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DEPARTMENT OF ECONOMICS

TESTING FOR EFFICIENT CONTRACTS IN UNIONIZED LABOUR MARKETS*

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Abstract

This paper addresses the design of empirical tests to distinguish between two competing explanations of wage and employment determination in unionized labour markets, the labour-demand and efficient-contract models. We argue that most of the tests employed are restrictive, propose an alternative non-nested approach, a central feature of which is the variation in the set of instrumental variables across the models, and provide an illustration of how it might be implemented, using data from the Workplace Industrial Relations Survey (WIRS) 1984 Panel File. The results demonstrate how the traditional approach can lead to inappropriate conclusions, and thereby emphasize the empirical importance of the specification of the instrumental variables.

JEL Classification: J51
Keywords: Unions, empirical tests, efficient contracts

I. INTRODUCTION

This paper addresses an issue that has attracted much attention in the last few years, namely the design of empirical tests to distinguish between two competing explanations of wage and employment determination in unionized labour markets, the labour-demand and efficient-contract models. We argue that most of the tests employed are restrictive, propose an alternative approach that builds upon work by Manning (1987), and attempt its implementation using the Workplace Industrial Relations Survey (WIRS) 1984 Panel File.

There are a variety of labour-demand models. The most general of these is the right-to-manage model: the firm and union bargain over the wage, but the union concedes to the firm the right to set the level of employment. The monopoly-union model is a special case of this in which the union unilaterally chooses the wage that maximizes utility subject to the constraint of the firm's labour-demand curve. The critical feature common to all such models, though, is that, because the firm unilaterally sets employment, the wage-employment combination always lies on the competitive labour-demand schedule.

The alternative efficient-contract model recognizes that, if the union values employment, there exist unexploited welfare gains (from the point of view of the union and the firm) at any point on the labour-demand curve, since the union's downward-sloping indifference curves intersect the firm's isoprofit curves, which are horizontal at the demand curve. If the union negotiates over both wages and employment, therefore, the efficient-contract model yields a wage-employment combination that lies above the labour-demand curve.

If the union does not value employment—if, that is, it voluntarily chooses not to bargain over employment—this yields a special case of both the efficient-contract and labour-demand models. Only the wage enters the union's utility function,[1] and its indifference curves are therefore horizontal in wage-employment space. As a result, the contract curve, the locus of tangencies between the indifference curves and the firm's isoprofit curves, coincides with the labour-demand curve.

Many empirical attempts to distinguish between labour-demand and efficient-contract solutions exploit this equivalence between the two models that arises when restrictions are placed on the latter. Equations are formulated in which wage-employment combinations on the demand curve represent special cases of efficient contracts (with solutions off the demand curve); this allows a nested test that specifies the labour-demand solution as a restriction of the efficient-contract solution,[2] and the restriction is tested using standard methods.

[1] Oswald (1993) defends this as a reasonable representation of a union's utility function, on the grounds that the level of employment is irrelevant to the median union member.

[2] A notable exception is Martinello (1989), who uses a non-nested test to discriminate between the monopoly-union version of the labour-demand model and the efficient-contract model. See also Christofides (1990).

It is our contention that the labour-demand model is not in general nested in the efficient-contract model in this way. Solutions on the demand curve require *either* that the union is prevented from bargaining over employment, even though it would like to, *or* that it does not care about employment. The latter case represents the nested test described: a utility function for a union that values wages but not employment as a special case of one where the union cares about both wages and employment. It is arguably the case, however, that the distinction between the labour-demand and efficient-contract models is of more interest when the union's utility function is the same for both.

If this is accepted, the implication is that the competing models incorporate alternative behavioural assumptions—whether or not the union is able to bargain over employment—and are thus non-nested. They can, however, both be nested in a more general model. Moreover, the criticism sometimes levelled at such an encompassing framework—that the joint alternative model does not have a sensible economic interpretation—does not apply in this case.

The remainder of our paper is organized as follows. First, we set out a simple model that allows us to describe, and illustrate the restrictions implicit in, the typical nested test. Next, we present the alternative procedure. Section IV describes a model consistent with this approach, and illustrates, via its estimation using data from Workplace Industrial Relations Survey (WIRS) 1984 Panel File, how the traditional approach can lead to inappropriate conclusions, thereby emphasizing the empirical importance of the specification of the instrumental variables. A short summary completes the paper.

II. NESTED TESTS

The firm maximizes utility defined over profit

$$V = V(\pi); \qquad \pi = R(N; X_1) - wN,$$

where $R(\cdot)$ is some well-defined revenue function, w and N are the nominal wage and employment, and X_1 is a variable that independently influences the firm's utility. (Throughout, we use the convention that a semi-colon denotes the division between endogenous and exogenous variables.) The union maximizes

$$U = U(w, N; X_2),$$

utility defined over the wage, employment, and X_2, an exogenous variable.[3]

A wage-employment combination, if it is efficient, must lie on the contract curve, the locus of tangencies between the firm's isoprofit contours and the union's indifference curves,

[3]In empirical applications, both X_2 and X_1 will more generally be vectors of exogenous variables.

that is, it must satisfy

$$\frac{R_N(N;X_1)-w}{-N}=\frac{U_N}{U_w}\equiv\sigma(w,N;X_2),$$

where subscripts denote partial derivatives, $\sigma(\cdot)$ is the marginal rate of substitution, and the marginal revenue product, $R_N(\cdot)$, can be thought of as linear without affecting the generality of the analysis that follows. Most tests of efficient contracts are based on a rearrangement of this equation,[4]

$$R_N(N;X_1)=w-\sigma(w,N;X_2)N. \tag{1}$$

The basis for the test is clear: if the second term on the right-hand side is zero, the expression reduces to a solution on the labour-demand curve.

It is usual to specify a functional dependence of σ on X_2. If this is not the case—if, that is, the utility function exhibits weak separability between X_2 and the remaining arguments—the locus of efficient wage-employment combinations will not shift with changes in X_2. Consider, for instance,

$$U=N^\theta\left(\frac{w}{w_0}\right);\qquad\qquad \theta\geq 0,$$

where $X_2=w_0$, the alternative, or delay, wage. Equation (1) reduces to

$$R_N(N;X_1)=(1-\theta)w.$$

Such an equation is observationally equivalent to $R_N(N;X_1)=w$, the labour-demand model; θ is not identified.[5]

If, however, the absence of weak separability is admitted, a test can be formulated. Consider, for example,

$$U=N^\theta(w-w_0);\qquad\qquad \theta\geq 0. \tag{2}$$

In this case, equation (1) becomes

$$R_N(N;X_1)=(1-\theta)w+\theta w_0. \tag{3}$$

If, for instance, R_N is parameterized as

$$R_N=\phi_0-\phi_1 N+\phi_2 X_1, \tag{4}$$

[4]The first to adopt this approach were Brown and Ashenfelter (1986) and MaCurdy and Pencavel (1986). See also, *inter alia*, Alogoskoufis and Manning (1991), Bean and Turnbull (1988), Card (1986, 1990), and Christofides and Oswald (1991).

[5]See Bean and Turnbull (1988, p. 1093) and MaCurdy and Pencavel (1986, p. S13).

this yields

$$N = \left(\frac{\phi_0}{\phi_1}\right) + \left(\frac{\phi_2}{\phi_1}\right) X_1 - \left(\frac{\theta}{\phi_1}\right) w_0 - \left(\frac{1-\theta}{\phi_1}\right) w \tag{5}$$

as the equation to be estimated.

Now if $\theta = 0$, equation (3) reduces to $R_N(N; X_1) = w$, the labour-demand model. Equivalently, the alternative wage does not appear in equation (5). This is the basis of the usual test of the null hypothesis of the labour-demand model: the exclusion of X_2 variables is tested once a particular functional form for $U(\cdot)$ is chosen.

If $\theta = 1$, only w_0 determines the efficient contract; this is what is sometimes termed strong efficiency: a vertical contract curve, coinciding with the labour-demand schedule at the alternative wage. Thus, testing the restriction of a zero coefficient on w in equation (5) represents a test of strong efficiency. If this is rejected, weak efficiency merely requires that the coefficient on w_0 is also nonzero. As a justification for the latter as a test of weak efficiency, Brown and Ashenfelter argue that "the alternative wage rate must determine, at least in part, the marginal revenue product of employment" (1986, p. S43). As we have earlier noted, however, this is the case only if the utility function is not weakly separable between w_0 and the other arguments. Otherwise, the marginal rate of substitution, the basis of the efficiency condition, is independent of w_0. In terms of (5), a typical estimating equation, w_0 would not appear and θ would not be identified.

The question then arises: when a test is possible, what exactly is being tested? In equation (3), for example, the null hypothesis is $\theta = 0$, against the alternative of $\theta > 0$. Now, $\theta = 0$ is a necessary and sufficient condition for the exclusion of N from $U(w, N; X_2)$. This is clear from equation (2): $\theta = 0$ implies and is implied by

$$U = (w - w_0),$$

that is the union cares only about the per-worker rent. If, then, the null hypothesis cannot be rejected, the union's indifference curves are horizontal, so that the efficient contract lies on the labour demand curve. In other words, the null hypothesis is formulated to generate the labour-demand model by appropriate restrictions on the utility function, with efficiency (equation (1)) being retained as part of the maintained hypothesis. Figure 1 illustrates the null and alternative hypotheses, and shows clearly that efficiency is always imposed; as a result, *inefficient* labour-demand solutions cannot be examined in this framework.

What is required, therefore, is a test that explicitly allows the union's utility function to be the same under both the null and alternative hypotheses. Such an approach, albeit one with rather severe data requirements, is proposed in the next section.

III. A MORE GENERAL APPROACH

Manning (1987) proposes that the wage and employment are determined by a sequence of two Nash bargains, the *second* of which is a bargain over employment, written as

$$\max_N q \log U(w, N; \mathbf{X}_2) + (1-q) \log V(w, N; \mathbf{X}_1),$$

where q is the power of the union in this bargain, $1-q$ is the power of the firm, and $\mathbf{X}_1$ and $\mathbf{X}_2$ (now vectors of exogenous variables, replacing X_1 and X_2) include the *status quo* levels of the firm's and union's utilities. The solution is given by

$$N = N(w; q, \mathbf{X}_1, \mathbf{X}_2). \tag{6}$$

The first Nash bargain, that over wages, is written as

$$\max_w p \log U(w, N(w, q; \mathbf{X}_2, \mathbf{X}_1); \mathbf{X}_2) + (1-p) \log V(w, N(w, q; \mathbf{X}_2, \mathbf{X}_1); \mathbf{X}_1),$$

where p is the power of the union in the wage bargain. The wage solution is given by[6]

$$w = w(p, q, \mathbf{X}_1, \mathbf{X}_2). \tag{7}$$

Equations (6) and (7) jointly determine w and N. In empirical applications,[7] equation (6) can be viewed as a structural equation and equation (7) as a reduced form. This recursive structure arises because of the order in which the bargains take place. The reduced form for employment is similarly

$$N = \Pi(p, q, \mathbf{X}_1, \mathbf{X}_2). \tag{8}$$

Both the labour-demand and efficient-contract models are special cases of Manning's model. Consider the case where the union has no power in the employment bargain. In this situation, $q = 0$, and the second stage becomes

$$\max_N \log V(w, N; \mathbf{X}_1) \quad \text{subject to} \quad V_N(w, N; \mathbf{X}_1) = 0,$$

which yields the labour-demand schedule

$$N = N(w; \mathbf{X}_1). \tag{9}$$

[6]As in the previous section, it is usually the case that, when particular functional forms are assumed for U and V, the specification of the employment and wage equations becomes restrictive. For instance, if U_N/U is independent of $\mathbf{X}_2$, $\mathbf{X}_2$ will not appear in equation (6). This will be the case if, as is often assumed, $U(w, N; \mathbf{X}_2) = \phi_1(w; \mathbf{X}_2)\phi_2(N)$, that is, if N is separable from the remaining arguments in the utility function. Alternatively, if a Cobb-Douglas revenue function is assumed, q does not appear in equation (7) (Manning, 1987, p.130).

[7]See, for example, Nickell and Wadhwani (1991).

If there is bargaining over the wage, as in the right-to-manage version of the labour-demand model, the first-stage bargain is written

$$\max_{w} p \log U(w, N(w; \mathbf{X}_1); \mathbf{X}_2) + (1-p) \log V(w, N(w; \mathbf{X}_1); \mathbf{X}_1)$$

subject to the outcome in the second stage. This yields a wage equation of the form[8]

$$w = w(p, \mathbf{X}_1, \mathbf{X}_2). \tag{10}$$

The restriction that yields the efficient-contract model is $p = q$. Let $p = q = \lambda$; the problem reduces via the envelope theorem (see proposition 1 in Manning (1987)) to a *joint* Nash bargain over wages and employment of the form

$$\max_{N,w} \lambda \log U(w, N; \mathbf{X}_2) + (1-\lambda) \log V(w, N; \mathbf{X}_1).$$

Eliminating λ from the first-order conditions yields the contract curve, which can be written as

$$N = N(w; \mathbf{X}_1, \mathbf{X}_2); \tag{11}$$

the corresponding wage solution is

$$w = w(\lambda, \mathbf{X}_1, \mathbf{X}_2). \tag{12}$$

The two pairs of equations, (9) and (10), and (11) and (12), define the models of interest for our study,[9] but before describing the empirical implementation of this approach, we consider first some pertinent issues, specifically the identification of the different models, and the restriction $p = q$.

Identification of a unique wage-employment locus depends crucially on whether separate proxies for p, q and λ are available. We must admit the possibility of multiple proxies, and use $\mathbf{P}$, $\mathbf{Q}$ and Λ as vector representations. If the functions $w(\cdot)$ and $N(\cdot)$ are linear, estimation of each of the models described above is straightforward: apply instrumental-variables methods to the structural equation for N, using as instruments the variables listed as arguments in the corresponding reduced-form equation for w. Furthermore, if the structural employment equations were considered in isolation, it might seem natural to use the same set of instrumental variables for both models. This would treat the labour-demand model as a special case of the efficient-contract model, with the advantage that, because the same

[8]If the union sets the wage unilaterally, as in the monopoly-union version of the labour-demand model, $p = 1$ and the wage solution is $w = w(\mathbf{X}_1, \mathbf{X}_2)$.

[9]That is to say, we do not estimate Manning's general model, only the special cases of interest in the present context.

set of instruments would be used in both the restricted and unrestricted models, inference would be straightforward (Godfrey, 1984). We have earlier argued, however, that the labour-demand model is not, in general, nested in the efficient-contract model, and this can be seen by inspection of the reduced forms corresponding to the models' structural equations. Recall that instrumental variables must be absent from the structural equation estimated, but included in the implied reduced form. Clearly, therefore, each model uses a different set of instrumental variables.

Figure 2 illustrates the implications of our argument for the identification of the two models. For the labour-demand model, it is variations in $\mathbf{P}$ and $\mathbf{X}_2$ that trace out the wage-employment locus, the latter because changes in the union's indifference map in wage-employment space occur without altering the position of the locus. This locus is of course the labour-demand schedule. For the efficient-contract model, the contract curve is the wage-employment locus, and variations in Λ identify its slope. Hence estimation can only succeed if suitable proxies for Λ are available. In an instrumental-variables context, one can only replace Λ by $\mathbf{P}$ and $\mathbf{Q}$, that is, replace equation (12) by equation (7).

To summarize, for the efficient-contract model, only variations in Λ induce shifts along the contract curve; variations in $\mathbf{X}_1$ and $\mathbf{X}_2$ shift the curve itself. For the labour-demand model, it is $\mathbf{P}$ and $\mathbf{X}_2$ that identify the wage-employment locus. Thus, as restrictions on structural-form parameters are imposed in moving from the efficient-contract to the labour-demand model, exogeneity restrictions are relaxed in the corresponding sequence of wage equations, as a consequence of which a test of the two models is non-nested. This is why the specification of appropriate instrumental variables is crucial to a formal comparison of the labour-demand and efficient-contract models, and remains so even if the parameterization on $\mathbf{P}$ and $\mathbf{Q}$ that forms Λ, analogous to $p = q = \lambda$, is not considered.

This last comment poses the question: if the restriction is not considered, can we claim to be testing the efficient-contract model against the labour-demand model? The answer is yes, and the reason can be seen by once again examining the pairs of equations that define the two models in our framework. The crucial distinction between the two in this context is that $\mathbf{P}$ appears in both but $\mathbf{Q}$ appears only in the efficient-contract model. It follows that all that is required is to be able to specify variables that are elements of $\mathbf{Q}$ but not of $\mathbf{P}$ and hence have no bearing on the employment decision if the firm retains the right to manage.

As a demonstration of the points we have been making, we write the models as they would be estimated, assuming linearity (the validity of which is discussed further below), and also that, in the case of the efficient-contract model, $\mathbf{P}$ and $\mathbf{Q}$ enter separately, rather than as Λ.

First consider a linearized version of the employment reduced form, equation (8). The first two terms are then written $\gamma_{1q}q + \gamma_{1p}p$, and p and q, because they are both latent variables, are substituted out using

$$q = a_q'\mathbf{Q} + b_q'\mathbf{Z}$$
$$p = a_p'\mathbf{P} + b_p'\mathbf{Z}.$$

This specification allows for the possibility that there are variables, $\mathbf{Z}$, that influence both the wage and employment bargains. The vectors b_q' and b_p' are vectors of the same dimension, but a_q' and a_p' need not be. The labour-demand model requires $a_q' = 0$; the efficient-contract model requires $\gamma_{1p} = \gamma_{1q}$.[10] Unfortunately, in the absence of any obvious normalizing restrictions on a_p' and a_q', neither γ_{1q} nor γ_{1p} is identified; accordingly, the reduced-form is written with Π_{1q}' replacing $\gamma_{1q}a_q'$, Π_{1p}' replacing $\gamma_{1p}a_p'$, and Π_{1Z}' replacing $\gamma_{1q}b_q' + \gamma_{1p}b_p'$. Identical considerations apply to the wage reduced-form, equation (7), so that the model, if it were estimated, would be written[11]

$$N = \Pi_{11}'\mathbf{X}_1 + \Pi_{12}'\mathbf{X}_2 + \Pi_{1q}'\mathbf{Q} + \Pi_{1p}'\mathbf{P} \tag{13a}$$
$$w = \Pi_{21}'\mathbf{X}_1 + \Pi_{22}'\mathbf{X}_2 + \Pi_{2q}'\mathbf{Q} + \Pi_{2p}'\mathbf{P}. \tag{13b}$$

Equations (9) and (10), the labour-demand model, yield

$$\begin{pmatrix} 1 & -\alpha \\ 0 & 1 \end{pmatrix} \begin{pmatrix} N \\ w \end{pmatrix} = \begin{pmatrix} \mathbf{B}_1' & 0 & 0 & 0 \\ \Pi_{21}' & \Pi_{22}' & 0 & \Pi_{2p}' \end{pmatrix} \begin{pmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \mathbf{Q} \\ \mathbf{P} \end{pmatrix} \tag{14}$$

whose relationship with the reduced forms (equations (13)) implies

$$\Pi_{11} - \alpha\Pi_{21} = \mathbf{B}_1, \tag{15a}$$
$$\Pi_{12} - \alpha\Pi_{22} = 0, \tag{15b}$$
$$\Pi_{1q} = \Pi_{2q} = 0, \tag{15c}$$
$$\Pi_{1p} - \alpha\Pi_{2p} = 0. \tag{15d}$$

Similarly, equations (11) and (12), the efficient-contract model, yield

$$\begin{pmatrix} 1 & -\alpha \\ 0 & 1 \end{pmatrix} \begin{pmatrix} N \\ w \end{pmatrix} = \begin{pmatrix} \mathbf{B}_1' & \mathbf{B}_2' & 0 & 0 \\ \Pi_{21}' & \Pi_{22}' & \Pi_{2q}' & \Pi_{2p}' \end{pmatrix} \begin{pmatrix} \mathbf{X}_1 \\ \mathbf{X}_2 \\ \mathbf{Q} \\ \mathbf{P} \end{pmatrix} \tag{16}$$

[10] This might appear a little unusual. The point is that both p and q exert the same influence on employment, not that they take the same value in the data.

[11] We drop $\mathbf{Z}$ only for expositional convenience.

together with

$$\Pi_{11} - \alpha\Pi_{21} = \mathbf{B}_1, \tag{17a}$$

$$\Pi_{12} - \alpha\Pi_{22} = \mathbf{B}_2, \tag{17b}$$

$$\Pi_{1q} - \alpha\Pi_{2q} = 0, \tag{17c}$$

$$\Pi_{1p} - \alpha\Pi_{2p} = 0. \tag{17d}$$

A comparison of the two sets of restrictions reveals that they are not nested. The labour-demand model is tested by the overidentifying restrictions implied by $\Pi_{12} - \alpha\Pi_{22} = 0$ (assuming Π_{12} and Π_{22} are not scalars) and by $\Pi_{1q} = \Pi_{2q} = 0$; the efficient-contract model is tested by the overidentifying restrictions implied by $\Pi_{1q} - \alpha\Pi_{2q} = 0$. If, then, the variables represented by $\mathbf{Q}$ are significant in *neither* the estimated reduced-form equation for the wage *nor* that for employment, this represents evidence in favour of the labour-demand model; if either is significant, if, that is, $\Pi_{1q} \neq 0$ or $\Pi_{2q} \neq 0$, their variation helps identify the contract curve in the efficient-contract model (together with variation in $\mathbf{P}$ variables).

Now that we have established the non-nested nature of the restrictions on the reduced forms, it is worth considering what happens if there are no suitable proxies $\mathbf{Q}$ and $\mathbf{P}$, but only a general set of union power variables $\mathbf{Z}$, that is, $a'_q = a'_p = 0$. The theoretical restriction $p = q$ is tested by $b'_q = b'_p$, normalising γ_{1p} and γ_{1q} to unity. Now the employment reduced-form contains the term $(b'_q + b'_p)\mathbf{Z}$, and so $b'_q = b'_p$ cannot be tested, even when using full-information methods. Moreover repeating the algebra above reveals that the difference between the models is $\Pi_{12} - \alpha\Pi_{22} = \mathbf{B}_2$ for the efficient-contract model, and $\Pi_{12} - \alpha\Pi_{22} = 0$ for the labour-demand model. In other words—reinforcing our discussion earlier—when the instrumental variables are the same, the test is a nested one, namely $\mathbf{B}_2 = 0$. This is the (standard) test discussed in Section II.

IV. AN EMPIRICAL ILLUSTRATION

The competing labour-demand and efficient-contract models each specify two equations determining employment and the wage, which necessitates the use of non-nested techniques in a systems framework. This can be achieved in one of two ways. The models can be considered as complete, and estimated using full-information methods, or they can be considered as single structural equations, and estimated using limited information methods such as instrumental-variables. In what follows, we adopt the latter approach, using the test proposed by Smith (1989).

The prospects for implementation of our procedure clearly depend critically on data considerations. It must be acknowledged that it is frequently difficult enough to find measures of union power, without having to make the distinction between whether they relate to the wage or employment part of the bargain. Yet without this distinction, the two models cannot be separated.

A data set that has the potential for making this distinction is the establishment-level information collected in the UK by the Workplace Industrial Relations Surveys (WIRS) of 1980 and 1984, which specifically asked questions (of establishment managers) that related directly to the ideas emphasized in the previous section, namely about issues other than pay that were the subject of negotiation. Each year's survey data taken alone do not provide enough other information to prove useful for our purposes: no variables are available that measure the size of the establishment, which is required to parameterize the equation to be estimated in wage-employment space.[12] A number of establishments were, however, surveyed in both years, some by design, some by accident, from which the WIRS 1984 Panel File has been assembled. By differencing these panel data, we are able to abstract from considerations of scale. In this way, estimation of the following empirical model is feasible.

IV.1. THE MODEL

The two structural equations to be estimated are the top rows of equations (14) and (16). Because these equations are linear, we can difference out the fixed effect. Further we argue that it is appropriate for the data to be measured in levels, not logarithms, since differenced variables for a small establishment will possibly cause it to be over-represented in the sample if the differences measure percentage, rather than absolute, changes. A linear-in-levels specification, equation (5), was derived from (2) and (3) earlier, but various modifications are necessary for empirical implementation.

First consider the union's utility function, (2) above. The appropriate wage variables are the contract wage (w) and the alternative wage (w_0), both deflated by the consumer price index, p_c. Thus, equation (2) becomes

$$U = N^{\theta}\left(\frac{w}{p_c} - \frac{w_0}{p_c}\right); \qquad \theta \geq 0. \tag{18}$$

For the firm,[13] we assume that it faces an inverse demand for its output (Y) of the form

$$p_y = p^* \phi(Y); \qquad \phi' \leq 0,$$

[12] A regression of employment (itself a measure of establishment size) on wages cannot be a labour-demand or efficient-contract schedule because the data refer to shifts of the schedule as establishment size varies across a given cross section.

[13] The usage of 'firm' reflects standard terminology, although as we have already indicated, the unit of observation is the establishment.

where p_y is the firm's output price and p^* is the industry price. For an industry that is perfectly competitive, ϕ' is zero, and $\phi(Y)$ is normalized to unity. The revenue function can now be written as

$$p^* R(N, K),$$

which has the advantage that, irrespective of whether the firm is able to set a price different from the industry price, the appropriate deflator in the real product wage is the (exogenous) industry price, which is observed. (The firm's output price, like its output, is not observed, but because it is endogenous it can be substituted out anyway.) The linear marginal revenue product schedule, (3) above, implies that

$$R(N, K) = -\frac{1}{2}\phi_1 N^2 + \phi_2 NK. \tag{19}$$

The solutions to the Nash bargains are

$$N(w; \mathbf{X}_1) = \frac{1}{\phi_1}\left(\phi_2 K - \frac{w}{p^*}\right) \tag{20}$$

for the labour-demand model, and

$$N(w; \mathbf{X}_1, \mathbf{X}_2) = \frac{1}{\phi_1}\left(\phi_2 K - (1-\theta)\frac{w}{p^*} - \theta\frac{w_0}{p^*}\right) \tag{21}$$

for the efficient-contract model. Note that the appropriate deflator for w_0 is the industry price, not the consumer price. This occurs when the union's utility function is homogeneous of degree one in both w/p_c and w_0/p_c, in which case it is written

$$U = \left(\frac{p^*}{p_c}\right) U(w/p^*, w_0/p^*, N)$$

with the obvious implication that the wedge, p^*/p_c, cannot influence the outcome of the Nash bargain. Our particular functional form exhibits this sensible property.

Although our choices of revenue function (quadratic) and utility function (Stone-Geary) generate linear structural forms, necessary for the reasons given above, the associated restricted reduced forms for wages are not linear in p and λ; specifically, they are

$$w = w_0 + \frac{p}{2 + p(\theta - 1)}(\phi_2 K - w_0)$$

for the labour-demand model and

$$w = w_0 + \frac{\lambda}{2 + \lambda(\theta - 1)}(\phi_2 K - w_0) \tag{22}$$

for the efficient-contract model.

The empirical counterparts to both (20) and (21) can be written as

$$N_{it} = \gamma_t + \alpha W_{it} + \beta K_{it} + \mathbf{B}_1' \mathbf{X}_{1it} + \mathbf{B}_2' \mathbf{X}_{2it} + u_{it}; \qquad t = 1, 2 \tag{23}$$

where i indexes the establishment, $t = 1$ refers to 1980, and $t = 2$ to 1984. $W \equiv w/p^*$, where p^* is the SIC 4-digit industry producer price index. $W_0 \equiv w_0/p^*$ is included, together with other proxies for the typical worker's opportunity costs, in $\mathbf{X}_{2it}$. Finally, $\beta \equiv \phi_2/\phi_1$, but α is defined as either $-1/\phi_1$ or $-(1-\theta)/\phi_1$, depending on which model is being estimated.

Variables that independently influence revenue ($\mathbf{X}_1$ earlier) are separated into the capital stock, K_{it}, and any others, $\mathbf{X}_{1it}$. Since the former is the standard measure of a firm's scale, its absence from this particular dataset poses a serious problem, to which there are a number of possible solutions.

The first assumes that the capital stock is a fixed effect, that is, $K_{it} = K_i$ in (23). Differencing yields

$$\Delta N_i = \gamma + \alpha \Delta W_i + \mathbf{B}_1' \Delta \mathbf{X}_{1i} + \mathbf{B}_2' \Delta \mathbf{X}_{2i} + \Delta u_i \tag{24}$$

where $\gamma \equiv \gamma_2 - \gamma_1$, and Δ represents the change between 1980 and 1984 for any particular variable. Equation (24) is a simple cross-section regression, and falls precisely into the instrumental-variables framework discussed above. The associated real-product-wage unrestricted reduced forms, the bottom rows of equations (14) and (16) above, are linear in the differences by implication.[14]

A more general variant is to assume the proportionate change in the capital stock is the same for all plants:[15]

$$K_{i2} = \rho K_{i1},$$

which reduces to the previous case when $\rho = 1$. Now the model requires quasi-differencing:

$$N_{i2} = \gamma^* + \rho N_{i1} + \alpha \Delta^* W_i + \mathbf{B}_1' \Delta^* \mathbf{X}_{1i} + \mathbf{B}_2' \Delta^* \mathbf{X}_{2i} + (u_{i2} - \rho u_{i1}) \tag{25}$$

where $\gamma^* \equiv \gamma_2 - \rho\gamma_1$ and $\Delta^* Z_i \equiv Z_{i2} - \rho Z_{i1}$ for any variable Z_i. Estimation is by non-linear instrumental-variables, where an instrument is additionally required for N_{i1}, which is correlated with the equation error. The WIRS dataset records total (that is, manual and non-manual) employment for 1979, the year prior to the first survey, which is ideal in this context.

A third approach is to difference (23) as it stands, and replace ΔK_{it} by total investment over the four-year period. Investment at the level of the individual establishment is not

[14] Were we to adopt full-information estimation methods, these would be derived by linearizing the restricted reduced forms above.

[15] We are grateful to Mark Stewart for this suggestion.

observed, but data do exist on investment by SIC 4-digit industry groups. The WIRS data report the SIC 4-digit code for each establishment, and an estimate of the establishment's share of the industry's investment can be calculated by dividing by the number of firms in the industry.[16] This yields

$$\Delta N_i = \gamma + \alpha \Delta W_i + \beta I_i + \mathbf{B}_1' \Delta \mathbf{X}_{1i} + \mathbf{B}_2' \Delta \mathbf{X}_{2i} + \Delta u_i \tag{26}$$

where $I \equiv \Sigma_{j=0}^{3} I_{80+j}$; I_t is nominal net capital expenditure deflated by the price of plant and machinery in year t. The advantage of this specification is that it deals with other fixed effects not related to the capital stock, providing our approximation is good enough.

IV.2. THE DATA

The WIRS 1984 panel comprises 235 responding establishments, of which 217 reported that they employed skilled manual workers, the subset of the workforce on which we have chosen to concentrate.[17] Of these 217, 147 establishments indicated that one or more unions were recognized for the negotiations of pay and conditions in both 1980 and 1984.[18] The 147 unionized establishments reduce to 107 once we impose the further condition that information should be available for both years on the wages of skilled manual workers and the number employed; an additional 8 establishments were dropped from the data set because the first difference of skilled manual employment seemed implausibly large, suggesting a change in the nature of the establishment between the two surveys. Absence of investment data forced the exclusion of a further 21 plants, but 16 of these are public-sector establishments, for which the firm-union bargaining paradigms above may be anyway less appropriate. The outcome is a dataset covering 78 unionized establishments. The descriptive statistics for all variables used are reported in Table 1.

For employment (N) and wages (w) we take the reported number of skilled manual employees and their gross weekly earnings. The nominal wage reported is a categorical variable, and we use the midpoint of each range. For the lowest range (running from zero) and the open-ended uppermost range, we imposed bounds to close the groups following the procedure adopted by Blanchflower (1984). It should be noted that the survey questions relating to the wage changed between the two years: in 1980, an average across male and female workers was requested, but in 1984, the wage of the group forming the majority of the

[16]The sources for the data required to construct these variables are *Business Monitor*, published by the Business Statistics Office, and *British Business*, published by the Department of Trade and Industry.

[17]This is the only category of the manual workforce for which employment and wage data are available for both 1980 and 1984. Total manual employment is provided for both years, but not the associated wage. The latter could be constructed for 1984 as a weighted average, but this is not possible for 1980.

[18]In 34 establishments, unions were not recognized in either year, and these could be treated as competitive firms. No plant changed its status between the two years; see Millward and Stevens (1986).

relevant skill category was instead collected. This can pose problems for some applications,[19] but does not seriously trouble us since the vast majority of our establishments employed only male skilled manual workers.[20] $\mathbf{X}_{1it}$ collects the other variables, apart from the capital stock, that independently shift the revenue function. We include the price of raw materials and fuel deflated by the industry price, $Q_i \equiv q_i/p_i^*$, for those plants where this information is available.[21] Although our formal derivation above did not explicitly include raw materials and fuel (M) as a third factor of production, it is straighforward to show it is consistent with adding a term $\phi_3 NM - (1/2)\phi_4 M^2$ to the revenue function, (19) above, for those plants that purchase M (otherwise, Q_{it} is set to zero). Both q_i and p_i^* are indices ($p_{i1}^* = q_{i1} = 100$), but this is not a problem because the regressors are rates of change. We also include six (minus one) one-digit industry dummies, after differencing.[22]

In our sample, the average fall in employment from 1980 to 1984 was 14 employees, or 8.4%; the real wage increased by 12.8%. Average net capital expenditure was positive, and real raw material and fuel prices fell by 1.9% (including those industries that do not purchase M). In spite of the appearance of a negative wage-employment relationship, the correlation in their changes across plants was only -0.07.

The vector $\mathbf{X}_{2it}$ represents variables other than N and w that independently influence the union's utility, and typically includes proxies for the alternative wage, w_0/p^*. Bean and Turnbull (1988) use real earnings of fulltime manual workers in manufacturing by region. Nickell and Wadhwani (1991) do likewise, except by industry rather than region, and also include the unemployment rate by industry. We employ real earnings by industry, matched to establishments according to the SIC 2-digit code, and real earnings, and the unemployment rate, both by region.[23] The alternative wage, like the contract wage, rose between 1980 and 1984, by 8.0% across regions and by 9.0% across industry. That the levels of these two variables are higher than the contract wage is not a problem, as we are concerned with changes only. The unemployment rate rose 7.4% over this period. Ten (minus two) region dummies are also added.[24]

[19] See, for instance, the complications introduced by this change for the analysis in Stewart (1991).

[20] Nearly three-quarters of the establishments in our sample employed no women as skilled manual workers at all, and in over 80% of the establishments the proportion of skilled manual workers that was female was less than 5%.

[21] At the two-digit SIC level.

[22] Using a greater number of dummies, to distinguish between, say, two-digit groups, exhausts too many degrees of freedom. The six one-digit codes we use are 1 to 6.

[23] The earnings data are taken from the *New Earnings Survey* for 1980 and 1984, and the unemployment data from various issues of the *Department of Employment Gazette*.

[24] This is best interpreted as a misspecification check, given that the unemployment rate varies only at the regional level. This is because the choice of the eight independent dummies is quite arbitrary, yielding a meaningless estimate on the regional unemployment rate. This parameter can only be interpreted if the dummies can be dropped. A similar problem occurs with regional earnings: although the data actually vary

The additional instruments used in estimating both structural equations are the empirical counterparts to p and q, the scalar quantities ($0 < p, q < 1$) that measure the power of the union relative to the firm in the wage and employment bargains respectively. These are vectors of proxy variables **P** and **Q**. Section III emphasizes that it is variation in such proxies across establishments that identifies the structural equation being estimated;[25] moreover, further variation (that is, change) in these variables between 1980 and 1984 is also needed given that all the instruments in the model will be used as differences.

Because we use limited-information estimation methods, we cannot examine the theoretical restriction $p = q$. As we have earlier noted, however, a crucial difference between the two competing models is that **Q** variables appear only in the efficient-contract model, though **P** variables appear in both. In other words, all that is required is to specify which indicators of union power are *not* appropriate if the firm retains the right to manage.

There are three variables that can represent **P**, that is, indicate potential power in a wage, and possibly employment, bargain: a union density variable, the proportion of full-time manual employees in the establishment who were members of unions, plus two dummy variables. The first takes a value of one when some or all manual workers had to be members of a union to have or keep their jobs (a closed shop) and zero otherwise,[26] and the second dummy takes a value of one when this arrangement required that some or all of the workers had to be union members before starting work (a pre-entry closed shop) and zero otherwise.

As we have already noted, because it is differences in **P** that are to be used as instruments in our estimation, sufficient variation is required between 1980 and 1984 to render these proxies useful. There is some, albeit weak, evidence of such variation. Table 1 shows that there was almost no change in average union density for our sample, but within individual establishments there was considerable change, as is evidenced by the standard deviation of the difference of 11.0%. The number of establishments (out of 78) reporting a closed shop increased by 8, offset by a fall of 5 in pre-entry closed shop; more importantly, 9 report a change in closed-shop status between the two years, and 11 report a change in pre-entry

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for each plant, this is only because p^* varies across industries.

[25] Earlier authors, notably Bean and Turnbull (1988, p. 1094), have recognised that the choice of instruments is important and difficult, without the added complication of separating potential candidates into either **P** or **Q**. Brown and Ashenfelter (1986) attempt to identify their efficient-contract schedules using lagged contract wages, MaCurdy and Pencavel (1986) use city dummies and time trends, whereas Card (1990) makes use of imperfect indexation provisions, that is, unexpected real wages are used as an instrumental variable. Bean and Turnbull (1988) themselves use proxy variables for the *status quo* points in the bargains as instruments.

[26] In the 1984 survey, a distinction was made between required closed shops and those recommended by the management. Stewart treated only the former as closed-shop agreements, but expresses the concern that, in the absence of such a distinction in the 1980 survey, some recommended closed shops may have been identified with the required closed shops (1988, p. 24n). We have reversed his procedure, so our concern is that such recommended closed shops were not so identified in the 1980 survey.

closed-shop status.

Respondents to WIRS were also asked various question about issues besides pay that affect the largest negotiating group. Five issues were offered as possibilities: physical working conditions, recruitment, redeployment, redundancy pay, and staffing levels. We constructed five dummy variables, one for each of these categories, set to one if it was indicated that this issue was the subject of negotiation (either at the establishment or at a higher level) and zero otherwise; these are used to represent **Q**. Notice that the survey does not ask whether employment itself is subject to negotiation; that employment is *not* subject to negotiation is well-established (for the UK, see, for example, Oswald (1993) and Booth (1995, p. 121)). In this context the literal interpretation of the efficient-contract model is clearly inappropriate. The real issue is whether changes in these dummies are correlated with both changes in employment and wages in the reduced forms for the efficient-contract model.

It should be emphasized that, although the five questions were asked about issues besides pay that are negotiated over, it is not clear that redundancy pay is necessarily a **Q** variable. Another possibility is to treat the response as a general indicator of potential bargaining power, that is include it as a **P** variable. The effect of doing so is addressed below.

In the case of **Q**, there is considerable variation between 1980 and 1984, which can be seen from the following two summary tables. In the first table, the initial two columns report, for each issue, the number of establishments in each of the two years that indicated that the issue was the subject of negotiations. For a particular issue, the difference between the two columns understates the true variation unless all establishments changed in the same direction, so the third column records the number of establishments reporting a change between the two years.

Issue (78 plants)	1980	1984	Gross Change
Physical conditions	74	60	18
Recruitment	47	27	29
Redeployment	73	60	16
Redundancy payments	76	44	32
Staffing levels	54	41	27

The second table provides a crosstabulation of the number of nonwage issues negotiated in 1980 and the number negotiated in 1984.

1980	1984: 0	1	2	3	4	5	Total
0	1						1
1			2				2
2	1	1		1			3
3	4		5	3	2	2	16
4	1			5	3	3	12
5	1	7	3	12	9	12	44
Total	8	8	10	21	14	17	78

This evidence establishes that the dummy variables proxying **Q** in our sample[27] do exhibit a reasonable degree of variation between the survey years. It also indicates a fall in the number of issues negotiated over, from an average of 4.15 in 1980 to 2.97 in 1984. This could be interpreted as a shift away from efficient bargaining in 1980 towards wage-only bargaining in 1984. Because of the need to difference the data, which imposes constancy on the parameters in (17), this hypothesis cannot be examined here.

Of course p could have fallen as well as q, which would then be interpreted as evidence in favour of the efficient contract model. If so, we would expect that our proxies are (positively) correlated, as well as *both* being correlated with employment and wages. To examine this question, we summed the elements of **Q** for each establishment, that is, the number of nonwage issues that were the subject of negotiation, and calculated the correlations of this measure with the three components of **P**. The results are as follows:

	union density	post-entry closed shop	pre-entry closed shop
1980	0.0176	0.0941	0.0245
1984	0.2231	0.2215	0.0312

For the differences in the number of issues between 1980 and 1984 (denoted by Δ), and the differences in the components of **P**, the correlations are:

	change in union density	change in post-entry closed shop	change in pre-entry closed shop
Δ	-0.2425	-0.1550	-0.0634

There is no evidence of a relationship between our proxies for p and q.

[27] For details of these variables in the full WIRS samples, see Millward and Stevens (1986).

Before discussing our results, a number of matters merit some discussion. First, one potential avenue for discriminating between the two models is that the labour-demand model implies a distinct sequence of events: wages are bargained first, followed by the firm setting employment, the argument being that the wage is negotiated once a year, with employment-related changes occurring more frequently. The data we have cannot make use of this *a priori* information, since they refer to one year or wage round. Instead, N and w are simply treated as jointly determined in both models; this is checked using standard exogeneity tests. If the wage is endogenous, Sargan's overidentification test is also reported.

Second, large plants, which tend to be more heavily unionized, were oversampled in WIRS. We cannot tell to what extent our much smaller sub-sample is non-representative; this is just one among a number of reasons why we report heteroskedastic-consistent standard errors.

Third, though we recognize that static models of labour demand are generally misspecified, we nonetheless eschew a dynamic generalization of (23). There are two reasons. Primarily, the data are not adequate, since they record total employment for 1979 or 1983, not the skilled manual employment, the behaviour of which we are attempting to explain. Also, there is no corresponding information on right-hand-side variables for these years. But even if there were adequate data, the relationship between dynamics and fixed effects is a tricky one in these models, given that differencing is used to remove the fixed effects. In fact each model *could* be viewed as being an ADL(1,1) with a common-factor restriction of unity being imposed, but whether the data are picking up any genuine dynamics is not clear.[28]

Fourth, the unconditional sample means for the dependent variable, by region, display little variation: the $F(9,68)$-statistic for the null hypothesis of no variation is 0.84 [0.58].[29] There is, however, variation in the unconditional means by 2-digit industries ($F(5,72)$=2.54 [0.036]). This disappears when estimating the conditional means, as neither set of dummies (region or industry) was significant, and they were therefore dropped from the equations, and from the instrument sets (where appropriate). Their omission allows a meaningful interpretation of the proxies for the alternative wage (see footnote 24 above).

Finally, in all specifications the capital stock variable was the most significant variable, so (26) was preferred to (24) and (25) as a method for dealing with the scale problem.

An additional comment is appropriate before we turn to a consideration of the results

[28]Lockwood and Manning (1989) have formalized the use of costs of adjustment in union-firm bargaining models and show that dynamic bargaining involves more than simply adding lagged employment terms to the static regressions that we estimate.

[29]We report F-statistics throughout, since they are the best small-sample approximation to asymptotic chi-square distributions. P-values are reported in square brackets.

themselves. In the light of the various qualifications regarding the quality of the data—for example, there are only 78 plants, there is no directly observed control for the size of the plant, and the dependent variable is skilled manual employees only—it is important to avoid the temptation to read much into the results. We should stress, therefore, that our purpose in this exercise is solely illustrative. We seek only to demonstrate how application of the standard model can lead to inappropriate conclusions, and thereby to emphasize the empirical importance of the specification of the instrumental variables.

Table 2 presents our results, based on differences of the 78 observations.[30] Columns 1 and 3 report instrumental-variable estimates of the efficient-contract and labour-demand models; columns 2 and 4 are the equivalent least-squares estimates. The fifth and sixth columns are the reduced forms for employment and contract wage respectively. Both are specified with a full set of instruments, that is, they correspond to the efficient-contract model.[31]

The contract wage in the labour-demand model is reasonably well determined when estimation is by instrumental-variables (column 3). The exogeneity test compares columns 3 and 4, and suggests that the least squares estimates should be discounted. The contract wage in the efficient-contract model is less well-determined, so the choice between instrumental-variables and least-squares is less clear-cut. This, of course, may simply reflect a vertical contract curve as a consequence of risk-neutral union preferences, with the alternative wage picking up any wage-employment correlations.

If the coefficients of the efficient-contract model are interpreted in the context of the utility function and the linear marginal-revenue function given in equations (18) and (19), then the two alternative wage variables should be combined. For the instrumental-variables case, column 1, if the restriction that the two coefficients are equal[32] is imposed, the (restricted) parameter estimates are -0.137 for the contract wage and -0.153 for the alternative wage. These yield $\phi_1 = 3.45$, and a value of 0.53 for θ in the utility function, which suggests a smaller weight on employment than on the per-worker rent. (This is why the contract curve is downward sloping.) In the least-squares case it is the alternative wage, not the contract wage, that shows up, mainly through the industry proxy. Summing the two alternative wage estimates yields $\phi_1 = 3.92$ and $\theta = 0.97$.

For the labour-demand model, $\phi_1 = 4.05$, and so the first three columns of results generate quite similar estimates of ϕ_1. A direct estimate of the employment-contract wage elasticity

[30] The estimation packages were DPD, written in the Gauss programming language by Arellano and Bond (1988), and TSP.

[31] The equivalent reduced forms for the labour demand-model, not reported, omit the five **Q** variables.

[32] The $F(1,70)$ statistic is 0.003.

of about 1.80 is implied,[33] which is quite high. The estimate on the capital stock is also similar for the first three columns, that is $d\Delta N/dI$ is estimated at about 320, converting to an elasticity of 0.056. In the absence of capital-stock data, an elasticity of employment with respect to the capital stock cannot be computed. The coefficient on the real price of raw materials and fuel is, however, less robust, though always positive, indicating that the substitution effect dominates the scale effect, a finding not in line with most UK evidence. Both employment and the real price of raw materials and fuel did, however, fall on average over the four-year period. The estimate is probably poorly determined as a consequence of there being 49 out of 78 plants for which the price is zero.

We now examine whether the reported results support the labour-demand model or the efficient-contract model. Past practice has typically involved assessing the joint significance of coefficients on $\mathbf{X}_2$. If we were to take this route, a test statistic could be calculated from the results reported in Table 2 in one of three ways. Either the least-squares estimates (column 2 versus column 4) or the instrumental-variables estimates (ensuring that the instrument sets are the same for both the null and alternative hypotheses) could be used, and in the latter case, $\mathbf{Q}$ could be included in, or excluded from, the instrument set. The $F(3,71)$-statistics [P-values] for these three cases are 1.07 [0.37], 0.28 [0.84] and 0.21 [0.89], none of which is significant, which would be interpreted as failure to reject the null, and hence confirmation of the labour-demand model.

Consider again Figure 1 in the context of the two models estimated by instrumental variables. When the efficient-contract model is estimated, union preferences take their usual shape, the point estimate of θ being 0.53. This parameter (together with the parameter on the regional unemployment rate) is not estimated with enough precision for it to reject the null hypothesis that the labour demand model is true. By construction, therefore, $\theta = 0$, that is the union's indifference curves are flat. This is the basis of our argument in Section II that this approach is restrictive. Figure 2 illustrates the more general case.[34] Section III showed that a direct comparison of the labour-demand model against the efficient-contract model is not possible in this framework, and a non-nested test is required to distinguish between the models. We therefore apply such a test, and since our exposition of the non-nested framework rests crucially on employing alternative sets of instrumental variables, we consider in what follows only columns 1 and 3 of Table 2.

For the limited information approach we have adopted, we choose a non-nested test with

[33] The ratio of sample means was 6.46 in 1980; 7.96 in 1984.

[34] Unfortuately when limited information methods are used, an estimate for θ cannot be obtained for the labour-demand model. If full information methods were used, this would be obtained from the *restricted* reduced form for the contract wage, equation (22) above.

a J-test interpretation.[35] The information from the 'other' model is unidimensional, and is constructed by a projection of the structural residual on the own instrumental-variables set, then added to the model being tested; the significance or otherwise of this information is interpreted in the usual way.

When the labour-demand model is the null hypothesis and the efficient-contract model is the alternative, the F-statistic is 0.90; if the hypotheses are reversed so that the efficient-contract model becomes the null, the F-statistic is 0.91. The two models are therefore observationally equivalent, quite a different conclusion from that of the traditional approach, where the efficient-contract model is clearly rejected.

We indicated above that the redundancy pay dummy might be better treated as a **P** than as a **Q** variable. Such a reclassification cannot have any effect on our reported estimates for the efficient-contract model, as the instrumental-variables set is unchanged. The estimates for the labour-demand model will necessarily change, there being one more instrument ($M = 10$), but they alter by so little they are not reported. When the labour-demand model is the null hypothesis the F-statistic is 5.14; when the efficient-contract model is the null hypothesis it is 6.29. Now the alternative model is rejected, whichever model is the null.

Clearly, the test outcomes are sensitive to the choice of instrumental variables. We view this as a demonstration of the validity of our approach, which emphasizes the role of instrumental variables in identifying the structural-form parameters of interest. Whether redundancy pay is best treated as a **P** or a **Q** variable is left as an open question, but one implication of the sensitivity of our results to the choice one makes is that the redundancy pay dummy is strongly correlated with either employment or the contract wage or both. In fact, it has the biggest effect on employment of any of the **Q** variables: those plants that did not negotiate redundancy pay lost, on average, 42 more employees between 1980 and 1984 than those that did not.

We now examine the estimated reduced form equations, columns 5 and 6 of Table 2, to establish which features are driving our results. (The relationship between the two models and the two reduced forms are given by equations (15) and (17) above.) In general most variables are more strongly correlated with employment than the contract wage, but those variables that are correlated with the contract wage help identify α, the parameter on the contract wage in both structural models, as α is identified by all expressions of the form $\Pi_{1i} - \alpha\Pi_{2i} = 0$ (equations 15b, 15d, 17d). For the efficient-contract model, α is effectively identified by correlations in the industry wage with both employment and the contract wage;[36] for the labour demand model α is also identified by the pre-entry closed shop dummy.

[35] For details of this test, see Smith (1989).
[36] $\widehat{\alpha} \approx -(-0.124)/0.898$

(This explains why the contract wage is better determined when instrumental variables are used, given that employment and wages are themselves uncorrelated.) Notice also that the coefficients on $\mathbf{X}_1$ are mainly determined in the employment reduced form, because the $\alpha\Pi_{21}$ terms in (15a) and (17a) are much smaller than the Π_{11} terms.

As noted in Section III, the first potential difference between the two models is which of equations (15b) or (17b) is better supported by the data. Since we have already argued that the industry wage identifies α, and because $\mathbf{B}_2$ in the efficient contract curve model is close to zero, the evidence favours (15b), the labour-demand model. This part of the comparison is the standard approach.

The second potential difference between the two models arises because of the five variables in $\mathbf{Q}$ that are included in the two reduced forms for the efficient-contract model, but are excluded from those for the labour-demand model. Recall that these are central to the non-nested nature of the two models: without them the models are nested. In the equation reported in column 5, the employment reduced form for the efficient-contract model, the variables are jointly significant at a 11% significance level: $F(5{,}64) = 1.89$. They are, however, much less well determined in the equivalent reduced form for contract wages in column 6: $F(5{,}64) = 0.19$. This constitutes evidence *against* the labour demand model, that is equation (15c) does not hold. It also suggests that (17c) does not hold.

Taken together there is evidence against both models. Whether this evidence is strong enough for a formal rejection in the non-nested test statistics depends on whether the redundancy pay variable is a $\mathbf{P}$ or $\mathbf{Q}$ variable. When it is a $\mathbf{P}$ variable, there is an extra over-identifying restriction in $\Pi_{1p} - \alpha\Pi_{2p} = 0$. Because the estimated coefficient in the contract wage reduced form (not reported) is insignificant, this is enough to reject the labour demand model, and therefore the efficient-contract model. As a consequence the Sargan test increases from 0.28 to 0.80.

The reader may feel that, given our expressed qualifications regarding the quality of the data, we are falling foul of our warning and reading too much into the results. We re-emphasize, therefore, that we seek only to illustrate that, given our data, if there were no separate $\mathbf{Q}$ variables, but only general union power proxies $\mathbf{P}$, we would not be able to reject the labour-demand model against the more general efficient contract model. In our approach, because employment is correlated with the $\mathbf{Q}$ variables, this constitutes evidence against the labour-demand model (that is, $q \neq 0$ in Manning's framework), and so a different test outcome is obtained, namely that the two models cannot be separated.

V. SUMMARY

We argue that the labour-demand model is not in general a special case of the efficient-contract model, and that nested tests that distinguish between the two in terms of restrictions on the union's utility function are restrictive. Following Manning (1987), we advocate a more general approach that allows the utility function to be the same for both models and focuses instead on what we regard as the critical distinction between the two models, namely the power of the union to negotiate over employment. In this framework, the labour-demand and efficient-contract models, although non-nested, are nested within Manning's general model. A central feature is the variation in the set of instrumental variables across the models under consideration.

The advantage of our approach is demonstrated in an illustration based on an implementation that uses the WIRS 1984 Panel File. Our non-nested test outcomes suggest that the labour-demand and efficient-contract models cannot be separated, which is a result that could never be reported in standard comparisons of the two models, where variables that shift union preferences are added to a standard labour demand equation, and tested for significance. Such a test, faced with our results, would incorrectly reject the efficient-contract model against the labour-demand model, given the observed correlations between employment and alternative wages, and between employment and the variables we have used to proxy power in employment bargains.

Our approach is different because it tests whether outcomes are efficient, instead of retaining efficiency as part of the maintained hypothesis. In particular, the labour-demand model does *not* require efficiency for it to reject the efficient-contract model, as is usually required in the design of tests that attempt to discriminate between these competing models of wage and employment determination in unionized labour markets.

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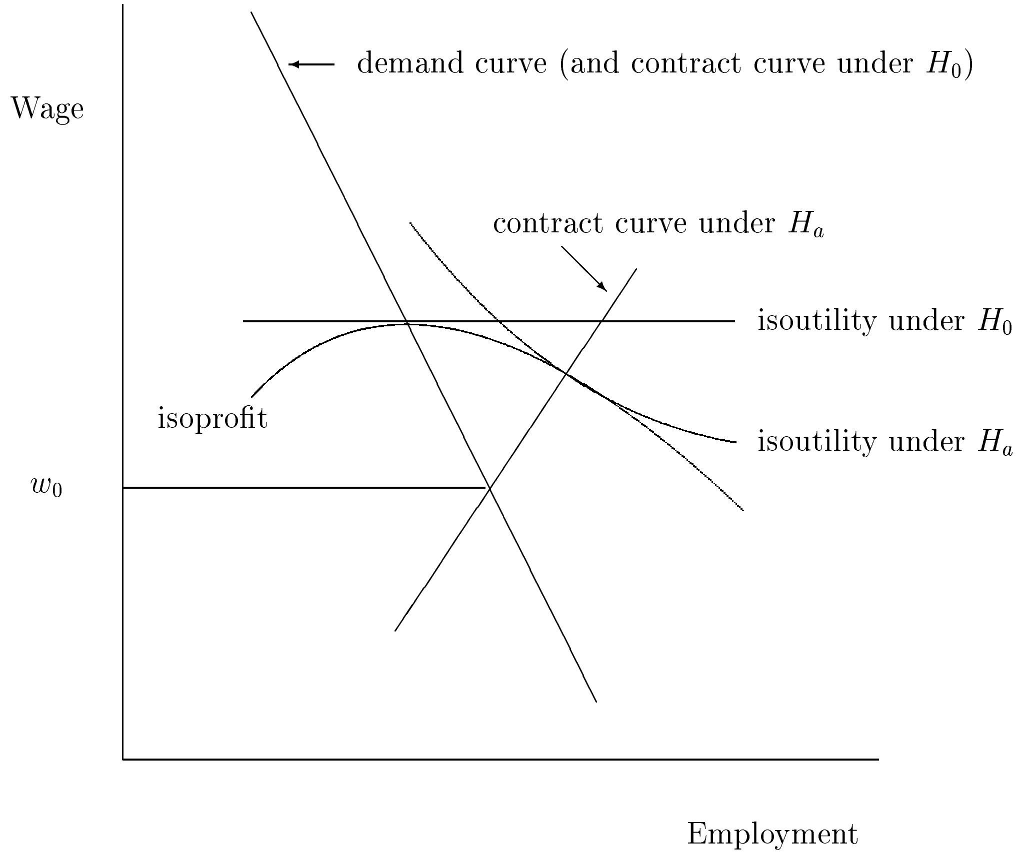

Figure 1: The standard, nested approach

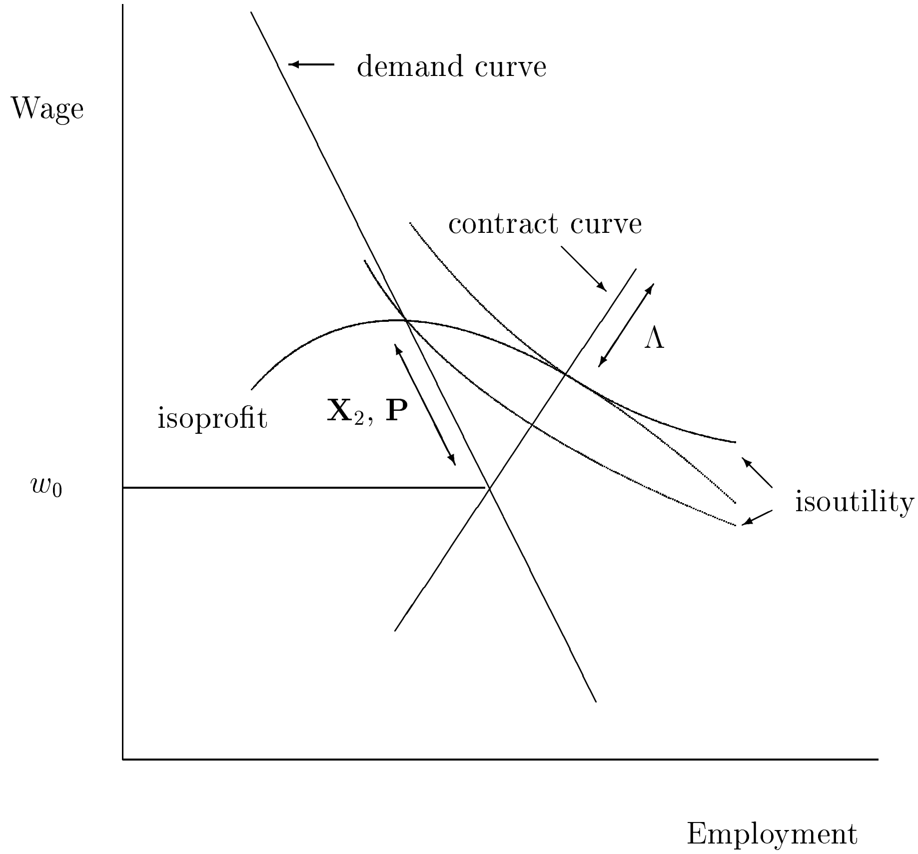

Figure 2: Our proposed, non-nested approach

Table 1: Descriptive Statistics

	Levels, 1980				**Levels, 1984**				**Differences**			
Variable	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Employment	166.141	217.281	0	1049	151.897	200.151	2	983	–14.243	76.217	–359	266
Contract Wage	1072.891	192.498	649.39	1650.86	1209.597	264.428	651.27	1970.58	136.706	220.420	–272.10	799.77
$\mathbf{X}_1$ Variables												
Capital Stock									0.029	0.074	0.00	0.27
Real Price of Raw												
Materials and Fuel					1.019	0.064	0.76	1.16	0.019	0.064	–0.23	0.16
$\mathbf{X}_2$ Variables												
Industry Wage	1129.389	100.804	909.54	1504.16	1231.855	164.242	916.87	1540.00	102.465	101.482	–243.03	346.84
Region Wage	1103.861	36.357	1030.81	1189.24	1192.107	102.403	816.98	1453.92	88.246	87.453	–213.82	303.79
Region Unem. Rate	7.992	1.900	5.40	10.90	15.414	3.307	11.30	19.80	7.421	1.635	5.20	9.50
P Variables												
Union Density	0.876	0.189	0.30	1	0.864	0.196	0.14	1	–0.012	0.110	–0.36	0.49
Closed Shop	0.666	0.474	0	1	0.769	0.424	0	1	0.102	0.345	–1	1
Pre-entry Closed Shop	0.179	0.386	0	1	0.115	0.321	0	1	–0.064	0.372	–1	1
Q Variables												
Physical Conditions	0.948	0.222	0	1	0.769	0.424	0	1	–0.179	0.448	–1	1
Recruitment	0.602	0.492	0	1	0.346	0.478	0	1	–0.256	0.568	–1	1
Redeployment	0.935	0.246	0	1	0.769	0.424	0	1	–0.166	0.438	–1	1
Redundancy Pay	0.974	0.159	0	1	0.564	0.499	0	1	–0.410	0.495	–1	0
Staffing	0.692	0.464	0	1	0.525	0.502	0	1	–0.166	0.567	–1	1

Table 2: Instrumental Variables Estimation[a,b,c]

Model:	Efficient Contract		Labour Demand		Reduced Form	
Estimation Method:	IV	OLS	IV	OLS	OLS	OLS
Dependent Variable:	Employment	Employment	Employment	Employment	Employment	Contract Wage
IVs:	$\mathbf{X}_1,\mathbf{X}_2,\mathbf{P},\mathbf{Q}$		$\mathbf{X}_1,\mathbf{X}_2,\mathbf{P}$			
Contract Wage	–0.143 (0.171)	–0.008 (0.040)	–0.247 (0.139)	–0.023 (0.042)		
$\mathbf{X}_1$ Variables						
Constant	33.7 (53.7)	18.6 (46.0)	9.13 (23.1)	–20.1 (8.28)	38.5 (48.1)	117.1 (144)
Capital Stock	308 (122)	345 (101)	285 (131)	294 (127)	249 (102)	–108 (433)
Real Price of Raw Materials and Fuel	243 (243)	319 (203)	111 (128)	28.9 (103)	272 (192)	–413 (664)
$\mathbf{X}_2$ Variables						
Industry Wage	–0.061 (0.284)	–0.190 (0.171)			–0.124 (0.156)	0.898 (0.640)
Region Wage	–0.088 (0.268)	–0.057 (0.258)			–0.186 (0.249)	–0.147 (0.699)
Region Unem. Rate	–3.76 (6.05)	–3.14 (5.69)			–7.13 (6.38)	–6.34 (18.0)
$\mathbf{P}$ Variables						
Union Density					–121 (70.3)	114 (258)
Closed Shop					15.4 (17.0)	59.5 (82.6)
Pre-entry Closed Shop					17.6 (13.8)	–91.1 (77.7)
$\mathbf{Q}$ Variables						
Physical Conditions					2.08 (14.8)	67.5 (72.3)
Recruitment					28.9 (22.3)	13.0 (59.7)
Redeployment					–19.6 (15.9)	–23.6 (73.6)
Redundancy Pay					–42.0 (18.2)	7.11 (59.7)
Staffing					–12.9 (18.2)	–15.9 (59.1)
No. of IVs (M)	14		9			
No. of regressors (k)	7	7	4	4	14	14
SSR	454649	391210	593899	408961	332430	3348270
Standard error	80.02	74.22	89.58	74.34	72.07	228.7
R-squared	0.063	0.125	0.284	0.086	0.256	0.104
Adjusted R-squared	–0.015	0.514	–0.109	0.048	0.105	–0.076
IV minimand	56265		11343			
Non-nested test[d]	0.91		0.90			
$(1,78-k-1)$	[0.34]		[0.35]			
Sargan test	1.25		0.28			
$(M-k,78-k)$	[0.28]		[0.92]			
Exogeneity test	0.46		3.01			
$(1,78-k-1)$	[0.50]		[0.09]			
Added region dummies	1.09	1.12	0.67	0.90		
$(78-k-9)$[e]	[0.38]	[0.36]	[0.74]	[0.53]		
Added industry dummies	0.64	1.10	0.67	1.20		
$(78-k-5)$	[0.67]	[0.37]	[0.65]	[0.32]		

[a] Standard errors and variances in parentheses below estimates are heteroskedastic-consistent estimates.

[b] All variables are differences between 1984 and 1980 values.

[c] The number of observations is 78.

[d] All test statistics reported are distributed F under H_0. P-values are reported in square brackets. The degrees of freedom for each test statistic are given in parentheses beneath the name of the test.

[e] There are only 8 region dummies when the region's unemployment rate is included.

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