A Bargaining Model of Wages, Employment and Investment for UK Manufacturing.

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Abstract.

This paper presents a framework for evaluating whether union activity discourages investment through the mechanism identified in recent papers by Grout. It presents a time-consistent dynamic theoretical model for the determination of wages employment and investment which is estimable, and suggests a number of ways to test for the Grout effect. These tests are then applied to UK manufacturing. No evidence for the Grout effect is found.

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1. Introduction

The bulk of theoretical work and virtually all the empirical work on trade unions has concentrated on the effect of collective bargaining on wages and employment. For example, Layard and Nickell (1985) estimate wage and employment equations conditional on the capital stock and use these equations to evaluate the effect of unions on wages and employment while keeping the capital stock constant[1]. If unions affect the capital stock this is likely to lead to a miscalculation of the total effect of unions on the economy. As union activity will, in general, affect the level of employment which will affect the marginal revenue product of capital, we would expect unions to influence capital accumulation in this way. Bruno and Sachs (1985) look at this effect but Bruno (1986) concludes that the rise in real wages does not account for the bulk of the slowdown in capital accumulation. However, union activity might affect the incentive to invest in another way. In two recent influential papers, Grout (1984, 1985) has argued that unions are likely to have an additional adverse effect on investment particularly in Britain where the legal structure means that contracts are not binding. The basic idea is that after employers have invested in capital, increasing the productive capacity of the firm, the union will increase wages to take some share of the increased rents. This reduces the incentive of the employer to undertake investment in the first place. In this case, even if real wages are low, investment may be low if employers expect a high respnosiveness of the wage to increases in the capital stock.

While this is an attractive theoretical idea there has been no attempt to estimate its quantitative importance. In this paper we present a dynamic framework which allows us to do this and then apply it to UK manufacturing industry. In the process of doing this, we will also derive conditions under which the conventional practice of estimating wage and employment equations conditional on the capital stock and other current or lagged variables is a legitimate procedure.

The plan of the paper is as follows. In the next section we present a dynamic version of Grout's one-period model. We then discuss the ways in which we might pick up and estimate the Grout effect. In the fourth section we discuss the data used while the fifth section presents our results.

2. A Theoretical Framework

The models of Grout (1984, 1985) are not suited to empirical implementation as they are one-period models. van der Ploeg (1987) has presented a dynamic version of the model which, unfortunately, is rather too complex to estimate. Here we present an alternative dynamic model which produces simple results.

In each period t, the employer and union choose investment, I_t, wage W_t and employment, N_t. Assume that the per-period pay-offs to employer and union are given by:

$$\pi_t = f(K_t, N_t, \underset{\sim}{X}_{1t}) - W_t N_t - P^I_t I_t - P^I_t . \varphi(I_t, K_t) \qquad (1)$$

$$u_t = u(W_t, N_t, \underset{\sim}{X}_{2t}) \qquad (2)$$

where f( ) is a concave revenue function, $\underset{\sim}{X}_{1t}$ is a vector of other variables affecting the revenue function, P_t^I is the price of investment goods, $\underset{\sim}{X}_{2t}$ a vector of exogenous variables affecting union utility, and $P_t^I\Psi(I_t, K_t)$ an adjustment cost function. We assume that this adjustment cost function does not depend on N_t or $\underset{\sim}{X}_{1t}$, and that adjustment costs are proportional to the investment goods price.[2] For the moment, assume there are no corporate taxes. We also assume that union utility depends only on current wages and employment; there are, for example, no wealth effects. While this is a conventional assumption in the literature on union preferences it is quite restrictive. Manning (1987b) presents a model in which this assumption is not made, and shows that it leads to potentially very complicated dynamics.

The dynamics of the capital stock are assumed to be given by:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{3}$$

so that current period investment is productive today. This is consistent with the usage of Layard and Nickell (1985,1986).

I will model the determination of investment, wages and employment at time t in the following sequential way

(Stage I) I_t is chosen unilaterally by the employer

(Stage II) W_t is negotiated between employer and union

(Stage III) N_t is negotiated between employer and union.

This sequential structure is chosen on the grounds of "realism". It has the feature that the capital stock in any period is chosen before the negotiation of wages and employment so that the lock-in effects identified by

Grout (1984) will be present. Within the period capital cannot be resold.

In the original Grout model, union and employers were assumed to bargain about investment, but our assumption that the employer unilaterally controls investment seems consistent with the available evidence for the bulk of establishments. Daniel and Millward (1983) found that investment was a subject of negotiation between employers and (manual) unions in 25% of manufacturing establishments in 1980. However, as a reasonably sized minority of establishments do appear to have some negotiations over investment, we will discuss what happens if our assumption is relaxed.

For the modelling of wage and employment determination we will use the flexible framework developed in Manning (1987a). This has the advantage of encompassing two of the more common union models; the monopoly union model (see Oswald, 1982) and the efficient bargain model (see MacDonald and Solow, 1981). It is important to maintain a flexible framework at this stage as the choice of a particular model for wage and employment determination might prejudice our results about the effects of unions on investment (see below for an example).

In modelling wage and employment determination in single period models, one need only use the current pay-offs to both parties. This is, of course, fairly obvious, but this practice is commonly extended to models where there is more than one period (e.g. the theoretical section of Layard and Nickell, 1985, among many other potential examples). But, in the contxt of a dynamic model, it is not immediately obvious that this is a legitimate procedure. In the bargaining solutions of the dynamic model presented below, we will not use the per-period pay-offs of (1) and (2), but the expected discounted future pay-offs to both parties.

In a dynamic model, one also needs to specify the assumptions about the nature of any precommitment that is feasible. In applying the model to collective bargaining in Britain, the reasonable assumption would seem to be that no precommitment is possible. We maintain this assumption throughout. van der Ploeg (1987) provides a theoretical analysis of what happens if this assumption is relaxed.

At stage II of the bargaining at time t (the wage determination stage) the firm has an inherited capital stock K_t. This plays the role of a state variable in the wage and employment bargaining, so that we can write the wage and employment negotiated as $W_t = W(K_t, \underset{\sim}{X}_t)$, $N_t = N(K_t, \underset{\sim}{X}_t)$ where $\underset{\sim}{X}_t$ is a vector of relevant exogenous variables, which need not include only current dated variables. The precise form of these wage and employment functions will be derived later.

Now define $\Pi_t(W_t,N_t;K_t)$ to be the expected discounted pay-off to the employer from the beginning of Stage II onwards if (W_t,N_t) are negotiated today, K_t is the capital stock, and future wages employment and investment follow their solution paths. It is convenient to use a dynamic programming approach in order to find the time-consistent solution.

From our assumption that the employer unilaterally controls investment we have:

$$\Pi_t(W_t,N_t;\ K_t) = \max_{I_{t+1}} [f(K_t,N_t,\ \underset{\sim}{X}_{1t}) - W_tN_t + \beta_t(-P^I_{t+1}I_{t+1} - P^I_{t+1}\Phi(I_{t+1},K_{t+1})) + \beta_t\Pi_{t+1}(W(K_{t+1},.),\ N(K_{t+1},.);K_{t+1})] \qquad (4)$$

$$\text{s.t.} \quad K_{t+1} = I_{t+1} + (1-\delta)K_t$$

where β_t is the employer's discount factor in period t.

In applying a bargaining solution to determine (W_t, N_t) we also need to specify what happens in the event of a failure to agree W_t and/or N_t, i.e. what are the pay-offs in the event of a strike. If there is a strike current pay-offs will be zero, and the expected discounted pay-off to the employer from today, $\bar{\Pi}(K_t)$ will be given by

$$\bar{\Pi}(K_t) = \max_{I_{t+1}} [\beta_t(-P^I_{t+1}I_{t+1}-P^I_{t+1}\varphi(I_{t+1},K_{t+1}) + \Pi_{t+1}(W(K_{t+1},.), N(K_{t+1},.);K_{t+1}))]$$

$$\text{s.t.} \quad K_{t+1} = I_{t+1} + (1-\delta)K_t \tag{5}$$

There are several implicit assumptions in this specification which deserve some discussion. First, note that we have assumed that the employer can still invest even if the current workers are on strike. This might not be a reasonable assumption in all situations particularly if union labour is required to instal capital. Secondly, note that on the right-hand side of (5) the functions $\Pi_{t+1}(.)$ and $W_{t+1}(K_{t+1},.)$, $N_{t+1}(K_{t+1},.)$ are assumed to be the same as in (4), i.e. the same as if there was no strike today. So we are assuming that a strike today has no effect on future profitability of the firm and no effect on future wages and employment. This is reasonable in the context of the theoretical model, given our assumptions about the lack of commitment and perfect information. But it might not be so reasonable in the real world for a number of reasons. First, it is a widely-held belief that frequent strike action deters customers in which case $\Pi_{t+1}(.)$ will depend on current strike action. However, we know of no formal evidence on this. Secondly, in a world of imperfect information current strike action may convey some information about bargaining power.[3] In this case the functions $W_{t+1}(K_{t+1}\ .)$ and $N_{t+1}(K_{t+1}\ .)$ will be affected by strikes today. Thirdly it is possible that the corporate tax system also produces effects particularly if a current strike influences the tax regime the employer is in tommorrow.

We will proceed on the basis of the assumptions underlying (4) and (5), but we discuss the consequences of relaxing them below.

Comparing (4) and (5) we can see that under the assumptions made the level of investment at t+1 will not depend on whether there has been agreemment on wages and employment today or not. This is not surprising. Investment tomorrow determines tomorrow's capital stock and the optimal level of it will not depend on the wage and employment agreed today.

Now turn to the union. Define $U_t(W_t,N_t;K_t)$ to be the expected discounted pay-off to the union if (W_t,N_t) are negotiated today and K_t is inherited.

Then:

$$U_t(W_t,N_t;K_t) = u(W_t,N_t,\underset{\sim}{X}_{2t}) + \gamma_t U_{t+1}(W_{t+1}(K_{t+1},.),N_{t+1}(K_{t+1},.)K_{t+1}) \quad (6)$$

where γ_t is the union's discount factor.

Define $\bar{U}_t(K_t)$ to be the union's discounted pay-off if there is disagreement at

t. We will have:

$$\bar{U}_t(K_t) = \gamma_t U_{t+1}(N_{t+1}(K_{t+1},.), N_{t+1}(K_{t+1},.), K_{t+1}) \tag{7}$$

assuming that the union receives no current utility in the event of a strike.

From the argument above we know that K_{t+1} will be the same whether there is agreement or not today and so will the function $U_{t+1}(.)$.

This completes the specification of pay-offs. We now need to consider in more detail the determination of W_t and N_t. As stated earlier we will use the general bargaining framework of Manning (1987a).

Assume that in Stage III of the bargaining at time t, N_t is chosen, given W_t, to maximise the bargaining solution

$$[U_t(W_t,N_t;\ K_t) - \bar{U}_t(K_t)]^{\lambda_{2t}}\ [\Pi_t(W_t,N_t;\ K_t) - \bar{\Pi}_t(K_t)]^{1-\lambda_{2t}} \tag{8}$$

which using (4) - (7) can be written as:

$$u(W_t,N_t;\ \underset{\sim}{X}_{2t})^{\lambda_{2t}}\ [f(K_t,N_t;\ \underset{\sim}{X}_{1t}) - W_tN_t]^{1-\lambda_{2t}} \tag{9}$$

(8) shows the convenience of the assumptions made above, for they mean that N_t is determined only by current dated variables. (8) will yield a solution of the following type:

$$N_t = N(W_t,\ K_t,\ \underset{\sim}{X}_t,\ \lambda_{2t}) \tag{10}$$

In Stage II, the wage determination stage, we will assume that W_t is chosen to maximise the following bargaining solution:

$$[U_t(W_t,N_t;\ K_t) - \bar{U}_t(K_t)]^{\lambda_{1t}}\ [\pi_t(W_t,N_t;\ K_t) - \bar{\pi}_t(K_t)]^{1-\lambda_{1t}} \tag{11}$$
$$\text{s.t. } N_t = N(W_t,\ K_t,\ \underset{\sim}{X}_t,\ \lambda_{2t})$$

Again using (4) - (7) this can be simplified to

$$\max_{W_t}\ u(W_t,\ N_t;\ \underset{\sim}{X}_{2t})^{\lambda_{1t}}\ [f(K_t,N_t;\ \underset{\sim}{X}_{1t}) - W_tN_t]^{1-\lambda_{1t}} \tag{12}$$
$$\text{s.t. } N_t = N(W_t,\ K_t,\ \underset{\sim}{X}_t,\ \lambda_{2t})$$

which again is simply a static bargaining solution conditional on K_t. From this bargaining framework will come solutions of the form

$$W_t = W(K_t,\ \underset{\sim}{X}_t) \tag{13}$$
$$N_t = N(K_t,\ \underset{\sim}{X}_t)$$

where $\underset{\sim}{X}_t$ is the vector of exogenous variables $(\underset{\sim}{X}_{1t},\ \underset{\sim}{X}_{2t},\ \underset{\sim}{\lambda}_t)$.

Notice that although the bargaining model we have presented is explicitly dynamic, the wage and employment equations that are the solution of this model are simply the ones that one would derive using a myopic model. The discount factors and the future play no role in the determination of current wages and employment once we condition on the capital stock. The model presented here can be thought of as an explicit theoretical foundation for the empirical practice followed by Layard and Nickell and others. In order to derive this result we had to make certain assumptions notably:

(a) the costs of adjusting the capital stock are independent of employment,

(b) investment can still occur even if there is a strike in the negotiations over wages and employment,

(c) the occurrence of strikes has no effect on future profitability.

The failure of any one of these assumptions will mean that current wages and employment will depend not only on the current exogenous variables but also the values of these variables into the infinite future. While it is obviously impossible to test whether all these future variables affect current wages and employment, we can include some future variables in wage and employment equations in order to make some attempt to test the assumptions described above. This will be done in the empirical section below.

It should also be noted that the solution of the model presented above is considerably simpler than the solution of the dynamic model of van der Ploeg (1987). This is because van der Ploeg uses constant fall-back positions rather than (5) and (7). In this case the future will affect the current bargin. This amounts to the assumption that, in some sense, disagreements once they occur are permanent. However the approach taken here seems more reasonable as disagreements are not likely to be permanent where the agents cannot precommit themselves.

Before proceeding it is worthwhile reminding us of the special cases of the model presented above. The popular labour demand model is the case λ_{2t} =

0 where the union has no power in employment determination. The efficient bargain model is the case $\lambda_{1t} = \lambda_{2t}$. As we vary λ_{1t} and λ_{2t} we trace out a whole variety of other models (see Manning, 1987a, for more details of this).

Before considering the determination of investment it is worth considering the way in which the model presented above can be generalised while still maintaining the simple structure of the solution. Two restrictive assumptions we have made are the absence of uncertainity and no corporate taxation. Introduction of uncertainty has no effect on the solution. The only modification to the specification we need to make is that the future valuation functions in (4), (5), (6) and (7) should be replaced by their expected values but as these terms drop out of the bargaining solutions this has no effect on wages and employment conditional on the capital stock. Introducing a corporate tax system like that analysed by Poterba and Summers (1983) also does not affect the solution. The corporate tax system will have no effect on wages and employment conditional on the capital stock.

Now consider the determinants of investment. Whatever the investment path chosen by the employer, s/he knows that wages and employment in each period will be determined by (13). So investment will be chosen to maximize discounted profits by choice of $\{K_t, I_t\}$ subject to (13) i.e. to solve the problem

$$\max \sum_{i=0}^{\infty} \beta^{i}[f(K_{t+i},N_{t+i},\underset{\sim}{X}_{1t+i}) - W_{t+i}N_{t+i} - P^{I}_{t+i}\cdot I_{t+i} - P^{I}_{t+i}\varphi(I_{t+i},K_{t+i})]$$

$$\text{s.t.} \quad W_{t+i} = W(K_{t+i}, \underset{\sim}{X}_{t+i})$$

$$N_{t+i} = W(K_{t+i}, \underset{\sim}{X}_{t+i}) \qquad (14)$$

$$K_{t+i} = I_{t+i} + (1-\delta)K_{t+i-1}$$
$$K_{t-1} = \bar{K}_{t-1}$$

The first-order condition for I_{t+i} defining a multiplier η_{t+i} for the third constraint is:

$$-\beta^{i}{}_{t+i}\,[P^{I}_{t+1} + P^{I}_{t+i}\cdot\varphi_{I}(I_{t+1}, K_{t+1}] + \eta_{t+i} = 0 \qquad (15)$$

The first-order condition for K_{t+i} taking account of the first two constraints in (14) is:

$$\beta^{i}_{t+i}\,[f_K + (f_N - W_{t+i})\,\frac{\partial N_{t+i}}{\partial K_{t+i}} - N_{t+i}\,\frac{\partial W_{t+i}}{\partial K_{t+i}} - \varphi_K] - \eta_{t+i} + (1-\delta)\eta_{t+i+1} = 0 \qquad (16)$$

How can we measure the Grout effect from this. The natural measure to use is the term:

$$\Delta = (f_N - W)\,\frac{\partial N}{\partial K} - N\,\frac{\partial W}{\partial K} \qquad (17)$$

as this measures the size of the wedge between the marginal revenue product of capital and the marginal profitability of capital which comes about through the dependence of W and N on K, and is the cause of suboptimal investment decisions in the Grout model. However, it should be noted that even if this effect is zero unions may still affect investment and the capital stock as they will in general affect employment and this has a direct effect on f_K. However as this is the normal factor substitution effect it makes sense not to include it in the Grout effect.

It should also be noted that the Grout effect is not necessarily to discourage investment. In certain circumstances it can increase it. An example of this is the model which seems to lie behind Lawrence and Lawrence (1985) who adopt the labour demand curve model in which ($f_N = W$) so the first term in (17) drops out and they argue that new investment reduces the elasticity of the labour demand and consequently reduces the union wage i.e. $\frac{\partial W}{\partial K} < 0$. This effect will then lead to over-investment in the presence of unions.

However in other models the Grout effect does discourage investment. In the models of Layard and Nickell $f_N = W$ and $\frac{\partial W}{\partial K} > 0$.

So far, we have assumed that the employer has unilateral control over investment. What happens if union and employer negotiate about investment? As long as we assume that next periods investment is not prevented by a strike about wages and/or employment today, then the wage and employment equations derived above will still be valid. But the investment equation (15) and (16) will not be valid. It only makes sense to talk about union influence over investment if unions can prevent investment when they are negotiating about it. In this bargaining the fall-back levels of employer and union will depend on the capital stock in the event of disagreement i.e. $(1-f)K_{t-1}$. The future value terms will not disappear from the bargaining solution, and we will be unable to derive a simple Euler equation for investment as in (15) and (16). Additionally, the preferences of the union will now affect investment. Given all these complications, we will not use this case as our standard model, but we will try to see whether there is any evidence of unions bargaining over investment.

Before we proceed to our empirical section we present a simple example to illustrate the theoretical framework presented above, to give some idea of the likely sign of (17) for some specific functional forms.

An Example

Assume that the revenue function is of the form

$$f = AK^{1-\alpha}N^{\alpha} \qquad (18)$$

where A captures the effects of the output price, other inputs, demand effects and technological progress.[4]

Assume that the union utility function is of the form:

$$u = N^{\gamma}\ ((\frac{W}{S})^{\delta} - B^{\delta})^{1-\gamma} \qquad (19)$$

where S is the wedge between producer and consumer wages and B is some measure of the alternative wage. This Stone-Geary formulation has had some success in empirical work - see, for example, Pencavel (1984).

Consider the employment determination stage. Applying (9) we can derive the following employment rule:

$$N = A^{\frac{1}{1-\alpha}}.K.W^{-\frac{1}{1-\alpha}}\ [\frac{\lambda_2\gamma + (1-\lambda_2)\alpha}{\lambda_2\gamma + (1-\lambda_2)}]^{\frac{1}{1-\alpha}} \qquad (20)$$

which in log linear form can be written as (using lower case letters for log variables):

$$n-k = \frac{1}{1-\alpha}.(a-w + \log[\frac{\lambda_2\gamma + (1-\lambda_2)\alpha}{\lambda_2\gamma + (1-\lambda_2)}])$$

From (20) we can see that $\frac{dN}{dW} < 0$ and that $\frac{dN}{d\lambda_2} > 0$ so that, as usual in these models, a rise in union influence over employment raises employment. Notice how similar this equation is to a conventional labour demand curve; the only effect of unions bargaining about employment is the addition of an extra term incorporating the union influence over employment. If this term is constant or modelled very badly it may be difficult to decide whether employment is on the labour demand curve or not.

Using (18) and (20) we can derive current revenue conditional on the wage as

$$f - WN = (1-\alpha)\ A^{\frac{1}{1-\alpha}}.K\ W^{-\frac{\alpha}{1-\alpha}}\ (1-\lambda_2)\ [\frac{\lambda_2\gamma + (1-\lambda_2)\alpha}{\lambda_2\gamma + (1-\lambda_2)}]^{\frac{\alpha}{1-\alpha}} \tag{21}$$

It is straightforward to check that $\frac{\partial(f-WN)}{\partial\lambda_2} < 0$.

Now consider the wage determination stage. Applying (12) and using (20) and (21) we can derive:

$$W = B.S.[\frac{\gamma\lambda_1 + (1-\lambda_1)\alpha}{\gamma\lambda_1 + (1-\lambda_1)\alpha - \delta\lambda_1(1-\gamma)(1-\alpha)}]^{\frac{1}{\delta}} \tag{22}$$

or in log-linear form:

$$w-b-s = \frac{1}{\delta}.\log\left[\frac{\gamma\lambda_1 + (1-\lambda_1)\alpha}{\gamma\lambda_1 + (1-\lambda_1)\alpha - \delta\lambda_1(1-\gamma)(1-\alpha)}\right]$$

From this we can deduce that a rise in the alternative wage the wedge and λ_1 all lead to a rise in the wage. In fact an increase in the wedge is passed on one for one to employers who bear all the cost. Also note that the wage does not depend on A or the capital stock, or λ_2. This is in contrast to the wage equations of Layard and Nickell (1985), and Bean, Layard and Nickell (1986), which argue that it is capital accumulation which accounts for the long-run increase in real wages. However, there is not necessarily any conflict here. We are looking at the effect of the capital stock of an individual firm on its own wages. Even if this effect is zero, capital accumulation in the economy as a whole will increase labour demand, reduce unemployment, and this will increase the alternative wage available to workers, B. This, in turn, leads to an increase in wages. So, the effect of capital accumulation on wages may be indirect but still very strong. In fact Nickell and Wadhwani (1987) and Nickell and Kong (1987) find that external influences like unemployment are more important in determining a firm's wage than internal variables like productivity.

Note also that if λ_1, λ_2 and γ are constant one cannot identify them from the wage and employment equations (20) and (22). This identification problem is discussed more fully in Manning (1987a).

Now measuring the Grout effect as in (17) we have

$$\Delta = - \frac{WN\ (1-\alpha)\ \lambda_2\gamma}{\lambda_2\gamma + (1-\lambda_2)\alpha} \tag{23}$$

$$\Delta = -\frac{WN\ (1-\alpha)\ \lambda_2\gamma}{\lambda_2\gamma + (1-\lambda_2)\alpha} \tag{23}$$

This is always less than zero as $f_N < W$ and $\frac{dN}{dK} > 0$, and it is only zero if $\lambda_2 = 0$, i.e. if we have the monopoly union model. An increase in λ_2 always increases the Grout effect while if $\lambda_2 > 0$ an increase in λ_1 has the same effect through W. So for the particular specification of technology and preferences in this example the Grout effect can never work to increase investment.

We can also show that whatever the values of λ_1 and λ_2 the actual level of the capital stock will be lower. To see this, consider (21) when combined with (22). This yields:

$$f - WN = (1-\alpha)A^{\frac{1}{1-\alpha}}(1-\lambda_2)\left[\frac{\lambda_2\gamma + (1-\lambda_2)\alpha}{\lambda_2\gamma + (1-\lambda_2)}\right]^{\frac{\alpha}{1-\alpha}}(B.S)^{-\frac{\alpha}{1-\alpha}}$$

$$\cdot\left[\frac{\gamma\lambda_1 + (1-\lambda_1)\alpha}{\gamma\lambda_1 + (1-\lambda_1)\alpha - \delta\lambda_1(1-\gamma)(1-\alpha)}\right]^{-\frac{\alpha}{\delta(1-\alpha)}}K \tag{24}$$

(24) gives the profit function after concentrating out both wages and employment. The effect of a rise in λ_1 or λ_2 has the same effect from the point of view of the employer as a reduction in A. So a rise in any dimension of union power reduces the marginal profitability of capital which will discourage investment. However it should be remembered that we cannot use (24) to read off the Grout effect as it compounds the two effects unions have on the marginal profitability of capital; one, their effect on employment and

hence the marginal product of capital, and the other, the dependence of W and N on K, which leads to the wedge between the marginal product and marginal profitability of capital in which we are interested.

3. Estimating the Grout Effect

In this section we outline a number of approaches to estimating the sign and size of the Grout effect which might be helpful in practice. We identify three possible ways to do this:

(a) from the estimation of wage-employment equations conditional on the capital stock;

(b) from the estimation of investment equations; and

(c) from the estimation of Q-equations.

All these methods have their advantages and disadvantages.

A. Wage and Employment Equations

From the estimation of wage and employment equations conditional on the capital stock one can work out $\frac{dN}{dK}$ and $\frac{dW}{dK}$. As long as one believes that $f_N < W$ (which is the case in all union models as long as the union does not dislike employment and in competitive models as long as there is no monopsony) this may be enough to sign the Grout effect. But unless one has separate estimates of (f_N-W) one cannot quantify it and if $\frac{dN}{dK}$ and $\frac{dW}{dK}$ differ in sign one may not even be able to derive the sign of the Grout effect. One could attempt to do this by parameterizing technology and preferences and attempting to estimate structural equations, but this is likely to be fraught with difficulty. An additional problem is that in many empirical situations, the capital stock measure may be very poor.

However this approach does have the advantage of being simple allowing one to make inferences about the Grout effect from existing studies of wage and employment determination.

A. Investment Equations

The problem with estimating investment equations is that they need to be forward-looking. But, from (15) and (16) we can derive the following Euler equation for investment by eliminating the multipliers η:

$$P_t^I \Psi_I(I_t, K_t) = -P_t^I + f_K - P_t^I . \Psi_K + (f_N - W_t) \frac{\partial W_t}{\partial K_t} - N_t \frac{\partial W_t}{\partial K_t} + (1-\delta)\beta_t \, [P_{t+1}^I + P_{t+1}^I . \Psi_I(I_{t+1}, K_{t+1})] \quad (25)$$

This is theoretically estimable (a similar techique has been used by Abel, 1980). We can include union power terms to try to capture the Grout effects. The disadvantage of this is that we then only have the direct effect of unions on investment and we cannot isolate the channels by which this effect results. Another practical problem is that if one thinks of (15) as the basic behavioural equation and tacks a white noise error onto it, then (25) will have a moving average error which is somewhat awkward for estimation.

C. Q-equations

The investment model which comes out the theoretical model presented above is consistent with a Q theory. Equation (15) is the basic one used to derive Q equations. There are the usual problems in measuring the relationship between marginal and average Q (see Hayashi, 1982) but the addition of the bargaining model making wages endogenous creates no additional problems i.e it does not alter the basic homogeneity of the employer's concentrated revenue function. Given that we can establish a relationship between the unobservable multiplier η and an observable adjusted Q figure, we can estimate the Euler equation (16) for Q, including union power terms to try to pick up any Grout effect.

These three approaches described above are not mutually exclusive; if one tried all three one would hope for consistent answers. In this paper we will try all three, although the last we treat in a somewhat rudimenatary way.

4. The Data

We are going to apply the model developed above to annual data for UK manufacturing. Annual data is rather limiting in the sense that it does not contain much information but has the advantage for our purposes that it generally does not have a complex dynamic structure and so it is not too difficult to force the data to correspond to the simple dynamic structure of the theoretical model.

There are three types of variable included in our study apart from wages, employment and investment. There are those variables which affect the firm's production function, there are those which do not affect this function but enter the union utility function and there are those which affect neither the profit function, but do affect the extent of union bargaining power. We will describe each of the variables used in turn.

<u>Variables in the Production Function</u>

As our output price we use the manufacturing value added deflator. We also include the real oil price which we found to work best with a one year lag. We also introduce the capital stock which is conventional in these studies. There is a potential problem in using the published data for the capital stock as it is commonly believed that in certain periods (notably 1974 and 1981) there was substantial unrecorded premature scrapping of capital made uneconomic by adverse shocks. However it should be noted that the econometric evidence on the extent of this is somewhat conflicting (e.g. Wadhwani and Wall, 1985, Muellbauer, 1984). We included dummies for years in which these might have been substantial unrecorded scrapping but with no success.

Finally we follow the approach of Layard and Nickell in incorporating certain demand variables which can be justified by appealing to the existence of imperfect competition in product markets. We use two of these variables; real competitiveness (P*/P), which, and a measure of overtime worked (OH). The inclusion of this last variable has some similarities to Gregory's (1985) inclusion of hours worked as a crude proxy for demand and Muellbauer's (1984) use of a (non-linear) function of overtime worked as a measure of labour utilization.[5] It could be argued that overtime is really a measure of unanticipated demand as anticipated demand would be met by increasing employment. In this case employment might be negatively related to overtime. However, as we shall see, the data do not seem to support this interpretation.

Variables in the Union Utility Function.

Existing studies and the example presented in the previous section contain two variables; the wedge between the product wage and the consumption wage, and some measure of the alternative wage.

The wedge variable, WDG we measure in a conventional way taking account of differences between the consumer and manufacturing producer prices, the direct and employer labour tax rates.

For the alternative wage, we require some measure of the alternative income available to union members who are not employed in manufacturing. This will be affected by the level of unemployment benefit, the level of aggregate wages and the probability of being unemployed or employed elsewhere. However, to conserve degrees of freedom we decided to use a single summary measure of the alternative wage, $\bar{W}$. We use the measure

$$\bar{W} = B^{u} . W^{a\,1-u} \tag{26}$$

where B is the level of unemployment benefit, W^a the aggregate wage and u the aggregate unemployment rate, to capture the idea that the alternatives available to workers not finding work in this firm are unemployment or employment elsewhere with the likelihood of one or the other being related to the unemployment rate. Using the unemployment rate in (26) probably gives too great a weight to W^a as the probability of being employed is lower if you are already employed than if you are unemployed. A better weight might be the outflow rate from unemployment although as Pissarides (1986) shows this is closely related to the aggregate unemployment level. Experimentation with various specifications of $\bar{W}$ showed that the results were not that sensitive to the actual weight used. It should be noted that the aggregate wage obviously contains some element of manufacturing wages, but as other variables are used in the construction of $\bar{W}$, we do not worry about this although it will obviously always be treated as endogenous.

When we take logs of (20) because we only measure (B, W^a) up to a multiplicative constant we need to also include the level of u. However, the unemployment rate could be included on other grounds; as a measure of demand or as a measure of union power.

Variables affecting Union Power

We use three measures of autonomous union power which affect bargaining power but neither the profit function nor the union utility function. These are manufacturing union density (DEN); a measure of the union non-union mark-up (MU) used by Layard and Nickell (1985), and an incomes policy dummy for 1976-77, (IPD). There are arguments that DEN and/or MU should be in the union utility function but while this would be important if we wanted to test alternative models of wage-employment bargaining (see Alogoskoufis and Manning, 1987) it is not so important here as this is not our main interest.

5. Results

Employment Equation

For the employment equation we adopt the approach used by Alogoskoufis and Manning (1987) to test the labour demand curve model against alternatives. If employment is on the labour demand curve then if we regress employment on the wage the only other significant variables should be those from the profit function. If variables affecting union utility or bargaining power are significant this is evidence against the labour demand curve model. From the point of view of this paper this is important because of the term of $(f_N - W) \frac{dN}{dK}$ in the definition of the Grout effect (17). If employment is on the labour demand curve, this term will be zero while if the labour demand curve model is rejected we will assume that $(f_N - W) < 0$ although we cannot test this.[6]

Table 1 presents a series of employment equations while the misspecification tests for these equations are presented in Table 2.

Column 1 of Table 1 presents our estimates of a labour demand equation. We have imposed constant returns to scale throughout (this restriction is always accepted at conventional significance levels) so the long-run elasticity of employment with respect to the capital stock is constrained to be unity. In column 1 we find a significant negative coefficient on the wage and the anticipated signs on the coefficients for competitiveness the real oil price and overtime. We experimented with a variety of lag structures but the model of column 1 was always accepted against more general labour demand curves. But even though very simple our labour demand curve's dynamics are more complicated than our theoretical model has allowed for because of the highly significant N_{t-1} term. The significance of this term is, of course, commonplace but causes problems for our theoretical framework because the presence of N_{t-1} implies some source of dynamics (e.g. adjustment costs) which have not been modelled. As Lockwood and Manning (1987a,b) have shown it is not straightforward to derive the solution to the dynamic bargaining problem when the source of dynamics is employment adjustment costs. However even if we did make proper allowance for the existence of these extra dynamics in our theoretical model, it is not clear that this would affect our conclusions about the effect of unions on investment.[7] One possible way to avoid the N_{t-1} term would be to estimate a static employment equation with an autoregressive error to capture variables affecting employment which are observed by employer and union but not by the econometrician. This does not work.

Column 2 presents a general employment equation which we might expect to be appropriate if the general bargaining framework was the correct model (see Alogoskoufis and Manning, 1987)[8]. None of these variables are significant. Alogoskoufis and Manning (1987) show that an appropriate test of the labour demand curve model against the alternative of the Manning (1987a) general bargaining framework is a test of exclusion of the extra variables in Column 2. The F-type test for this is $F(6,20) = 1.59$. For a 5% significance level the critical value of the test statistic is 2.60 so the labour demand curve model is accepted. Of course one possible reason for this is the inclusion of many variables which are not significant with a few that are. Columns 3 and 4 present estimates of more restricted employment equations to see whether this is the case. Column 3 presents the employment equation that would be the product of the sequential model presented above (20), i.e. excluding the wedge and the alternative wage. An F-type test statistic of 3 against 1 is $F(3,23) = 1.12$ with a critical value of 3.03, so the labour demand curve model is accepted again. Finally, column 4 presents an employment equation which would be used for testing the efficient bargain model against the labour demand curve model. This excludes union power terms but includes the alternative wage and the wedge. Again, the labour demand curve model is accepted with an F-type test statistic of $F(3,23)=1.00$ with a critical value of 3.03. Again the labour demand curve model is accepted.

The pattern from the employment equation seems to be that the labour demand curve model seems to be an adequate representation of the data. Of course, it is possible that this is because our measures of union power are very poor, but that problem is unavoidable.

Wage Equation

Table 3 presents estimates of some wage equations, while Table 4 presents their misspecification tests. Column 1 presents a wage equation which includes all the variables found significant in the employment equation plus the variables in the union utility function plus the union power variables.

None of the first group of variables is significant. In particular, K_t has an insignificant negative coefficient. Experimentation with different specifications failed to alter this result. It is possible that we obtain this result because our measure of the capital stock is very poor, but it is not so poor that we could not accept the hypothesis of constant returns in the employment equation. However, the result that wages do not appear to depend on the capital stock is in contrast to other studies (e.g. Layard and Nickell, 1986) so should perhaps be treated with some caution.

Turning to the variables in the union utility function, the strong negative effect of unemployment suggests that this variable may not be entering only because of the measurement of $\bar{W}$ and Wdg but because of the more conventional reason that it reduces union power. The alternative wage $\bar{W}$ and the wedge have the expected signs and although the coefficient on the wedge is larger than one the difference is not significant. The union power terms all have the expected signs and the mark-up is significant.

Column (2) presents the estimates of the wage equation imposing some of the restrictions implied by the assumptions of a Cobb-Douglas production technoloy and Stone-Geary preferences. Under these assumptions, from (22), variables in the production function (the A of (18)) should have no effect on the wage. The test of these restrictions is marginally rejected ($F(5,20) = 2.81$). From (22) it is apparent that the coefficients on $\bar{W}_t$ and Wdg_t should both be unity. While the latter can be easily accepted the former is rejected and we do not impose these restrictions. However the equation of column 2 does have some other problems, as from Table 4 we can see that its overidentifying restrictions are rejected.

The equation of column 3 overcomes these problems by including our measure of overtime. This might be justified on the grounds that our wage variable is weekly earnings, which is obviously influenced by overtime. The inclusion of OH_t also increases the significance of the union power terms. The problem of misspecification appears to disappear. The test of model 3 against model 1 has $F(4,20)=0.51$ so we can easily reject the inclusion of the other production function variables.

In all three equations the inclusion of K_t is totally insignificant. So, on this basis we conclude that $\frac{\partial W_t}{\partial K_t} = 0$. As we also concluded that the evidence against the labour demand curve model was not very strong, this suggests that the Grout effect is zero. Whether we can confirm this using an investment equation is our next task.

Investment Equations.

In order to confirm or reject the conclusions drawn from the analysis of the wage and employment equations, an attempt was made to estimate an investment equation using the Euler equation (25).

There are several problems in this. First, even if the production technology is Cobb-Douglas, the investment equation in (25) is highly non-linear. No attempt to estimate such a non-linear equation was made; instead, I estimated a straightforward log-liear version. The second problem is that if one puts a white noise error into the adjustment cost function, as is commonly done, the error on the Euler equation (25) should have a moving average error term with a negative coeffcient on the moving average error component. No evidence of this was ever found, so no allowance for it was made in estimation.

From the Euler equation (25), we would expect to find that, in the absence of any Grout effect, investment is positively related to the marginal product of capital, future investment and the future real investment goods price, and negatively related to the current real investment goods price, and the real interest rate.

One might hope to find all these predicted signs in an estimated investment equation. However, because of the existence of gestation and delivery lags, one should not be too surprised if the coeffcieints on variables of particular dates are wrongly signed. I would be quite satisfied with an investment equation in which the long-run effects of all variables are correctly signed even if the short-run effects are not. As investment is notoriously difficult to model, this does not seem unreasonable.

As described above investment should depend positively on the marginal product of capital. From the employment equation estimated previously I have some idea of the external variables that affect the marginal product of labour, and we might expect all these variables to appear in an investment equation. However, to include all these variables may be rather profligate with degrees of freedom. An alternative procedure is to use the idea that the production function is reasonable well approximated by Cobb-Douglas. in this case, the external variables that affect the marginal product of labour will affect the marginal product of capital in exactly the same way. So, if we can write the employment equation as:

$$(n-k)_t = \beta_1 \cdot x_t + \beta_2 \cdot w_t + \epsilon_t \qquad (26)$$

where x_t is the vector of external variables, then the effect of x_t on the marginal product of capital should be proportional to β_1. The simplest way to capture this cross-equation restriction is to re-arrange (26) to yield:

$$\beta_1 \cdot x_t = (n-k)_t - \beta_2 \cdot w_t - \epsilon_t \qquad (27)$$

Hence, rather than include all the x_t variables in the investment equation we can simply include the labour-capital ration and the real producer wage. Note that we must use IV estimation beause of the correlation of $(n-k)_t$ with ϵ_t. The labour-capital ratio should also enter the marginal product of capital separately if we have constant returns to scale. We would expect both (n-k) and w to have positive coefficients. The wage has this positive effect conditional on employment because, for a given level of employment a high level of the wage indicates that the other external variables were favourable to employment. Note, that it is straightforward to test whether this assumption based on the Cobb-Douglas is reasonable; one can simply see whether any of the x_t's have an additional effect on investment conditional on $(n-k)_t$ and w_t.

The first column of Table 5 presents estimates of the investment equation predicted by the theory described above. The coefficients on $(n-k)_t$ and w_t have the expected signs and are significant. However, all the other estimated coefficients are insignificant, and the coefficients on the investment goods price terms have the wrong sign. Furthermore, there is evidence of substantial misspecification in the Durbin-Watson and the other tests presented in Table 6.

The investment equation in column 2 of Table 5 attempts to overcome this problem by including $(i-k)_{t-1}$ and $(n_{t-1}-k_t)$. Of course, these lags cannot be explained in terms of the theory presented above but the presence of excess dynamics is common in many investment equations (e.g. Poterba and Summers, 1983), and is normally rationalised in terms of gestation and delivery lags. The presence of a term involving n_{t-1} might also be justified interms of interactions between adjustment costs of labour and capital (see e.g. Meese, 1980). This investment equation passes all the misspecification tests.

Also, $(i-k)_{t+1}$ is now significant and the investment goods price is estimated to have a negative effect which is almost significant, although it is the future value of this variable which is most significant. However, this equation is not without its problems. The estimated wage effect is now insignificant and, more seriously, the real interest rate is estimate to have a significant positive effect on investment. This is clearly inconsistent with the theory. Furthermore, the model is effectively an equation in the difference of (i-k) and n in which case there will be no long-run solution.

However, in experimentation with alternative specifications, I was unable to come up with an investment equation which resolves all the above problems. Investment is traditionally regarded as difficult to model, and it is perhaps not surprising if, in a small sample, there are problems in picking up all the expected theoretical effects.

So, with these reservations, column 3 includes the union power variables to see whether any Grout effect can be picked up. These variables are all insignificant. The F-type test statistic for their joint exclusion is $F(3,19)=0.81$ so we can reject the hypothesis of a Grout effect. Experimentation with a few of the union power variables, with their lags and with variables like the alternative wage and the wedge failed to find any significant effects. So from the investment equation, there is no evidence of any Grout effect.

Q Equations.

Most Q models of investment have concentrated on the effect of a measure of Q on investment (e.g. Poterba and Summers, 1983; Dinenis, 1985). But, implicit in these models is an equation determining Q. It is this equation that we aim to estimate here.

The starting-point is the first-order condition for investment and capital, (15) and (16). We can rewrite (15) as:

$$\psi_I(I_t,K_t) = \beta_t.[(\eta_t/\beta_t.P^I_t)-1] \tag{28}$$

$(\eta_t/\beta_t.P^I_t)$ is Tobin's marginal q. Rearranging this we have that $\eta_t=\beta_t.P^I_t.q_t$. Substituting this expression for η_t into (16) we obtain an Euler equation in q_t. It is this that we shall try to estimate. The particular measure we shall use as our dependent variable is $q'=(P^I/P).q$, where q is the measure of marginal q for UK manufacturing constructed by Dinenis (1985). As this variable is negative in some periods (although this is inconsistent with the theory) I am not able to use a log formulation. Also, as this series is only available until 1980, I will be forced to estimate the Q equation on a reduced sample.

From (16) we would expect q'_t to depend positively on the marginal product of capital, negatively on the real interest rate and positively on q'_{t+1}. if the Grout effect is siginficant, we would expect to find significant union power terms with neagtive coefficients.

Just as was done with the investment equation I included only $(n-k)_t$ and w_t to measure the marginal product of capital rather than all the external variables of the employment equation.

Column 1 of table 7 presents estimates of the Q-equation which is predicted by the theory presented above. All the variables have the predicted sign but only the coefficient on q'_{t+1} is significant. Additionally, the equation fails the residual autocorrelation and Basmann tests.

The equation of Column 2 attempts to get round these problems by introducing q'_{t-1}. This reduces the problems of misspecification although there still appears to be some problems of residual autocorrelation. But, the introduction of this extra variable basicaly turns the model into an equation in the difference of q' with all other variables insignificant. However, in experimentation with alternative specifications no better equations were found that were consistent with the theory. This is perhaps not surprising given the very small sample and the inevitable difficulties in calculating q.

Given these reservations, column 3 puts the union power terms into the Q-equation. They are totally insignificant. An F-type test of their joint exclusion yields a test statistic of F(3,17)=0.11. Again, no evidence of any Grout effect is found here.

6. Conclusion.

This paper has presented a time-consistent dynamic theoretical model of the determination of wages, employment and investment under collective bargaining. It has shown how this theoretical framework can be used to look at the effect that unions have on investment not only through factor substitution effects, but also through the Grout effect, which arises because of the absence of binding wage and employment contracts. A variety of ways to try to estimate this effect were suggested.

These methods were then applied to annual data on UK manufacturing. The three different methods all led to the same conclusion: that there was no evidence of any Grout effect. This arises because employment seems to be on the labour demand curve and wages do not seem to be responsive to the level of capital accumulation. However, these results should be interpreted with some caution. The investment and Q-equations were both unsatisfactory in a number of ways, and the evidence from the wage equation conflicts with that found in both more aggregated and more disaggregated studies.

But the techniques developed here should be useful when applied to other and better data. In particular, a look at quarterly data on manufacturing would be worthwhile. However, when we move to quarterly data the dynamic structure of the estimated equations will be richer still and this will not be consistent with the simple theory described above. In particular, it will be important to take account of the dynamics of employment adjustment which introduce considerable theoretical complications (see Lockwood and Manning, 1987a,b). This integration of capital stock and employment dynamics is, therefore, left to another paper.

Table 1
Employment Equations
Dependent Variable $(N_t - N_{t-1})$

Sample 1954-85
Method of Estimation: Instrumental Variables.

	(1)	(2)	(3)	(4)
C	−0.05	−0.28	0.25	−0.07
	(0.33)	(0.58)	(0.46)	(0.40)
$(n-k)_t$	−0.21	−0.26	−0.19	−0.19
	(0.06)	(0.11)	(0.07)	(0.07)
$0.5(p^*-p)_t + (p^*-p)_{t-1}$	0.15	0.17	0.18	0.16
	(0.04)	(0.05)	(0.06)	(0.04)
$(op-p)_t$	−0.040	−0.034	−0.038	−0.036
	(0.013)	(0.013)	(0.015)	(0.012)
oh_t	1.97	2.33	3.06	2.01
	(0.38)	(0.72)	(0.75)	(0.37)
w_t	−0.35	−0.26	−0.51	−0.19
	(0.08)	(0.19)	(0.12)	(0.17)
u_t		−0.13		−0.07
		(0.50)		(0.32)
$\bar{w}_t$		−0.11		−0.07
		(0.12)		(0.12)
Wdg_t		−0.24		−0.23
		(0.17)		(0.15)
MU_t		0.038	0.060	
	(0.030)	(0.034)		
den_t		−0.07	0.061	
		(0.11)	(0.058)	
Ipd_t		0.005	−0.010	
		(0.013)	(0.013)	
R	0.86	0.91	0.82	0.89
s.e.	0.0112	0.0102	0.0133	0.0103
DN	2.17	2.66	2.66	2.42

Table 2

Employment Equations

Misspecification Tests

F-type	(1)	(2)	(3)	(4)	Reduced Form
AR(2)	0.53 (2,22)	4.14 (2,16)	4.98 (2,19)	2.41 (2,19)	1.09 (2,10)
LIN	2.95 (2,24)	0.90 (2,18)	3.38 (2,21)	1.70 (2,21)	0.61 (2,12)
HET	1.13 (3,23)	0.40 (3,17)	0.57 (3,20)	0.55 (3,20)	0.20 (3,11)
ARCH(2)	1.67 (2,21)	0.55 (2,15)	1.11 (2,18)	2.23 (2,18)	0.37 (2,9)
BAS	0.71 (12,14)	0.31 (6,14)	0.28 (9,14)	0.61 (9,14)	-
CHOW	0.57 (4,22)	1.37 (4,16)	1.66 (4,19)	0.85 (4,19)	0.94 (4,10)
χ^2-Type					
AR(2)	1.38(2)	10.22(2)	10.31(2)	6.08(2)	5.39(2)
LIN	6.31(2)	2.92(2)	7.79(2)	4.46(2)	2.97(2)
HET	4.13(3)	2.13(3)	2.51(2)	2.43(3)	1.68(3)
ARCH(2)	3.96(2)	1.92(2)	3.16(2)	5.71(2)	0.37(2)
BAS	12.07(12)	3.77(6)	4.94(9)	9.05(9)	-
NORM	1.19(2)	2.76(2)	0.32(2)	2.30(2)	0.08(2)

All the misspecification tests used are explained in the Appendix.

Table 3
Wage Equations

Dependent Variable W_t

Sample 1954-85

Method of estimation: Instrumental Variables

	(1)	(2)	(3)
c	6.26	1.19	0.72
	(5.03)	(0.06)	(0.16)
n_{t-1}	-0.39		
	(0.25)		
k_t	-0.20		
	(0.35)		
$0.5((p*-p)_t$	-0.14		
$+(p*-p)_{t-1})$	(0.12)		
$(op-p)_{t-1}$	0.018		
	(0.028)		
oh_t	1.64		2.38
	(1.18)		(0.76)
u_t	-2.58	-1.65	-0.77
	(1.30)	(0.22)	(0.35)
$\bar{w}_t$	0.43	0.76	0.46
	(0.16)	(0.10)	(0.13)
Wdg_t	1.20	1.02	0.75
	(0.38)	(0.11)	(0.14)
mu_t	0.12	0.002	0.084
	(0.06)	(0.028)	(0.038)
den_t	0.28	0.09	0.21
	(0.26)	(0.06)	(0.07)
Ipd_t	-0.044	-0.025	-0.037
	(0.025)	(0.017)	(0.017)
R^2	0.9964	0.9955	0.9961
s.e.	0.0183	0.0182	0.0173
DW	2.44	1.90	2.40

Table 4

Wage Equations

Misspecification Tests

F-Type	(1)	(2)	(3)	Reduced Form
AR(2)	1.85 (2,16)	0.56 (2,21)	1.87 (2,20)	0.79 (2,10)
LIN	0.08 (2,18)	0.35 (2,23)	0.13 (2,22)	0.00 (2,12)
HET	0.20 (3,17)	0.48 (3,22)	0.43 (3,21)	0.15 (3,11)
ARCH(2)	0.14 (2,15)	0.56 (2,20)	0.21 (2,19)	0.24 (2,9)
BAS	1.16 (6,14)	3.30 (11,14)	1.04 (10,14)	-
CHOW	5.14 (4,16)	1.80 (4,20)	1.37 (4,19)	1.12 (4,10)
χ^2-type				
AR(2)	5.64(2)	1.51(2)	4.74(2)	4.09(2)
LIN	0.27(2)	0.96(2)	0.38(2)	0.05(2)
HET	1.11(3)	1.98(3)	1.86(3)	1.13(3)
ARCH(2)	0.53(2)	1.51(2)	0.63(2)	1.38(2)
BAS	10.64(6)	23.09(11)	13.63(10)	-
NORM	0.97(2)	0.40(2)	0.48(2)	0.97(2)

Table 4
Investment Equations

Dependent Variable $(i-k)_t$

Sample 1954-84
Method of estimation: Instrumental Variables

	(1)	(2)	(3)
c	2.92	-9.73	-3.31
	(9.53)	(5.90)	(13.98)
$(n-k)_t$	1.29	3.27	4.83
	(0.34)	(0.76)	(1.37)
w_t	1.36	0.35	0.59
	(0.46)	(0.34)	(0.52)
$(p^I-p)_t$	0.66	0.023	-0.19
	(1.51)	(0.89)	(1.10)
$R_t-(p_t-p_{t-1})$	-0.17	0.72	1.21
	(0.51)	(0.34)	(0.62)
$(p^I-p)_{t+1}$	-0.46	-1.60	-0.76
	(1.45)	(0.86)	(1.82)
$(i-k)_{t+1}$	0.16	0.33	0.31
	(0.22)	(0.15)	(0.18)
$(i-k)_{t-1}$		0.64	0.40
		(0.10)	(0.21)
$n_{t-1}-k_t$		-3.21	-3.96
		(0.72)	(1.00)
den_t			0.70
			(0.58)
mu_t			0.22
			(0.18)
ipd_t			-0.054
			(0.114)
R^2	0.89	0.96	0.96
s.e.	0.090	0.053	0.061
DW	1.24	1.92	1.97

Table 6

Investment Equations

Misspecification Tests

F-Type	(1)	(2)	(3)	Reduced Form
AR(2)	7.64 (2,20)	2.03 (2,18)	1.60 (2,15)	0.12 (2,9)
LIN	2.20 (2,22)	0.47 (2,20)	0.54 (2,17)	1.00 (2,11)
HET	0.37 (3,21)	0.64 (3,19)	0.73 (3,16)	1.66 (3,10)
ARCH(2)	0.46 (2,19)	0.70 (2,17)	0.87 (2,14)	0.64 (2,8)
BAS	4.32 (11,13)	1.04 (9,13)	0.69 (6,13)	-
CHOW	3.60 (4,20)	0.30 (4,18)	- (4,15)	0.47 (4,9)
χ^2-type				
AR(2)	12.56(2)	5.34(2)	5.10(2)	0.76(2)
LIN	5.17(2)	1.40(2)	1.85(2)	0.55(2)
HET	1.57(3)	2.84(3)	3.73(3)	10.31(3)
ARCH(2)	1.29(2)	2.09(2)	3.00(2)	3.62(2)
BAS	24.30(11)	13.02(9)	7.45(6)	-
NORM	1.68(2)	0.60(2)	0.29(2)	0.04(2)

Table 7
Q Equations

Dependent Variable q'_t

Sample 1954-79
Method of estimation: Instrumental Variables

	(1)	(2)	(3)
c	0.0082	-0.0033	-0.0057
	(0.0066)	(0.0057)	(0.0224)
$(n-k)_t$	0.0025	-0.0010	-0.0016
	(0.0019)	(0.0017)	(0.0059)
w_t	0.0025	-0.0011	-0.0008
	(0.0025)	(0.0021)	(0.0040)
$R_t-(p_t-p_{t-1})$	-0.0012	-0.0007	-0.0007
	(0.0046)	(0.0034)	(0.0044)
q'_{t+1}	-0.65	0.53	0.57
	(0.21)	(0.16)	(0.19)
q'_{t-1}		0.60	0.60
		(0.15)	(0.16)
den_t			-0.0002
			(0.0065)
mu_t			-0.0005
			(0.0008)
ipd_t			-0.00004
			(0.00048)
R^2	0.62	0.79	0.80
s.e.	0.00065	0.00049	0.00051
DW	1.59	2.35	2.40

Table 8

Q Equations

Misspecification Tests

F-Type	(1)	(2)	(3)	Reduced Form
AR(2)	3.54 (2,17)	4.70 (2,16)	3.39 (2,13)	0.65 (2,4)
LIN	0.12 (2,19)	0.31 (2,18)	0.11 (2,15)	0.93 (2,6)
HET	0.91 (3,18)	1.59 (3,17)	1.35 (3,14)	0.11 (3,5)
ARCH(2)	0.01 (2,16)	0.05 (2,15)	0.09 (2,12)	0.01 (2,3)
BAS	6.56 (13,8)	3.39 (12,8)	5.81 (9,8)	-
CHOW	0.20 (4,17)	0.04 (4,16)	0.07 (4,13)	-
χ^2-type				
AR(2)	7.06(2)	8.89(2)	8.22(2)	5.89(2)
LIN	0.33(2)	0.88(2)	0.39(2)	6.13(2)
HET	3.44(3)	5.70(3)	5.85(3)	1.73(3)
ARCH(2)	0.03(2)	0.14(2)	0.33(2)	0.15(2)
BAS	23.77(13)	21.73(12)	22.55(9)	-
NORM	1.34(2)	0.06(2)	0.22(2)	0.63(2)

Footnotes

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1. In Layard and Nickell's model, the long-run effect of a change in the capital stock is to increase only the wage and leave employment unaltered.

2. This is consistent with the existing evidence. Dinenis (1985) using a Q-theory concluded that the adjustment cost function should be of this form. As we shall see the theoretical framework adopted here implies that the Q framework is still legitimate.

3. However it should be noted that in this case all current and past agreements will affect current beliefs so that the model will become impossibly complicated.

4. The choice of a Cobb-Douglas production technology is of some interest because of our empirical application to UK manufacturing for which Muellbauer (1985) in a very careful study has found that the Cobb-Douglas is a reasonable approximation.

5. We attempted without success to use Muellbauer's non-linear function but, with annual data one probably cannot pick up the non-linearities.

6. We will have $f_N < W$ in most static union models as long as the union does not dislike employment.

7. The expression for the Grout effect in (17) will still be correct, but the wage and employment equations should be estimated as Euler equations.

8. In Alogoskoufis and Manning (1987) one of the union power variables is eliminated from the employment equation to identify the wage effect. As we are already estimating by instrumental variables, this has not been done here.

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