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A Dynamic Model of Trade Union Contract Duration

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ABSTRACT

There has been a great deal of research on trade unions and wage contracts in recent years, but there has been relatively little work on the determinants of contract length. This is unusual given that the duration of union contracts has varied substantiallly in post-war industrial economies both across across time and across countries (See Dunlop J. and Bok D. (1970), Christofides L.N. and Wilton D.A. (1983), Ehrenberg Danziger and San (1984), Christofides L.N. (1985), Cecchetti (1987) and Bils M. (1987). This paper reviews the existing literature on contract duration and presents a simple explanation of optimal contract length for a wage setting trade union in a dynamic, uncertain environment. It is argued that optimal contract duration depends on a basic welfare trade-off between the benefits of wage precommitment and the costs of reduced ex-post wage flexibility. The cyclical characteristics of contracts in the model arguably provide an explanation for actual contractual cycles quite different from some alternative current models. The model may also be used to provide certain empirical predictions concerning the determinants of contract length.

Keywords: dynamic, uncertain, trade union, wage contract, welfare trade-off, precommitment, ex-post flexibility, contractual cycles.

JEL Classification: J40, J41, J51.

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INTRODUCTION

Traditionally, economic models predict that transactions costs and the uncertainty faced by economic agents are key determinants of contract length.[1] More recent models, such as Danziger(1988), Ragan(1990) and Anderson and Devereux(1991), have attempted to combine this traditional analysis of optimal contract duration with an emphasis on the underlying individual preferences of the firm and union in the bargaining unit. In the model presented in this paper, the key factor underlying the determinants of contract length is *the strategic value of wage commitment.* It is argued that contract duration depends on a basic trade-off between the benefits of wage commitment and the costs of reduced ex-post wage flexibility. As such contract lengths across unionised industries should vary depending on the relative importance of each of these factors.

Contracts are interpreted in the model as legally binding agreements which embody full commitment for their duration. An important assumption is that contracts are incomplete in the sense that they cannot be made contingent on all aspects of the employment relationship. This is seen as a rough approximation to actual, observed union contracts, where in almost all cases the only explicit contingencies in the contract are (COLA) cost-of-living allowances (c.f. Card (1986)).

The intuition behind the model can be stated briefly. A firm or industry hires labour competitively at a given wage and uses internal funds for capital investment subject to some physical costs of adjusting the capital stock. With fully efficient contracts a trade union always does better if it negotiates a wage contingent on the firm's investment decisions.[2] This result has been reported in a number of recent papers that analyse strategic issues involved with trade union wage setting (e.g. Grout(1984), Calmfors and Horn(1985), Anderson and Devereux(1988), Van Der Ploeg(1987)). In a dynamic model this implies that a union will desire to precommit to a given sequence of wage rates in advance of

1 See Gray(1978), Fischer(1977) and more recent work by Canzoneri(1980), Dye(1985) and Ball(1987).

2 ie. if it binds itself to a wage before the firm makes its investment decision.

investment and production. Interpretting the period of precommitment as the 'length' of the contract, then with complete contracts longer duration contracts are always better than shorter ones.

However, if fully contingent contracts cannot be written, the inability to adjust wages to labour demand shocks during the life of a contract raises the cost to the union of binding itself to longer contracts. Under incomplete contracts there exists the benefits of wage commitment on the one hand while on the other there are costs of reduced ex-post wage flexibility. Optimal contract duration represents the optimal trade-off between these two factors.

Various parameters of the game determine the importance of each factor. The greater is the elasticity of substitution between labour and capital in production, the greater the benefits from precommitment and the longer contracts will tend to be. Conversely, the higher is the variance of shocks to labour demand, the greater is the cost of reduced ex-post wage flexibility and the shorter will be the length of contracts. A lower discount rate and a higher cost of adjustment for capital both militate in favour of longer term contracts. The model presented analyses the structure of trade union contracts of different lengths in a stationary environment. Stationarity of the contract equilibrium implies that wages, investment and employment, cycle with the same periodicity as the contract length. The cyclical nature of contracts in the model arguably provides an explanation for observed contractual cycles rather different from some alternative current models. The model may also be used to provide certain empirical predictions concerning the determinants of contract duration.

It should be noted at this point that the paper abstracts from any of the issues concerning the appropriate structure within which to model the interaction between union and firm. We choose not to take up the Monopoly Union(Oswald(1982)) versus 'Right to Manage'(Nickell(1986)) versus Efficient Contracts (McDonald and Solow(1981)) debate. It is assumed that labour contracts do *not* contain provisions on the level of employment and that unions set wages independently of any bargaining with firms. Firms take the sequence of union determined wages as given and choose a sequence of capital stocks and labour stocks to maximise present discounted cash flow. This monopoly union framework is used to analyse the separate issue of precommitment versus flexibility which is the focus of this particular paper. Other aspects of trade union wage setting besides bargaining, such as union voting arrangements,[3] union membership effects[4] and insider - outsider effects[5] are left for future consideration.

The paper is organised as follows. The next section reviews the literature while Section III presents the model and examines the characteristics of different length contracts in a stationary environment. Section IV looks at some empirical implications of the contract based dynamics. Finally, Section V contains some concluding observations.

A REVIEW

In the well known paper of Jo Anna Gray(1978), optimal contract length is determined at the margin as a trade-off between the per period losses due to some exogenously postulated transactions costs of contract negotiation and the welfare costs associated with an inability to adjust contract contingencies to ex-post realised deviations of output and employment from desired levels. Given incomplete markets and a distribution for disturbances that associates greater uncertainty with more distant points in the future, it follows that increased uncertainty decreases contract length. On the other hand, increased costs of recontracting lead to a lengthening of contracts.

In a stochastic, continuous time framework Gray develops a simple neoclassical model

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3 See Oswald(1984) and Farber(1986).

4 See Jones and McKenna(1992).

5 See Lindbeck and Snower(1986).

incorporating short-term wage rigidities. These wage rigidities are due to an exogenous contracting cost and a contracting scheme which requires the nominal base wage and an indexing parameter to be set before full information over variables affecting production is obtained. Uncertainty arises in the form of stochastic disturbances in money supply and production functions. This implies both real and monetary shocks to the system. Fixed nominal wages over the life of a contract lead to fluctuations in employment and output via changes in the real wage rate and the marginal product of labour in response to such disturbances. The shocks to both technology and money supply are assumed to follow a Wiener process, hence forecast variances are increasing functions of time. This has the direct implication that optimal contract duration in a particular industry is a negative function of industry specific nominal and real uncertainty.

Thus Gray shows optimal contract length to be a trade-off between fixed transactions costs and the costs due to ex-post wage inflexibility in the face of realised shocks. Contract length may vary across industries due to variations in the size of industry specific disturbances. Also, if indexing is costly then such provisions will only be made in longer contracts. Contract duration is shown to be decreasing in uncertainty and increasing in the costs of renegotiation.

The analyses of Gray(1978), Fischer(1977) and more recent work by Canzoneri(1980), Dye(1985) and Ball(1987) using similar models, predict that transactions costs and uncertainty faced by economic agents are key determinants of contract length. Canzoneri demonstrates that a role for monetary policy is available as a stabilisation instrument in a model of endogenous contract length. Unions set the nominal wage rate and then seek the contract length that optimally trades off contracting costs against costs of greater price level prediction errors and hence greater deviations of the real wage from desired levels. Dye formulates the determination of optimal contract length in a discounted dynamic programming framework. Dye shows that optimal contract lengths are only finite when there exists some rigidity in the contracts and are only non-zero when there exists non - trivial recontracting costs. Again, the comparative dynamics resulting from his model predict that contract length is increasing in the costs of renegotiation. The degree of uncertainty has an insignificant effect on contract length but this is attributed to the assumed risk neutrality of the firm. The relationship between contract length and the correlation between prices in input and output markets is examined and given sufficiently small contracting costs and risk averse workers, optimal contract length is seen to be shortest for the case in which ouput prices and spot market prices are independent.

More recent models, such as Danziger(1988), Ragan(1990) and Anderson and Devereux(1991), attempt to combine the traditional analysis of optimal contract duration with an emphasis on the underlying individual preferences of the firm and union in the bargaining unit. Ragan constructs a model based on risk - sharing motives that emphasise the importance of both real wage and employment variability [6] . The union is risk averse over wages and employment and is shown to always prefer short-term contracts over longer contracts as under longer contracts wages cannot be indexed to real shocks. Ex-post inflexibility of wages induces excess employment variability which serves to lower union expected utility. In contrast the firm has preferences convex in uncertainty and prefers longer contracts under which the union cannot alter wages in response to real shocks.

The costs of ex-post inflexibility in contracting is thus expounded in Ragan and some empirical evidence is presented to support this. However, as Anderson and Devereux(1991) note, investment considerations in such models may allow long term contracts to increase union welfare by providing a commitment value. They analyse a similar model to that of Grout(1984) and Van der Ploeg(1987) where they embed the union in an environment with a competitive industry. Their analysis emphasises the role of precommitment as well as that of flexibility and is essentially a static version of the model presented here.

The analysis presented in the next section of this paper is different from the fixed

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[6] Danziger's paper assumes employment is constant so that there is no allocational role for the real wage in a long term contract. This abstracts from the role of contracts as insurance to workers against possible employment variability.

cost of recontracting analysis in that the interpretation of the costs of renegotiation is very different. The analysis has the cost of more frequent renegotiation postulated not ex ante, but rather as the strategic cost of the absence of precommitment when the environment includes wage setting trade unions.

THE MODEL

The analysis centres around a dynamic model of a monopoly trade union that faces a firm which employs only union labour and invests in physical capital. Employment and production take place each period and time goes on forever. Firms' product price and the rental price of capital are normalised to one throughout and the discount factor ρ obeys $0 < \rho < 1$.

At any time t the firm has cash flow defined by

$$\Pi(k_t, l_t, \theta_t, w_t) \equiv F(k_t, l_t, \theta_t) - w_t l_t - k_{t+1} + k_t - (\frac{\gamma}{2})(k_{t+1} - k_t)^2 \qquad (1)$$

Production depends upon the use of capital input, k_t ,union labour, l_t , and a technology disturbance θ_t which affects the productivity of labour. The disturbance is assumed to be a random variable identically and independently distributed over time with mean $\tilde{\theta}$ and variance σ_θ^2 . There is a direct investment cost to the firm of $k_{t+1} - k_t$ and an internal cost of adjusting the capital stock given by $\frac{1}{2}\gamma(k_{t+1} - k_t)$. $\gamma > 0$ is a coefficient that determines costs, internal to the firm, of adjusting its capital stock rapidly.

The production function is assumed linear quadratic to facilitate use of certainty equivalence operations[7] :

[7] The solution to the quadratic problem has the characteristic that only the conditional means of the exogenous random variables appear, not higher moments. This allows a separation of forecasting from optimisation considerations which is not a feature of most general functional forms but which is computationally very convenient.

$$F(k_t, l_t, \theta_t) = ak_tl_t - \frac{1}{2}bl_t^2 - \frac{1}{2}ck_t^2 + \theta_tl_t + dk_t \qquad where \quad bc > a^2 \tag{2}$$

The coefficient a in the production function is monotonically related to the elasticity of substitution between labour and capital and will be shown to be a key determinant of contract length in the model.

Given the monopoly union bargaining framework employed, the firm behaves in a competitive (Nash) fashion and takes the sequence of union determined wages as given. The objective of the firm at any time is to maximise the expected present value of cash flow from that time onwards. Hence for period one the firm chooses a sequence of capital stocks $\{k_{t+j}\}_{j=0}^{\infty}$ and labour stocks $\{l_{t+j}\}_{j=0}^{\infty}$ to maximise present discounted value

$$V = E_0 \sum_{t=0}^{\infty} \Pi(k_t, l_t, \theta_t, w_t)\rho^t \tag{3}$$

where E is the mathematical expectations operator. This represents a straightforward control problem of the type analysed at length in Sargent(1987).

The first order conditions are given as

$$ak_t - bl_t = w_t - \theta_t \tag{4}$$

$$1 + \gamma(k_{t+1} - k_t) = \rho E_t[al_{t+1} - ck_{t+1} + d + 1 + \gamma(k_{t+2} - k_{t+1})] \tag{5}$$

Optimal employment is determined in each period given the observed θ_t. However, the capital stock has to be chosen in advance of production based on the expected value of both employment and θ_t. The first order conditions can be manipulated to generate a solution for firms' optimal capital stock given a sequence of wage rates. A second order stochastic difference equation is derived as

$$\left[\gamma(1+\rho) + \frac{(bc - a^2)\rho}{b}\right]k_{t+1} - \gamma k_t - \gamma\rho E_tk_{t+2} = \rho d - (1-\rho) - (\rho\frac{a}{b})E_t(w_{t+1} - \theta_{t+1}) \tag{6}$$

It can be shown that this equation has roots $\lambda_1 > 1$ and $\lambda_2 < 1$. The unique convergent solution is given by

$$k_{t+1} = (\frac{1}{\lambda_1})k_t + (\frac{1}{\lambda_1})\sum_{i=0}^{\infty}\lambda_2^i[\rho d - (1-\rho) - (\rho\frac{a}{b})E_t(w_{t+1+i} - \theta_{t+1+i})]/\gamma \tag{7}$$

Trade union behaviour is characterised by an exogenously given fixed membership and risk neutrality on the part of union members. There is also an outside opportunity for union members to earn ω per period. Given any wage, it is also assumed that each union member is employed with equal probability at any time period[8] . The trade union intertemporal welfare function is then given by

$$W = E_0\sum_{t=0}^{\infty}\rho^t(w_t l_t + (N - l_t)\omega) \tag{8}$$

The union's problem is that of determining a wage for each period given the following constraints: a) the current capital stock, b) the labour demand curve for each period, given implicitly by (4), and c) the solution for the determination of future capital stocks given by (7). Thus the model represents a dynamic game between the firm and the union where the union's strategy is the sequence of wage rates $\{w_{t+j}\}_{j=0}^{\infty}$, and the firm's strategy is the sequence of labour and capital inputs $\{l_{t+j}, k_{t+j}\}_{j=0}^{\infty}$.

The crucial factor affecting strategy choice is *the degree of commitment available to the union.* If contracts could be written fully contingent or if there were no unforeseen shocks to labour demand, then commitment is always beneficial. A trade union choosing a sequence of wages subject to a series of labour demand schedules can never be worse off if it takes into account the secondary effect of its wage choice on labour demand through adjustments in capital stock ie. through equation (7). However, given the stochastic environment assumed and the interpretation of contracts as commitment devices, optimal

[8] This assumption is taken to imply that being employed in the past does not increase the current probability of being employed, for given wage and labour demand function.

contract length is *not* infinite. Incomplete contracts and the inability to design contracts containing any contingencies other than wage rates implies that infinite precommitment is not optimal to the extent that ex-post wage inflexibility in the presence of labour demand shocks is inefficient.

To illustrate the forces at work in the contracting decision, the union's problem is solved for one, two and three period contracts. In this way the trade-off between precommitment and flexibility is shown. The optimal contract is the one that delivers the highest expected union welfare. The analysis is restricted to stationary paths for investment and employment.

ONE PERIOD CONTRACTS

When contracts are assumed to be renegotiated each period they effectively have no commitment value. A union that cannot commit to any wage rate beyond the current period takes the current capital stock as predetermined in making wage choices in any period. Thus, the one period contract case is modelled as just a repeated series of static problems for the union. Periods are only interlinked by intertemporal capital stock adjustment.

At any time period t the union chooses the current wage rate to maximise its intertemporal welfare function given by (8), subject to the labour demand schedule given by (4).

$$\max_{w_t} W = E_0 \sum_{t=0}^{\infty} \rho^t (w_t l_t + (N - l_t)\omega) \qquad s.t. \quad l_t = \frac{ak_t + \theta_t - w_t}{b}$$

This gives the solution

$$w_t^1 = \frac{1}{2}(\theta_t + \omega + ak_t) \tag{9}$$

The wage rate responds directly to current shocks under one period contracting. Using equation (6) with $k_{t+2} = k_{t+1} = k_t$ and using the solution for the one period wage rate given by (9) then solving for the stationary value of capital gives the solution

$$k^1 = \frac{(b(\rho d - (1-\rho)) - (\rho\frac{a}{2})(\omega - \tilde{\theta}))}{\rho(bc - (\frac{a^2}{2}))} \tag{10}$$

The level of employment in a stationary equilibrium is derived from equations (4), (9) and (10) to be

$$l^1 = \frac{1}{2}\frac{(a(\rho d - (1-\rho)) + \rho c(\theta_t - \omega))}{\rho(bc - (\frac{a^2}{2}))} \tag{11}$$

and using (8), (9), (10) and (11), the stationary level of union welfare is given as

$$W^1 = \frac{1}{(1-\rho)}\Big\{\frac{1}{4}b\Big[\frac{(a(\rho d - (1-\rho)) + \rho c(\tilde{\theta} - \omega))}{\rho(bc - (\frac{a^2}{2}))}\Big]^2 + \frac{1}{4}(\frac{\sigma_\theta^2}{b}) + N\omega\Big\} \tag{12}$$

TWO PERIOD CONTRACTS

Now examine contracts that allow for two period commitment. Let the union chooses wages in every *even* period, commencing at t=0. Thus at t=0,2,4,..... the union chooses a wage for that period and the following period. By definition contracts are designed such that no decisions are made in odd periods. The key difference relative to single period contracts is that in choosing the odd - period wage the union will find it advantageous to take account of adjustments in the capital stock in response to that odd period wage.

For any representative *even* period, the union faces the problem

$$\max_{w_t, w_{t+1}} E_t \sum_{i=0}^{\infty} \rho^i (w_{t+i} l_{t+i} + (N - l_{t+i})\omega)$$

subject to equations (4) and (7) and the assumption that the set of contract wage rate pairs, $\{w_{t+1+i}, w_{t+2+i}\}_{i=1}^{\infty}$, is determined in the same manner.

First order conditions for the problem are given by:

$$-(w_t - \omega)(\frac{1}{b}) + l_t = 0 \tag{13}$$

$$(w_{t+1}-\omega)(\frac{1}{b}+(\frac{\rho a^2}{\gamma b^2\lambda_1}))+E_t[l_{t+1}+\sum_{i=0}^{\infty}(\frac{\rho}{\lambda_1})^{i+1}(w_{t+2+i}-\omega)(\frac{\rho a^2}{\gamma b^2\lambda_1})]=0 \tag{14}$$

Given these conditions, it is conjectured that a stationary two - period contract equilibrium will produce a *single* value of the capital stock, for all *even* periods and one for all *odd* periods. Investment, the *mean wage* and employment levels are hypothesised to follow a deterministic cycle of periodicity equal to the contract length in steady state. These guesses are verified in the following way:

Let the *mean wage* in even (odd) periods be w_e (w_0) and the capital stock in even (odd) periods be k_e (k_0). For a stationary contract equilibrium to hold it must be the case that first order conditions (4) and (5) hold in every even and odd period. Thus substituting (4) into (5) gives the two conditions

$$(\gamma(1+\rho)+\frac{(bc-a^2)\rho}{b})k_e-\gamma k_o-\rho\gamma k_o=\Omega+(\rho\frac{a}{b})(\tilde{\theta}-w_e) \tag{15}$$

$$(\gamma(1+\rho)+\frac{(bc-a^2)\rho}{b})k_o-\gamma k_e-\rho\gamma k_e=\Omega+(\rho\frac{a}{b})(\tilde{\theta}-w_o) \tag{16}$$

where $\Omega=-(1-\rho)+\rho d$

To determine w_e and w_o we use (13) and (14) in stationary equilibrium:

$$w_e=\frac{1}{2}(\theta_t+\omega+ak_e)-\frac{1}{2}(\theta_t-\tilde{\theta})=w_{t/e}-\frac{1}{2}(\theta_t-\tilde{\theta}) \tag{17}$$

$$w_o=\frac{\omega(1+a^2+(\frac{\rho}{\lambda_1}))\frac{\phi a^2}{b\gamma})}{(2+(\frac{a^2\phi}{b}))}-w_e\frac{(\frac{\rho}{\lambda_1})(\frac{\phi a^2}{b\gamma})}{(2+(\frac{a^2\phi}{b}))}+\frac{(\tilde{\theta}+ak_o)}{(2+(\frac{a^2\phi}{b}))} \tag{18}$$

where $\phi\equiv\frac{(\frac{\rho}{\lambda_1})}{(1-(\frac{\rho}{\lambda_1})^2)}$ and $w_{t/e}$ is defined as the *actual wage in every even period.*

Because the wage is conditional on the current disturbance θ_t, $w_{t/e}$ and w_e will not coincide. It should also be noted that with a = 0, (17) and (18) are the same. This is the extreme case where there is *no cross interaction between capital and labour in technology.* When no cross interaction exists the duration of contracts makes no difference at all for average wages ie. $w_e = w_o = \frac{1}{2}(\omega + \tilde{\theta})$ and the law of motion for capital stock is irrelevant with respect to wage setting decisions for the union.

Equations (15) - (18) can be solved for the values of w_e, w_o, k_e, k_o, l_e and l_o in a two-period stationary contract equilibrium. The stationary level of union welfare under two period contracts can be derived as:

$$W^2 = \frac{1}{(1-\rho)}(w_e - \omega)l_e + \frac{\sigma_\theta^2}{b(1-\rho^2)} + \frac{\rho}{(1-\rho^2)}(w_o - \omega)l_o + \frac{N\omega}{b(1-\rho^2)} \qquad (19)$$

Due to the complexity involved in solving the dynamic game, to evaluate the properties of the stationary equilibrium it is easiest to resort to numerical simulation. This is done with the aid of Tables 1 - 5. In the tables the values of the relevant variables for one period contracts are also shown for comparative purposes.

TABLE 1 Model parameters are specified as follows: $\rho = 0.75$, $a = 1.0$, $\gamma = 1.0$, $\sigma_\theta^2 = 0.07$

Wage	*Capital Stock*	*Employment*
w_1=2.047619	k_1=1.095238	l_1=0.523810
w_e=2.052308	k_e=1.104615	l_e=0.526154
w_o=1.965570	k_o=1.111648	l_o=0.573039

The characteristics of long term contracts display interesting features. With two - period contracts investment, wages and expected employment display two period cycles. The wage is higher in the first period of the contract, falling in the second period due to the fact that the union takes into account the firm's investment decision over the life of the contract. Given such wage behaviour, the optimal capital stock is greater in the second period of the contract. Thus investment is higher in the first period of the contract. Similarly, expected employment is seen to rise over the life of the contract.

Tables 2 - 5 report the level of expected trade union welfare for one and two period contracts, allowing for variations in the four key parameters of the model; a, σ^2, ρ and γ.

TABLE 2 Model parameters are specified as follows: $\rho = 0.75$, $\gamma = 1.0$, $\sigma_\theta^2 = 0.07$

Technology Parameter	*Welfare 1 Period Contracts*	*Welfare 2 Period Contracts*
a=0.8	1.780937	1.726311
a=0.9	2.035694	1.986027
a=1.0	2.335011	2.294074
a=1.2	3.114420	3.114202
a=1.3	3.628259	3.671563
a=1.8	8.967060	10.559680

TABLE 3 Model parameters are specified as follows: $\rho = 0.75$, $a = 1.0$, $\gamma = 1.0$

Variance	*Welfare 1 Period Contracts*	*Welfare 2 Period Contracts*
$\sigma_\theta^2 = 0.005$	2.205011	2.219789
$\sigma_\theta^2 = 0.010$	2.215011	2.225503
$\sigma_\theta^2 = 0.030$	2.255011	2.248360
$\sigma_\theta^2 = 0.070$	2.335011	2.294074
$\sigma_\theta^2 = 0.250$	2.695011	2.499789
$\sigma_\theta^2 = 1.000$	4.195011	3.356931

The higher is a, the greater is the elasticity of substitution between labour and capital in production. This implies that a higher a is associated with greater benefits from pre-commitment and the longer contracts tend to be. Alternatively, the higher is the variance of shocks to labour demand σ_θ^2, the greater is the cost of ex-post wage inflexibility. This implies greater benefits to the short term and contract duration tends to be shorter.

An increase in the discount rate ρ, implies that short term considerations are more prevalent as less account is taken of the future investment actions of the firm in response to the wage rate. This militates in favour of shorter contracts. Increases in γ affect both the intertemporal capital decision and wage smoothing process considerations. As such the initial tendency towards one period contracts and the short term is moderated and reversed at higher levels of γ as wage smoothing effects dominate and precommitment becomes more attractive.

TABLE 4 Model parameters are specified as follows: $\rho = 0.75$, $a = 1.0$, $\sigma_\theta^2 = 0.07$

Cost of Capital Adjustment	*Welfare 1 Period Contracts*	*Welfare 2 Period Contracts*
γ= 0.1	2.335011	2.294237
γ= 0.5	2.335011	2.293444
γ= 1.0	2.335011	2.294074
γ= 3.0	2.335011	2.313489
γ= 4.0	2.335011	2.330482
γ= 4.5	2.335011	2.340415
γ= 5.0	2.335011	2.351227
γ= 10.0	2.335011	2.502210

TABLE 5 Model parameters are specified as follows: $a = 1.0$, $\gamma = 1.0$, $\sigma_\theta^2 = 0.07$

Discount Rate	*Welfare 1 Period Contracts*	*Welfare 2 Period Contracts*
ρ= 0.50	0.787105	0.804694
ρ= 0.55	0.876928	0.896928
ρ= 0.60	0.976051	0.985848
ρ= 0.65	1.103555	1.081818
ρ= 0.70	1.221287	1.197828
ρ= 0.75	1.351565	1.326157
ρ= 0.90	6.522840	6.412406

If contract structures evolve optimally in response to these factors then one should expect to see certain empirical characteristics in the determination of contract length. Industries with greater demand or technological uncertainty should generally exhibit shorter contracts. Industries with a large degree of complementarity between labour and capital should have longer contracts. There is little direct evidence available for these predictions but Christofides (1985) reports that the duration of union contracts in Canada during the 1970's fell siginificantly, even those contracts in which COLA clauses existed. This feature he attributes to the greatly increased environment of uncertainty during that time which is in line with the predictions of the model presented here.

THREE PERIOD CONTRACTS

The solution method for stationary values of wages, capital and expected employment under three period contracts is exactly as in the two period contracts case. Instead of working through unintuitive algebraic derivation again for this case, we choose to report only the results in Table (6).

TABLE 6 Model parameters are specified as follows: $\rho = 0.75$, $a = 1.0$, $\gamma = 1.0$, $\sigma_\theta^2 = 0.07$

Wage	*Capital Stock*
w_a=2.119167	k_a=1.238335
w_b=2.023524	k_b=1.248311
w_c=1.986456	k_c=1.254734

As shown, the main features of the two period contract case are mirrored in the three period contract case. Wages decline over the life of a contract while expected employment and the capital stock increase.

EMPIRICAL IMPLICATIONS

The contract-based dynamics presented above have some empirical interest. Evidence on international differences in average contract duration and bargaining procedures provided by Christofides(1985) suggests that complex institutional histories in the bargaining process across countries makes it more appropriate to concentrate on differences in contract duration across time and across industries *within* a particular country[9] .

Christofides and Wilton(1983) empirically evaluate the claim that uncertainty is a factor determining contract length using a large sample of individual contract data from the Canadian unionised sector. They provide evidence that inflation uncertainty diminishes contract length and that this effect is significant over and above transaction cost considerations. Christofides(1985) also notes that average contract length in Canada fell

[9] Christofides reports that average contract duration in North America tends to be over two years whereas the same measure in European countries or in Japan tends to be much shorter with the average being around 12 months.

significantly during the 1974-75 period even those covered by COLA clauses. Evidence for the U.S. given in Ehrenberg, Danziger and San(1984) and Cecchetti(1987) seems to suggest little or no significant relationship between inflation uncertainty and contract duration. Alternatively, Vroman((1984), (1988)) does find a significant negative response of contract length to inflation uncertainty for U.S. data. For the U.K. little evidence of significant variation in contract lengths is reported in Gregory, Lobban and Thompson(1985).

Mark Bils(1988) developed and tested a monopoly union model of wage and employment behaviour over the contract cycle based on the Gray(1978)-Fischer(1977) nominal wage contracting models. If wage rigidites from long-term contracts are seen to be important then one should observe adjustments in employment after recontracting to undo movements in employment that occurred during the previous contract period. Wages are not rigid at points of recontracting and *rebounding effects* should show up as negative moving average terms that occur in employment after periods of recontracting. Bils finds that contract rigidities are important in that considerably larger fluctuations in employment occur than would have under flexible wages eg. in the motor vehicle industry it is found that longer term contracts more than double the size of fluctuations in employment. He cites that contracting explains as much as 40% of the employment variability observed in the twelve industries considered.

In the monopoly union framework used by Bils, bargainers choose the contract wage to maximise the expected value of the firm/union match ie. there exists a fixed side-payment component of compensation available to provide the necessary expected utility to each side of the bargain. The model is set up such that adjustment in the wage occurs if period t begins a new contract. If there exists some persistence in labour demand and supply disturbances, useful information becomes available at the time of recontracting and there exist movements in employment at the beginning of the new contract to undo (partially) the movements under the prior contract. This can be compared to the Blanchard and Summers(1986) hysteresis hypothesis undr which wages are not flexible, even under recontracting, and persistence in the disturbances occurs beyond the length of contracts due to union membership effects. This implies it may be necessary to look at the behaviour of both wages and employment together.

Bils' model predicts that there should be a discrete upward jump in real wages at the beginning of new contracts to compensate for previous inflation shocks under old contracts. In contracts with limited contingencies, real wages and employment are taken to adjust discretely at times of renegotiation to undo past shock effects. His tests on US. data do indeed support such propositions.

The model that is presented here also contains shifts in wages and employment associated with the period of contract renegotiation but for very different reasons. This model is fully 'real' so that inflation is not an issue. The key reason for the contract cycle here is seen to be strategic. It arises from the interaction between wage and investment setting decisions in the presence of trade unions.

CONCLUSION

This paper has developed a simple explanation of optimal contract duration for a wage setting trade union in a dynamic, uncertain, steady state environment. A detailed analysis of trade union contracts of different lengths is provided using a theory of contract length which differs sharply from the previous theoretical literature. The cost of frequent contract renegotiation is shown to be the strategic cost of the absence of precommitment rather than some exogenous resource cost of recontracting. This is exactly the type of inefficiency highlighted in Grout (1984) and Van der Ploeg (1987). Incomplete contracts and an uncertain environment imply a trade-off between the benefits of precommitment to a sequence of wage rates in advance of production and investment decisions and the costs of ex-post wage inflexibility.

Investment, employment and wages are seen to cycle with the same periodicity as contract length in a stationary environment. Characterisation of the contract equilibrium using computational experiments provides a set of empirical predictions over the determinants of contract length. Demand or technological uncertainty decreases contract duration while a large degree of complementarity between labour and capital increases the length of contracts. Variation in these factors provides an explanation for observed differences in contract lengths across industries.

Possible extensions to the work presented here include empirical testing of the model's predictions and allowing for persistence in the disturbance of the model. A more substantial undertaking would be to re-work the model in a dynamic bargaining framework to allow for bargaining over the wage rate ('Right to Manage') or both wages and employment (Efficient Contracts). This would allow an examination of whether the results generated are specific only to the Monopoly Union framework used. Finally, insider - outsider or endogenous union membership effects might also be considered.

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