend on the degree of unionisation . They defined labour input in efficiency units which are a function of the level of employment and union density:

$$L = \bar{L} \cdot (1 + c_L \cdot U) \qquad (3)$$

Where $\bar{L}$ is the level of employment, U is density and c_L is a parameter to be estimated. If this parameter is negative then unions lower the productivity of labour. If we substitute (3) into (2) and take logarithms then an approximation can be written as[3] :

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3 Lower case letters denote logarithms. Equation (4) is exact if we write (3) as $L = \bar{L} \cdot \exp(c_L \cdot U)$

$$y = \alpha + \alpha_1 \cdot c_L \cdot U + \alpha_1 \cdot l + \alpha_2 \cdot n + \alpha_3 \cdot k \qquad (4)$$

and this can be estimated directly by least squares. An alternative approach is to assume that it is the "shift" term, A, in the production function that is affected by trade unions e.g. :

$$A = A_0 \cdot \exp(b \cdot U) \qquad (5)$$

Substituting (5) into (2) however implies:

$$y = \alpha_0 + b \cdot U + \alpha_1 \cdot l + \alpha_2 \cdot n + \alpha_3 \cdot k \qquad (6)$$

This is observationally equivalent to (4) so if we assume that both relationships may hold (i.e. (5) and (3)) then the two parameters of interest are not identified. One way round this problem is to assume that there are constant returns to scale and perfect competition in input and output markets in which case factors are paid their marginal products. In that case it is well known the coefficients on L,N and K are equal to factor shares in Value Added and sum to one. This would imply an empirical model:

$$y = \alpha_0 + b \cdot U + \omega_L \cdot l + c_L \cdot \omega_L \cdot U + \omega_N \cdot n + (1 - \omega_L - \omega_N) \cdot k \qquad (7)$$

where ω_L, ω_N, $1 - \omega_L - \omega_N$ are the shares of manual labour, non-manual labour and capital respectively.

While this allows one, in principle, to identify two distinct unions effect it is unlikely to be of any practical help. Unless there is a lot of variation in the factor shares the two union terms will be collinear. If there is a lot of variation this calls into question the underlying model since the α terms are technological, by assumption. The problem becomes more complicated when we realise that the efficiency of the capital stock can also be a function of the

level of unionisation. That is, the unions through restrictive practices or whatever may limit the managements ability to exploit the capital stock to the full. If , by analogy with (3), we assumed that:

$$K = \overline{K} \cdot (1 + c_K \cdot U) \tag{8}$$

then this generates a further term in U which is not identified. It is possible to identify different unionisation effects if we relax the Cobb Douglas assumption, say by adopting the Translog functional form (Christensen *et al*(1973)):

$$y = \Sigma_i a_i x_i + \left(\frac{1}{2}\right)\Sigma_i \Sigma_j x_i x_j \tag{9}$$

The non-linear terms in (9) generate interactions which imply over-identifying restrictions on the parameters. However it is very doubtful if this approach is worthwhile since the large number of additional terms are not well determined. This is compounded when we allow some parameters to vary over time. Since our estimate of the capital stock is likely to be measured with error, adding higher powers (in Log K) could seriously increase measurement error bias.

A final word is necessary about factor utilisation. Hitherto we have assumed that the flow of factor services is proportional to the stock of that factor. Clearly this may not be true and we might expect utilisation rates to vary both secularly and cyclically. To control for this we augment the production function by including a measure of hours worked by manual workers. We have no explicit control for the utilisation of either non-manual labour or the capital stock since none is available. However one can expect utilisation rates to be correlated across factors in the short run since if a firm wishes to increase the use of its capital it is likely to make some use of overtime.

A consistent finding of estimates of aggregate production functions is that the coefficient on log Hours is greater than on the log of Employment and is frequently greater than one. A thorough discussion of this finding can be found in Muellbauer(1987) who refers to this as the "Feldstein-Craine" result after earlier work by those authors. This result is often invoked in debated about whether the government should encourage job sharing or shorter working weeks. However unless one can be sure that one has controlled for the utilisation of all inputs it is difficult to infer anything about the "productivity of hours" debate.

3 Empirical Results:

In this section we present estimates of the models described above using data on manufacturing industries. It is important to note that the data is a panel since this allows us to control for any characteristics of different industries which are fixed but unobserved. Similarly we can control for time specific effects which are common to all industries (e.g. aggregate shocks). There are a number of ways of doing this which have very similar consequences. To control for fixed effects we will simply use the "first difference" transformation of the data. To eliminate time specific effects a full set of time dummies will be included .

In Table 1, we illustrate the consequences of allowing for fixed effects. The first regression is the simplest possible specification, imposing the same intercept for all industries for each year. Trade unions appear to have a negative effect on productivity. However as later columns shows this regression is mis-specified. Note the presence of first and second order serial correlation. In column 2 we control for fixed effects by first differencing. This increases the coefficient on manual labour to a level comparable typically found in other studies. However the significance of Capital is now diminished. The impact of unions, 'though of a bigger absolute size, is less well determined. The sum of the coefficients on the three inputs is less than one, suggesting decreasing returns to scale. Note that estimating in first differences eliminates second order serial correlation. The significance of the m1 statistic is to be expected since if the underlying error process (in levels) is iid then first differencing should induce an MA(1) process. Including time effects but excluding fixed effects (as in column 3) implies a much smaller coefficient on log manual employment.

The effect of unions is not as well determined when fixed effects are controlled for suggesting that in (1) and (3) trade unions are picking up permanent characteristics of an industry. These could include industrial relations variables or anything else which is correlated with it. The final column of Table 1 allows for the impact of unions

to vary over time by interacting unions with a "Thatcher dummy"[4]. This produces a rather striking result: the negative impact of unions appears to occur only in the latter part of the sample: before 1979 unions are statistically insignificant. This conflicts with a commonly held view that trade unions in the 1970's acted to retard economic performance but that the impact of the legislative reforms of the early 1980's combined with high unemployment reduced union power.

4 This is 0 before 1979, 0.5 in 1979 and 1 thereafter. Replacing the 0.5 with either 0 or 1 makes little difference.

Table 1

Basic Results

Dependent variable: Log Real Net Output

	1 OLS	2 OLS	3 OLS	4 OLS	5 OLS
log L	0.151 (9.04)	0.578 (8.64)	0.125 (7.30)	0.578 (9.49)	0.571 (7.37)
log N	0.494 (25.36)	0.168 (1.72)	0.465 (23.48)	0.199 (2.10)	0.197 (2.09)
log K	0.364 (24.63)	0.036 (0.29)	0.423 (23.85)	0.059 (0.40)	0.060 (0.41)
log H	1.600 (8.99)	1.202 (4.26)	1.011 (6.10)	0.952 (2.71)	0.938 (2.65)
Coverage	-0.125 (1.91)	-0.376 (1.68)	-0.257 (3.39)	-0.262 (1.19)	-0.111 (0.49)
Coverage x Thatcher					-0.289 (2.10)
se(levels)	0.04231	0.00801	0.03939	0.00769	0.00768
m1	10.40 (54)	-2.61 (54)	10.14 (54)	-2.47 (54)	-2.49 (54)
m2	10.43 (54)	-0.50 (54)	10.38 (54)	0.62 (54)	-0.63 (54)
Time dummies:	no	no	yes	yes	yes
Data in :	levels	Δ's	levels	Δ's	Δ's

Notes:
(i) Absolute T ratios in parentheses. Standard errors are robust to heteroskedasticity.
(ii) m1 is a test against an AR(1)/MA(1) error process, distributed N(0,1) under the null.
(iii) m2 is a test against an AR(2)/MA(2) error process, distributed N(0,1) under the null.

While the results of Table 1 suggest a negative relationship between unions and the level of productivity there are several reasons to be cautious. In Table 2 we consider some refinements of the basic specification used in Table 1. In column 6 we consider two additional variables which might effect productivity. We include the five firm concentration ratio as a measure of product market power.

One can think of a number of models where market structure influences efficiency[5]. For example firms which earn a quasi rent, say through a barrier to entry, may experience lower productivity if part of that quasi-rent is distributed to the workforce in the form of lower effort. Alternatively the existence of barriers to entry may give firms a greater incentive to achieve higher levels of efficiency so long as the firms can insure they will capture the ensuing quasi-rents. The higher the degree of concentration the less likely it is that innovations in work practices or product development will spillover to other rival firms. Aside from theoretical considerations, it may be a question of *measurement* since the dependent variable (Real Net Output) uses an output price deflator and this may be correlated with industry concentration.

The recession of the early 1980's is widely accepted to have had a long lasting effect on the performance of the UK economy. For example Muellbauer(1986) suggested the "Batting Average" effect: productivity may have increased after the recession because the recession drove out the less efficient factors (less efficient firms, managers, workers) although Oulton(1990) casts doubt on this possibility.

Nickell,Wadhwani & Wall(1992) model the impact of the recession by introducing a "Shock variable" into their productivity equations: "Shock" is defined as 0 before 1982, thereafter it is the percentage change in employment that occurred between 1979 and 1981. That is, for each industry, it changes once and once only by an amount which varies across industries. We allow the level of productivity to depend on this variable so that the first difference of "Shock" appears in the regression where all the other variables are differenced. This

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5 See, for instance, Haskel(1991).

implies that industries which experienced a greater fall in employment between 1979 and 1981 experienced a higher *level* of productivity thereafter not *growth* as in Nickell,Wadhwani and Wall(1992). We shall consider this possibility later.

Column 6 suggests a strong positive connection between productivity, the "Shock" effect has the expected negative sign (remember "Shock" itself is negative) but is not well determined. It does not appear to change the other coefficients much. Unlike Haskel(1991) we find that concentration is associated with a higher level of productivity. Since concentration has been trending downwards in the 1980's this cannot help explain the recovery in productivity growth after the recession of the early 1980's. In column 7 we consider the specification of the employment terms. Hitherto we have assumed that manual and non-manual labour are separate factors but with a fairly high degree of substitutability i.e. an elasticity of substitution equal to one. An alternative possibility is that they are essentially identical i.e. they have an infinite elasticity of substitution. So we include , in addition to the existing separate terms, the log of total employment. This term dominates the other two and a Wald test allows one to accept the hypothesis that log L and Log N are jointly insignificant. Of course this is conditional on the assumption that technology is Cobb-Douglas in employment and capital which seems less likely. In this case the role of trade unions are less clear.

A noticeable feature of the results so far is that when we allow for fixed effects, capital appears to play no role in explaining change in output. There are a number of explanations for this, there may simply not be enough variation in the data. It is also likely that capital is measured with error which we expect to bias down the coefficient[6]. Indeed the measurement of capital aggregates is so fraught with difficulties that it has even been suggested (Muellbauer(1987)) that is should be omitted from the specification. In column 8 we use Instrument Variables/Generalized Method of Moments

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6 The capital data is generated by applying the perpetual inventory method to investment in plant and machinery data.

estimator to deal with measurement error[7]. Instruments include lagged concentration, the share of manual employment in total employment lagged and the first two moment restrictions from lags of the log of total employment. We avoid using lagged capital in the instrument set since this tends to lead to rejection of the over-identifying restrictions.

Instrumenting increases the coefficient on Capital markedly, consistent with the measurement error story. Indeed if we take the sum of the coefficients on capital and employment as a measure of the degree of homogeneity of the production function (over 2.2) than we have evidence of massive increasing returns. That aside, the impact of unions is slightly weakened by the use of IV.

A common criticism of the direct or primal approach to estimating technologies is that the regressors, factor inputs, are endogenous. Shocks to output will be correlated with input levels being transmitted via the first order conditions i.e. the factor demand functions. One response to this is to estimate the corresponding cost function. An alternative is to use IV to purge the regressors of the endogeneity. This has the advantage that one can avoid having to specify the firms objectives and related problems such as the modelling of factor dynamics and the formation of expectations.

In column 9 we instrument employment , hours as well as capital. This leads to considerable changes in parameter estimates; if we ignore capital which is statistically insignificant then output displays constant returns to employment. For our purposes the most noteable change is the neither Trade Union term is well determined. Column 10 allows the "Shock" variable to effect the long run growth of productivity as well as its level. This further reduces the significance of Trade Unions. The evidence seems to suggest that when we take into account the special circumstances arising from the recession of 1980/1981 there is little role left for Trade Unions to play in explaining manufacturing productivity over the period.

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7 See Arellano and Bond (1988),(1991).

There are numerous other experiments one could report. Changing the Instrument set does not appear to lead to significantly different conclusions. Allowing other regressors to be endogenous (e.g. Unions), is similarly uninformative. We also considered the possibility that parameters other than those on Trade Unions varied over time but could find no evidence of this. Lastly we allowed for non-Cobb Douglas technology by including log employment squared, log capital squared and log capital times log employment but were unable to reject the restriction that the three variables were jointly insignificant.

Table 2

Alternative specifications

Dependent variable: Log Real Net Output

	6 OLS	7 OLS	8 IV	9 IV	10 IV
log L	0.587 (7.434)	-0.376 (0.827)			
log N	0.195 (2.208)	-0.204 (1.062)			
log K	0.102 (0.703)	0.051 (0.359)	1.585** (2.051)	1.119** (1.092)	1.244** (1.120)
log H	0.907 (2.700)	0.893 (2.670)	1.011 (2.829)	0.458** (0.563)	-0.158** (0.226)
Coverage	-0.133 (0.581)	-0.108 (0.474)	-0.253 (1.178)	-0.267 (1.231)	-0.065 (0.279)
Coverage* Thatcher	-0.287 (2.044)	-0.281 (1.995)	-0.229 (1.707)	-0.174 (1.053)	-0.176 (0.927)
"Shock"	-0.168 (1.039)	-0.172 (1.045)	-0.284 (2.074)	-0.504 (2.500)	-0.341 (1.484)
Concentration	0.720 (4.071)	0.714 (4.168)	0.683 (4.066)	0.643 (4.169)	0.648 (3.436)
Log(L + N)		1.359 (2.078)	0.647 (5.286)	1.056** (2.005)	1.337** (2.776)
"Shock" in levels					-0.246 (2.810)
se(levels)	0.00737	0.00733	0.00811	0.00803	0.00880
m1	-2.29 (54)	-2.28 (54)	-1.84 (54)	-1.97 (54)	-2.08 (54)
m2	-1.11 (54)	-1.17 (54)	0.45 (54)	0.82 (54)	-0.96 (54)
m3			29.13 (26)	30.9 (25)	32.07 (25)
Time dummies:	yes	no	yes	yes	yes
Data in :	Δ's	Δ's	Δ's	Δ's	Δ's

Notes:

(i) m3 is the Sargan test for the validity of the Instruments, distributed Chi square, degrees of freedom in parentheses.

(ii) Starred parameters (**) are Instrumental Variable estimates.

(iii) Instruments for (8) are: lagged concentration, the share of manual in total employment lagged and the first two moment restrictions from lags on log total employment beginning at t-2.

(iv) Instruments for (9) and (10) are: lagged concentration, lagged hours, the share of manual in total employment lagged and the first two moment restrictions from lags on log total employment beginning at t-2. This is equivalent to using two lags on log employment as instruments but allowing the coefficients on these instruments to differ for each cross section.

One of the weaknesses of the dataset used here is that one of the independent variables, Union coverage, is only observed for three years of the sample, 1973, 1978 and 1985. Intervening years are linearly interpolated[8]. To check that our results are not simply due to this interpolation we carried out a number of regressions using only those years for which Union coverage was observed. These are reported in Table 3. Once we control for time effects and fixed effects (the latter either by differencing or using the "Within Groups" transformation) it can be seen that unions do not have a well determined effect on industrial productivity.

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8 We also experimented with a non-linearly interpolated series, using the change in aggregate union density to determine how the change between the three observed years was distributed. The results are much the same.

Table 3

Using 1973,1978 and 1985 only

Dependent variable: Log Real Net Output

	11 OLS	12 OLS	13 OLS	14 OLS
log K	0.471 (11.323)	0.233 (2.703)	0.432 (3.624)	0.325 (2.330)
log H	0.713 (1.660)	1.346 (2.725)	0.543 (1.099)	0.339 (0.583)
Coverage	-0.234 (1.463)	-0.530 (3.332)	-0.207 (1.159)	-0.276 (1.412)
Coverage* Thatcher	-0.131 (1.586)	0.271 (4.535)	-0.194 (0.974)	-0.123 (0.543)
Concentration	0.242 (2.100)	0.230 (0.905)	0.323 (1.321)	0.440 (1.475)
Log(L+N)	0.576 (12.521)	1.081 (11.661)	0.988 (10.571)	0.993 (7.346)
se(levels)	0.06139	0.02524	0.02300	0.01909
m1	5.698 (54)	-3.632 (54)	-3.848 (54)	-1.489 (54)
m2	2.851 (54)	-3.950 (54)	-4.157 (54)	
Time dummies:	no	no	yes	yes
Data in :	levels	industry dummies included	industry dummies included	Δ's

Note:
(i) Columns (12) and (13) above are "Within Group" or Covariance estimates, equivalent to transforming the data to deviations from industry means.

4 Conclusions:

This paper has investigated the impact of trade unions on productivity between 1973 and 1985. Using a panel of 54 industries drawn from the manufacturing sector we have shown that the precise relationship between unions and productivity is difficult to pin down. There is some evidence of a negative effect of unions on productivity but it is far from robust. In particular controlling for aggregate shocks and the possibility endogeneity of the regressors reduces the statistical significance of our measure of union presence.

A further finding is that if we allow for the differential impact of the 1981 recession to have long lasting effects on the subsequent performance of industries then the influence of unions is further reduced. We have allowed for the effects of unions to vary over time, in particular to change with the onset of a Conservative government in 1979. While there is some evidence that the effect of unions became less benign in the 1980's (contrary to much of the folklore on the subject) this result is not well determined. In short, we are unable to find conclusive evidence that trade unions have any well defined significant impact on the level of manufacturing productivity given the data available.

This may come as no surprise since there is little well documented evidence to the contrary. On the other hand it appears to conflict with the widely held notion that organised labour was a significant determinant of Britain's economic malaise in the 1970's and that the subsequent reduction in union power was a causal factor in the recovery of productivity growth in the 1980's. On a more positive note we find that higher levels of concentration are associated with higher levels of productivity, a result at variance with that found by some other authors.

Data Appendix and Descriptive Statistics

The dataset consists of a panel of 54 industries beginning in 1973 and ending in 1985. As is well known the Industrial Classification used by the Central Statistics Office changed in 1980 from SIC68 to SIC80. Fortunately the 1979 Census was published under both classifications and this combined with the relevant CSO publications permits one to construct a set of industries which can be tracked continuously over the entire period. The exception to this is the measure of Trade Union power which is the number of manual workers covered by Trade Union bargaining. This is derived from the New Earnings Survey for he years 1973, 1978 and 1985 and has been linearly interpolated for the intervening years. The New Earnings Survey is also the source of the Hours data. See Nickell and Kong(1989) for further details of the construction of the dataset.

DESCRIPTIVE STATISTICS (Differences)

Variable	Mean	Std Deviation	
lnNO/P	-0.01923	0.14182	Log Real Net Output
lnL	-0.04347	0.07908	Log Manual Employment
lnN	-0.02848	0.08513	Log Non-manual Employment
lnE	-0.03904	0.07237	Log Total Employment
lnK	0.02729	0.03150	Log Capital
lnHour	-0.00210	0.02620	Log Hours
Conc	-0.00582	0.03558	5 Firm Concentration Ratio
Coverage	-0.01038	0.01471	Union Coverage
Thatcher	0.07692	0.18053	Thatcher step dummy
Shock	-0.01707	0.06875	See text

Correlation Matrix

lnNO/P	lnL	lnN	lnE	lnK	lnHour	Shock	Conc	Cov	Thatcher
1.00									
0.39	1.00								
0.26	0.51	1.00							
0.40	0.95	0.74	1.00						
0.14	0.37	0.32	0.40	1.00					
0.25	0.10	-0.00	0.08	-0.06	1.00				
0.13	0.39	0.30	0.41	0.22	-0.02	1.00			
0.21	0.06	0.05	0.07	0.04	0.05	0.02	1.00		
0.04	0.18	0.13	0.18	0.21	0.04	0.13	0.07	1.00	
-0.10	-0.14	-0.01	-0.11	0.01	-0.24	0.11	-0.11	-0.16	1.00

DESCRIPTIVE STATISTICS (Levels)

Variable	Mean	Std Deviation
lnNO/P	15.44847	1.31962
lnL	3.66692	1.28114
lnN	2.66128	1.36383
lnE	4.00316	1.28525
lnK	2.05435	1.32037
lnHour	3.77345	0.05176
Conc	0.49723	0.21961
Cov	0.72406	0.13068
Thatcher	0.50000	0.48073
Shock	-0.08534	0.13342

Correlation Matrix

lnNO/P	lnL	lnN	lnE	lnK	lnHour	Shock	Conc	Cov	Thatcher
1.00									
0.93	1.00								
0.97	0.93	1.00							
0.95	0.99	0.97	1.00						
0.95	0.86	0.90	0.88	1.00					
0.04	-0.04	-0.07	-0.06	0.07	1.00				
0.18	0.20	0.18	0.20	0.04	0.22	1.00			
-0.15	-0.31	-0.20	-0.28	-0.06	0.18	0.08	1.00		
0.32	0.37	0.33	0.35	0.30	-0.02	0.26	0.18	1.00	
-0.08	-0.15	-0.09	-0.14	0.06	-0.26	-0.67	-0.12	-0.31	1.00

Acknowledgements

This paper is a revision of chapter 3 of Denny(1991). My thanks to Steve Nickell for advice, to Jonathan Haskell for comments and to Paul Kong for generously helping with the data. The usual disclaimer applies.

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