JOURNAL OF ECONOMIC DEVELOPMENT 117
Volume 28, Number 2, December 2003

THE RELATIONSHIP BETWEEN EFFICIENCY WAGES AND PRICE INDEXATION IN A NOMINAL WAGE CONTRACTING MODEL

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This paper examines how a link between efficiency wages and price indexation can arise in a simple nominal wage contracting model. We show that, the more elastic the worker's effort is with respect to real wages, the looser the optimal linkage of nominal wages is to the price level. This is simply because, as the worker's effort becomes more sensitive to real wages, the output-stabilizing indexing scheme has to make nominal wages less dependent on the price level, thereby delegating firms more flexibility for adjusting the output level. As long as efficiency wages as an incentive device work well in the economy, our result may help explain the recent decline in the share of U.S. union contracts adjusting to a cost of living index.

Keywords: Efficiency Wages, Wage Indexation, Nominal Wage Contracting
JEL classification: J33, J41

1. INTRODUCTION

In recent decades, one important trend in U.S. labor markets has been a decline in the share of union contracts that index wages to inflation. According to Bureau of Labor Statistics data, cost of living adjustment (COLA) clauses in major collective bargaining contracts fell from 61% in 1977 to 22% in 1996. Ragan and Bratsberg (2000) stressed that there are several views for explaining this decline in COLA clauses: reduction in inflationary uncertainty, the erosion of union power, and structural shifts.[1] Some examples of structural shifts in the U.S. economy are economic deregulation, changes in

[1] Based on these views, there are some papers on analyzing the decline in wage indexation. Drudi and Giordano (2000) showed that the degree of price indexation is reduced as the union becomes weaker and the government's reputation improves. Duca and VanHoose (1998b) provided theoretically and empirically an inverse relationship between the optimal degree of indexation and goods-market competition. In order to find the contributions of various factors to the decline in COLA rates, Ragan and Bratsberg (2000) estimated a model of COLA coverage.

compensation schemes, industrial shifts, and more women in the workforce, etc.

In order to explain the recent decline in wage indexation, this paper focuses on changes in compensation schemes. According to Drudi and Giordano (2000), incentive pay systems, either in the form of wage premia and productivity bonuses or in the form of profit-sharing, have been widespread in the U.S. economy. Actually dominant features of compensation in 1990s were pay for promoting increased productivity. Duca and VanHoose (1998a) showed that, as goods markets become more competitive, contract wages become more closely linked to profits, and thus become less frequently indexed to the price level. Our view is that efficiency wages as an incentive device may be one possible explanation for the fall in indexation.[2]

Efficiency wage theories are based on the basic hypothesis that workers' effort depends positively on their wages. When there is a link between workers' effort and their wages, firms may pay high wages to enhance productivity.[3] We derive the optimal degree of indexation by using a single-period contract cum efficiency wage models and show that, when efficiency wage considerations as an incentive device become important in the economy, the optimal degree of indexation decreases for output stabilization. Our result may help explain the recent decline in the share of U.S. union contracts adjusting to a cost of living index.

The paper is organized as follows. Section 2 introduces the basic model with economic shocks, derives the optimal degree of indexation under efficiency wage considerations, and investigates the relationship between efficiency wages and price indexation. In Section 3, the analysis is extended to a two-sector framework. The final section summarizes the main results and explores further studies.

2. THE BASIC MODEL AND THE RELATIONSHIP BETWEEN TWO PARAMETERS

We use a single-period contract cum efficiency wage model that combines the basic efficiency wage model with the Gray's (1976) model of single-period wage contract. The basic hypothesis of efficiency wages is that the production of output depends on labor inputs' effort (or productivity), which in turn is an increasing function of the real wage. Let the relation between workers' effort (E) and the real wage (W/P) be given by

[2] Ritter and Taylor (1994, 1997) showed theoretically that efficiency wages may be needed as a complementary incentive device for employee motivation, even though they are a second-best solution.

[3] There are several explanations why firms pay high wages: reduced shirking, lower turnover and training costs, increased ability of screening and obtaining a high-quality, and improved morale and loyalty (see Yellen (1984), Katz (1986)).

$$E = (\frac{W}{P})^{\theta}, \quad 0 \le \theta < 1, \tag{1}$$

where θ is a productivity responsiveness parameter, W is the nominal wage rate, and P is the price level. If $\theta = 0$, efficiency wage considerations are absent. When $\theta > 0$, the real wage may be used an incentive device and thus efficiency wage considerations are relevant.

Consider the following log-linearized version of the single-period contract cum efficiency wage model. All lower case variables denote the logarithms of their capital variables and intercepts are suppressed to simplify the exposition. As in Duca (1987) and Duca and VanHoose (1991), all variables are measured as logarithmic deviations from trend and the analysis is limited to small percentage changes in the endogenous variables.

$$y^s = a(e+n) + u, \quad 0 < a < 1, \tag{2}$$

$$n = -b(1 - a\theta)(w - p) + bu, \quad b = \frac{1}{1-a} > 0, \tag{3}$$

$$y^d = m - p. \tag{4}$$

Equation (2) represents the effort-augmented production function where n is the employment level, u is a real shock, and e is the effort function in terms of the real wage: $e = \theta w$, $w = \log(W/P)$ and $0 \le \theta < 1$. It is assumed that e enters the production function multiplicatively. The labor demand equation in Equation (3) equalizes the firm's marginal productivity of labor to real wage per efficiency unit of labor.[4] For simplicity, we assume, as in Ball (1988), that firms face a pool of immobile workers who supply labor inelastically and thus the labor supply equation is zero. Equation (4) represents aggregate demand for output, which is obtained from the simple quantity equation with constant velocity. m is a monetary shock. It is assumed that u and m are stochastic disturbances with zero means and constant variances, σ_u^2 and σ_m^2, respectively.

In the efficiency wage literature, the "Solow condition" holds in equilibrium: the elasticity of effort with respect to the real wage is unity. Due to the multiplicative form of inputs, the productivity responsiveness parameter should be one: $\theta = 1$. Gorden (1990) pointed out this condition as one criticism of the efficiency wage approach: if workers gear their effort to the real wage, there appears to be no barrier to full wage indexation that allows firms simultaneously to maintain workers' effort through

[4] See Appendix A and B for the derivation of Equations (2) and (3).

maintenance of the optimal real wage, while changing the nominal wage in tandem with the nominal price. In a nominal wage contracting model, the unity condition can be not applied since firms' choice variable is the employment level, not the wage rate which in fact is predetermined by labor contracts. For this reason, the productivity responsiveness parameter (θ) is treated as a given constant between zero and one, and the value of θ becomes larger as the productivity-enhancing effect of efficiency wages increases.

Now, consider the wage equation of contracting firms. The contract wage is determined by the base nominal wage and an adjustment for unexpected inflation:[5]

$$w = \underline{w}^e + \gamma(p - p^e), \quad 0 \le \gamma \le 1, \tag{5}$$

where p^e is the mathematical expectation of $\log P$ conditional on the information set available at the end of the previous period, γ is an indexation parameter, and $\underline{w}^e$ is the base nominal wage that is expected to clear the labor market. Notice that, in the nominal wage contracting model, the contract wage is set before full information on the economic variables and the base nominal wage is fixed for the period of the contract.

Combining the wage equation, Equation (5) with the labor demand, Equation (3), the aggregate supply can be expressed as

$$y^s = ab(1-\theta)(1-\gamma)(p - p^e) + bu\ . \tag{6}$$

Eliminating the expected price level by solving the aggregate supply and demand side, Equations (6) and (4), we obtain the following aggregate output:[6]

$$y = \frac{ab(1-\theta)(1-\gamma)}{1+ab(1-\theta)(1-\gamma)}m + \frac{b}{1+ab(1-\theta)(1-\gamma)}u\ . \tag{7}$$

In order to determine the optimal degree of indexation, suppose that wage contractors seek to minimize the variance of y around the output supply of the frictionless economy (y^*),[7 8]

[5] For notational simplicity we delete time subscripts in the equations. The information set here refers to that available at the end of period $t-1$ if the current period is t .

[6] In our single-period contract cum model, the price expectation (p^e) is zero.

[7] The market clearing wage is $p + \{1/(1-a\theta)\}u$. If this puts into Equation (2), y^* is given by $\{1/(1-a\theta)\}u$.

[8] Notify that, in our nominal-wage contracting framework, the optimal degree of indexation is indeterminate when $\theta = 1$. Here we exclude the case of $\theta = 1$.

$$E(y-y^*)^2 = \frac{[ab(1-\theta)(1-\gamma)]^2}{[1+ab(1-\theta)(1-\gamma)]^2}\sigma_m^2 + \frac{[ab^2(1-\theta)\gamma]^2}{\{[1+ab(1-\theta)(1-\gamma)][1+ab(1-\theta]\}^2}\sigma_u^2. \tag{8}$$

Given a value of θ, let us obtain the optimal degree of indexation under efficiency wage considerations. Differentiating Equation (8) with respect to γ and setting the result equal to zero, the optimal degree of indexation should be set at

$$\gamma^* = \frac{(1-a\theta)\sigma_m^2}{(1-a\theta)\sigma_m^2 + b\sigma_u^2}. \tag{9}$$

From Equation (9), we can see clearly how different shocks may affect the real sector. In case that efficiency wage considerations are absent ($\theta = 0$), the result corresponds to the costless-indexation solution obtained by Ball (1988). Given the value of the productive responsiveness parameter ($0 \le \theta < 1$), our outcome is similar to Gray's (1976); while indexing insulates the real sector from monetary shocks, it exacerbates the real effects of real shocks. Thus, in an economy subject to both types of shocks, the optimal degree of indexation depends on the underlying stochastic structure of the economy.

Now let us examine how a change in the productive responsive parameter affects the optimal indexation choice. Differentiating Equation (9) with respect to θ, we have the relationship between the two parameters:

$$\frac{\partial\gamma^*}{\partial\theta} = -\frac{ab\sigma_m^2\sigma_u^2}{[(1-a\theta)\sigma_m^2 + b\sigma_u^2]^2}. \tag{10}$$

Equation (10) represents the negative relationship between two parameters. That is, the more elastic the effort function is with respect to real wages (an increase in θ), the looser the optimal linkage of nominal wages is to the price level. This is simply because, as the effort function becomes more sensitive to real wages, the output-stabilizing indexing scheme has to make nominal wages less dependent on the price level, thereby delegating firms more flexibility for adjusting the output level.

As an illustration, consider a positive monetary shock which increases the price level. The shock leads to a decrease in the real wage. When efficiency wage considerations are absent ($\theta = 0$), indexing is likely to insulate the real sector from monetary shocks. However, when the value of θ is close to one, a non-indexed case may leave output unchanged since the fall in the real wage has two offsetting output effects. First, the decrease in real wages causes firms to increase employment, and thus increase output. Second, the decreased real wage induces a decrease in workers' effort that lowers output. Consequently, output remains even in a non-indexed case. This implies that the role of indexation becomes weaker, when efficiency wages as an incentive device become more important in the economy.

3. EXTENSION TO A TWO-SECTOR FRAMEWORK

Now the basic model is extended to a two-sector framework. The economy consists of two sectors: one having nominal wage contracts without wage indexation and efficiency wage considerations (henceforth sector 1), and the other having nominal wage contracts under wage indexation and efficiency wage considerations (henceforth sector 2).[9] For simplicity, each sector produces one identical commodity and output is sold in a single market but labor is immobile between the two sectors.

The equations for output, labor demand, the contract wage for sector 1 are given below:

$$y_1^s = an_1 + u \,, \tag{11}$$

$$n_1 = -b(w_1 - p) + bu \,, \tag{12}$$

$$w_1 = \underline{w}_1^e \,, \tag{13}$$

where $\underline{w}_1^e$ is the expectation of the market-clearing nominal wage for sector 1.[10] While the wage rate for sector 1 is predetermined at the beginning of the contract period, the wage rate for sector 2 is indexed to unexpected inflation. In addition, sector 2 uses efficiency wages. Then the equations for output, labor demand, the contract wage for sector 2 are characterized by

$$y_2^s = an_2 + a\theta(w_2 - p) + u \,, \tag{14}$$

$$n_2 = -b(1 - a\theta)(w_2 - p) + bu \,, \tag{15}$$

$$w_2 = \underline{w}_2^e + \gamma(p - p^e) \,, \tag{16}$$

where $\underline{w}_2^e$ is the base nominal wage for sector 2, which is expected to clear the labor market.[11]

Combining the wage equations with the labor demand equations, we have the

[9] Dual labor markets provided by Doeringer and Piore (1971) show that high wages can arise in the sector where efficiency wage considerations are salient, while the secondary sector, where efficiency wages are less important, acts as a competitive labor market. Even though sector 1 uses the market clearing wage rather than the predetermined wage, our result is consistent with theirs.

[10] The market clearing wage for sector 1 is $p + u$.

[11] The market clearing wage for sector 2 is $p + \{1/(1 - a\theta)\}u$.

following semi-reduced forms of each sector's output:

$$y_1^s = ab(p - p^e) + bu\,, \tag{17}$$

$$y_2^s = ab(1-\theta)(1-\gamma)(p - p^e) + bu\,. \tag{18}$$

As in section 2, aggregate demand for output (y^d) is represented by the simple quantity equation with constant velocity. Assume that aggregate supply for output (y^s) is defined as a geometric average of two sector outputs. Then aggregate demand and supply equations are given by

$$y^d = m - p\,, \tag{19}$$

$$y^s = \alpha\, y_1^s + (1-\alpha) y_2^s\,, \quad 0 \le \alpha \le 1\,. \tag{20}$$

Eliminating the expected price level by solving the aggregate supply and demand side, Equations (19) and (20), we obtain the following price level and output for sector 2:

$$p = \frac{1}{1+\alpha ab + (1-\alpha)ab(1-\theta)(1-\gamma)} m \; - \; \frac{b}{1+\alpha ab + (1-\alpha)ab(1-\theta)(1-\gamma)} u\,, \tag{21}$$

$$y_2 = \frac{\alpha ab + (1-\alpha)ab(1-\theta)(1-\gamma)}{1+\alpha ab + (1-\alpha)ab(1-\theta)(1-\gamma)} m \; + \; \frac{b + \alpha ab^2[1 - ab(1-\theta)(1-\gamma)]}{1+\alpha ab + (1-\alpha)ab(1-\theta)(1-\gamma)} u\,. \tag{22}$$

If it is assumed that wage contractors for sector 2 seek to minimize the variance of y_2 around the output supply of the frictionless economy (y_2^*), we have the following optimal degree of indexation:[12]

$$\gamma^* = \frac{(1-a\theta)\sigma_m^2 - \alpha ab^2 \sigma_u^2}{(1-a\theta)\sigma_m^2 + [b + \alpha ab^2(1-\theta)]\sigma_u^2}\,. \tag{23}$$

[12] Putting the market clearing wage for sector 2 into Equation (14), the sector 2's output supply of the frictionless economy (y_2^*) is given by $p + \{a\theta/(1-a\theta)\}u$. See Appendix C for the derivation of Equation (23).

The optimal indexation choice for the two-sector framework is similar to that in the previous section. That is, if the economy is only subject to monetary shocks, full indexation is optimal. In an economy subject to real shocks, the optimal degree of indexation is binding at zero. Notice that Equation (23) is exactly the same as Equation (9), when sector 1 does not exist in the economy ($\alpha = 0$).

In order to examine how a change in the productive responsive parameter (θ) affects the optimal indexation choice, differentiating Equation (23) with respect to θ provides the relationship between two parameters:

$$\frac{\partial \gamma^*}{\partial \theta} = -\frac{(1+\alpha ab)[ab\sigma_m^2\sigma_u^2 + \alpha ab^3\sigma_u^2\sigma_u^2]}{[(1-a\theta)\sigma_m^2 + (b+\alpha ab^2(1-\theta))\sigma_u^2]^2} \,. \tag{24}$$

Equation (24) shows that the negative relationship between the two parameters holds even in a two-sector framework. The result indicates that the optimal degree of indexation decreases as efficiency wage considerations as an incentive device become more important in the economy.

4. CONCLUSION

This paper derived the optimal degree of indexation by using a single-period contract cum efficiency wage model and demonstrated the negative relationship between efficiency wages and price indexation. Our approach is quiet different from the Duca and VanHoose's (1998a). Their view attributes the decline in wage indexation to increased product market competition, but our view focuses on efficiency wage considerations as an incentive device for employee motivation.

Our results are as follows. First, given the value of a productivity responsiveness parameter, our result is similar to Gray's: while indexing insulates the real sector from monetary shocks, it exacerbates the real effects of real shocks. Thus, in an economy subject to both types of shocks, optimal degree of indexation depends on the underlying stochastic structure of the economy. Second, we have the negative relationship between efficiency wages and price indexation: the role of optimal indexation becomes weaker more important when efficiency wage considerations as an incentive device are more important in the economy.

In reality, incentive pay systems have been widespread in the U.S. economy and indexing costs exist in the contracting sectors. Under these circumstances, wage contractors considering efficiency wages may prefer less indexing for output stabilization as well as reducing indexing costs. Therefore, as long as efficiency wages as an incentive device work well in the economy, our result may help explain the recent decline in the share of U.S. union contracts adjusting to a cost of living index

Our model has some limitations. More realistically, if we use a monopolistic competition framework in product markets, it is possible to analyze how the degree of market competition affects labor practices. Moreover, in order to improve our theoretical predictions, we should empirically check whether, during recent decades, union contracting sectors have been using efficiency wages as a productivity-enhancing device. We leave the exploration of these to future research.

APPENDIX A

Derivation of Equation (2)

The effort-augmented production function with a real shock is given by

$$Y^S = (E \cdot N)^a e^u \,, \quad E = (\frac{W}{P})^\theta \,, \quad 0 \le \theta < 1 \,. \tag{A.1}$$

Taking the log of the both sides of (A.1), we have

$$y^s = a(e+n) + u \,. \tag{A.2}$$

APPENDIX B

Derivation of Equation (3)

The firm facing a given real wage is assumed to demand labor so as to maximize the following profit function (π):

$$\pi = (E \cdot N)^a e^u - (\frac{W}{P})N \,. \tag{B.1}$$

Differentiating (B.1) with respect to N, we have

$$(\frac{W}{P}) = a(E \cdot N)^{-(1-a)} E e^u \,. \tag{B.2}$$

Taking a log on both sides, the labor demand logarithmically is given by

$$n = -b(1-a\theta)(w-p) + bu \,, \quad b = \frac{1}{1-a} \,. \tag{B.3}$$

APPENDIX C

Derivation of Equation (23)

The difference between y and the output supply of the frictionless economy (y_2^*) is given by

$$y_2 - y_2^* = \frac{ab(1-\theta)(1-\gamma)}{[1+\alpha ab+(1-\alpha)ab(1-\theta)(1-\gamma)]}m \qquad \text{(C.1)}$$

$$+\frac{ab(1-\theta)\{\gamma+\alpha ab[1-(1-\theta)(1-\gamma)]\}}{[1+\alpha ab+(1-\alpha)ab(1-\theta)(1-\gamma)](1-a\theta)}u\,.$$

Squaring (C.1) and taking an expectation of the result, we have the following the loss function:

$$E(y_2 - y_2^*)^2 = \frac{[ab(1-\theta)(1-\gamma)]^2}{[1+\alpha ab+(1-\alpha)ab(1-\theta)(1-\gamma)]^2}\sigma_m^2 \qquad \text{(C.2)}$$

$$+\frac{[ab(1-\theta)]^2\{\gamma+\alpha ab[1-(1-\theta)(1-\gamma)]\}^2}{[1+\alpha ab+(1-\alpha)ab(1-\theta)(1-\gamma)]^2(1-a\theta)^2}\sigma_u^2\,.$$

Then, differentiating (C.2) with respect to γ, we have Equation (23).

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Manuscript received February, 2003; final revision received September, 2003.