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by

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ABSTRACT

Traditional theoretical explanations of union wage effects rely on a monopoly theory of wage determination. Using union monopoly power to set wages implies that unions face a tradeoff between higher wages and lower union sector employment. Earle and Pencavel (1990) find a positive union effect (relative to the nonunion sector) on wages and hours of work. Their empirical result appears to be inconsistent with the theoretical implications of union monopoly power. If unions are able to force unionized firms off their labor demand curve to the point where both wages and hours worked increase, then in a competitive environment, nonunion firms would displace union firms in the long-run. This paper presents a theoretical competitive model that is consistent with positive union wage and hours worked effects. The model investigates firms short-run behavior under uncertainty about the quality of labor services. The model assumes that union labor services are known with certainty (based on the observed lower turnover rate in the union sector) and nonunion labor services are assumed to be uncertain. The theoretical results show that output declines under uncertainty. The decline in output is the result of the marginal productivity of nonunion workers being reduced by the presence of uncertainty. The model predicts that wages and hours worked will be greater for union workers relative to nonunion workers. As firm risk aversion increases, the model predicts that the union wage and hours worked effect will be larger than in the risk-neutral case. Finally, as uncertainty about nonunion services declines, the model shows that nonunion wages and hours worked converge to union wages and hours worked.

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I. Introduction

While union wage effects have been studied extensively, union effects on employment and hours worked have received little attention. The basic underlying assumption is that if unions have sufficient power to increase wages via monopoly control of the labor market, then, given a downward sloping labor demand curve, union sector employment should fall. However, a recent study by Earle and Pencavel (1990) finds a positive association between unions and annual hours and weeks worked.[1] Moreover, they find that the increase in hours worked is positively correlated with the size of the union wage differential (i.e., the larger the union wage effect, the greater the difference between union and nonunion hours worked). In combination with a positive wage effect, the positive employment effect in hours worked per worker suggests that either unionization actually increases the efficiency of the firm (i.e., the labor demand shifts out) or union bargaining power is strong enough to force unionized firms off their demand curve. Earle and Pencavel conclude that these findings merit further research. This paper addresses this issue by developing a theoretical model of labor demand under uncertainty.

II. Monopoly Union Effects

The prevailing models of union effects on wages and employment are based on the theoretical

[1]The above association reflects cross-sectional estimates. Earle and Pencavel report a long-run finding of a negative relationship between unions and annual hours worked over time. This is consistent with Blanchflower *et al* (1991) who show that union sector firms have a lower employment growth than nonunion sector firms by about 2% to 4% per year. Also, Brannon and Craig (1994) find that union firms respond to output fluctuation by varying hours of work or wages rather than employment (in response to the higher benefits and thus fixed costs of union workers). The time series studies, however, are unable to control for all variables that influence long-run employment effects.

premise of union monopoly power. Demand models argue that unions set wages and fringe benefits at an optimal level and that management exercises control over the level of labor employment.[2] The efficient contract model of McDonald and Solow (1981) argues that unions and management have joint control over the determination of wages, hours of work, and number of workers employed along a pareto-optimal contract curve. Both the demand and efficient contract models imply a trade-off between a union wage differential and annual hours of work, and are theoretically inconsistent with Earle and Pencavel's finding of greater union wage and employment effects relative to similar nonunion firms.

The recursive or semi-efficient bargaining model by Johnson (1990) argues that powerful unions may in fact push union firms far enough off their labor demand curves to increase both wages and hours worked.[3] This model is theoretically consistent with Earle and Pencavel. However, such aggressive union bargaining behavior could induce capital substitution and intensify the threat of union busting. This model is not consistent with the long-run existence of a viable union sector.[4] The observed decline in the union sector employment during the 1980s while the union wage gap was near 30% may reflect the semi-efficient bargaining and potential end game effects.[5]

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[2]For example, Dunlop (1944) hypothesizes that unions set wages to maximize the wage bill.

[3]Unions essentially bargain over the capital-labor ratio using restrictive work practices or featherbedding.

[4]Navarro (1983) argues that aggressive union bargaining and featherbedding is partially responsible for the decline of the union sector in the coal industry. Other examples may include the railroads' and longshoremen's unions.

[5]Lawrence and Lawrence (1985) suggest that unions may trade off future jobs for higher current wages and employment in declining industries since they have limited opportunities to invest in new capital. Linneman *et al* (1990) show that the union wage differential rose during the 1980s while the union participation rate declined. Dickens and Leonard (1985), however, show that much of the decline in union participation from the 1960s to the 1980s was primarily due to shift in production from manufacturing to service sector and the changes in labor-force demographics, rather than semi-efficient bargaining practices.

Farber (1990) provides evidence that the rate of decline in union coverage was greatest in the heavily unionized industries (hence, shifts in the industrial structure are not the primary cause of the decline in the proportion of union employment). Farber's empirical results indicate that increased firm resistance has largely accounted for the decline in the percentage of union coverage. One plausible explanation is that increasing international trade shares has increased product market competitiveness and resulted in more aggressive firm resistance. (Firms cannot be perfectly competitive and share economic rents with unions; otherwise, the higher union wage levels would make these firms unprofitable and drive them out of business). Farber also finds that demand for unions declined in the 1970s and 1980s. If the change in workers' preferences are related to fears of job loss, then the decline in union coverage is also related to union monopoly power.

So has the semi-efficient bargaining model reconciled the finding of Earle and Pencavel? Not necessarily. Rather than competitive pressure, much of the decline in union coverage may be due to aggressive firm resistance related to drastic changes in the political environment of the 1980s (Freeman and Kleiner, 1990; Linneman *et al*, 1990). Moreover, unions are currently experiencing a resurgence. Total membership numbers have increased in 1993, and the proportion of unionized workers has remained at 15.8%, ending the declining trend that began in the 1960s. Recently, managers have been lauding a new era of cooperativeness where unions have helped improve productivity by endorsing new technology and innovative production systems such as self-managed work-place teams (*Business Week*, May 23, 1994). This evidence suggests that unions may act to increase firm productivity by increasing the efficiency by which raw labor units are converted into effective labor inputs in the production process. The efficiency argument may help explain why union firms have not been completely displaced by nonunion firms over the long-run.

II. Nonmonopoly Union Effects

Empirical evidence has established that union sector workers have a lower voluntary turnover rate than nonunion workers.[6] The lower probability of quits is attributed to the union voice versus nonunion exit tradeoff. Unions establish and enforce rules on grievance procedures, promotion, unsafe work conditions, and so forth, and provide a system of industrial jurisprudence through which workers voice their industrial relations problems. Nonunion workers, having no means (or power) to voice their labor-management disputes, must utilize a market response system and exit the firm.

Lower turnover rates in union firms suggests two efficiency implications. First, union workers should have higher firm-specific skills on average, since a lower quit rate reduces hiring and training of replacements. Hence, union firms should have greater labor productivity. Studies support a positive effect of unions on productivity, but the effect is small at best and insufficient to offset the larger union wage rates.[7] Second, lower turnover in union firms should reduce the variance of firm-specific training below that of nonunion firms, which suggest greater certainty about the quality of labor inputs. Nonunion firms, conversely, must hire and train more new workers; at any given point, there is a greater uncertainty of the quality of effective nonunion labor inputs in production. If there is greater certainty over work force quality, then there will be a decrease in the variability of worker productivity, which in turn will increase productive efficiency and labor demand. We contend that these theoretical arguments are consistent with Earle and Pencavel's finding of positive union effects

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[6]To the degree that the quit rate is lower due to higher union wages, the lower union turnover rate would be associated with monopoly union effects. Freeman (1980) controls for wages and other differences between union and nonunion workers and finds that the probability of union worker quits are about 3% lower.

[7]Brown and Medoff (1978) found a large union productivity effect, but Addison and Hirsch (1989) find evidence of small if any effect at all. A small positive effect is found by Clark (1980) in the cement industry, which Clark attributes to more professional management. Boal (1990) also finds a positive effect in large, labor-intensive coal companies (small ones actually have a negative effect) which is attributed to a reduction in labor turnover.

on wages and hours worked.[8]

Additionally, unions may increase contract efficiency because workers have greater assurance of receiving fair compensation under the explicit rules of a collective bargaining agreement. Thus, unions may act to decrease uncertainty by decreasing asymmetric information about workers' true productive capabilities and transaction costs associated with introducing new production technologies (like self-managed work teams). The issue of reduced quality uncertainty in a unionized work force has not been addressed by the literature. We propose a short-run production model with labor input uncertainty.

III. Assumptions and the Model

The analysis assumes a short-run time frame for the firm. The firm operates in a competitive setting in both the output and factor markets. All inputs are assumed to be fixed except labor, L. Define L to be the quantity of labor acquired for current use, and L_1 to be the quantity of labor service actually supplied. It is assumed that L is a decision variable for the firm and that L_1 is a random variable. This assumption is based on arguments presented by Ratti and Ullah (1976), and Walter's (1960, p.325) lucid exposition of why labor supplied is a random variable: " ...although the number of workers on the payroll is fixed, the flow of labor services does not stay at one value. It varies from day to day according to weather, sickness, whim, and other accidental influences."

We are interested in the differences in the flow of labor services of union and nonunion labor. We shall assume that Walter's "accidental influences" are identical for both types of labor. However, we argue that the variability in the flow of labor services is higher for nonunion workers due to higher turnover rates, less efficiency in contracting, *et cetera*. Under this assumption, ceteris paribus,

[8]The exact magnitude of this argument remains an empirical issue and may not be sufficient to offset the observed union wage differential alone. However, a combination of both union labor unit certainty and productivity may be sufficient to give a positive wage and hours worked effect.

the flow of labor services from union labor is assumed, for simplicity, to be known with certainty.

In the short-run, the firm can acquire its labor L from two separate markets for labor inputs: 1) union; and 2) nonunion. The union market for labor is assumed to be the full information market for labor. That is, the flow of factor services from union labor is therefore known with certainty. Union labor is defined as L, actual labor hours. The nonunion labor market is assumed to be the incomplete information market. That is, there is uncertainty about the flow of factor services from nonunion labor. The flow of labor services provided by the nonunion market is defined as L_1, realized labor hours.

Following the modeling procedure developed by Ratti and Ullah, L and L_1 are linked in the following way:

$$L_1 = vL, \tag{1}$$

where v is a strictly positive random variable with the variable's density function defined as $f(v)$ with a unit mean.[9] The firm's short-run production function when it hires labor in the nonunion market is defined as

$$Q = h(L_1) = h(vL),\ h'(L_1) > 0,\ h''(L_1) < 0 \tag{2}$$

a random variable. The third derivative of the production function is assumed to exist, and the marginal product of the input is positive but declining.

Beginning with firm behavior under certainty with respect to the flow of labor services, it is assumed the firm's goal is to maximize profits (Π). The output price of final goods and the input price of labor services and the fixed cost of production are defined respectively as p, w, and C. The firm's profit function is defined as:

$$\Pi = p \cdot h(L) - w \cdot L - C. \tag{3}$$

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[9] In the following analysis, the model developed in this paper is a modified version of the model developed by Ratti and Ullah (1976). Ratti and Ullah give credit to Walters (1960), and Roodman (1972) for the method of specification of the input variables.

The first order condition for profit maximization is:

$$d\Pi/dL = p \cdot h' - w = 0. \tag{4}$$

The second order condition for profit maximization is:

$$d^2\Pi/dL^2 = p \cdot h'' < 0. \tag{5}$$

Rearranging the equation 4, the following equilibrium condition is arrived at:

$$p \cdot h' = w \text{ or } p = w/h'. \tag{6}$$

Equilibrium condition (6) is the standard result. The firm will pay the labor input its marginal value product (*MVP*), i.e., its marginal contribution to the production of output.

If the firm hires labor from the nonunion market, then there is uncertainty over flow of factor services from nonunion labor. Profits are now defined in terms of utility. Assuming that the firm's utility function conforms to characteristics of a von Neumann-Morgenstern utility function and its third derivative exists, the firm's expected utility from profits can be written as:

$$E[U(\Pi)] = E[U(p \cdot h(L_1) - w \cdot L - C)]. \tag{7}$$

It is assumed that the marginal utility of profit is positive $U'(\Pi) > 0$, and the value of $U''(\Pi)$ being negative if the firm is risk averse, 0 if the firm is risk neutral, and positive if the firm is risk preferring.

The first order condition for maximizing expected utility of profits is:

$$dE[U(\Pi)]/dL = E[U'(\Pi) \cdot (p \cdot v \cdot h'(L_1) - w)] = 0. \tag{8}$$

The second order condition is:

$$d^2E[U(\Pi)]/dL^2 = E[U''(\Pi) \cdot (p \cdot v \cdot h'(L_1) - w)^2 + p \cdot v^2 \cdot h''(L_1) \cdot U'(\Pi)] < 0. \tag{9}$$

IV. <u>The Effect of Uncertainty on Firm Behavior</u>

The first question to be addressed in this section is; "how does uncertainty over the flow of

labor services affect that firm's level of production as compared to the certainty case?" The certainty case is when the firm hires union labor. The uncertainty case is when the firm hires nonunion labor. This question leads to the first proposition:

PROPOSITION I: *The firm's expected output when employing nonunion labor, ceteris paribus, is less than the firm's output when employing union labor.*

To establish the above proposition, Jensen's inequality and the definition of expected value are applied to the firm's production function, $f(L_1)$. Certainty in this situation means to replace (L_1) with its expected value, L. Then by the Jensen Inequality,

$$E[f(L_1)] < f(L), \tag{10}$$

and proposition one is established.[10] Thus, the implication of the introduction of production uncertainty into the firm's production function is that the mere presence of uncertainty, ceteris paribus, reduces the firms output as compared to a world of certainty for a given fixed level of labor. Consequently, the model implies that the *MPP* of L_1 in an uncertain environment is less than the *MPP* of L_1 if production had taken place at the expected value of the random variable, L_1 (i.e., L or the certainty environment).

The second issue to be discussed is how does input quality uncertainty in conjunction with the firm's attitude toward risk affect the wage paid to labor by the firm. The analysis begins with rewriting equation (8) in the following manner:

$$E[U'(\Pi) \cdot (p \cdot v \cdot h'(L_1))] = E[U'(\Pi)] \cdot w. \tag{11}$$

Adopting Horowitz's (1970) alternative expression of equation (11),

$$p \cdot E[v \cdot h'(L_1)] = w - \{p \cdot \mathrm{Cov}(U', v \cdot h') \, / \, E[U'(\Pi)]\}. \tag{12}$$

From equations (11) and (12), the *MPP* and *MVP* of nonunion labor are now random

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[10] The Jensen inequality states that if a function is concave the following is true: $E[h(X)] < h[E(X)]$. See Rao (1973), page 58 for an explanation of Jensen's inequality. Ratti and Ullah employed Jensen's inequality in a similar fashion.

variables given by $v \cdot h'$ and $p \cdot v \cdot h'$ respectively. Examining the covariance term in equation (12), it is clear that when $U''(\Pi) = 0$, the covariance term is also equal to zero. The implication of equation (12) is that the risk neutral firm hiring labor from the nonunion labor market sets wages equal to $w = E[MVP]$. As in the paper by Ratti and Ullah, when $U''(\Pi) \neq 0$, the sign of the covariance term can not be ascertained. Furthermore, Ratti and Ullah demonstrate that given the assumption that the input elasticity of the marginal product curve has an absolute value of less than one, then *sign Cov* = *sign* $U''(\Pi)$:

$$\mathcal{E} = dh'(L_1)/dL_1 \cdot L_1/h'(L_1) = L_1 \cdot h''(L_1)/h'(L_1) > -1. \tag{13}$$

If equation (13) is true, then examining the derivatives of the two components of the covariance term with respect to v,

$$d[v \cdot h'(L_1)]/dv = h'(L_1) \cdot [1 + \mathcal{E}] > 0, \tag{14}$$

and

$$dU'(\Pi)/dv = U''(\Pi) \cdot p \cdot L \cdot h'(L_1), \tag{15}$$

verifies that *sign Cov* = *sign* $U''(\Pi)$. That is, since the sign of equation (15) is dependent on $U''(\Pi)$, and equation (14) is positive, *sign Cov* must equal *sign* $U''(\Pi)$.

Applying this result to equation (12), the following condition is arrived at

$$p \cdot E[v \cdot h'(L_1)] \gtreqless w, \tag{16}$$

depending on whether $U''(\Pi) \lesseqgtr 0$.

Following Ratti and Ullah's interpretation of these results, at the margin: 1) the risk-neutral firm will hire nonunion labor at a wage equal to its $E[MVP]$; 2) the risk-averse firm will hire nonunion labor at a wage less than its $E[MVP]$; and 3) the risk-preferring firm will hire nonunion labor at a wage greater than its $E[MVP]$. The implications of these results are that a firm's input

demand for nonunion labor is dependent on its attitude toward risk.[11]

V. Labor Separation and Wage Differentials

In this section the analysis will begin with the assumption that the firm is risk neutral. As stated above, the supply of labor is segregated into two markets, union and nonunion, and the firm decides from which market it will hire labor. This market structure implies that there are actually two distinct labor market facing the firm.[12] Thus, across the industry, some proportion of all firms will hire from the union labor market and the remaining firms will hire from the nonunion labor market. All firms will maximize profit by setting $MVP=MC$. Rearranging equations (6) and (12),

$$p = w/h', \tag{17}$$

and

$$p = [w - \{p \cdot \mathrm{Cov}(U', v \cdot h')/E[U'(\Pi)]\}] \;/\; E[v \cdot h'(L_l)]. \tag{18}$$

To simplify the analysis, replace w in equation (18) with w^*. Given that output price p is the same regardless of the input market the firm purchases in, the following equilibrium condition is derived from equations (17) and (18),

$$w/h' = [w^* - \{p \cdot \mathrm{Cov}(U', v \cdot h')/E[U'(\Pi)]\}] \;/\; E[v \cdot h'(L_l)]. \tag{19}$$

Equation (19) leads to the second proposition in the paper:

PROPOSITION II. *Risk neutral firms purchasing inputs from one of two (worker separated) distinct markets, where the two groups supply equal labor hours and differ only in the amount of information available on the flow of labor services, will purchase those inputs from the group with uncertainty about quality (flow of labor services) at a lower wage than from the group whose quality is known with prefect information.*

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[11] These results concur with the results derived in the paper by Ratti and Ullah (1976).

[12] This assumption implies that firms are constrained to hiring from either the union or nonunion labor market. In reality, union coverage is determined by workers' demand for union coverage relative to a firms resistance or cost of unionization. Thus, firms are union or nonunion by a union certification (or decertification) process which management typically opposes. This assumption is not critical as long as the union coverage rate is in equilibrium in the short-run (which seems to be reasonable).

To establish proposition II, it is assumed that the third derivative of the production function is negative. This implies that the marginal product function $h'(L_1)$ is itself a concave function. This assumption is consistent with equation (13) and implies that $d\mathcal{E}/dL_1 < 0$. The implication of $h'''(L_1) < 0$ is that the *MPP* of L_1 is a non-increasing function of L_1.[13] Under the assumption that $h'''(L_1) < 0$, and employing Jensen's inequality the following result is attained:

$$E[h'(vL)] < h'(L). \tag{20}$$

Equation (20) implies that the risk-neutral firm's expected *MPP* generated by L_1 is less than the *MPP* that would be achieved under conditions of certainty given the same factor combination. Certainty implies a situation where the random variable v is replaced by its expected value. Due to the greater *MPP* in the union sector, the union firm's labor demand curve is always greater than the nonunion firm's. Thus, the result derived in equation (20) and (19) implies that w must be greater than w^* for a risk-neutral firm facing a fixed level of labor input. Thus, proposition II is established.

Proposition II demonstrates that when an industry of perfectly competitive firms faces a competitive but segregated labor market structure where the two distinct factor markets vary only in the information available on quality, the result will be a *market* wage differential between union and nonunion labor. That is, all workers are paid their expected marginal value product. Consequently, union and nonunion workers receive unequal wage rates due to the uncertainty associated with the quality of nonunion labor. This proposition presents an interesting and plausible explanation for union wage differentials in the labor market without unions having market power.

If it is assumed that the firm is risk-averse, then equation (19) demonstrates that the degree of wage differentials will increase. This last statement leads to the third proposition of the paper:

PROPOSITION III. *The size of union wage differentials will vary positively with the degree of firm risk aversion.*

[13]Ratti and Ullah (1976) note that this assumption is consistent with many of the common forms of production functions used in the economics profession.

To established proposition III, proposition II is reasserted. Proposition II established that w is greater than w^* for the risk-neutral firm. Then by equations (16 & 19), w^* must be greater than say any w^{**}, the price that a risk-averse firm would pay for nonunion labor. Thus, proposition III is established.

VI. Comparative Statics: An Decrease in Uncertainty over the Flow of Nonunion Labor Services

In this section, the effect of a change in the amount of information available to the firm on the quality of labor services coming from the nonunion labor market is examined. A change in the amount of information available implies a change in the amount of uncertainty associated with nonunion labor. For example, the nonunion turnover rate in a specific industry converges to the union rate. To capture this effect of a marginal change in uncertainty, the distribution of ν will undergo a mean preserving change in the dispersion of the distribution. The results developed below are only determinant in the risk-neutral case. A modification of equation (8) is now undertaken by replacing ν with $\nu^* = (\alpha \cdot \nu + \beta)$, where α is a shift parameter and β is a function of α with the following properties:

1) $\beta' = -E[\mathrm{v}] = -1$, and 2) $\beta(\alpha = 1) = 0$. This transformation implies that $L_l = (\alpha \cdot \nu + \beta) \cdot L$. Assuming the firm is risk neutral, equation (8) is now:

$$dE[\Pi]/dL = E[p \cdot \nu^* \cdot h'(L_l) - w] = 0. \tag{21}$$

Replacing ν^* with $(\alpha \cdot \nu + \beta)$, and renaming equation (21) $E[Z]$,

$$E[Z] = E[p \cdot (\alpha \cdot \nu + \beta) \cdot h'(L_l) - w] = 0, \tag{22}$$

the comparative static analysis can begin. Invoking the implicit function theorem around the equilibrium value of L and $\alpha = 1$, then taking the total differential of $E[Z]$ and setting all of the differentials to zero except dL and $d\alpha$, the partial derivative $\partial L / \partial \alpha$ is:

$$\partial L / \partial \alpha = -E[\{p \cdot (\nu - 1) \cdot h'(L_l) \cdot (1 + \varepsilon)\} \ / \ \{p \cdot \nu^{*2} \cdot h''(L_l)\}]. \tag{23}$$

The sign of the partial derivative derived above can be determined by examining the following

relationship:

$$p \cdot E[(v\text{-}1) \cdot h'(L_l) \cdot (1 + \mathscr{E})] = \mathrm{Cov}((v\text{-}1),\ h'(L_l) \cdot (1 + \mathscr{E})). \tag{24}$$

By ascertaining the sign of $\mathrm{Cov}((v\text{-}1),\ h'(L_l) \cdot (1 + \mathscr{E}))$, the sign of the numerator of equation (24) can be determined. Examining the derivatives of the two components of the covariance term with respect to v,

$$d[h'(L_l) \cdot (1+\mathscr{E})]/dv < 0, \tag{25}$$

and

$$d(v\text{-}1)/dv = 1 > 0, \tag{26}$$

verifies that the sign of the covariance is negative and thus the sign of the partial derivative $\partial L/\partial\alpha < 0$.

The above result leads to the last proposition of the paper:

PROPOSITION IV: *As uncertainty over the flow of labor services for nonunion labor decreases, the magnitude of the union wage differential in the industry declines.*

To establish the above proposition the implications of $\partial X/\partial\alpha$ are analyzed. The negative sign indicates that as quality uncertainty decreases, demand for L via the nonunion market increases. The implication is that for a fixed level of L_l a decrease in uncertainty increases the expected *MPP* of L_l. This means that $E[v \cdot h'(L_l)] < E[v^* \cdot h'(L_l)]$ when $\alpha < 1$. Examining this result in the context of equation (19), we can verify that an increase in the expected *MPP* of L hired via the nonunion market will increase w^* relative to w. Thus, the degree of the union wage differential declines as uncertainty declines and proposition IV is established.

VII. Wage and Labor Unit Effects

In this section we will discuss the effect of uncertainty over the flow of labor services on firm employment practices. Proposition I established that for a given level of labor input, the firm's

output will be greater with union labor than for nonunion labor. This result is shown in figure 1a, a graphical representation of equation (10). The graphical analysis demonstrates that the introduction of uncertainty reduces output from Q^c to Q^u. Proposition II demonstrates that the marginal product of nonunion labor is less than the marginal product of union labor. This result is shown in Figure 1b. The graphical analysis shows that the introduction of uncertainty with a fixed level of labor input (L) reduces wages from w to w^*. If we assume an upward sloping market labor supply, w^* is not an equilibrium wage. To restore the equilibrium, the market wage for nonunion labor must rise to w^u_{r-a}, which reduces hours worked in the nonunion sector to L^u_{r-a}. The implication is that in the union sector, the relative effects are higher wages and hours worked. Thus, proposition II supports Earle and Pencavel's finding of a positive association between unionization and wages and hours worked.

Proposition III demonstrates that for a risk-averse firm, the nonunion wage, w^{**}, given a fixed level of labor input, is even lower than the nonunion wage, w^*, for the risk neutral case. In Figure 1b, this effect is represented by the labor demand curve, MVP^u_{r-a}, which is farther to the left of the risk-neutral labor demand curve, MVP^u_{r-n}. Proposition III implies that the union wage differential and the hours worked vary positively with the level of firm risk aversion. Proposition III supports Earle and Pencavel's finding of a greater union effect on hours worked as the union wage effect increases (i.e., the more risk averse the firm the greater will be hours worked *and* wages). Hirsch and Morgan (1994) find evidence that union firms have a lower systematic risk component in their rate of return. This implies that risk-adverse firms (which is consistent lower beta values) may actually view union labor agreements as a management strategy to reduce risk exposure.

Finally, Proposition IV demonstrates that the nonunion wage converges to the union wage as the uncertainty over the flow of labor services declines. In Figure 1b, this effect would be shown by a rightward shift in the risk neutral labor demand curve, MVP^u_{r-n}, toward the union labor demand curve, MVP^c.

VIII. Conclusion

This paper deals with the issue of labor quality uncertainty in a short-run production function. The theoretical results derived in this paper are consistent with Earle and Pencavel (1990), who find a positive union effect on both wages and hours of employment. This paper makes a contribution by merging the literature on competitive firm behavior under uncertainty with the literature on labor union effects.

Proposition I demonstrates that the mere introduction of uncertainty over the flow of labor services will reduce firm output, as compared to firm output in a world of certainty about a fixed level of labor input.

Proposition II shows that for the risk neutral firm, the introduction of uncertainty over the flow of labor services reduces the marginal productivity of the nonunion labor unit relative to the union labor unit (or the certainty case). Consequently, given a fixed labor unit, the wage received by nonunion workers will be less than the wage received by union workers. At a market equilibrium, this implies a positive union wage differential and greater hours worked in the union sector.

Proposition III shows that the union wage differential and union hours worked will vary positively with the degree of firm risk aversion, suggesting that the more risk-averse firms become, the greater will be the union wage differential and the union effect on hours worked.

Finally, Proposition IV finds that as the uncertainty between union and nonunion labor quality declines, the union wage and hours worked differential will decline. Thus, with the elimination of uncertainty, the wage and hours worked will be identical for both union and nonunion labor services.

This paper only presents the theoretical results of a short-run determination of the union wage differential and hours worked. A further extension of the theoretical issues addressed by this study will be pursued in an empirical analysis of the hypotheses in propositions one through four.

VIII. References

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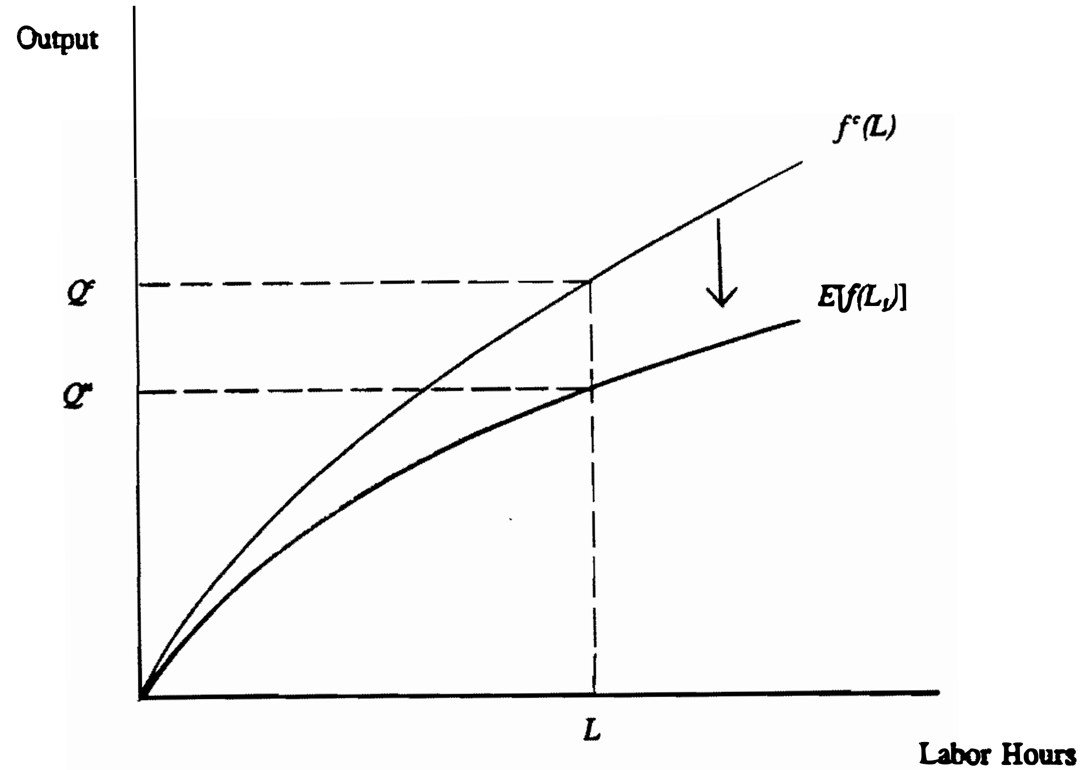
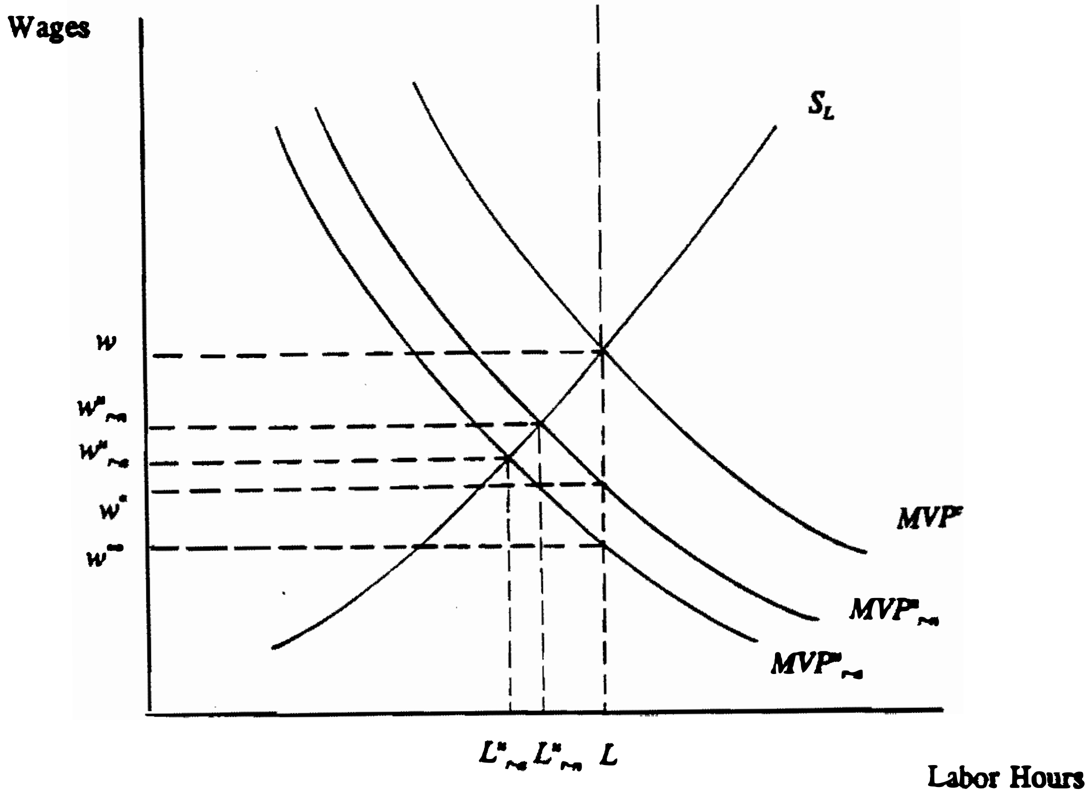
FIGURE 1.

1a



1b



UNCERTAINTY OVER THE QUALITY OF LABOR INPUTS: A NON-MONOPOLY THEORY OF UNION WAGES AND HOURS WORKED

MATHEMATICAL APPENDIX

$$EQ.\ 8: \quad \frac{dE[U(\Pi)]}{dL} = E\left[\frac{dU(\Pi)}{d\Pi} \quad \frac{d\Pi}{dL}\right]$$

$$\frac{dU(\Pi)}{d\Pi} = U'(\Pi)$$

$$\frac{d\Pi}{dL} = p \cdot \frac{dh(L_1)}{dL_1} \cdot \frac{dL_1}{dL} - w$$

$$\frac{d\Pi}{dL} = P \cdot h'(L_1) \ \frac{dL_1}{dL} - w$$

$$\frac{dL_1}{dL} = v$$

$$\frac{d\Pi}{dL} = P \cdot v \cdot h'(L_1) - w$$

$$EQ.\ 8: \quad \frac{dE[U(\Pi)]}{dL} = E[U'(\Pi) \cdot (P \cdot v \cdot h'(L_1) - w)]$$

$$EQ\ 9: \quad \frac{d^2E[U(\Pi)]}{dL^2} = E\left[\frac{d^2U(\Pi)}{d\Pi^2} \quad \frac{d\Pi}{dL} + \frac{d^2\Pi}{dL^2} \quad \frac{dU(\Pi)}{d\Pi}\right]$$

In the paper EQ. 9 is derived in the same manner as EQ. 8. EQ. 9 in the paper can be derived following the mathematical expression given above.

EQ. 11: EQ(11) is just EQ (8) rearranged.

EQ. 12: Horowitz, p. 364-367 uses the following definition E(xy) = E(y) · E(x) + COV(x,y). Thus the left hand side of EQ. 11 is equivalent to $E\{U'(\Pi)] \cdot E[P \cdot v \cdot h'(L_1)] + COV[U'(\Pi), v \cdot h'(L_1)]$ replacing the LHS with this equivalent expression and solving for $E[P \cdot v \cdot h'(L_1)]$ gives us EQ. 12.

EQ. 13: Equation (13) gives the standard procedure for deriving an elasticity coefficient.

$$EQ.\ 14:\quad \frac{d[v \cdot h'(L_1)]}{dv} = h'(L_1) + v \cdot \frac{dh'(L_1)}{dv}$$

$$\frac{dh'(L_1)}{dv} = \frac{dh'(L_1)}{dL_1}\ \frac{dL_1}{dv}$$

$$\frac{dh'(L_1)}{dL_1} = h''(L_1)$$

$$\frac{dL_1}{dv} = L$$

$$\frac{dh'(L_1)}{dv} = h''(L_1) \cdot L$$

$$\frac{d[v \cdot h'(L_1)]}{dv} = h'(L_1) + v \cdot [h''(L_1) \cdot L]:\quad \text{where } L_1 = v \cdot L$$

$$= h'(L_1) + h''(L_1) \cdot L_1$$

$$= h'(L_1) \cdot [1 + \varepsilon] > 0$$

$$EQ.\ 15:\quad \frac{dU'(\Pi)}{dv} = \frac{dU'(\Pi)}{d\Pi}\ \frac{d\Pi}{dv}$$

$$\frac{dU'(\Pi)}{d\Pi} = U''(\Pi)$$

$$\frac{d\Pi}{dv} = \frac{d\Pi}{dL_1}\ \frac{dL_1}{dv}:\quad \text{where } \frac{d\Pi}{dL_1} = p \cdot h'(L_1) \wedge \frac{dL_1}{dv} = L$$

$$EQ\ 15: \quad \frac{dU'(\Pi)}{dv} = U'' \cdot P \cdot L \cdot h'(L_1)$$

Given that P, L, $h'(L_1)$ are all positive, the sign of EQ (15) is the same as the sign of $U''(\Pi)$.

EQ. 16: Eq. (16) is expressing the implications coming from EQs. 13 - 15 on EQ. 12.

Equations 17 - 19 should be clear.

After proposition I, it is stated that if $h'''(L_1) < 0$, then $d\gamma/dL_1 < 0$.

$$\frac{d\gamma}{dL_1} = \frac{d\left[\frac{L_1 \cdot h''(L_1)}{h'(L_1)}\right]}{dL_1}$$

$$= \frac{h'(L_1)\ [h''(L_1) + h'''(L_1) \cdot L_1] - [h''(L_1) \cdot L_1 \cdot h''(L_1)]}{h'(L_1) \cdot h'(L_1)}$$

$$- \quad (+) \qquad - \qquad (-) \qquad +$$

$$= \frac{h''(L_1)}{h'(L_1)} + \frac{h'''(L_1) \cdot L_1}{h'(L_1)} - \frac{[h''(L_1)]^2 \cdot L_1}{[h'(L_1)]^2} < 0$$

Thus $h'''(L_1) < 0$ *assures that* $\frac{d\gamma}{dL_1} < 0$.

EQ. 21. The first order condition is rewritten to incorporate V^* and the assumption of a risk neutral firm.

$$21. \quad \frac{dE(\Pi)}{dL} = E[p \cdot V^* \cdot h'(L_1) - w] = 0$$

Eq. 22 replaces V^* with $(\alpha \cdot v + \beta)$ and renames the Foc E[Z].

$$22. \quad E[z] = E[p \cdot (\alpha \cdot V + \beta) \cdot h'(L_1) - w] = 0$$

EQ. 23 is the result of comparative static analysis. Taking the total differential of E[z] and setting all differentials to zero except dL, $d\alpha$, and

remembering that $dv^*/d\alpha = (v-1)$, we have,

$dE[z] = E[P \cdot (V^*)^2 \cdot h''(L_1)]\ dL + E[P \cdot v \cdot h'(L_1) - P \cdot h'(L_1) + P \cdot h''(L_1) \cdot (\alpha \cdot v + \beta) \cdot L \cdot (v - 1)]\ d\alpha$

Now the above equation reduces to:

$$dE[z] = E[P \cdot (V^*)^2 \cdot h''(L_1)]\, dL + E[P \cdot (v - 1) \cdot h'(L_1) \cdot (1 + \delta)]\, d\alpha$$

Setting dE[z] to zero allows $\partial L/\partial \alpha$ to be derived.

$$\text{EQ.23.} \quad \frac{\partial L}{\partial \alpha} = -\left[\frac{P \cdot E[(v - 1) \cdot h'(L_1) \cdot (1 + \delta)]}{P \cdot E[(V^*)^2 \cdot h''(L_1)]}\right] < 0$$

NOTE: When doing the comparative statics one must remember that $L_1 = (\alpha \cdot v + \beta) \cdot L$ so that

$$\frac{dL_1}{d\alpha} = (v - 1) \cdot L$$

The sign of equation 23 is dependent on the numerator, since the denominator is negative and the entire expression has a negative sign. The key to signing the numerator is the following relationship:

NEXT PAGE

$$E(x \cdot y) = E(x) \cdot E(y) + Cov(x,y) \text{ thus}$$

$$EQ.\ 24.\quad E[(v-1) \cdot h'(L_1) \cdot (1+\delta)] = E[(v-1)] \cdot E[h'(L_1) \cdot (1+\delta)] +$$

$$+ Cov[(v-1),\ h'(L_1)\ (1+\delta)],\ but = E[(v-1)] = 0.$$

So we have EQ. 24.

$$24.\quad E[(v-1) \cdot h'(L_1) \cdot (1+\delta)] = Cov[(v-1),\ h'(L_1) \cdot (1+\delta)]$$

$$EQ.\ 25.\quad \frac{d[h'(L_1) \cdot (1+\delta)]}{dv} = \frac{d[h'(L_1) + L_1 \cdot h''(L_1)]}{dv} =$$

$$\frac{d[h'(L_1)\ (1+\delta)]}{dv} = h''(L_1) \cdot \alpha \cdot L + \alpha \cdot L \cdot h''(L_1) + L_1 \cdot h'''(L_1) \cdot \alpha \cdot L$$

Given that h'', h''' are negative,

$$\text{then } \frac{d[h'(L_1) \cdot (1+\delta)]}{dv} < 0$$

$$EQ.\ 26.\quad \frac{d(v-1)}{dv} = 1 > 0$$

Thus equations 25 and 26 have opposite signs, so the covariance is negative, which means $\partial L/\partial \alpha < 0$ ∴.