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ABSTRACT

This paper is an application of the theory of rational expectations to the demand for labor in 11 two-digit industries. There were several specific goals: (1) to test the hypothesis that firms, to some extent, look past cyclical changes in determining their demand for output; (2) to try to explain the estimated finding of increasing returns to scale implied by most labor demand models; (3) to illustrate how the assumption of rational expectations is useful in distinguishing speeds of adjustment to different sources of output change--in our case, between cyclical changes and imports; (4) to make an explicit comparison with a model which assumes that expectations are static, i.e., the usual partial adjustment model.

We find that in most of the industries, firms do take account of the future in their demand for labor. Taking account of the future lowers the estimated returns to scale. We find, too, that speeds of adjustment differ by the source of output change and that the expectations model has statistical properties superior to the static model.

September 26, 1980

LABOR ADJUSTMENT UNDER RATIONAL EXPECTATIONS

by

*Robert A. Levy**
James M. Jondrow*

INTRODUCTION

Empirical studies of labor demand characteristically come up with two results that conflict with predictions drawn from simple static theory. First, theory suggests that, because labor is usually assumed to be the most variable factor in the short run, increasing amounts of it will be needed for added increments of output. In fact, over the business cycle, the opposite occurs. As output rises, employment increases less than proportionately. Second, theory suggests that, over the long run, with all inputs variable, returns to scale will be constant or diminishing.[1] In fact, empirical studies of labor demand appear to imply long-run increasing returns to scale.

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[1]For a discussion of constant returns as a truism, see Friedman [4], pp. 136-138. Engineering cost curves at the plant level do tend to find only modest deviations from constant returns to scale (see Scherer [19], pp. 94-98).

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A widely accepted explanation for the implied increasing returns is labor hoarding; during a downturn in output, firms hold unneeded skilled workers "in inventory" in order to avoid the cost of funding replacements when demand picks up again. In accounting for labor hoarding, the first step has been the use of partial adjustment models. However, the accounting has been incomplete--the implied returns to scale are still increasing, which is, in part, a consequence of failure to adequately model expectations.

The standard assumption, implicit in partial adjustment models (including models of interrelated factor demand), is that future values of the exogeneous variables are expected to be the same as the present or differ by a time trend. This assumption, however, can not be an accurate assumption of how expectations move over the business cycle; employers have information from previous cycles which tells them that their business will recover from a recession.

Expectations of exogenous variables become important when there are high fixed costs to changing employment levels. This importance has been noted by a number of economists including Gould [3], Brechling [1], and Nadiri and Rosen [14]. With the recent work on modeling expectations, especially rational expectations, labor demand models have begun to explicitly include the future (see Sims [20], Sargent [16], and Kennan [7]).

The Sims and Kennan papers both discuss the tendency to find increasing returns to labor in empirical studies. Sims attributes the findings to measurement error and the assumption of static expectations. By taking these into account, he does find a proportional response of employment to output, but only when the labor input is measured as man-hours, not when it is measured as the number of workers employed. Kennan finds sharply decreasing returns for both durables and nondurables, the latter to an extent which he considers unreasonable.

The usefulness of extending the study of the role of expectations in labor demand becomes clear in light of various government policies on employment adjustment. For example, it has been standard practice to use input-output studies to analyze the effect of imports on the domestic demand for the output of competing and related industries. Input-output assumes that imports cause proportional and immediate effects on industry employment. Rising imports, according to the input-output model, will cause large, sudden, decreases in employment. In response to this perceived problem, programs have been designed to provide federal aid to workers hurt by imports.

The assumption of immediate and proportional adjustment does not accord with empirical evidence of gradual adjustment as well as labor output elasticities less than one. The assumption would therefore require that imports have a special effect. A possible justification for a "special" effect for imports is that firms, upon seeing competing imports enter their market, interpret the change as permanent, completely revising their view of the future and adjusting their workface accordingly, even if skilled workers (i.e., workers with high hiring and training costs) are involved. We test for a special effect of imports in a model in which expectations are rational. The model must include two parts, one describing how expected output affects labor demand, the other describing how output (and, hence, expected output) is generated as a function of imports and other determinants.

Our procedure illustrates a useful characteristic of the theory of rational expectations: In the process of generating expectations the researcher automatically finds out how different determinants (e.g., imports) effect expectations. Alternative assumptions about the formation of expectations such as surveys of anticipations or adaptive expectations do not have this characteristic.

The model is applied to 11 industries at the two-digit SIC level. This disaggregation is important for theoretical reasons since industries differ in the amount and specificity of human capital. As part of our study we: (1) disentangle the effects of expectations from the process that generates them (2) make a direct comparison with a model of static expectations (3) compare the short-run effects on labor arising from changes in imports and in GNP.

THE DEMAND FOR EMPLOYMENT

The theory of labor demand involves a firm's balancing two motivations on its the current holdings of labor: first, minimizing the cost of producing current output; second, keeping on hand enough workers to avoid large costs of adjusting to expected changes in output.

To derive a labor demand equation that incorporates those considerations, we begin with the assumption that, subject to a given production function, the employer minimizes the cost of producing a given stream of present and (expected) future output, including costs of adjustment.

To focus on the input of primary interest (the number of workers [N]), we combine all other inputs into a composite factor (Z). This includes inputs such as materials, energy, capital, capital utilization, and utilization of the labor force, e.g., average weekly hours or other unobservable measures of labor utilization.

The production function is of the general form:[1]

$$Q_t = f(N_t, Z_t), \quad f_N, f_Z > 0; \; f_{NN}, f_{ZZ} < 0 \quad . \tag{1}$$

We assume this can be rewritten in inverse form:

$$Z_t = g(Q_t, N_t) \tag{2}$$

and work with the second order Taylor expansion

$$Z_t = a + bN_t + \frac{c}{2} N_t^2 + dN_tQ_t + eQ_t + \frac{f}{2} Q_t^2 \tag{3}$$

The (external) adjustment cost is also assumed to be quadratic.

$$\phi_t = \frac{\phi}{2} (N_{t+1} - N_t)^2 \; , \; \phi_N > 0, \; \phi_{NN} > 0, \tag{4}$$

---

[1]A time trend could be included to represent other influences on labor demand that change smoothly over time, such as technological progress or the firm's capital stock. Since the derivation of labor demand is virtually the same, it is not included until the regression results are presented.

where ϕ is a dollar cost of adjustment per man.[1] The firm's cost in period t+j is:

$$C_{t+j} = W_{t+j}N_{t+j} + q_{t+j}Z_{t+j} + \frac{\phi}{2}(N_{t+j+1}-N_{t+j})^2$$

$$= W_{t+j}N_{t+j} + q_{t+j}(a+bN_{t+j} + \frac{c}{2}N_{t+j}^2 \qquad (5)$$

$$+ dN_{t+j}Q_{t+j} + eQ_{t+j} + fQ_{t+j}^2)$$

$$+ \frac{\phi}{2}(N_{t+j+1}-N_{t+j})^2$$

where W_{t+j} = wage paid to labor in time period t+j

q_{t+j} = wage paid to input Z in time period t+j

The demand for labor at time t+l will emerge as the solution to the minimization of the discounted expected flow of costs to the firm (V_t). Substituting for Z in (5) from (3), the required present value is:

$$V_t = E_t \sum_{j=0}^{\infty} (1+r)^{-j}\Big[W_{t+j}N_{t+j} + q_{t+j}(a + bN_{t+j}$$

$$+ \frac{c}{2}N_{t+j}^2 + dN_{t+j}Q_{t+j} + cQ_{t+j} + \frac{f}{2}Q_{t+j}^2) \quad (6)$$

$$+ \frac{\phi}{2}(N_{t+j+1}-N_{t+j})^2\Big]^2$$

---

[1]This cost function displays increasing marginal costs and so is consistent with lagged adjustment of N.

[2]E_t is the expectation operator. E_tY_{t+j} is the expected value of Y_{t+j} based on information in the $t^{\underline{th}}$ period.

We assume that wages (W_t), the price of input Z(q_t), and adjustment costs (ϕ_t) increase by the same percent over time.[1] Thus, the firm faces only an exogenous process $\left\{Q_{t+j}\right\}_{j=0}^{\infty}$ in its minimization problem.

Differentiating with respect to N_{t+j} yields the first order conditions:

$$E_{t+j}N_{t+j+1} - \frac{1}{h} N_{t+j} + aN_{t+j-1} = \frac{1}{\phi} X_{t+j} \qquad (7)$$

$$j = 0,1,2,...$$

where

$$h = \frac{1}{2+r+\frac{cq}{\phi}}$$

$$a = 1 + r$$

$$X_{t+j} = W + bq + dqQ_{t+j}$$

Equation (7) describes an infinite sequence of equations. Their solution is facilitated by rewriting (7) as

$$(1 - \frac{1}{h}L + aL^2)E_{t+j}N_{t+j+1} = \frac{1}{\phi}X_{t+j} \qquad (8)$$

where L is the lag operator ($Ly_t = y_{t-1}$)

Factoring the lag polynomial yields:

$$(1-\lambda_1 L)(1-\lambda_2 L)E_{t+j}N_{t+j+1} = \frac{1}{\phi}X_{t+j} \qquad (9)$$

---

[1]A generalization of the model that allows for different growth paths for the different prices is presented later in the paper.

where $\lambda_1 + \lambda_2 = \frac{1}{h} = a + \frac{\phi + cq}{\phi}$ (10)

and $\lambda_1 \lambda_2 = a$ [1]

It can be shown that for any finite ϕ, $\lambda_1 < 1$ and $\lambda_2 > a > 1$. Using the forward inverse of $(1-\lambda_2 L)$, since $\lambda_2 > 1$, we obtain

$$(1-\lambda_1 L)E_{t+j}N_{t+j+1} = -\frac{(\phi\lambda_2)^{-1}L^{-1}}{1-\lambda_2^{-1}L^{-1}} X_{t+j} \qquad (11)$$

$$= -\frac{\lambda_1}{a\phi}\frac{1}{1-\lambda_2^{-1}L^{-1}}E_{t+j}X_{t+j+1}$$

(since $L^{-1}X_{t+j} = X_{t+j+1}$)

Writing the denominator as

$$(1-\lambda_2^{-1}L^{-1}) = 1 + \lambda_2^{-1}L^{-1} + \lambda_2^{-2}L^{-2} + \ldots \qquad (12)$$

and using this expression in equation (11) leads to the final equation for labor demand in the t+j+1st period:

---

[1] A solution for λ_1 may be determined from equation 10. It turns out that

$$\lambda_1 = \frac{2ha}{1+\sqrt{1-4h^2a}}$$

This can be shown to be less than 1 for any bounded and positive ϕ and greater than 0 for any positive r.

$$N_{t+j+1} = \lambda_1 N_{t+j} - \frac{\lambda_1}{a\phi} \sum_{i=0}^{\infty} \left(\frac{\lambda_1}{\phi a}\right)^i E_{t+j+1} X_{t+j+1+i} \quad (13)^{1,2}$$

THE MODEL FOR GENERATING EXPECTATIONS

Equation (13) indicates that labor demand depends on current output and future outputs in a declining geometric pattern. Employers do not know future output, and so must act on the basis of expectations. We assume that output is generated by the following model.[2]

$$\ln D_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln(Y_t/Y_{t-1}) + \alpha_3 \ln P_t + \alpha_4 D1 + \alpha_5 D2 + \alpha_6 D3 + \alpha_7 t \quad (14)$$

$$\ln Y_t = \beta_0 + \beta_1 \ln Y_{t-1} + \beta_2 \ln Y_{t-2} + \beta_3 D1 + \beta_4 D2 + \beta_5 D3 + \beta_6 t \quad (15)$$

---

[1]This minimization and its solution is a special case of minimizing over a quadratic objective function with an infinite horizon. The general problem is discussed in papers by Simon [18], Theil [21], and Sargent [17], specific models concerned with labor demand in Kennan [7] and Sargent [16].

[2]These equations represent the basic version of the model. To capture differences among industries the actual regression equations will include only significant terms and some include alternative specifications of key variables (e.g., to capture cyclical elements, the variable $\ln(Y_t/Y_{t-4})$ may be used instead of $\ln(Y_t/Y_{t-1})$)

$$\ln M_t = \gamma_0 + \gamma_1 \ln M_{t-1} + \gamma_2 \ln M_{t-2} + \gamma_2 D1 \qquad (16)$$
$$+ \gamma_4 D2 + \gamma_5 D3 + \gamma_6 t$$

$$\ln P_t = \delta_0 + \delta_1 \ln P_{t-1} + \delta_2 \ln P_{t-2} + \delta_3 D1 \qquad (17)$$
$$+ \delta_4 D2 + \delta_5 D3 + \delta_6 t$$

$$Q = D-M \qquad (18)$$

where Q is domestic production
D is total demand for an industry's products (includes both domestic production and imports)
M is imports
Y is constant dollar GNP
P is the wholesale price index for the industry's output; relative to the overall wholesale price index

D1,D2,D3 are dummy variables used to account for seasonal factors
t is a time trend
AP is the average value of P over the current and three preceding periods

All variables except the dummy variables, the time trend, and GNP are specific to the individual industries.[1]

To summarize, for a specific industry, total demand (= domestic output plus imports) is expressed as a function of variables such as real GNP, relative prices (WPI of the industry/WPI of all manufactured goods),

[1]Note that the equation for imports (16) does not include the price of imports relative to domestic; this is a consequence of a lack of data on import prices at the 2-digit level.

seasonal dummies. Domestic output is determined as the difference between total demand and imports, the latter treated as exogenous.

The essence of rational expectations is that expectations are made according to the same statistical process that generates the actual variable. Hence, the model above is also a model of expectations. The model can be used to form expectations one period forward given the current and lagged information. For example, imports one period forward are projected from equation (16) with M_{t-1} now referring to the current period and M_{t-2} now referring to last period. Imports two periods forward are estimated with the same equation, with M_{t-2} refering to the current period and M_{t-1} refering to the forecast one period forward. To obtain expectations of output, the same recursive forecasting scheme is applied to the model as a whole. In other words, rational forecasts several periods forward are formed by making use of nearer term rational forecasts.[1]

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[1]The statistical theory behind this technique is discussed in an appendix available on request (or in [8]). Malinvaud [18] and Sargent [17] discuss these issues as well.

DATA

To estimate the equations for labor demand and for generating expectations , we used quarterly data at the two digit level on imports, output, prices, and employment in the following industries:

- Textile Mill Products (SIC 22)
- Apparel and Other Textile Products (23)
- Paper and Allied Products (26)
- Rubber and Plastic Products (30)
- Leather and Leather Products (31)
- Stone, Clay, and Glass Products (32)
- Primary Metals (33)
- Fabricated Metal Products (34)
- Machinery, Except Electrical (35)
- Electrical Equipment and Supplies (36)
- Transportation Equipment (37)

These industries exhibited varying degrees of import penetration--from less than 3 percent to almost 23 percent.

The quantity of imports is measured as the value (from BLS) deflated by the corresponding domestic producer price index. This technique, adopted because of data limitations, involves the implicit assumption that domestic products and the corresponding imports are perfect substitutes. Domestic output is measured as the value of shipments plus the change in inventories, both deflated by the industry's producer price index. Data on shipments and inventories are from the Bureau of the Census [26] and indexes of wholesale prices are from BLS [29]. For industries 23 and 31, quarterly shipment data had to be estimated using annual shipment data and the FRB quarterly data on physical production (from [23]). The measure of employment was the number of production workers, from BLS [27].

EMPIRICAL RESULTS

Empirical estimation of the model proceeded in two parts. First, for each industry, the three-equation system used to generate expectations ((14), (16), (17)) was estimated using OLS or, when appropriate, a GLS correction for serial correlation. In the interest of brevity, the regression equations are not shown here but are available in [8]. The estimated equations were then solved to generate forecasts of output. Second, labor demand (13) was estimated using nonlinear least squares with the infinite distributed lead in expected

TABLE 1

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current and Expected Output)

$$N_{t+1} = b_1 + b_2 \sum_{i=1}^{9} b_3^i Q^*_{t+i} + b_4 b_3 N_t + b_5 \text{ TIME} + b_6 D1 + b_7 D2$$

$$+ b_8 D3 + b_9 D37^*$$

Coef- ficient	Industry 22	23	26	30	31	32
b_1	9.24 (.112)	75.1 (.790)	112. (1.80)	210. (4.32)	9.51 (.261)	86.7 (3.09)
b_2	.937 (.815)	12.2 (.925)	1.13 1.07)	65.5 (.365)	22.2 (.137)	10.4 (1.37)
b_3	.791 (3.16)	.356 (1.57)	.703 (3.38)	.093 (.466)	.142 (.153)	.333 (2.48)
b_4	1.00 (4.03)	1.88 (1.77)	.784 (4.12)	.217 (.149)	5.68 (.156)	1.30 (3.57)
b_5	-.729 (-2.79)	.491 (1.29)	-1.42 (-3.97)	-1.58 (-4.14)	.237 (.697)	-.793 (-5.96)
b_6	-2.36 (-.370)	-43.1 (-5.46)	-4.71 (-1.22)	-10.7 (-1.58)	-4.73 (-1.59)	15.3 (4.91)
b_7	9.85 (1.58)	-16.3 (-1.62)	7.75 (1.88)	-16.8 (-1.55)	2.34 (.673)	27.8 (5.43)
b_8	11.3 (1.76)	-29.1 (-3.66)	4.96 (1.38)	14.7 (2.28)	-2.56 (-1.05)	18.9 (6.18)
b_9	--	--	--	--	--	--
R^2	.874	.940	.879	.894	.977	.956
DW	1.16	1.421	1.091	2.01	1.12	1.28

For industries 22, 26, 30, 32, 34, 35, 36, the range of the regressions was Q2 1968 to Q4 1977. For industries 23 and 37, the range was Q3 1968 to Q4 1977. For industry 33, the range was Q4 1968 to Q4 1977.

* Dummy variable used to represent the major automobile strike in Q4 1970.

TABLE 1 - continued

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current and Expected Output)

$$N_{t+1} = b_1 + b_2 \sum_{i=1}^{9} b_3^i Q^*_{t+i} + b_4 b_3 N_t + b_5\ \mathrm{TIME} + b_6 D1 + b_7 D2$$

$$+ b_8 D3 + b_9 D37^*$$

Coef-ficient	Industry 33	34	35	36	37
b_1	23.3 (2.06)	-168.3 (-.603)	45.8 (.643)	20.8 (2.32)	452.8 (3.00)
b_2	4.63 (1.49)	1.43 (1.13)	.522 (.687)	4.54 (1.07)	3.78 (.588)
b_3	.454 (2.52)	.831 (3.30)	.820 (3.06)	.484 (2.50)	.296 (.915)
b_4	.822 (2.93)	.717 (6.42)	.961 (4.18)	1.04 (3.79)	1.65 (1.04)
b_5	-2.85 (-5.55)	-.083 (-.392)	-1.08 (-2.45)	-4.43 (-5.20)	-4.54 (-2.89)
b_6	-4.14 (-.412)	-7.21 (-.944)	-11.2 (-1.05)	5.60 (.450)	-17.8 (-.930)
b_7	5.07 (.438)	6.08 (.843)	-22.6 (-2.06)	14.5 (1.15)	-18.0 (-.773)
b_8	14.0 (1.48)	26.3 (4.22)	-7.74 (-.676)	48.9 (3.75)	53.2 (2.55)
b_9	--	--	--	--	-165.0 (-3.68)
R^2	.934	.951	.951	.926	.864
DW	1.38	1.90	.934	2.08	2.01

For industries 22, 26, 30, 32, 34, 35, 36, the range of the regressions was Q2 1968 to Q4 1977. For industries 23 and 37, the range was Q3 1968 to Q4 1977. For industry 33, the range was Q4 1968 to Q4 1977.

*Dummy variable used to represent the major automobile strike in Q4 1970.

TABLE 2

INDUSTRIES GROUPED ACCORDING TO THE VALUE OF b_3

High Values of b_3	Textile Mill Products (22)
.7 and higher	Paper and Allied Products (26)
High implied adjustment costs	Fabricated Metal Products (34)
Expectations important	Machinery, exc. electrical (35)
Lower, but Significant Values of b_3	Stone, Clay, and Glass (32) Primary Metals (33)
b_3 = .3 to .5	Electrical Equipment and (36) Supplies
Insignificant b_3 Low implied adjustment costs Expectations unimportant	Apparel and Other Textile Products (23) Rubber and Plastic Products (30) Leather and Leather Products (31) Transportation Equipment (37)

output truncated at eight quarters.[1,2] The non-linear estimates of labor demand are shown in table 1.

For the hypothesis that expectations are important (and generated as assumed here), the crucial coefficient is b_3 which from equation (13) is equal to λ_1 /a. A high value for b_3 implies a strong effect of future output on current labor demand. Estimates are positive in all industries and significant in seven of the eleven. The industries can be grouped by b_3 as shown in table 2.

---

[1]The use of eight quarters, or two years, reflects the view that this time frame adequately captures the firm's planning horizon. Although it is true that tests over many different horizons might lead to slightly different results, the number of industries studied limits experimentation. Experimentation with longer leads in a few industries yielded similar results.

[2]Conceptually, the truncation of the expectation series at eight leads in the future means that the last coefficient has a somewhat different interpretation. The truncation implies that $Q^*_{t+9} = Q^*_{t+10} = \ldots$, so that the coefficient on the last expectation series used (Q^*_{t+9}) is really $b_3^9/(1-b_3)$. This number will vary from b_3^9 by a negligible amount and so is ignored in the computation of the estimated elasticities presented in this section.

The estimates of b_2 (= $\frac{dq}{\phi}$ in equation (13)) are not significant by a t-test at the 5 percent level. This, however, is purely a consequence of collinearity with b_3, for F tests of the hypothesis that output does not enter demand indicated rejection for every industry.

The coefficient b_4 should always be greater than one and from the theory should equal one plus the rate of interest. Though b_4 is always positive, it is estimated with wide confidence bounds and substantial variation across equations which sometimes result in values below 1.

The summary statistics are of interest primarily for comparisons with the partial adjustment model, a special case in which expectations are static. For a comparison of the two models, the results of estimating a (linear) partial adjustment equation are presented in table 3. The comparison suggests the superiority of the expectations model: the R^2 and Durbin-Watson statistics are greater in every case for the expectations model.

TABLE 3

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current Output Only)

$$N_{t+1} = a_1 + a_2Q_{t+1} + a_3N_t + a_4D1 + a_5D2 + a_6D3 + a_7TIME + a_8D37^*$$

Coefficient	Industry 22	23	26	30	31	32
a_1	120 (1.70)	134 (1.12)	161. (2.84)	222 (6.08)	12.2 (4.06)	116 (4.56)
a_2	3.38 (4.19)	7.18 (6.43)	2.00 (2.71)	6.84 (7.05)	3.56 (2.93)	6.84 (8.38)
a_3	.654 (7.24)	.603 (8.20)	.523 (3.53)	-.144 (-.109)	.802 (9.03)	.300 (3.66)
a_4	-2.83 (-.402)	-44.6 (-5.64)	-6.08 (-1.42)	-10.7 (-1.60)	-4.99 (-2.11)	21.3 (6.82)
a_5	4.64 (.666)	-25.7 (-3.09)	4.01 (.793)	-20.1 (-2.76)	1.92 (.831)	22.8 (5.51)
a_6	19.22 (2.64)	-35.2 (-4.59)	4.69 (1.18)	14.4 (2.28)	-2.72 (-1.21)	17.1 (5.87)
a_7	-.859 (-2.87)	.383 (1.63)	-1.24 (-2.85)	-1.55 (-4.23)	.214 (.750)	-.901 (-6.70)
R^2	.840	.934	.847	.893	.977	.950
DW	.936	1.42	.615	1.98	1.11	1.34

The range of the regressions is the same as in the previous labor demand regressions.

* Dummy variable used to represent the major automobile strike in Q4 1970.

TABLE 3 - continued

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current Output Only)

$$N_{t+1} = a_1 + a_2Q_{t+1} + a_3N_t + a_4D1 + a_5D2 + a_6D3 + a_7TIME + a_8D37^*$$

Coef-ficient	Industry 33	34	35	36	37
a_1	394. (4.77)	216. (3.95)	170. (2.50)	294. (3.68)	498. (3.63)
a_2	3.23 (5.68)	4.42 (7.89)	2.76 (4.92)	5.19 (6.63)	1.60 (2.74)
a_3	.313 (2.75)	.366 (4.40)	.620 (7.62)	.353 (3.59)	.455 (3.26)
a_4	-8.71 (-.860)	-13.6 (-1.82)	-23.3 (-1.83)	12.4 (.953)	-17.4 (-.918)
a_5	-17.0 (-1.52)	-24.5 (-2.67)	-38.1 (-3.06)	3.31 (2.52)	-31.9 (-1.53)
a_6	10.8 (1.07)	20.6 (2.87)	8.17 (.643)	67.5 (5.17)	59.3 (2.98)
a_7	-2.98 (-5.31)	.151 (.677)	-1.06 (-1.98)	-4.97 (-5.59)	-4.63 (-2.98)
a_8	-- --	-- --	-- --	-- --	-162.7 (-3.64)
R^2	.919	.934	.930	.915	.860
DW	1.03	1.49	.592	1.53	1.81

The range of the regressions is the same as in the previous labor demand regressions.

* Dummy variable used to represent major automobile strike in Q4 1970.

The familiar finding of strongly increasing returns to labor (i.e., elasticities much less than one) is evident in the elasticities calculated from the linear equation (partial adjustment model). The elasticities, shown in table 4, are all less than one and range from .483 (industry 37) to .792 (industry 36). The simple average over all industries is .644. The nonlinear equation incorporating expectations leads to elasticities that are higher in every industry than those found in the partial adjustment model. In those industries where b_3 was significant, the average is .91 which implies near constant returns. This result is obtained even though the labor input is measured by the number of workers. This contrasts with Sims findings of increasing returns to workers. In the other industries, taking account of the future did not appreciably improve the estimated returns to scale.

TABLE 4

LONG RUN ELASTICITIES OF LABOR
WITH RESPECT TO OUTPUT

Industry	e_1 (linear equation)	e_2 (nonlinear equation)
22	.659	1.008
23	.741	.835
26	.503	.684
30	.573	.660
31	.621	.654
32	.712	.732
33	.562	.733
34	.685	1.396
35	.757	.971
36	.792	.845
37	.483	.512
Average	.644	.821

$$e_1 = \frac{a_2}{1-a_3} \cdot \frac{\overline{Q}}{\overline{N}} \qquad e_2 = \frac{b_2 \cdot \sum_i b_3^i}{1-b_3\ b_4} \cdot \frac{\overline{Q}}{\overline{N}}$$

where the a_i's are the coefficients from the linear labor demand equation

the b_i's are the coefficients from the nonlinear labor demand equation

and $\overline{Q}$, $\overline{N}$ are the means of output and employment, respectively.

AUTOCORRELATION

That the nonlinear model improves the Durbin-Watson statistic seems to indicate that introducing expectations accounts for one source of autocorrelation. This accords with the interpretation of autocorrelation as the consequence of omitted variables (in this case, expectations) which are themselves autocorrelated (see Madalla [9] p. 274).

Because both the linear and nonlinear equations contain a lagged dependent variable the coefficients, t values, and the Durbin-Watson statistic are subject to bias. Whether it is worthwhile trying to do anything about autocorrelation is unclear. One view is that it is preferable not to perform a correction but to use a measure of autocorrelation, such as the Durbin-Watson or an estimated   to indicate the extent to which there remain problems of omission or specification. Further, Maeshiro [10] has shown that in small samples with trended explanatory variables, GLS can frequently lead to a greater mean square error and even greater bias, because of increased multicollinearity.

It may still be instructive to consider the results of adjusting the nonlinear equation for autocorrelation.

For 6 of the industries, this adjustment makes little difference. In 3 of the 6 (industries 30, 31, and 37) the estimated b_3 was still insignificantly different from 0 and so the simple partial adjustment model would suffice. In the other 3 (industries 32, 34 and 36) the estimated ρ was small and insignificant; the results presented in table 1 continue to be appropriate.

Results for the other five industries, where the adjustment does make a difference, are reported in table 5. For 2 industries, 22 and 33, the sharpest changes have to do with decreases in the value of b_4 (the estimate of 1+r). This finding is not unexpected when correcting for autocorrelation since b_4 is the coefficient on the lagged dependent variable. The estimated covariances imply that it is also, however, a consequence of added multicollinearity problems arising from the extra coefficient (ρ) to be estimated (since and b_4 are somewhat collinear). In a third industry, 23, the coefficients b_3 and b_4 increase in value and both now become significant. In all 3 industries, in spite of slight changes in the values of b_3 and b_4 the elasticities are similar to those calculated earlier when ρ was not estimated.

TABLE 5

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current and Expected Output)
(Correction for Autocorrelation)

$$N_{t+1} = b_1 + b_2 \sum_{i=1}^{9} b_3^i Q^*_{t+i} + b_4 b_3 N_t + b_5\ \text{TIME} + b_6 D1 + b_7 D2$$

$$+ b_8 D3 + b_9 D37 + b_{10} D26 + b_{11} \sum_{i=1}^{9} b_3^i W^*_{t+i}$$

Coef-ficient	Industry 22	Industry 23	Industry 26
b_1	60.8	96.2	133.2
	(.367)	(.66)	(1.82)
b_2	2.67	7.26	1.82
	(.827)	(1.01)	(1.03)
b_3	.751	.516	.505
	(2.62)	(2.28)	(2.39)
b_4	.638	1.18	1.15
	(2.74)	(2.29)	2.83)
b_5	-1.88	.569	-1.04
	(-1.85)	(.957)	(-3.17)
b_6	-3.62	-40.86	-4.39
	(.995)	(-6.24)	(-2.07)
b_7	6.29	-14.26	.513
	(1.42)	(-1.58)	(1.87)
b_8	13.1	-26.84	2.17
	(2.17)	(-4.3)	(1.18)
b_9	--	--	--
b_{10}	--	--	-28.8
	--	--	(-7.44)
b_{11}	--	--	--
ρ	.769	.433	.18
	(4.54)	(1.61)	(.76)

TABLE 5 - continued

LABOR DEMAND REGRESSION EQUATIONS BY INDUSTRY
(Current and Expected Output)
(Correction for Autocorrelation)

$$N_{t+1} = b_1 + b_2 \sum_{i=1}^{9} b_3^i Q^*_{t+i} + b_4 b_3 N_t + b_5 \text{ TIME} + b_6 D1 + b_7 D2$$

$$+ b_8 D3 + b_9 D37 + b_{10} D26 + b_{11} \sum_{i=1}^{9} b_3^i W^*_{t+i}$$

Coef-ficient	Industry 33	Industry 35
b_1	448. (2.90)	884. (2.27)
b_2	9.05 (1.85)	4.25 (1.60)
b_3	3.51 (2.28)	.535 (3.93)
b_4	2.81 (.736)	.576 (1.45)
b_5	-4.24 (-4.58)	-3.44 (-2.13)
b_6	-12.84 (-1.84)	-10.9 (-1.54)
b_7	-7.47 (-.728)	-18.1 (-2.46)
b_8	17.68 (2.54)	6.81 (.704)
b_9	-- --	-- --
b_{10}	-- --	-- --
b_{11}	-- --	-439.5 (-1.58)
ρ	.605 (3.86)	.677 (2.91)

In two industries, 26 and 35, estimating ρ induced a lack of convergence in the nonlinear routine, possibly because of added multicollinearity. For industry 26, the lack of convergence was overcome by including a dummy variable for the final quarter of 1974 and the first quarter of 1975. These were quarters of extreme labor dishoarding to an extent inconsistent with our model; they would make a good base for future work on the conditions when hoarding breaks down.

For industry 35, the problem of nonconvergence could be solved by including relative wage terms.[1] This required modifying the cost function (5). Otherwise the first order conditions lead to a second-order difference equation (given in equation (7)) with nonconstant coefficients (due to the term $\frac{cq_t}{\phi_t}$).

We adopt a variant of the cost function discussed by Sims and Kennan which assumes that costs are made up of disequilibrium (away from equilibrium level labor, N^*) and adjustment costs, and is given by

$$C_{t+j} = \frac{\alpha}{2} (N_{t+j}-N^*_{t+j})^2 + \frac{\phi}{2}(N_{t+j+1}-N_{t+j})^2. \qquad (19)$$

[1] In general, however, relative wages were included but did not improve the regression results.

Using this in the expected discounted cost function leads to a labor demand equation quite similar to equation (13) except that λ_1 now equals $\frac{2h'a}{1+\sqrt{1-4(h')^2a}}$ where $(h')^{-1} = \frac{\alpha+(2+r)\phi}{\phi}$ (previously, $h^{-1} = \frac{cq+(2+r)\phi}{\phi}$ so that ϕ substitutes for cq in the definition of h).

The results for industries 26 and 35 are included in table 5. The coefficient b_3 was quite significant in both cases although the magnitude fell somewhat from the previous regressions.

In general, the autocorrelation correction did not change the qualitative results; the same set of seven industries show a significant dependence between labor demand and rational expectations of the future and one industry (23) is added to the set.

AN APPLICATION OF THE MODEL: THE COMPARISON OF THE SHORT-RUN EFFECTS OF CHANGES IN OUTPUT FROM DIFFERENT SOURCES

This section describes how our models of labor demand and expected output may be used to distinguish between the effects of changes in imports and changes in GNP on labor demand. Although the results of this calculation are of interest for public policy reasons, they also illustrate the usefulness of the rationality assumption in distinguishing between different sources of output change. Changes from different sources that yield a given change in current output have very different effects on expectations and so will affect current labor demand differently.

The calculations of interest are short-run (i.e., one quarter) elasticities of labor with respect to imports and GNP, respectively. The model is used to evaluate the derivative of employment with respect to current output, which is then converted into an elasticity at the sample means. These short-run elasticities are calculated by combining the models for current labor demand with the models for current and expected output (in each of 8 future periods). The estimated short-run effects take into account both the direct effect of current changes in output on current labor demand and the indirect effect whereby current changes in output affect expectations of future output which, in turn, affect current labor demand.

The estimated short-term elasticities are presented in table 6. Short-run elasticities for output changes associated with GNP changes (e_G) and imports (e_m) are presented, along with long-run elasticities (repeated from table 4) and parameters measuring the

TABLE 6

SHORT-RUN ELASTICITIES AND ADJUSTMENT PARAMETERS
FOR A CHANGE IN GNP and IMPORTS

Industry	e_G	e_M	e_L	Adjustment Parameter η_G	η_M
22	.256	.113	1.008	.254	.113
26	.314	.140	.684	.459	.205
32	.636	.380	.732	.869	.519
33	.483	.326	.733	.659	.431
34	.726	.273	1.396	.520	.196
35	.474	.089	.971	.488	.092
36	.638	.386	.845	.755	.457

speed of adjustment, the fraction of adjustment completed within one quarter.

The results in table 6 suggest that, contrary to the initial hypotheses, adjustment to changes in imports is less rapid than to changes in GNP. In the framework of rational expectations, this means that the effect of current and recent past imports on future imports is smaller than the effect of current and recent past GNP on future GNP.

CONCLUSIONS

Our most important results are summarized below.

(1) Expectations of the future, though typically omitted from empirical studies of labor demand, have an important effect and should be incorporated explicitly. This is true even for the fairly simple output model developed earlier. In particular, we found that for eight of the eleven two-digit industries studied, expectations, as measured assuming rationality, had a significant effect on current labor demand.

(2) The incorporation of expectations tends to reduce measured economies of scale, pushing toward one the estimated long-run labor-output elasticity. This raises the possibility that any remaining deviation from constant returns is also a consequence of omitted variable bias.

(3) It does seem feasible to empirically distinguish the effects of different sources of output change. In our case, we started with the hypothesis that changes in imports would induce more rapid adjustment than changes in GNP, but the empirical evidence pointed in the opposite direction.

REFERENCES

[1] Brechling, Frank P.R. (1973), Investment and Employment Decisions, Manchester University Press.

[2] Brechling, Frank P.R. (1965), "The Relationship between Output and Employment in the British Manufacturing Industries," Review of Economic Studies 33: 187-215.

[3] Gould, J.P. (1968), "Adjustment Costs in the Theory of Investment of the Firm," Review of Economic Studies 35: 47-56.

[4] Friedman, Milton (1962), Price Theory: A Provisional Text, Chicago: Aldine Publishing Company.

[5] Hansen, Lars P. and Sargent, Thomas J. (1979), "Linear Rational Expectation Models for Dynamically Interrelated Variables," Mimeographed. Working Paper #135, Federal Reserve Bank of Minneapolis.

[6] Holt, C.; Modigliani F.; Muth, J.; and Simon, H. (1960), Planning Production, Inventories, and Work Force, Englewood Cliffs, N.J.: Prentice-Hall, Inc.

[7] Kennan, John (1979), "The Estimation of Partial Adjustment Models with Rational Expectations," Econometrica 47: 1441-1456.

[8] Levy, Robert A. (1980), "Employment Adjustment to Output Changes Under Rational Expectations," Ph.D. dissertation, Northwestern University.

[9] Maddala, G.S. (1977), Econometrics, New York: McGraw-Hill Book Company.

[10] Maeshiro, Asatoshi (1976), "Autoregressive Transformations, Trended Independent Variables and Autocorrelated Disturbance Terms," Review of Economics and Statistics 58: 497-500.

[11] Malinvaud, E. (1970), Statistical Methods of Econometrics, Asterdam: North-Holland Publishing Company.

[12] Mortensen, Dale T. (1973), "Generalized Costs of Adjustment and Dynamic Factor Demand Theory," Econometrica 41: 657-665.

[13] Mincer, Jacob (1962), "On-the-Job Training: Costs, Returns, and Some Implications," Journal of Political Economy, supplement: Investment in Human Beings 70: 50-79.

[14] Nadiri, M.I. and Rosen, S. (1973), A Disequilibrium Model of Demand for Factors of Production, National Bureau of Economic Research, Monograph No. 99, New York: Columbia University Press.

[15] Sargent, Thomas J. (1976), "A Classical Macroeconomic Model for the United States," Journal of Political Economy 84: 207-238.

[16] Sargent, Thomas J. (1978), "Estimation of Dynamic Labor Demand Schedules Under Rational Expectations," Journal of Political Economy 86: 1009-1045.

[17] Sargent, Thomas J. (1978), Macroeconomic Theory, New York: Academic Press.

[18] Simon, H.A. (1956), "Dynamic Programming Under Uncertainty with a Quadratic Criterion Function," Econometrica 24: 74-87.

[19] Scherer, F.M. (1980), Industrial Market Structure and Economic Performance, Rand-McNally, Chicago.

[20] Sims, Christopher A. (1974), "Output and Labor Input in Manufacturing," Brookings Papers on Economic Activity 3: 695-728.

[21] Theil, H. (1958), Economic Forecasts and Policy, Amsterdam: North-Holland.

[22] U.S. Board of Governors of the Federal Reserve System, Federal Reserve Bulletin, 1977.

[23] U.S. Board of Governors of the Federal Reserve System (1977), Industrial Production 1976 Revision.

[24] U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, various issues covering 1968 to 1977.

[25] U.S. Department of Commerce, Bureau of the Census, Census of Manufactures, 1967, 1972, 1977.

[26] U.S. Department of Commerce, Bureau of the Census, Manufacturers' Shipments, Inventories, and Orders, various issues during 1968 to 1977.

[27] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, 1978 edition.

[28] U.S. Department of Labor, Bureau of Labor Statistics, unpublished data on the value of manufacturing imports.

[29] U.S. Department of Labor, Bureau of Labor Statistics, Producer Prices and Price Indexes, various issues covering 1968 to 1977.

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