

# Labor Adjustment Patterns In The U.S. Steel Industry

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## Abstract

*This study examines labor demand in the U.S. steel industry. During the period of 1963-1988, the industry witnessed a tremendous decline in its output and employment. This decline has been particularly severe in the 1980s. The overall goal of this study is to estimate models of labor demand for the industry.*

*The study makes two main contributions. First, the study constructs a new high-frequency monthly data set on steel output and factor prices. Hamermesh (1993) notes that most studies of labor demand rely on annual data or quarterly data which is too intertemporally aggregated to model short-run labor adjustment. Second, labor demand in the industry is modeled as a function of the unfilled orders variable. This variable is included as a measure of future demand for the industry's output. The main challenge of this study is to deal with a number of econometric modeling issues. Recognizing that the industry's output demand is potentially an endogenous variable, the output is instrumented with a set of demand related variables including controls for various steel protection regimes. This study also corrects for serial correlation in these data through differencing and Hatanaka's autocorrelation procedures.*

*The main results of the study are fourfold. First, as in previous studies, the Instrumental Variable (IV) estimates show that the real wage rate and output are the key variables for explaining the fluctuations in employment. Second, the IV results do suggest that endogeneity of output is a problem and that the OLS results are biased downward. Third, the unfilled orders variable increases the demand for labor. However, this result is somewhat sensitive across specifications. Lastly, the study finds a fast short run employment adjustment period of 1.6 months. A final note of caution concerns serial correlation. Serial correlation is relatively severe in the data. The study solves this problem through both differencing and autocorrelation corrections. However, the success of these procedures proved to be mixed. Thus, the estimates reported herein vary across different estimation approaches.*

## 1.0 Introduction

**E**conomists have long been interested in the study of how labor demand adjusts to a variety of shocks. However, an important shortcoming in the existing literature concerns temporal aggregation issues. In particular economists often examine fluctuations in labor demand using quarterly and annual data while in fact, a monthly data are more appropriate. As Hamermesh (1993), states:

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*Readers with comments or questions are encouraged to contact the author via email.*

"Another difficulty is the remarkable heavy use of quarterly and even annual data in this area of research. Unlike excessive spatial aggregation, which is partly excusable because of the difficulty of obtaining microeconomic time series, the existence of large numbers of monthly economic time series makes excessive temporal aggregation inexcusable. In the United states there are good monthly data on production-worker employment and industry output, the most important measure in the vector of forcing variables. Monthly measures of earnings of production workers are also available by detailed industry. The focus on lower-frequency data is inexplicable given the ease of handling the larger sets of data that monthly observations represent. If we really believe that employers make decisions only once a year, this belief should be tested using higher-frequency data rather than imposed."

In this paper, I will improve on previous work by analyzing fluctuations in labor demand at a higher frequency and at a lower level of aggregation than in most other studies. While the overall goal is to generate estimates of labor demand adjustment using high frequency data, there are also some novel aspects of the data set used. In this research, I use unfilled orders in the steel industry as a proxy for future demand. The notion, here, is that a period with high unfilled orders may be less/more responsive in terms of labor adjustment to current period negative/positive demand shocks. The remainder of this study has four sections. In section II, the econometric employment is specified. Section III presents the data and measurement issues. In section IV, the estimates are discussed and section V presents the suggestions for future research.

**2.0 Empirical Labor Demand Model**

The quantity of the current production employment,  $L_t$  can be expressed as a function of the planned output demand,  $Q_d^*$ , of the input prices for labor ( $\omega$ ) and capital ( $r$ ), and of the unfilled orders variable,  $U_s$ . The general functional form can be stated as:

$$L_t = f(Q_d^*, \omega, r, U_s). \tag{1}$$

An endogeneity problem will arise in equation (1) when the actual output is used instead of the planned output in the firm’s cost minimization problem. Planned output may deviate from the actual output for a number of reasons—idle time caused by machine breakdown, inaccurate measures of demand, strikes, and input shortages (Dunne & Roberts, 1993). To solve the econometric problem, I will utilize the standard Errors in Variable Model (EVM) to correct for the output endogeneity problem. The period  $t$  planned or permanent output is stated as  $Q_d^*$  with the assumption that the planned output associated error term,  $v_t$ , follows  $N(0, \delta^2)$  distribution. Measurement errors are assumed to be uncorrelated with the planned output. The observed output,  $Q_d$ , at period  $t$  can therefore be stated as:

$$Q_d = Q_d^* + v_t. \tag{2}$$

Measurement errors in the observed output variable will bias the output parameter in equation (1) downward (Dunne & Roberts, 1993). One solution to this problem is the use of instrumental variables (IV) approach. The following reduced form output equation is estimated.

$$Q_d = f(Z, O_s, P_A, P_{RA}) \tag{3}$$

where  $Z$  controls for the import protection regimes, and  $O_s$ ,  $P_A$ , and  $P_{RA}$  are respectively other shipments (non-steel shipments), the price of aluminum, and the price of rubber and plastic. The labor demand can now be restated as a function of entirely exogenous variables and of the predicted output,  $\hat{Q}_d$  from equation (3) as:

$$L_t = f(\hat{Q}_d, \omega, r, U_s, L_{t-1}). \tag{4}$$

The lag of the current employment is included in equation (4) to assess the speed of the short run labor adjustment, and to capture the effects of the lags of the explanatory variables (Hogarty & Tierney, 1995). The appropriate standard errors are constructed for the model following the approach developed by Murphy & Topel (1985)<sup>1</sup>.

*Econometric Employment Specifications:* A number of different specifications of labor demand are explored. The foundation model mimics that used in Hamermesh (1993) and is specified in period *t* as:

$$\log L_t = \beta + \beta_1 \log \omega_t + \beta_2 r_t + \beta_3 \log \hat{Q}_{dt} + U_s + \eta_t \tag{5}$$

where  $\eta_t$  is the error term<sup>2</sup>. This basic model will also be altered to include the lagged employment as an independent variable. The model containing the lag of the employment will be used to estimate the speed of labor adjustment in the industry. OLS results are provided to make comparison to the literature and to the other appropriate alternative estimation techniques. The OLS results should be interpreted with caution.

**3.0 Data and Measurement Issues**

The data on monthly variables that describe the steel mill production employment cover the period from 1963 to 1988. These variables are retrieved from a variety of sources. The output variable represents the production of steel mill products. The unfilled orders variable is the domestic total of pending steel orders of steel consumers. To obtain the wage rate variable, I divided the total compensation cost including all fringe benefits for production workers by the weekly hours of the production workers.

The AAA-rated corporate bond yield<sup>3</sup> is a proxy for the cost of capital. I constructed the price indices for aluminum (SIC 3334), rubber and plastic goods (SIC 30), steel mill products (SIC 3312), and also constructed the non-steel shipments and steel protection variables<sup>4</sup>. The wage rate variable is deflated with CPI while the unfilled orders and steel shipments variables are deflated using a steel price index. Also, I constructed the real interest rate and appropriately deflated the other variables used in this study<sup>5</sup>. The descriptive statistics of the major series are presented in Table 1.

**Table 1: Summary Statistics**

Variable Name	Mean	Standard Deviation	Interquartile Range
Output (millions net tons) <sup>1</sup>	9.809	1.766	3.471
Production Employment <sup>2</sup> (thousands)	0.349	0.090	0.187
Real Wage Rate <sup>3</sup>	\$12.42	1.12	2.40
Unfilled Orders <sup>4</sup> (millions)	\$141.80	45.52	76.14
Observations: 312			

<sup>1</sup>(Source: *Metal Statistics 1969, 1974, 1979, 1984 and 1990 series, American Metal Market.*)

<sup>2</sup>(Source: *1909-1990 issue of the U.S. Employment and Earnings Survey Data, U.S. Department of Labor.*)

<sup>3</sup>(Source: *U.S. Employment and Earnings Survey Data, 1909-1990 issue, U.S. Department of Labor.*)

<sup>4</sup>(Source: *1958-1977, 1977-1982 and 1982-1990 Current Industrial Report series, U.S Department of Commerce.*)

Figure 1 shows the time series plots from the relative values<sup>6</sup> for steel output, employment, steel worker real wages, and unfilled orders.

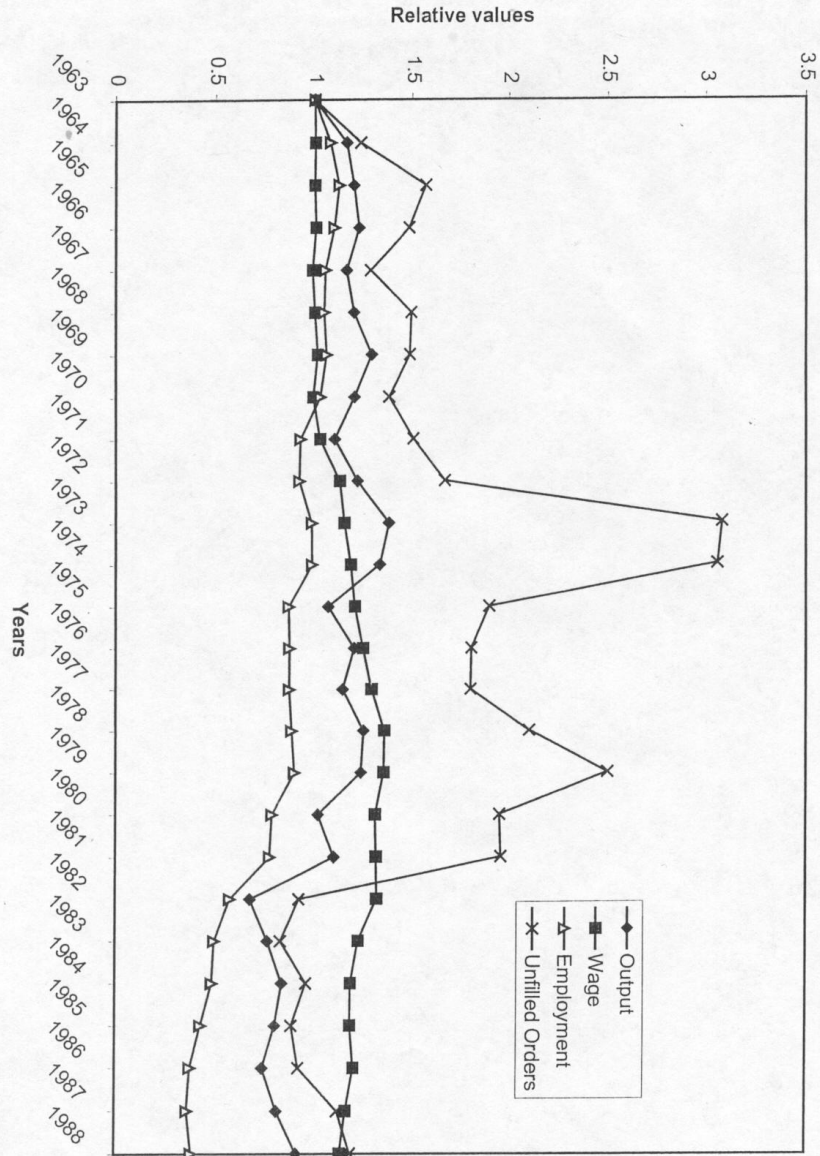


Figure 1 : Time series of Output, Wage, Employment, and Unfilled orders

In examining the steel output series, there are two periods of marked contracts—1974-1975 and 1979-1982. In both periods, steel production declined substantially but the contraction is striking in the 1979-1982 period. This period also began the steel decline in employment. From the 1979 through 1988, employment in steel declined by -7.49%. At the same time, the real wages in the industry have adjusted only modestly. Finally, the pattern in unfilled orders variable is quite volatile—rising markedly in both recessionary periods. This pattern is explained by the value of contract and contract changes, and by order errors and cancellations.

**4.0 Econometric Results**

The OLS and IV estimates from equation (5) and their alternative forms are reported in Table 2.

**Table 2: Production Worker Estimates From OLS and IV**

Models (Asymptotic Standard Error in Parentheses)

Explanatory Variable	1	2	3	4
	OLS Basic Model with $U_s$	IV Basic Model with $U_s$	IV DIFF Basic Model with $U_s$	IV Hatanaka AR Procedure
Constant Term	2.430 (1.600)	-0.849 (1.880)	-0.353* (0.080)	0.163* (0.039)
log $\omega$	-0.828* (0.138)	-0.718* (0.146)	-0.173* (0.088)	-0.107 (0.091)
r	-0.053* (0.004)	-0.044* (0.004)	0.006 (0.001)	0.001 (0.001)
log Q	0.821* (0.098)			
log $\hat{Q}$		1.006* (0.113)	0.026* (0.005)	0.095* (0.034)
log $U_s$	-0.139* (0.064)	-0.140* (0.063)	0.072* (0.017)	0.061* (0.019)
log $L_{t-1}$				0.651* (0.043)
$\bar{R}^2$	0.768	0.781	0.088	0.597
DW	0.232	0.225	1.411	
DH				-6.102
Rho	0.872	0.875	0.292	-0.231
Sample Size	312	309	308	307

\*Denotes estimates that are statistically significant at the marginal probability (P = 0.05) level.

Recalling that the OLS models give biased estimates, the results need to be interpreted with caution. The IV models correct the biased estimate problem.

*Detailed Result from IV Estimation Technique*<sup>7</sup>: The first two columns of Table 2 report the results from the OLS and IV estimation procedures. There is no correction for serial correlation in the results. The basic findings are comparable to the results reported in Hamermesh (1993). The wage estimates are somewhat inelastic and output estimate from the OLS results indicate substantial increasing returns. However, when one instruments the output variable, the coefficient on the output term rises from 0.821 to 1.006 indicating the technology in the industry is much closer to constant returns to scale than the OLS results would suggest. The negative estimate of the unfilled orders variable is picking up the declining time trend on the employment. While not reported, none of the estimated monthly dummies is statistically significant. A note of caution here is warranted. The DW statistic clearly indicates the presence of serial correlation in the error term.

Column 3 presents the results from applying differencing to the IV model<sup>8</sup>. Notice that the estimate of the unfilled orders variable switches sign and is positive in this specification. An increase in unfilled orders variable increases labor demand. The DW statistic, however, still indicates the presence of serial correlation in the differencing model. Also, note that differencing imposes a significant downward bias on the output variable.

Since the OLS estimator is inconsistent in a model containing the lagged dependent variable and autocorrelation, this study uses the Hatanaka (1974) autoregressive technique (AR) to correct this inconsistency. This technique uses a two-stage estimator. The first stage specifies the employment model in which the employment is instrumented with the vector of the independent variables. In the second stage where the predicted employment is included as a regressor, the residuals are predicted and used to specify the relationship ( $\rho$ ) between the current and the previous disturbance terms. The final (transformed) estimated model has the product of the  $\rho$  and the lag of each independent variable subtracted from the respective current variable. Hatanaka shows the estimates from this model as being asymptotically consistent and comparable to Maximum Likelihood estimates.

Column 4 presents the basic model (columns 1 and 2) using Hatanaka's AR procedure. This is the standard short-run labor adjustment model. Including the lagged employment, however, has important implications on the results. The estimates of the wage and output variables become very inelastic, as is often the case in this literature. In this column, the unfilled orders variable does have a positive impact on the short run labor demand as expected. With other factors being stable, a 1% increase in the unfilled orders variable will increase employment by 0.061%. Notice that the DW—h statistic indicates a rejection of the null hypothesis of serial autocorrelation<sup>9</sup>.


If one employs an AR model without the Hatanaka procedure, the coefficient (0.993) on the lagged employment variable indicates a very long adjustment period (97months)<sup>10</sup>. That is, given a shock to demand, it will take 97 months for employment to get halfway to the steady state level. The long adjustment period appears inconsistent with facts from comparable studies. This estimate is by far higher than the related estimates of 8.1 and 16.5 months from the manufacturing industries in Ball & St. Cyr (1966) and Hamermesh (1993).

With the Hatanaka procedure, the adjustment process is very short. The median length lag of the adjustment period is 1.61 months. This estimate falls between the adjustment period range of 0.4-2.1 months from monthly data of the manufacturing industries in Hamermesh (1993). The estimate is comparable to the related estimate of 1.4 months from the manufacturing industries, and is specifically comparable to the related estimates of 2.9 and 2.8 months from fabricated and primary metal industries (Topel 1982). The short adjustment period implies relatively low labor adjustment costs.

In summary, this study is successful in generating labor demand estimates from a high frequency monthly industry-level data set. Since employers make decisions on frequent basis, not quarterly or annually basis, the estimates here can describe the decisions. Previous studies concentrated in the use of quarterly or annual data. In addition, this study introduces into labor demand models, another significant factor—unfilled orders variable that describes the steel industry. Previous work did not model labor demand on this factor. The unfilled orders variable increases labor

demand in the short run. Finally, the results show that the speed of labor adjustment in the industry is relatively quick—1.6 months.

### 5.0 Suggestion for Future Research

An area for future research is the welfare implications of the steel protection policies on the demand for labor and on the different steel users in the society. This could highlight the gains or losses in societal welfare due to the protection policies. This area of further research could help to determine the extent to which the U.S. will continue to import or to make steel. 

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### Endnotes

<sup>1</sup>The problem with using the predicted value as an independent variable is its randomness. Since the predicting factors are drawn from the random samples of their respective populations, the predicted value will have a stochastic component. This will violate a vital assumption concerning nonstochastic independent variables in the OLS estimation technique. The standard errors from the instrumental variable estimator are therefore inflated, depending on the ratio of the error terms from the output and employment models. Thus, the instrumental variable estimator loses efficiency but is consistent in large samples.

<sup>2</sup>In Dunne & Roberts (1993),  $\eta_t = -\beta_Q v_t + \varepsilon_t$  where  $\beta_Q$  denotes the output coefficient and  $\varepsilon_t$  is the pure random shock in the empirical labor demand equation. Each of the error terms in  $\eta_t$  is assumed to be random, possesses zero mean, a constant variance and is uncorrelated with no other error term. Errors associated with measurement are assumed to be correlated with the deterministic variables of the estimating model.

<sup>3</sup>(Source: 1966-1990 issues of the Economic Report of the President).

<sup>4</sup>The indexed prices are constructed from the WPI 1963-1967, and PPI 1969-1989 of the Monthly Labor Review. Measured in millions of dollars, the non-steel shipments variable, a proxy for steel demand is the total U.S. manufacturing shipments minus the steel shipments. (Sources: 1958-1977, 1977-1982, 1982-1990 Current Industrial Report series. The steel protection variables are qualitative and attempt to control for the various trade protection regimes. Both the industrial goods price and the Consumer Price Index (CPI) are respectively retrieved from the 1965 to 1990, and 1964 to 1990 series of the Economic Report of the President.

<sup>5</sup>The constructed real interest rate,  $r_t = i_t - \Delta P_t$  where  $\Delta P_t$  is  $(P_t - P_{t-12})/P_{t-12}$  and  $i$  is the nominal interest rate. The relevant indexed prices, and the non-steel shipments variables are deflated by the industrial indexed price.

<sup>6</sup>Define a relative value as  $X_t/X_{1963}$  where  $X_t$  is the observation of period  $t$  and  $X_{1963}$  is the base year's observation.

<sup>7</sup>In the first stage IV estimation model, the lag of the output is included as a regressor to control the trend in the output. From this estimation technique, the estimate of the non-steel shipments variable is positive and statistically significant, and the protection instruments are jointly significant. The prices of steel substitute materials are not jointly significant. The DW converges to the value for the rejection of serial correlation.

<sup>8</sup>The Differencing (DIFF) approach uses first difference to correct for the serial correlation, time trend and multicollinearity problems.

<sup>9</sup>DW—h test indicates the rejection of first order autocorrelation in the model.

<sup>10</sup>The full regression results are available from the author by request.

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