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Long-run Relationship Between Union and Nonunion Wages - A Vector Error Correction Approach

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Abstract: The literature documents a union wage premium and suggests that this premium is somewhat stable over time. However, previously the focus has primarily been at the micro-level, and on whether or not a union worker receives greater compensation than an otherwise comparable nonunion worker. We examine the relationship between union and nonunion wages in the context of a vector autoregression error correction model (Engle and Granger, 1987), conditioned on a set of macroeconomic state variables. The error correction term provides information as to which wage (union or nonunion) adjusts to a "disequilibrium" in the long run error (i.e., cointegrating relation). Our results add to the literature on the relationship between the macroeconomy and the union-nonunion wage gaps.

Keywords: Cointegration; Representation Theorem; Union wage premium; Vector error correction

JEL classification: E240, J300, J500

I. Introduction

The literature documents existence of an overall union wage premium and suggests that this premium is reasonably stable over time based on standard wage regressions employing *micro data* (Freeman and Medoff, 1984; Addison and Hirsch, 1986; Lewis, 1986; Wunnava and Peled, 1999; Bratsberg and Ragan, 2002; Blanchflower and Bryson, 2004; Blackburn, 2006).[i] The main purpose of this research is to see whether a similar conclusion can be drawn based on *macro data*. The theoretical macroeconomic models

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imply that wages respond in certain ways to unanticipated changes (shocks) in aggregate measures of economic activity (Romer, 1996; Barron, Ewing and Lynch, 2006). In fact, Ewing and Wunnava (2004) find that the aggregate union-nonunion wage differentials, both for the entire private sector and by industry, respond predictably to macroeconomic shocks based on results from a vector auto regression (VAR) framework. We further build on Ewing and Wunnava's methodology. Specifically, we examine the time series relationship between aggregate level union and nonunion wages using a vector autoregression error correction (VEC) model, conditioned on a set of macroeconomic state variables. Essentially, we propose an error correction model (Engle and Granger, 1987; Johansen and Juselius, 1990) in which union and nonunion wages are entered individually, along with other relevant macroeconomic controls. The error correction term provides information on whether or not the union-nonunion wage gap is stable over the long run, and which wage — union or nonunion — adjusts to a "disequilibrium" in the long run error (i.e., the cointegrating relation).

2. Long-Run Wage Adjustments and Error Correction Framework

The union-nonunion wage gap is the difference between union and nonunion workers' wages. We examine the time series evidence on union and nonunion wages to test two hypotheses. First, we determine whether the aggregate-level wage gap is stable over time. If so, Engle and Granger's (1987) "Representation Theorem" indicates that the two wage series, which are nonstationary, are cointegrated and their relationship may be characterized by an error correction model. Letting U denote union wages and NU denote nonunion wages, the error correction model relates changes in U (i.e., ΔU_t), to departures from the long run equilibrium in the previous period ($U_{t-1} - \beta NU_{t-1}$), where β is the cointegrating parameter. In such a framework, a simple error correction model can be written formally as follows:

$$\Delta U_t = \alpha_{11} + \alpha_{21}(U_{t-1} - \beta NU_{t-1}) + \varepsilon_{tu} \qquad (1)$$

Specifically, the corrections in ΔU_t depend on the departures of the system from its long run equilibrium in the previous period. The shock ε_{tu} leads to a short term deviation (positive or negative) from the long run (i.e., cointegrating) equilibrium relationship. However, there will be a tendency to converge toward the long run equilibrium path. Specifically, ($U_{t-1} - \beta NU_{t-1}$) is the error correction term and the α_{21} coefficient captures the speed of adjustment to gravitate back toward the long run equilibrium path. It is logical to assume that the sign of the α_{21} coefficient will be negative (i.e., a relative decrease in union wages) in response to a positive departure (i.e., a widening union-nonunion wage gap) and vice versa. A similar model could also be set up for the nonunion sector:

$$\Delta NU_t = \alpha_{12} + \alpha_{22}(U_{t-1} - \beta NU_{t-1}) + \varepsilon_{tnu} \qquad (2)$$

In the above (nonunion) model, the sign of the α_{22} coefficient will be the opposite of what we expected in the union sector. In other words, any positive departure (i.e., a widening union-nonunion wage gap) from the long run equilibrium will be countered by a positive coefficient (i.e., a relative increase in nonunion wages) and vice versa.

Second, given the error correction model(s), we examine concurrently the adjustment to long-run equilibrium following a disturbance in both union and nonunion sectors. Hence we choose to estimate the above error correction models in a VAR framework. By doing so, we characterize the cointegrating relation between union and nonunion wages over time and estimate how and to what extent the respective wages adjust to eliminate disequilibrium. The actual empirical specification used in this paper is spelled out in equation (3) below.

3. Data and Methodology

Our analysis examines union and nonunion wages over the third quarter of 1976 through the third quarter of 2003 for four different sectors of the economy:[ii] goods-producing, services-producing, manufacturing, and non-manufacturing sectors. We use the seasonally adjusted Employment Cost Index (ECI) series for wages and salaries of (private industry) union workers and nonunion workers for the wage series. The eight wage series are defined as the natural logarthim of wages and salaries of union and nonunion workers.

Ewing and Wunnava (2004) note the importance of controlling for macroeconomic state variables in time series studies of aggregate level union-nonunion wages. Following the work of Bernanke and Blinder (1992), Thorbecke (1997), and Ewing (2001), we use changes in the fed funds rate to proxy the stance of monetary policy (*Mpolicy*). The consumer price index (*Inf*) for all urban consumers is used to capture the inflation rate (Park and Ratti, 2000). Real economic activity is gauged by the growth rate in real gross domestic product (*Growth*). Thus, the quarterly data consist of changes in the fed funds rate, growth in real gross domestic product, consumer price inflation, and the eight wage series. Data are from the Bureau of Labor Statistics Employment and Earnings, the Bureau of Economic Analysis, and the Federal Reserve Bank of St. Louis.

In order to examine the long-run adjustment of union and nonunion wages to disequilibrium we specify and estimate a VEC model. According to the "Representation Theorem" (Engle and Granger, 1987), if I(1) series are cointegrated then there exists an error correction representation.

A pair of I(l) time series is cointegrated if a linear combination of them is stationary. Tests for cointegration seek to discern whether a stable long-run relationship exists among a set of variables. A common trend between the union and nonunion wages in a particular sector of the economy means that in the long run the behavior of the common trend will determine the behavior of the two variables. Shocks that are unique to one time series will die out as the variables adjust back to their common trend. In the context of our study, cointegration would simply mean that the transmission mechanism among union and nonunion wages (and its determinants) is stable and thus more predictable over long periods. Thus, our first step was to check the univariate time series properties of each wage series using unit root tests, and the unit root test results indicated that these series were integrated of order one, I(1).[iii] Thus, it is appropriate to test for cointegration.[iv] We conduct the Engle-Granger (1987) test to see whether the union and nonunion wage series are indeed cointegrated by examining the behavior of the residuals from a regression of one series on the other.[v]

If union wages U_t and nonunion wages NU_t are cointegrated, the first differences of U_t and NU_t can be modeled using a VAR augmented by including ($U_{t-1} - \beta NU_{t-1}$), i.e. the *error correction term*, as an additional regressor (as mentioned earlier β is the cointegrating parameter). If the two wage series are cointegrated but the error correction term is not included, the model suffers from omitted variable bias. A significant coefficient on one or both of the error correction terms provides evidence that union and nonunion wages are cointegrated and that they share a long-run common trend. Examination of these coefficients in each equation provides information as to the degree and direction of the adjustment back towards the long-run equilibrium union-nonunion wage gap following a deviation. We used standard specification criteria as the decision rule for specifying the cointegrating relationship. Specifically, we used Akaike information (AIC) and Schwarz

(SC) criteria and found that, across all specifications, these statistics chose the model with cointegrating parameter of 'unitary' (i.e., β= '1').[vi] Intuitively, this suggests that over the long run, union and nonunion wages follow each other on a one-to-one basis. For example, if union wages fall (rise) by 10 percent, then eventually nonunion wages will also fall (rise) by the same amount. Of course, this adjustment process need not occur quickly and, indeed, may take a considerable amount of time. Hence for each pair of union wages (*U*) and nonunion wages (*NU*), the following is our empirical specification as shown in equation system (3):

$$\Delta lnU_t = \alpha_{11} + \alpha_{21}[lnU_{t-1} - lnNU_{t-1}] + [\text{lagged values of } \Delta lnU_t \text{ and lagged values of } \Delta lnNU_t] + [Inf, Mpolicy, Growth]_{t-1} + \varepsilon_{tu} \quad (3)$$

$$\Delta lnNU_t = \alpha_{12} + \alpha_{22}[lnU_{t-1} - lnNU_{t-1}] + [\text{lagged values of } \Delta lnU_t \text{ and lagged values of } \Delta lnNU_t] + [Inf, Mpolicy, Growth]_{t-1} + \varepsilon_{tnu}$$

The combined model in the above equations is called a vector error correction (VEC) model. In a VEC model, past values of ($lnU_{t-1} - lnNU_{t-1}$) help to predict future values of ΔlnU_t or $\Delta lnNU_t$. Essentially, the changes or corrections in the dependent variables depend on the departure of the system from its long-run equilibrium in the previous period. In other words, a shock in the respective error terms leads to a short-term departure from the cointegrating (long-run) equilibrium path; then, there is a tendency to move back toward the long-run equilibrium. The coefficients α_{21} and α_{22} capture the speed of adjustment back towards the long-run (cointegrating) equilibrium path. Hence a *positive* departure from equilibrium union nonunion wage gap in the previous period will be corrected by a negative α_{21} and a positive α_{22}. Just the opposite occurs from a *negative* departure. In response to any deviations from the long-run equilibrium wage gap, the magnitudes of the coefficients of the error correction terms will give us the relative responsiveness of union and nonunion wages in gravitating towards the long-run equilibrium wage gap.

4. Results

Table 1 provides a summary of the impact of error correction terms on different wage series.[vii] We examined the long-run equilibrium relationship between union and nonunion wages and, regardless of sector examined, we find evidence of cointegration. Thus, the long-run relationship between union and nonunion wages is stable over time. The stable wage gap provides important information for long-term strategic planning. Firms with union workers must recognize there are forces at work that maintain this wage gap over both business cycles and time. Moreover, this finding holds across the broad definitions of firm type, namely manufacturing/goods producing and non-manufacturing/services producing. For example, a finding of cointegration between union and nonunion wages simplifies the preparation of life-cycle cost comparisons for use with labor factors as the forecasts of relative wages can be made over a long planning horizon.[viii]

Table 1: Summary of the Error Correction Estimates based on Equation System 3

Sector	Union [α_{21}]	Nonunion [α_{22}]	Adjustment***
Goods Producing**	-0.029805 (-3.03417)	0.017391 (1.68624)	Falling Union wages *more* responsive than Rising Nonunion wages.
Service Producing**	-0.016565 (-1.65156)	0.017339 (1.79091)	Rising Nonunion wages *more* responsive than Falling Union wages.
Manufacturing**	-0.031896 (-2.57251)	0.024286 (2.09081)	Falling Union wages *more* responsive than Rising Nonunion wages.
Non-Manufacturing**	-0.012421 (-1.51104)	0.017316 (1.94147)	Rising Nonunion wages *more* responsive than Falling Union wages.

Note: ** Full VEC model estimates can be obtained on request. *** Refer to endnotes 9 and 10. Sample size = 109 quarterly observations. Figures in the parentheses indicate t-statistics.

Having established that the union and non-union wage gap is stationary over the long run, it is important to see how and to what extent the separate wage series respond to shocks to restore and maintain equilibrium. For the goods-producing and manufacturing sectors, the error correction term in the union equation is negative and statistically significant, whereas the corresponding term in the nonunion equation is positive and significant, so when the wage gap becomes wider than its long-run equilibrium level, both union and nonunion wages move or adjust to eliminate the disequilibrium. In other words, neither worker type nor industry is isolated from market forces. The gap may be wider due to (a) both sets of wages rising but union wages rising relatively more than the nonunion wages, (b) the union wage rising and the nonunion wage falling or not rising at all, or (c) union wages falling less than the fall in nonunion wages. In any event, union workers are unable to maintain the increased wage gap indefinitely as nonunion wages rise relative to union wages to eliminate the added spread. This type of outcome is consistent with many of the sticky wage macroeconomic models, namely, that union wages are relatively stickier than nonunion wages due to the long-term nature of union contracts.

Our results also indicate that in response to an unexpected widening of the wage gap, the union wage adjusts faster than the nonunion wage to eliminate the disequilibrium.[ix] So, although unions cannot maintain the higher wage gap indefinitely, they do capture this relative advantage for some period of time. Thus, the union wage tends to fall while the nonunion wage tends to increase to eliminate this wider wage gap, and the union wage falls at a faster rate than the rise in nonunion wage. On the other hand, in the services-producing and non-manufacturing sectors we find quite the opposite behavior (i.e., the error correction term in the non-union equation seems to be more dominant than in the union equation).[x]

The macro evidence of this paper that there exists a long term equilibrium union nonunion wage gap (i.e., a cointegrating relationship between union and nonunion wage series) can be corroborated with the existing micro evidence of statistically significant union wage premium across the industries and demographic groups. Furthermore, modeling union and nonunion wage series in a VEC framework enables us to see the relative magnitude and speed of these series reverting back to their long run relationship in response to any shocks.

5. Conclusion

This paper has helped to fill the gap in the union wage literature between the micro-based analyses and existing macroeconomic theories. In fact, the results found in the many longitudinal and panel union wage studies are solidified by our macro-based time series results. For instance, aggregation issues are often raised about empirical macro models; however, our results indicate that standard micro- and macro-based union models may not suffer from this bias. Thus, these findings suggest that time series modeling techniques provide policy makers at the firm, industry and national levels with a useful means to analyze union-nonunion wages over time.

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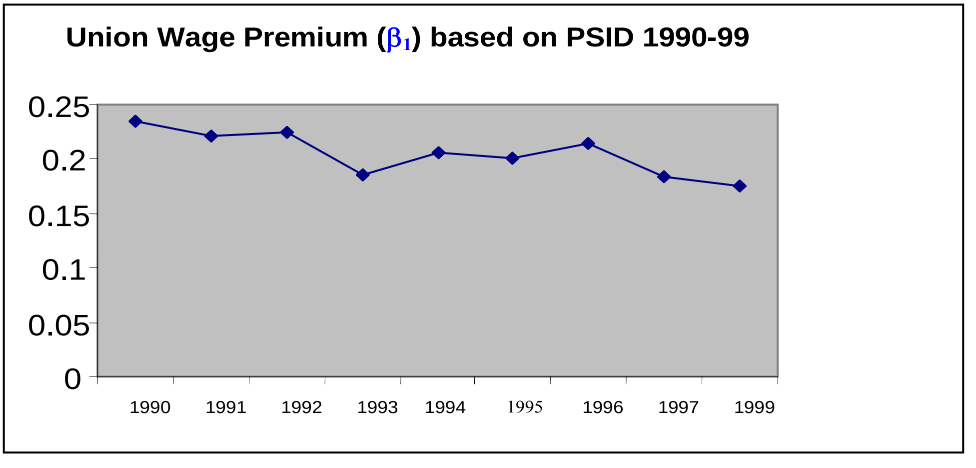
Endnotes

[i] One could note from the figure presented down below that the evidence from micro data (based on Panel Survey of Income Dynamics [PSID] – a widely used nationally represented micro dataset by many labor economists) after controlling for standard human capital, demographic and other controls the estimated overall union wage premium ranges from 23.5% in 1990 to 17.5 in 1999 and is somewhat stable. The following empirical specification is employed to the estimated overall union wage premium (which is captured by β_1 coefficient): ln W = α_0 + [Controls for: Education, Experience, Tenure, Marital Status, Gender, Race, Regions, Occupation, and Industry] + β_1 Union + error. Where 'ln W' is natural logarithm of real hourly wages, and 'Union' is a binary variable = 1 if union member, 0 otherwise. Full regression results for each year (sample sizes: 1990 = 8369, 1991 = 7979, 1992 = 8178, 1993 = 8156, 1994 = 6588, 1995 = 6229, 1996 = 5037, 1997 = 5697, and 1999 = 6337) can be obtained by a request. Please note that the PSID data were not available for 1998.



[ii] The raw data series start before this date, but due to data transformations (e.g., growth rates) the usable or adjusted sample period begins in the third quarter of 1977. The final effective sample is 109 quarterly observations.

[iii] The well-known ADF test was used as a benchmark unit root test. For those wage series where the ADF test indicated a possible stationary series, we employed the DF-GLS test to confirm the findings of the ADF test. Interestingly, for those wage series, our findings of the DF-GLS tests contradicted the ADF test results. We also conducted unit root tests on the macroeconomic variables (i.e., *Inf*, *Mpolicy*, and *Growth*) and found them to be stationary. These unit root test results can be obtained on request.

[iv] The popular multivariate maximum likelihood method of Johansen-Juselius (1990) to determine the number of cointegrating vectors is not required in this context because we focus on only two series (i.e., union and nonunion wage series). Hence we conducted the standard bivariate Engle-Granger test.

[v] Engle-Granger tests (i.e., one for each pair of union and nonunion wages) overwhelmingly reject the hypothesis that the resulting residual vectors are non-stationary. The absolute *t*-statistic values are 2.85 (goods-producing), 2.50 (service-producing), 2.58 (manufacturing), and 2.40 (non-manufacturing), all of which are greater than the corresponding 5 percent critical value of 1.94 (Mackinnon, 1996). Details of these test results can be obtained on request.

[vi] Details of these statistics can be obtained on request.

[vii] The full vector error correction model results based on equation system (3) can be obtained on request.

[viii] See Dahlen and Bolmsjo (1996) for more on the issue of life-cycle costing of labor factors, particularly as it pertains to production systems.

[ix] This can be seen by comparing the absolute values of the error correction coefficients of union sector with non-union sector [|-0.029805| > 0.017391] in goods producing, and [|-0.031896| > 0.024286] in manufacturing industries.

[x] This can be seen by comparing the absolute values of the error correction coefficients of union sector with non-union sector [|-0.016565| < 0.017339] in service producing, and [|-0.012421| < 0.017316] in non-manufacturing industries.