THE SHORT RUN DEMAND FOR EMPLOYMENT

by

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Abstract:

In this study a theoretical model of the short run demand for employment is developed. Two models are in fact developed, one of the short run demand for the number of production workers employed and the other of the short run demand for the number of hours paid for per production worker. From these two models the short run demand for total man-hours paid for can be derived. The basic equations of the model are estimated, and the results are compared with results of estimating equations of various alternative models. Using the model developed in this study as a base, various hypotheses regarding short run employment demand are developed and tested.

In the first three chapters previous studies of short run employment demand are summarized and criticized, and certain relevant empirical evidence on short run productivity fluctuations is presented. In the next three chapters the theoretical model of this study is developed and discussed, and the various hypotheses tested in this study are discussed. Then in the next four chapters the data used in this study are discussed and the empirical results are presented and discussed in detail. In the final four chapters a comparison is made of the demand for workers and the demand for hours paid for per worker, a comparison is made of short run employment demand across industries, the short run demand for non-production workers is discussed, and a summary of the major conclusions of this study is given.

Thesis Supervisor: Robert M. Solow
Title: Professor of Economics

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INTRODUCTION

In the past few years there has been a growing interest in cyclical or short run fluctuations in output per man-hour. An understanding of these short run fluctuations is essential in the analysis of short run movements in unit labor costs (and thus, possibly, of short run price movements), of the short run distribution of income, of the longer run movements in productivity, and of the growth of potential or full employment output. In the estimation of long run aggregate production functions, which has become so popular recently, some account must be made of cyclical fluctuations in output per man-hour and capital stock utilization.

Beginning with Hultgren (1960) and Kuh (1960), there have been a number of studies of short run fluctuations in output and employment. There are two basic procedures which can be used in this type of study. The first procedure is to examine output per man-hour directly and find out how it fluctuates with respect to short run fluctuations in output. The second procedure is to develop and estimate a model determining employment (men or man-hours) as a function of output and other relevant variables; and then this model, if it is specified correctly, will reveal how output per man

(or per man-hour) fluctuates with respect to output. Both of these kinds of studies seem to find that output per man-hour varies directly with output, that there are increasing returns to labor services in the short run.

The purpose of this study is to evaluate the basic model used in most of the previous studies of short run employment fluctuations and to develop and estimate an alternative model. In the first three chapters the theoretical models of short run employment demand of previous studies are summarized and criticized, and certain relevant empirical evidence on short run productivity fluctuations is presented. In the next three chapters an alternative theoretical model is developed and discussed. The model is developed in two parts. In the first part a theoretical model of the short run demand for (production) workers is developed, and in the second part a theoretical model of the short run demand for hours paid for per worker is developed. From these two models the short run demand for total man-hours paid for can be derived.

In the next four chapters the data used in this study are discussed and the empirical results are presented. The empirical results are quite detailed and so a summary of the major conclusions drawn from the results is given at the end of each chapter. In the next two chapters a comparison of the demand for workers and the demand for hours paid for per worker is made, as well as a comparison of short run employment demand across industries. In the next chapter a model of the short run demand for non-production workers is developed, and empirical results of testing this model are presented. Finally, a summary of the major results and conclusions of this study is given.

CHAPTER 1

A SUMMARY OF PREVIOUS STUDIES OF SHORT RUN EMPLOYMENT DEMAND

In this chapter previous studies of the short run demand for employment are summarized. The theoretical model of each of the studies is summarized, but no attempt is made to summarize the empirical results, as the data used and the periods of estimation vary widely from study to study.[1] Before the individual studies are summarized, however, the basic model which is common to most of the studies is presented. Having done this, it is easy to see how the individual models differ from the basic model and thus from one another.

The Basic Model

A short run production function is postulated,

$$(1.1) \qquad Y_t = F(L_t^*, K_t, T_t)$$

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1. In Chapter 2 the results of estimating the basic equation of the model of previous studies are presented, and in Chapter 8 the results of estimating the basic equation of the model developed in this thesis, using the same data and periods of estimation, are presented.

where Y_t = the rate of output, L_t^* = the amount of labor services, K_t = the existing stock of capital, and T_t = the existing level of technology (all during period t). Specifically, it is assumed that the production function is of the Cobb-Douglas form and that technology grows smoothly over time at rate c. Under these assumptions the production function (1.1) can be written:

$$(1.2) \qquad Y_t = A\, L_t^{*a}\, K_t^b\, e^{ct}$$

The elasticity of output with respect to labor services is a, and if there are diminishing returns to labor in the short run, a is less than one. If the assumption of constant returns to scale is made, then a + b = 1.

The firm is assumed to take the rate of output, the capital stock, and the level of technology as given in the short run and to adjust its employment according to changes in the three exogenous variables. The production function (1.2) can be solved for L_t^* to yield:

$$(1.3) \qquad L_t^* = A^{-1/a}\, Y_t^{1/a}\, K_t^{-b/a}\, e^{-(c/a)t}$$

L_t^* is the amount of labor services required for the production of Y_t. A change in the rate of output, the capital stock, or the level of technology from one period to the next will lead to a change in L_t^*. Rapid adjustments in L_t^* may be costly for the firm, however, and only part of the change in L_t^* may be made during any one period. To take this into account an adjustment process of the following form is postulated:

$$(1.4) \qquad L_t/L_{t-1} = (L_t^*/L_{t-1})^q \quad , \quad 0 < q < 1$$

L_t is the amount of labor services on hand during period t, whereas L_t^* is the amount of labor services actually required for the production process during period t. The adjustment process (1.4) implies that only part of any required change in labor services will be made in any one period. A ten percent increase in L_t^*/L_{t-1}, for example, will lead to a less than ten percent increase in L_t/L_{t-1}.

Solving for L_t^* in (1.4), substituting into (1.3), and taking logarithms yields:

$$(1.5) \qquad \log L_t - \log L_{t-1} = -\frac{1}{a}q \log A + \frac{1}{a} q \log Y_t - \frac{b}{a}q \log K_t - \frac{c}{a}q\, t - q \log L_{t-1}$$

Given time series for L, Y, and K, equation (1.5) can be estimated directly, and, as is seen below, most empirical studies of the short run demand for employment have been concerned with estimating equations very similar to (1.5). The previous studies of short run employment demand will now be summarized.

The Brechling Model

Brechling (1965) postulates a short run production function like (1.1), where Y, K, and T are assumed to be exogenous. He then postulates that labor services, L^*, is some function of the number of workers employed, M, and the average number of hours worked per worker, H:

$$(1.6) \qquad L^* = f(M, H)$$

Brechling assumes that there are two hourly wage rates: w_1, which is payable up to the standard number of hours of work per period per worker, H_s, and w_2, which is the overtime rate. The total wage bill (short run cost function) during period t is then,

$$(1.7) \qquad W_t = (H_{1t}w_{1t} + H_{2t}w_{2t})M_t$$

where M_t is again the number of workers employed during period t, and H_{1t} and H_{2t} are the average number of hours worked per worker during period t for standard and overtime pay respectively.

Given the amount of labor services needed during period t, L_t^*, the wage bill (1.7) can be minimized with respect to M_t and the average number of hours worked per worker, H_t. The cost minimizing number of workers, M_t^*, turns out to be a function of L_t^*, H_{st}, and w_{1t}/w_{2t}:[1]

$$(1.8) \qquad M_t^* = g(L_t^*, H_{st}, w_{1t}/w_{2t})$$

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1. Brechling ((1965), p. 190, n. 1) points out that for a unique cost minimizing solution to exist L_t^* cannot equal M_tH_t in (1.6), i.e. labor services cannot be approximated by man-hours. It should also be pointed out that since in the iso-quant— iso-cost diagram for M and H the iso-cost curve has a kink in it at the point where H equals H_s, it is likely, given reasonably smooth iso-quant curves, that the cost minimizing solution will be at the point where H^* equals H_s, i.e. where the cost minimizing level of hours worked per worker equals standard hours worked per worker.

Solving for L_t^* in the production function (1.1) yields,

$$(1.9) \qquad L_t^* = G(Y_t, K_t, T_t)$$

and substituting (1.9) into (1.8) yields:

$$(1.10) \qquad M_t^* = g(Y_t, K_t, T_t, H_{st}, w_{1t}/w_{2t})$$

Brechling assumes that w_{1t}/w_{2t} is constant over time and thus that it can be ignored. He assumes an adjustment process like (1.4) for M_t^*,[1]

$$(1.11) \qquad M_t - M_{t-1} = q(M_t^* - M_{t-1})$$

and the final equation which he estimates is like (1.5) except that the variables are not in log form and a term in H_{st} has been added. (H_s has fallen slowly over time in the United Kingdom.)

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1. Brechling gives empirical results for both the linear and log forms of his equations. In this summary attention is concentrated on the linear version of his model, as this is the version which Brechling concentrates on. The adjustment process (1.4) for the linear version is thus in linear rather than ratio form.

Brechling adds the variable t^2 to his equation to allow for the possibility that technical progress has been accelerating over time, and he also adds the change in output, $Y_t - Y_{t-1}$, arguing that firms may build up their labor requirements in anticipation of high levels of activity.[1]

The Ball and St Cyr Model

Ball and St Cyr (1966) approximate K by an exponential trend, and they assume that labor services, L*, can be adequately approximated by man-hours, MH, instead of some more complicated expression which Brechling is required to assume in (1.6). M is again the number of workers employed, and H is the average number of hours worked per worker. The production function (1.2) is therefore of the form,

$$(1.12) \qquad Y_t = A\,(M_t H_t)^a\, e^{pt}$$

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1. Brechling makes the assumption that $Y^e_{t+1} = Y_t + v(Y_t - Y_{t-1})$, where Y^e_{t+1} is the output which is expected to be produced during period t+1. Adding Y^e_{t+1} to an equation like (1.5) introduces the additional variable, $Y_t - Y_{t-1}$, in the equation. Brechling also tries a moving average of the past four quarters of the first differences in output, $Y_{t-i} - Y_{t-i-1}$, i = 0, 1, 2, 3, in his equation.

where $p = c$ + the growth rate of the capital stock times the elasticity of output with respect to capital.

They postulate a short run cost function of the form,

$$(1.13) \qquad W_t = w_{H_t} M_t H_t + F_t$$

where w_{H_t} is the "effective wage per man-hour"[1] during period t and is a function of H_t. F_t is the fixed cost during period t. Up to H_{st} (the standard number of hours of work per worker during period t) the cost to the firm of one worker working one week is $w_{1t}H_{st}$ (workers are assumed to be paid for H_{st} hours during period t regardless of how man hours they actually work), and after that the cost is $w_{1t}H_{st} + w_{2t}(H_t - H_{st})$, where again w_{1t} is the standard wage rate and w_{2t} is the overtime rate during period t.

In Figure 1-1 the relationship between w_{H_t} and H_t is depicted. Ball and St Cyr argue that a reasonable approximation for w_{H_t} is the quadratic:

$$(1.14) \qquad w_{H_t} = v_0 - v_1 H_t + v_2 H_t^2$$

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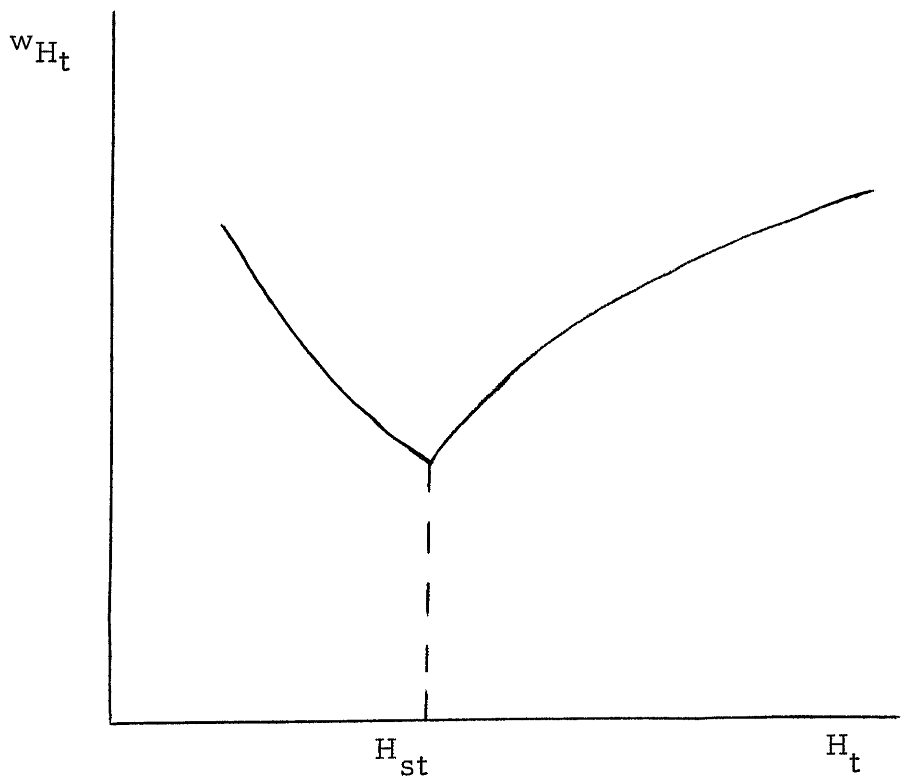
1. Ball and St. Cyr (1966), p. 180.

Figure 1-1



RELATIONSHIP BETWEEN w_{H_t} AND H_t IN BALL AND ST CYR'S MODEL

Substituting this expression for w_{H_t} into the cost function (1.13), solving for H_t in the production function (1.12), and substituting the resulting expression for H_t into the cost function, and then minimizing the resulting expression of the cost function with respect to M_t yields:

$$(1.15) \qquad M_t^* = (2v_2/(A^{1/a}v_1))e^{-(p/a)t}\, Y_t^{1/a}$$

M_t^* is the cost minimizing number of workers. Equation (1.15) is of the same form as equation (1.3) of the basic model without the capital stock variable.

Ball and St Cyr then assume an adjustment process like (1.4) for M_t^* and arrive an an equation like (1.5) without the log K_t variable.

Ball and St Cyr's results show strongly increasing returns to labor services, even when direct (as opposed to overhead) labor is considered alone, and they believe that this may be due to the fact that measured man-hours, denoted as $(M_tH_t)_m$, may not at all times be a good approximation of "productive" man-hours. They postulate that,

$$(1.16) \qquad M_tH_t = (M_tH_t)_m (1 - U_t)^r$$

where U_t is the "difference between the percentage unemployment... and the percentage chosen to represent full employment."[1] In other words, "as unemployment rises the degree of underutilization of employed labor is likely to increase."[2] Using relation (1.16) they estimate the parameters of the production function (1.12) directly (ignoring the adjustment process and using the variable M_tH_t instead of M_t in the estimated equation) to get an alternative estimate of short run returns to labor. The results in general give lower estimates of returns to labor services, but of the eleven industries for which estimates are made two of them give non-sensible results and five of the remaining nine give labor input elasticities (i.e. elasticities of output with respect to labor services) greater than one. Ball and St Cyr remain agnostic as to "the extent to which the estimated labour input elasticities are determined by the time structure of the production functions [i.e. by equations like (1.5) which incorporate lagged adjustment

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1. Ball and St Cyr (1966), p. 189

2. _Ibid_.

mechanisms like (1.4)] or a widespread propensity to hoard labour permanently [as exemplified by (1.16)] ."[1]

The Kuh Model

Kuh (1965b) makes a distinction between production workers and non-production workers, the latter being more like "overhead" labor and thus more like a fixed factor in the short run than the former. For production workers Kuh regresses log M_t on a constant, log Y_t, log Y_{t-1}, log K_{t-1}, log M_{t-1}, and log H_{t-1} - log H_{t-2} or log H_t - log H_{t-1}. It is clear from his discussion that his model is similar to the basic model discussed above. The lagged variables are added to the equation because they "depict the nature of the adjustment process."[2]

Kuh discusses the possibility that there may be some substitution in the short run between the number of hours worked per worker and the number of production workers employed in the sense that the number of hours worked per worker may be used as the principle short run adjustment tool with respect to changes in man-hour requirements.[3] With respect to the addition of

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1. Ibid., p. 192.
2. Kuh (1965b), p. 242.
3. Ibid., p. 239.

$\log H_{t-1} - \log H_{t-2}$ to the equation, he argues that one would expect that "the larger the rate of change in hours in the previous period, the greater will be employment in this period as a substitute, in order to reduce hours toward normal and thus minimize overtime production."[1]

For non-production workers Kuh finds the coefficient of $\log Y_{t-1}$ to be insignificant, and for his final equation he regresses $\log N_t$ on a constant, $\log Y_t$, $\log K_{t-1}$, and $\log N_{t-1}$, where N_t is the number of non-production workers employed during period t.

Kuh also estimates an equation determining the number of hours worked per week per production worker. He regresses $\log H_t$ on a constant, $\log Y_t - \log Y_{t-1}$, and $\log H_{t-1}$. According to Kuh, the main determinant of the number of hours worked per week per worker "is a convention established through bargaining and a variety of social and institutional forces."[2] But, "there is a lagged adjustment to the desired constant level of hours (more accurately, a gently declining trend) and a strong transient response to the rate of change of output."[3] This leads to an equation

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1. Ibid., p. 253.

2. Ibid.

3. Ibid.

of the form,

$$(1.17) \quad \log H_t - \log H_{t-1} = a(b - \log H_{t-1}) + c(\log Y_t - \log Y_{t-1})$$

or,

$$(1.18) \quad \log H_t = ab + (1-a)\log H_{t-1} + c(\log Y_t - \log Y_{t-1})$$

which is the equation he estimates.

Kuh also argues that the relative scarcity of labor may be important in determining the demand for hours worked per worker, and he adds $\log U_t$ and $\log U_t - \log U_{t-1}$ to equation (1.18), where U_t is the unemployment rate during period t, on the grounds that "tight labor markets generate a demand for additional hours."[1] When labor markets are tight firms have more inducement to increase H_t rather than M_t, due among other things to the "deterioration in the quality of the marginal work force."[2] $\log U_t - \log U_{t-1}$ enters as an "expectational variable."[3]

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1. *Ibid.*, p. 240.

2. *Ibid.*

3. *Ibid.*

The Solow Model

Solow's model (1964) is very similar to the basic model. He estimates an equation like (1.5) in both linear and log forms, trying as the labor services variable both the number of workers employed and total man-hours paid for. To the log form of his equation he adds the variable $\log Y_t - \log Y_{t-1}$, which he argues can be interpreted either as a carrier of expectations or as a variable which "simply converts a geometric distrubuted lag between employment and output to a slightly more general lag pattern, geometric only after the first term."[1]

It is clear from his discussion that Solow is not very satisfied with this model and the results he obtains, and in the latter part of his paper he discusses, as a possible alternative to the Cobb-Douglas production function model, a vintage capital model with fixed coefficients both *ex ante* and *ex post*.

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1. Solow (1964), p. 18.

The Soligo Model

Soligo (1966) postulates a Cobb-Douglas production function like (1.2),

$$(1.19) \qquad Y_t = A M_t^{*a} K_t^b e^{ct}$$

where the labor input variable is taken to be the number of workers, M*. He is concerned with the problem that in the short run capital may not be perfectly adaptable; and if capital is not perfectly adaptable, employment will not be adjusted as much in the short run as it would if capital were perfectly adaptable.[1]

In the production function (1.19), M_t^* is the desired work force if capital were perfectly adaptable. Call M_t^d the desired work force for the capital stock in existence during period t. Soligo postulates that,

$$(1.20) \qquad M_t^*/M_t^d = (C_t)^v \quad , \quad v > 0$$

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1. Perfectly adaptable capital stock is like putty-- the "marginal product curve of labor is congruent to the long run or <u>ex ante</u> curve." Soligo (1966), p. 166.

where C_t is the rate of capacity utilization during period t. What equation (1.20) says is that the further the firm deviates from the maximum rate of capacity utilization, the greater will be the gap between the desired work force if capital were perfectly adaptable and the desired work force for the capital stock in existence. Solving for M_t^* in (1.20), substituting this expression into equation (1.19), and then solving for M_t^d yields,

$$(1.21) \qquad M_t^d = A^{-1/a} Y_t^{1/a} K_t^{-b/a} C_t^{-v}$$

an equation similar to (1.3) with the addition of the C_t variable.

With respect to future output expectations Soligo assumes that,

$$(1.22) \qquad Y_{t+1}^e = Y_t(Y_t/Y_{t-1})$$

where Y_{t+1}^e is the output expected to be produced in the following period. If output increases by one percent during period t, for example, then it is expected to increase by one percent again during period t+1. Soligo assumes that the desired work force depends on future output expectations and adds the term $(Y_{t+1}^e/Y_t)^r$ (which by

(1.22) becomes $(Y_t/Y_{t-1})^r)$ to equation (1.21), where r is the "elasticity of the desired work force with respect to the predicted change in output."[1]

Soligo assumes an adjustment process like (1.4) for M_t^d and arrives at an equation like (1.5) with the additional terms $-\frac{q}{a}v \log C_t$ and $qr(\log Y_t - \log Y_{t-1})$.

The Dhrymes Model

Dhrymes (1966) postulates a CES production function:

$$(1.23) \quad Y_t = A(a_1 K_t^b + a_2 M_t^{*b})^{1/b}$$

The labor input variable is taken to be the number of workers, M*. Dhrymes assumes that optimal employment is given by,

$$(1.24) \quad \frac{\partial Y_t}{\partial M_t^*} = s w_t$$

where "s is a well defined function of the elasticity of the demand for output and supply of labor,"[2] and w is the product wage. s is

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1. Ibid., p. 172.

2. Dhrymes (1966), p. 3.

assumed to be a constant function. Solving (1.24) yields:

$$(1.25) \qquad M_t^d = A^{b/(1-b)} s^{b/(b-1)} w_t^{1/(b-1)} Y_t a_2^{1/(1-b)}$$

Dhrymes argues that Y_t and w_t in (1.25) should be replaced by Y_t^e and w_t^e, since M_t^d, the desired number of workers for period t, is based on expected output and the expected wage rate for period t. He assumes that $w_t^e = A_1 w_t$ and $Y_t^e = A_2 Y_t^u Y_{t-1}^v$, i.e. "expected wages are proportional to actual wages and expected output is proportional to some root of the actual output in the current period and the actual output of the period for which planning takes place."[1] He assumes an adjustment process like (1.4) for M_t^d.

Dhrymes is also concerned with the possible dependence of employment on investment, for "one might expect the (marginal) productivity of labor in general to depend on the type of capital equipment the unit employs."[2] Since "capital goods of different vintages embody in them different levels of technical advance,"[3]

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1. Ibid., p. 4.

2. Ibid.

3. Ibid., pp. 4-5.

he assumes that the parameter a_2 in the production function (1.23) depends with infinite lag on investment, I. Specifically, he assumes that:

$$(1.26)\quad \frac{1}{1-b}\log a_2 = \frac{c_1 \log I_{t-1} + c_2 \log I_{t-2} + c_3 \log I_{t-3} + c_4 \log I_{t-4}}{\log I_t + c_5 \log I_{t-1}}$$

Combining the above information Dhrymes arrives at the following non-linear equation to estimate:

$$\begin{aligned}(1.27)\quad \log M_t = {} & \text{constant} + \frac{q}{b-1}(\log w_t + c_5 \log w_{t-1}) \\ & + qu(\log Y_t + c_5 \log Y_{t-1}) + qv(\log Y_{t-1} + c_5 \log Y_{t-2}) \\ & + (1-q)(\log M_{t-1} + c_5 \log M_{t-2}) - c_5 \log M_{t-1} \\ & + q\sum_{i=1}^{4} c_i \log I_{t-i}\end{aligned}$$

In other words, $\log M_t$ is a function of $\log Y_t$, $\log Y_{t-1}$, $\log Y_{t-2}$; $\log M_{t-1}$, $\log M_{t-2}$; $\log w_t$, $\log w_{t-1}$; and $\log I_{t-1}$, $\log I_{t-2}$, $\log I_{t-3}$, $\log I_{t-4}$. Dhrymes estimates the model for all employees and then for production workers and non-production workers separately.

The Neild Model

Nield's approach (1963) is highly empirical in nature, his main concern being with forecasting. His basic postulate is that employment depends on a productivity trend and on "past and present levels of output."[1] He estimates two basic equations:[2]

$$(1.28) \qquad \log M_t - \log M_{t-1} = a_0 + a_1(\log Y_t - \log Y_{t-1}) + a_2(\log Y_{t-1} - \log Y_{t-2}) + a_3(\log Y_{t-2} - \log Y_{t-3})$$

and

$$(1.29) \qquad \log M_t - \log M_{t-1} = a_0 + a_1(\log Y_t - \log Y_{t-1}) + a_2(\log Y_{t-1} - \log Y_{t-2}) + b_1(\log M_{t-1} - \log M_{t-2})$$

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1. Nield (1963), p. 56.

2. Neild estimates the same equations for both workers, M_t, and total man-hours, M_tH_t. The equations presented in this summary are for M_t only.

Equation (1.29), which includes the lagged dependent variable on the right hand side, implies that the number of workers employed is a geometrically declining function of all past rates of output after the second period, while equation (1.28) implies that the number employed is a function of only the present and the past two rates of output.

The Wilson and Eckstein Model

The Wilson and Eckstein approach (1964) is considerably different from the basic model presented above. Wilson and Eckstein begin by postulating a long run production function,

$$(1.30) \qquad C_t = \frac{1}{a}(M_t H_t)_p$$

which, when solved for $(M_t H_t)_p$, they call the "long run labor requirements function":

$$(1.31) \qquad (M_t H_t)_p = a\, C_t$$

C_t is capacity output and $(M_t H_t)_p$ is the number of man-hours required to produce the capacity output.

In the short run the plant is fixed, and Wilson and Eckstein assume that the "plant man-hour requirements function" can be approximated by a straight line which intersects the long run function from above at capacity output,

$$(1.32) \qquad (M_t H_t)_e = a C_t + b(Y_t^e - C_t)$$

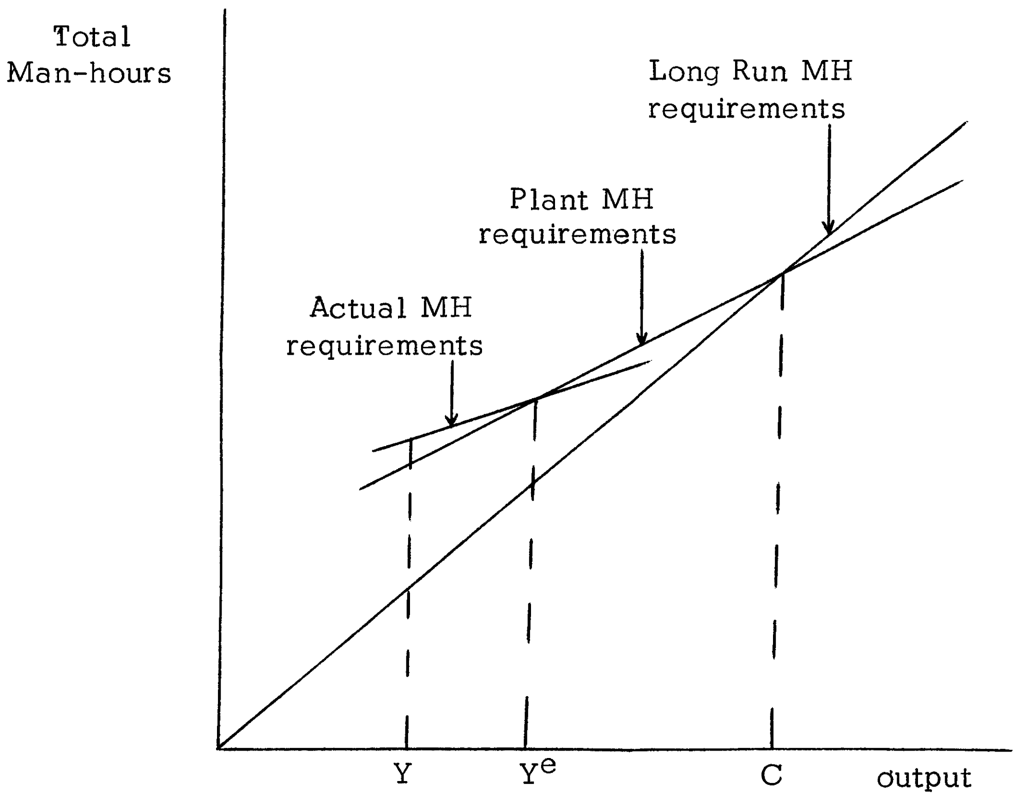
where Y_t^e is the output which is planned at the beginning of period t to be produced during period t, and $(M_t H_t)_e$ is the number of man-hours required to produce the planned output. b is assumed to be less than a.

Wilson and Eckstein then define a "short run maladjustment man-hour requirements function" which intersects the plant function from above at planned output,

$$(1.33) \qquad M_t H_t = a C_t + b(Y_t^e - C_t) + c(Y_t - Y_t^e)$$

where Y_t is the actual output produced during period t and $M_t H_t$ is the actual number of man-hours required to produce Y_t. c is assumed to be less than b. The relationships among the three man-hour requirements functions can be seen graphically in Figure 1-2.

Figure 1-2



WILSON AND ECKSTEIN'S MAN-HOUR REQUIREMENTS FUNCTIONS

Wilson and Eckstein include technical change in their model by assuming that:

(1.34a) $a = a_0 + a_1 t$

(1.34b) $b = b_0 + b_1 t$

(1.34c) $c = c_0 + c_1 t$

They also assume that,

(1.35) $$Y_t^e = \frac{S_t}{6}\left(3Y^*_{t-1} + 2Y^*_{t-2} + Y^*_{t-3}\right)$$

where Y^*_{t-i} is seasonally adjusted output for period t-i, and S_t is the seasonal factor for period t. They use seasonally unadjusted data and seasonal dummies in the estimation of equation (1.33), and they estimate the equation separately for production worker straight time hours and production worker overtime hours. They also estimate a modified version of equation (1.33) for non-production workers.

The Hultgren, Raines, and Masters Studies

As mentioned in the introduction, an alternative approach to the study of short run fluctuations in output and employment is to examine output per worker (or per man-hour) directly and find out how it fluctuates with respect to short run fluctuations in output. Hultgren (1960), (1965), Raines (1963), and Masters (1967) have used this approach, and although this is not the basic approach used in this thesis, these studies will be briefly summarized.

After seasonally adjusting the data, Hultgren (1960) examines how output per man-hour fluctuates during contractions (falling output) and during expansions (rising output). He finds that output per man-hour increases during expansions, although there is some evidence that near the end of the expansions this phenomenon is less widespread, and that output per man-hour decreases during contractions, although again there is some evidence that this phenomenon is less widespread near the end of the contractions. In another study (1965), using different data, Hultgren arrives at a similar conclusion.[1]

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1. Hultgren (1965), pp. 39-42.

In the Raines model (1963), output per man-hour is taken to be a function of capacity utilization (both the level and the change), the amount and quality of the capital stock, and time. Raines estimates the following equation,

$$(1.36) \qquad \log(Y_t/M_tH_t) = a_1t + a_2(Y_t/C_t) - a_3(Y_t/C_t)^2 + a_4\Delta(Y_t/C_t)_+ + a_5\Delta(Y_t/C_t)_- + a_6\Delta(Y_t/C_t)_{t-1} - a_7 A_t$$

where Y_t/C_t is the capacity utilization in period t and A_t is the average age of the capital stock. The notation $\Delta(Y_t/C_t)_+$ means that when $\Delta(Y_t/C_t)$ is positive $\Delta(Y_t/C_t)_+$ is set equal to this value and when it is negative $\Delta(Y_t/C_t)_+$ is set equal to zero, and conversely for $\Delta(Y_t/C_t)_-$.

Raines finds that output per man-hour is positively related to the level of capacity utilization and also to the change in capacity utilization. The coefficient a_4 is larger than a_5,[1] which implies that output per man-hour is more positively related to positive

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1. Raines (1963), Table I, p. 187.

changes in capacity utilization than it is negatively related to negative changes in capacity utilization.

Masters (1967), using seasonally adjusted data, examines how output per worker behaves during contractions. For the years 1947-1961 he finds 64 contractions occuring in 24 three- and four-digit industries. For each of these 64 cases he computes the change in output and the change in output per worker, using as end points the peak and the trough of the output series. Using these 64 observations, he regresses the change in output per man on the change in output and a constant and finds that the change in output per man is positively related to the change in output, i.e., that output per man decreases during contractions.

This concludes the summary of most of the previous studies of short run employment demand and short run productivity fluctuations. In the next chapter a critique of some of these studies is made.

CHAPTER 2

A CRITIQUE OF PREVIOUS STUDIES OF SHORT RUN EMPLOYMENT DEMAND

The studies of Brechling (1965), Ball and St Cyr (1966), Kuh (1965b), Solow (1964), Soligo (1966), and Dhrymes (1966) summarized in Chapter 1 are all very similar to the basic model introduced at the beginning of the chapter. While the details of the various models differ considerably from one another, the models themselves all center around the concept of a short run production function and a simple lagged adjustment process. Equations similar to (1.5) of Chapter 1 are the ones most often estimated in these works. It is seen below that this basic model of these studies of short run employment demand appears to be poorly specified, but before proceeding with this discussion, the relationship between the specification of the production function inputs and the assumption of cost minimizing behavior is discussed.

The Necessity of Cost Minimizing Assumptions Regarding the Workers-Hours Mix

There are two different, though not mutually exclusive, cost minimizing assumptions which can be made regarding the short run employment decisions of firms. One assumption is that firms are concerned with the optimal short run allocation of total factor inputs between labor services and capital services, and the other assumption is that firms are concerned with the optimal short run allocation of labor services between the number of workers employed and the number of hours worked per worker. Brechling and Ball and St Cyr make the second assumption but not the first, i.e. they assume that in the short run firms are concerned with adjusting their workers-hours worked per worker mix so as to achieve a minimum wage bill but that firms are not concerned with achieving an optimal capital-labor mix by adjusting the amounts of capital services and labor services used to changing factor prices. Dhrymes, on the other hand, makes the second assumption but does not discuss the optimal short run allocation of labor services between worker and hours worked per worker. Kuh, Solow, and Soligo do not make any assumptions about short run cost minimizing behavior.

Without the assumption of cost minimizing behavior with respect to the workers-hours worked per worker mix, there is a contradiction between the production function (1.2) (or (1.1)) of Chapter 1 and the lagged adjustment process (1.4). Equation (1.3) of Chapter 1 is derived from the production function (1.2) and gives L_t^* (the amount of labor services needed) as a function of the exogenous variables, Y_t, K_t, and t. Assume that for period t equation (1.3), given Y_t, K_t, and t, calls for an L_t^* greater than L_{t-1}. The lagged adjustment process (1.4) implies that L_t (the amount of labor services used) will be less than L_t^*. The production function (1.2), however, reveals that, given Y_t, K_t, and t, this cannot be the case and still have Y_t produced, i.e. it is not possible to have the amount of labor services used, L_t, less than the amount of labor services needed, L_t^*. For L_t^* less than L_{t-1} no problem arises, but for L_t^* greater than L_{t-1} (1.2) and (1.4) are incompatible. In other words, for (1.2) and (1.4) to be compatible, the labor services input variable in the production function cannot be the same variable that is subjected to the lagged adjustment process (1.4).

The cost minimizing assumptions made by Brechling and Ball and St Cyr are sufficient for the compatibility of the production function and the lagged adjustment process. Actually, their assumptions are more complicated than is necessary. Assume, as Ball and St Cyr do, that labor services can be approximated by man-hours, so that in the notation of the basic model of Chapter 1, $L_t^* = (M_tH_t)^*$, where M_t denotes the number of workers employed and H_t denotes the number of hours worked per worker. A simplier assumption to make than either Brechling's or Ball and St Cyr's is that the cost minimizing number of workers during period t, denoted as M_t^d, equals $(M_tH_t)^*/H_{st}$, where H_{st} is the standard (as opposed to overtime) number of hours of work per worker per period t.[1] The adjustment process (1.4) can then be in terms of M_t^d,

$$(2.1) \qquad M_t/M_{t-1} = (M_t^d/M_{t-1})^q$$

and whenever M_t^d is greater than M_{t-1}, the number of hours worked per worker, H_t, can be assumed to make up the difference in the short run.

Ball and St Cyr approximate Figure 1-1 by the quadratic (1.14) of Chapter 1, and their cost minimizing level of hours is a function

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1. The standard number of hours of work per worker, H_s, may be subject to long run trend influences (due to such things as institutional forces), and this is the reason for the time subscript on H_s.

of the parameters of the quadratic function. The simplier assumption made here takes the least cost level of hours at H_{st} in Figure 1-1, which is the least cost point before any quadratic approximation is made.

It should be pointed out that Dhrymes's cost minimizing assumption regarding the optimal capital services-labor services mix does not alleviate his model from the above mentioned incompatibility. It is still necessary to make some assumption about the optimal short run workers-hours worked per worker mix. Dhrymes does not discuss this mix at all and merely uses the number of workers as the labor input variable in his CES production function.

In an appendix, Brechling presents estimates of his equations for man-hours as well as for workers, and since the variable man-hours does not enter his model either as an input of the production function nor as the variable in the lagged adjustment process, it is not at all clear how these estimates relate to his theoretical model.

This concludes the discussion of this rather minor point regarding the basic model of Chapter 1, and more serious objections to the studies mentioned at the beginning of this chapter will now be presented, beginning with the seasonal adjustment problem.

The Seasonal Adjustment Problem

In all of the studies under consideration here the authors either use seasonally adjusted data or non-seasonally adjusted data with seasonal dummy variables to estimate their equations. Brechling, Kuh, Solow, Soligo, and Dhrymes use seasonally adjusted data, while Ball and St Cyr use non-seasonally adjusted data and seasonal dummies.

Many, if not most, industries have large seasonal fluctuations in output, and, to a lesser extent, in employment. In Table 2-1 the percentage change from the trough month to the peak month of the year in output, Y, in production workers, M, and in the average number of hours paid for per week per worker, H_p, is presented for the years 1950, 1955, 1960, and 1964 for the seventeen three-digit United States manufacturing industries used in this study.[1] The output fluctuations in most cases are quite large, with the rate of output during the peak month being between 10.2 and 151.7 percent larger than during the trough month. The fluctuations in workers and hours paid for per worker are in

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1. The data are discussed in Chapter 7.

TABLE 2-1

THE PERCENTAGE CHANGE FROM THE TROUGH MONTH TO THE PEAK MONTH OF THE YEAR IN Y, M, AND H_p FOR THE YEARS 1950, 1955, 1960, AND 1964

Industry	1950			1955			1960			1964		
	Y	M	H_p	Y	M	H_p	Y	M	H_p	Y	M	H_p
201	42.5	14.6	13.7	34.6	8.3	11.4	20.1	6.6	6.7	24.9	7.9	8.6
207	93.1	32.1	9.1	79.0	25.5	7.2	76.0	23.4	6.8	79.7	17.2	3.1
211	35.5	7.9	23.2	18.8	6.6	10.2	14.3	5.0	21.7	44.9	3.9	28.9
212	32.1	10.4	18.1	19.5	11.2	10.3	15.1	5.0	13.3	79.3	19.2	15.3
231	22.8	7.1	7.2	25.7	9.3	9.1	34.3	2.8	7.6	30.4	4.4	4.2
232	41.3	7.3	8.0	24.3	6.4	7.7	28.9	6.0	7.4	24.8	6.6	7.1
233	53.7	25.4	12.5	31.6	16.4	5.1	27.7	12.2	7.1	19.2	5.8	9.7
242	66.2	23.3	9.4	24.4	11.5	4.8	42.1	19.2	8.8	28.7	10.8	8.1
271	24.9	4.6	2.9	27.7	5.1	4.7	23.9	3.1	2.8	23.3	2.8	2.8
301	27.1	11.9	9.8	28.9	5.8	8.2	30.4	10.5	9.7	19.9	5.0	12.0
314	21.4	7.1	13.5	23.5	8.8	6.9	22.5	5.8	10.4	17.0	4.8	6.7
311	17.8	7.3	5.7	10.2	2.0	2.8	12.7	5.5	4.9	19.8	7.3	3.5
324	58.0	7.0	2.9	43.2	4.9	1.7	93.7	17.0	4.3	99.0	15.9	3.7
331	19.8	9.2	9.6	19.6	14.5	4.0	108.3	38.0	16.0	25.3	13.3	3.7
332	51.3	36.6	14.0	21.5	19.0	5.8	53.8	14.3	8.0	24.6	7.7	5.0
336	60.3	35.7	10.4	17.1	12.1	4.0	34.4	13.1	4.3	13.2	4.6	2.9
341	151.7	42.4	10.7	114.0	21.3	8.7	90.4	18.0	9.1	71.8	14.4	6.4

general much less, but still are reasonably large.

A major criticism of the above studies of short run employment demand which are based on the concept of a short run production function is that the use of seasonally adjusted data or seasonal dummies is incompatible with the production function concept. A production function is a technical relationship between certain physical inputs and a physical output and is not a relationship between seasonally adjusted inputs and a seasonally adjusted output. Unless one has reason to believe that the technical relationship itself fluctuates seasonally, and at least for manufacturing industries it is difficult to imagine very many instances where this is likely to be true, the use of seasonally adjusted data or seasonal dummy variables is unwarranted.

Likewise, when seasonally adjusted data or seasonal dummy variables are used, the lagged adjustment process (1.4) of Chapter 1 must be interpreted as implying the lagged adjustment of the seasonally adjusted number of workers rather than the actual number of workers. Interpreted in this way, it implies that the adjustment coefficient q fluctuates seasonally. Here again there seems little reason to believe that q should fluctuate seasonally. It is possible to argue that the adjustment costs might be less in the spring and fall when a large number of students can be hired and then laid off, but in general the interpretation of (1.4) in seasonally adjusted terms seems theoretically less warranted than in non-seasonally adjusted terms.

Results of Estimating Equation (1.5) of the Basic Model

The proof of any model is how well it stands up under empirical tests. If the basic model of Chapter 1 is to lead to any empirically meaningful results, non-seasonally adjusted data must be used. In Table 2-2 the results of estimating equation (1.5) of the basic model of Chapter 1 (with the log K_t variable being assumed to be absorbed in the time trend) using non-seasonally adjusted monthly data for the period 1947-1965 for the seventeen three-digit manufacturing industries used in this study are presented.

Two equations have been estimated for each industry, one including the log Y_{t-1} variable and one excluding it. For the equation without the log Y_{t-1} variable, the implied value of the production function parameter a is given in Table 2-2 for each industry. For the equation with the log Y_{t-1} variable, the steady state solution has been derived (by setting $M_t = M_{t-1} = \bar{M}$ and $Y_t = Y_{t-1} = \bar{Y}$) giving log $\bar{M}$ as a function of a constant, log $\bar{Y}$, and t. The resulting coefficient of log $\bar{Y}$ is taken to be 1/a, and this

TABLE 2-2

PARAMETER ESTIMATES FOR EQUATION (1.5):

$$(1.5)\quad \log M_t - \log M_{t-1} = a_0 + a_1 \log Y_t + a_2 t + a_3 \log M_{t-1}$$

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	$1000\ \hat{a}_2$	$\hat{a}_3$	R^2	SE	DW	Value of $-\hat{a}_3/\hat{a}_1$
201	192	.813	.032	-.062	-.131	.076	.0194	1.03	4.09
		(3.40)	(1.94)	(1.45)	(3.83)				
207	136	.701	.226	-.847	-.333	.579	.0299	1.36	1.47
		(3.05)	(13.34)	(8.92)	(7.64)				
211	136	-.109	.047	-.089	-.036	.084	.0119	2.20	0.76
		(0.55)	(2.96)	(1.62)	(1.27)				
212	136	-.283	.097	-.420	-.058	.227	.0188	2.57	0.60
		(1.65)	(6.17)	(3.52)	(2.20)				
231	136	.573	.118	-.221	-.196	.273	.0245	2.00	1.66
		(1.81)	(6.15)	(2.97)	(4.13)				
232	136	.709	.057	-.105	-.137	.199	.0132	1.43	2.40
		(3.52)	(4.72)	(2.18)	(4.87)				
233	136	.681	.163	-.271	-.220	.301	.0348	1.32	1.35
		(1.60)	(6.24)	(2.89)	(4.15)				
242	154	.601	.210	-.797	-.245	.589	.0171	0.98	1.17
		(3.88)	(14.16)	(9.35)	(10.96)				
271	166	.782	.043	.068	-.147	.312	.0059	2.02	3.42
		(3.95)	(7.43)	(2.21)	(5.29)				
301	134	.187	.057	-.307	-.073	.173	.0152	1.86	1.28
		(1.12)	(4.62)	(4.71)	(3.11)				
311	170	.196	.094	-.349	-.138	.146	.0136	1.62	1.47
		(1.33)	(4.80)	(4.07)	(4.73)				
314	136	3.129	.178	-.407	-.560	.383	.0190	1.30	3.15
		(7.13)	(7.28)	(6.67)	(8.30)				

TABLE 2-2
PARAMETER ESTIMATES FOR EQUATION (1.5) (continued)

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	$1000\ \hat{a}_2$	$\hat{a}_3$	R^2	SE	DW	Value of $-\hat{a}_3/\hat{a}_1$
324	187	.773	.096	-.379	-.234	.383	.0228	1.27	2.44
		(5.03)	(9.82)	(8.43)	(8.07)				
331	128	1.493	.173	-.484	-.307	.772	.0103	1.53	1.77
		(12.87)	(20.08)	(15.14)	(17.39)				
332	170	.424	.131	-.203	-.174	.382	.0175	1.99	1.33
		(4.05)	(9.84)	(5.55)	(8.52)				
336	170	.006	.081	-.173	-.085	.126	.0240	1.19	1.05
		(0.05)	(4.74)	(3.33)	(3.90)				
341	191	1.698	.121	-.088	-.402	.425	.0282	0.77	3.32
		(8.71)	(10.65)	(2.14)	(10.59)				

t-statistics are in parentheses.

TABLE 2-2 (continued)

PARAMETER ESTIMATES FOR EQUATION (1.5) WITH THE ADDITION OF THE VARIABLE log Y_{t-1}:

$$(1.5)' \log M_t - \log M_{t-1} = a_0 + a_1 \log Y_t + a_2 t + a_3 \log M_{t-1} + a_4 \log Y_{t-1}$$

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{a}_3$	$\hat{a}_4$	R^2	SE	DW	Value of $-\hat{a}_3/(\hat{a}_1+\hat{a}_4)$
201	192	.717	.125	.033	-.083	-.135	.252	.0175	1.47	-8.30
		(3.31)	(6.11)	(0.79)	(2.63)	(6.65)				
207	136	.562	.226	-.747	-.290	-.022	.582	.0299	1.47	1.42
		(2.01)	(13.32)	(5.05)	(4.42)	(0.88)				
211	136	-.135	.032	-.101	-.041	.023	.095	.0119	2.04	0.75
		(0.69)	(1.16)	(1.82)	(1.44)	(1.27)				
212	136	-.302	.153	-.264	-.031	-.079	.296	.0180	2.81	0.42
		(1.84)	(7.05)	(2.16)	(1.17)	(3.58)				
231	136	.895	.053	-.366	-.305	.131	.446	.0215	1.95	1.66
		(3.17)	(2.66)	(5.30)	(6.78)	(6.39)				
232	136	.770	.055	-.196	-.170	.032	.230	.0130	1.36	1.95
		(3.85)	(4.65)	(3.19)	(5.45)	(2.31)				
233	136	.158	.211	-.077	-.082	-.138	.371	.0331	1.62	1.12
		(0.37)	(7.58)	(0.75)	(1.33)	(3.84)				
242	154	.573	.215	-.770	-.237	-.011	.590	.0171	1.02	1.16
		(3.43)	(11.42)	(7.42)	(8.42)	(0.46)				
271	166	.532	.068	.049	-.093	-.046	.475	.0051	2.19	4.23
		(3.00)	(10.98)	(1.79)	(3.64)	(7.06)				
301	134	.208	.025	-.360	-.085	.043	.202	.0150	1.80	1.25
		(1.26)	(1.29)	(5.23)	(3.56)	(2.14)				
311	170	.198	.101	-.318	-.124	-.019	.149	.0136	1.68	1.51
		(1.34)	(4.75)	(3.40)	(3.74)	(0.84)				

TABLE 2-2
PARAMETER ESTIMATES FOR EQUATION (1.5) WITH THE ADDITION OF THE VARIABLE log Y_{t-1} (continued)

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{a}_3$	$\hat{a}_4$	R^2	SE	DW	Value of $-\hat{a}_3/(\hat{a}_1+\hat{a}_4)$
314	136	2.013	.221	-.135	-.292	-.185	.513	.0169	1.73	8.11
		(4.64)	(9.62)	(1.89)	(3.88)	(5.91)				
324	187	.250	.181	-.187	-.094	-.133	.579	.0189	1.91	1.96
		(1.80)	(14.74)	(4.38)	(3.31)	(9.22)				
331	128	1.257	.208	-.421	-.265	-.054	.782	.0101	1.76	1.72
		(8.38)	(12.52)	(10.33)	(10.83)	(2.42)				
332	170	.363	.158	-.182	-.155	-.039	.391	.0174	2.02	1.30
		(3.26)	(7.33)	(4.67)	(6.56)	(1.58)				
336	170	.000	.190	-.107	-.053	-.145	.237	.0225	1.60	1.04
		(0.00)	(6.89)	(2.12)	(2.49)	(4.89)				
341	191	.659	.165	-.015	-.137	-.136	.657	.0218	1.84	4.72
		(3.72)	(17.15)	(0.46)	(3.62)	(11.23)				

t-statistics are in parentheses.

value of a is given in Table 2-2 for each industry.

In all but five of the thirty-four cases the implied value of a turns out to be greater than one, and in one of the remaining five cases it is negative. In nine of the thirty-four cases a is greater than two, and in seven of these cases it is greater than three. The results clearly do not appear to be consistent with the interpretation of a as the short run elasticity of output with respect to labor services.

If one believes that the short run production function is one of fixed proportions instead of the Cobb-Douglas type and thus that capital services are expanded and contracted along with labor services in the short run, then a should not be interpreted as returns to labor services alone but as returns to labor services given the fact that capital services have been expanded or contracted also. Even under this interpretation, however, one would expect that a should be equal to or slightly less than one, since during high rates of output less (or at least not more) efficient capital stock is likely to be utilized, and workers are likely to be more (or at least not less) fatigued from working longer hours. One would certainly not expect a to be considerably greater than one, as is the case for most of the estimates presented in Table 2-2. The model, even under this alternative interpretation of a, appears to be poorly specified.

In addition to the unrealistically large values of a, the estimates of the constant term turn out to be negative as expected in only four of the thirty-four cases.

The Durbin-Watson statistics given in Table 2-2 are biased towards two because of the existence of a lagged dependent variable among the set of regressors in equation (1.5).[1] Even without considering this bias, however, the DW statistics presented in Table 2-2 reveal the existence of first order serial correlation in about half of the thirty-four equations estimated. The existence of serial correlation appears to be less pronounced in the equations which include the log Y_{t-1} variable, but the problem is still there for at least five of the industries. In general the DW statistics cast some doubt on the specification of the model.

Although seasonally unadjusted (monthly) data have been used to estimate equation (1.5), as this seems to be the theoretically preferred procedure, in the previous studies, where seasonally adjusted (quarterly) data or non-seasonally adjusted (quarterly) data and seasonal dummies have been used,

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1. See Nerlove and Wallis (1966).

the results in general also show strongly increasing short run returns to labor services. The results given in Table 2-2 are not unique to the type of data used.

This completes the critique of the basic model of previous studies. The model does appear to be poorly specified and further work in this area appears to be called for. In Chapter 3 some empirical evidence on short run productivity fluctuations is presented and in Chapter 4 an alternative model of short run employment demand is developed. Before proceeding with this discussion, however, a critique of the Wilson and Eckstein model is made, since their model is considerably different from the basic model discussed above and is not subject to the same criticisms.

A Critique of the Wilson and Eckstein Model

Wilson and Eckstein have three concepts of output--capacity output, C_t, planned output, Y_t^e, and actual output, Y_t. Man-hour requirements differ to the extent that planned output differs from capacity output and actual output from planned output. Their "short run maladjustment man-hour requirements function" (1.33) is repeated here,

$$(1.33) \qquad M_tH_t = a\,C_t + b(Y_t^e - C_t) + c(Y_t - Y_t^e)$$

where $a < b < c$. Figure 1-2 in Chapter 1 depicts the relationships among the long run, plant, and short run maladjustment man-hour requirements functions.

As can be seen from Figure 1-2, the model has the rather odd implication that if actual output is greater than planned output, the actual man-hour requirements per unit of output are less than the plant man-hour requirements per unit of output, and also if actual output (or planned output) is greater than capacity output (which they state can happen[1]), actual man-hour requirements per unit of output are less than long run man-hour requirements per unit of output. Wilson and Eckstein argue that this may be possible by sacrificing maintenance work and using machinery more intensively.[2] This may be possible to some extent, but it does not seem likely that the effects on man-hour requirements should be symmetrical for positive and negative deviations of planned output from capacity output or actual output from planned output. It is also open to

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1. Wilson and Eckstein (1964), p. 42.

2. Ibid.

question whether man-hour requirements per unit of output are really less at output greater than capacity, especially if less efficient machines are brought into use at high rates of output.

Wilson and Eckstein estimate equation (1.33) first for production worker standard hours, which are defined to be 37.5 M_t, and then for production worker overtime hours, which are defined to be $M_t(H_t - 37.5)$. This procedure appears to be inconsistent with their overall model. Equation (1.33) is interpreted as a man-hour requirements function, and if M_tH_t number of man-hours are required to produce the output, Y_t, then the relevant dependent variable is M_tH_t and not some fraction of it.

Actually, (1.31) of their model may be better interpreted as expressing desired man-hours as a function of capacity output, with (1.32) and (1.33) showing how, due to adjustment lags in the short run, desired man-hours deviate from actual man-hours used. Equation (1.33) can perhaps be interpreted as a reduced form of some more complicated employment demand equation, combining a man-hour requirements function and a lagged adjustment process. The theoretical underpinnings of the overall model do not appear to be well developed.

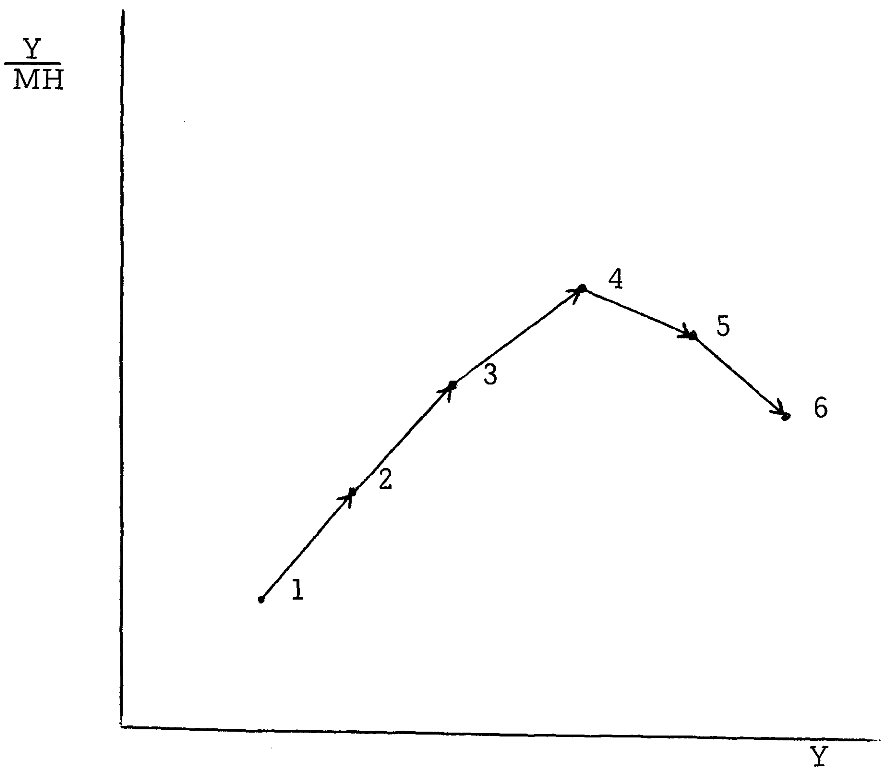
CHAPTER 3

SOME EMPIRICAL EVIDENCE ON SHORT RUN PRODUCTIVITY FLUCTUATIONS

In this chapter some empirical evidence on short run productivity fluctuations is presented. From Table 2-1 of Chapter 1 it can be seen that for most of the industries and years man-hours fluctuate less than output. Since this is true and since it is also true that the phases of the man-hours and output series are approximately the same, it is not surprising that output per man-hour (henceforth called productivity) is positively correlated with output and thus that increasing short run returns to labor services are observed.

In any one year, however, (where the level of the capital stock and technical knowledge can be assumed to be fairly constant) if there is any kind of an observable production function in the short run, one would expect that as output approached the peak months of the year productivity would level off and decline somewhat, especially if the year were a peak year as well. One would thus expect the relationship between productivity and output to look like that depicted in Figure 3-1 for any one year (providing perhaps that the year were not a

Figure 3-1



EXPECTED RELATIONSHIP BETWEEN PRODUCTIVITY AND OUTPUT recession year where even the rate of output in the peak month were low compared with past standards).[1] In Figure 3-1 output is at its lowest in month 1 and at its highest in month 6.

These scatter diagrams were made for each of the seventeen industries for the years[2] 1947-1965. There were a total of 310 diagrams. The results were divided into six mutually exclusive categories demonstrated in Figure 3-2. The arrows point in the direction of calender time movements. As was mention above, one would expect that at high rates of output productivity would decline or at least level off (Figures 3-2a and 3-2b and perhaps 3-2e) if a short run production function is in fact observed at these high output rates. The number of diagrams in each category is presented in Figure 3-2.

Slightly over half of the cases (Figure 3-2d) showed no evidence that productivity growth even slowed down at high rates of output, let alone decline. About twelve percent of the cases

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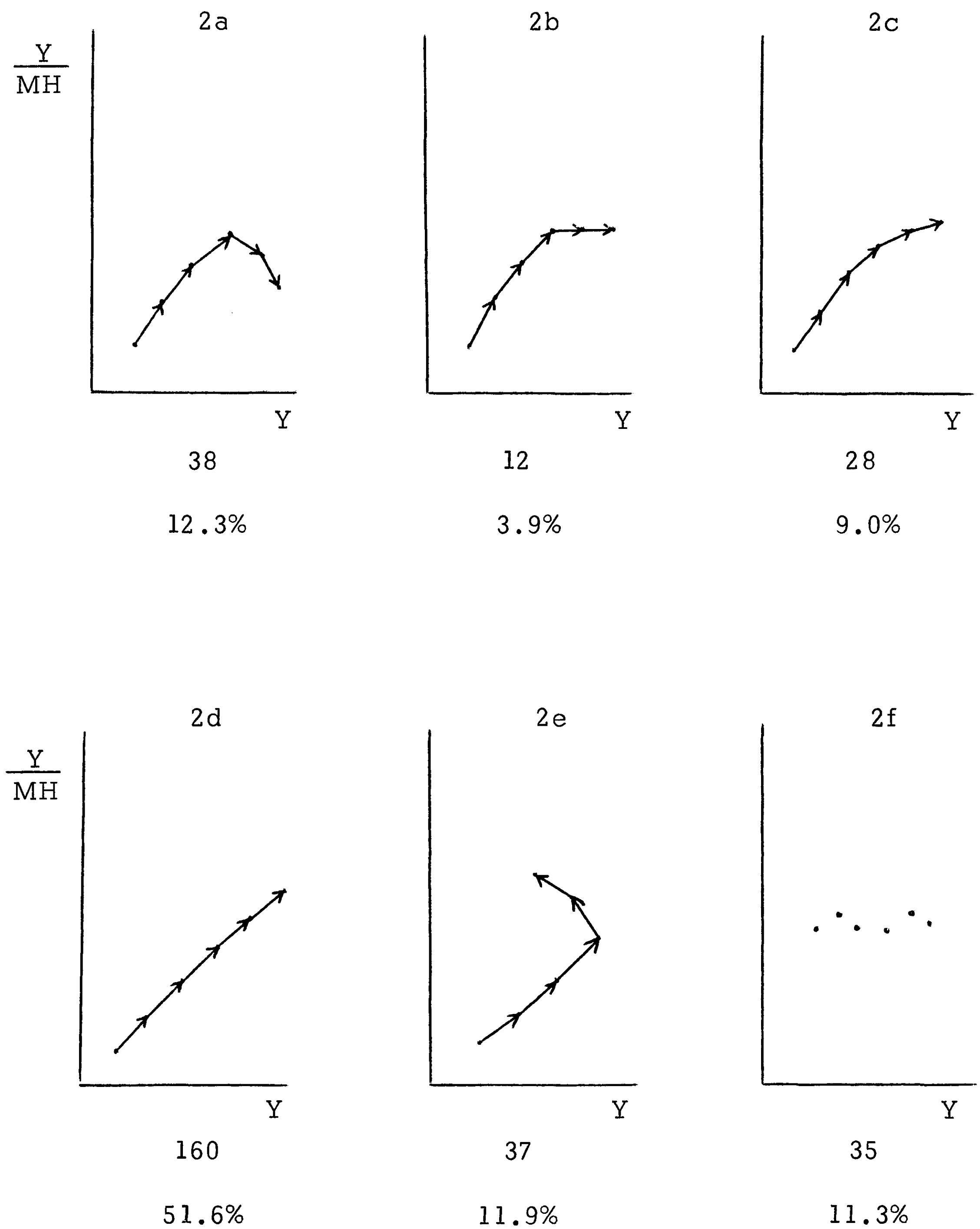
1. If in fact technical progress and the capital stock grow smoothly over time, this will bias the scatter against a downward bend. In the short run, however, the short run productivity fluctuations dominate the longer run productivity movements, and this bias is likely to be quite small.

2. A year being defined in this case as the (approximate) twelve month period between troughs.

Figure 3-2



OBSERVED RELATIONSHIP BETWEEN PRODUCTIVITY AND OUTPUT

(Figure 3-2a) showed a definite downward bend in productivity growth, and about twenty-five percent of the cases showed either a downward bend, a leveling off, or a slowing down (Figures 3-2a, 3-2b, and 3-2c). Eleven percent of the cases (Figure 3-2f) showed a less clear cut scatter, but perhaps could be interpreted as showing that the same productivity ceiling was reached more than once during the year. The twelve percent of the cases depicted by Figure 3-2e is also difficult to interpret since the time movements are odd;[1] but perhaps these cases could be interpreted as showing decreasing returns at high rates of output.

The general conclusion of this exercise is that there is some evidence that productivity growth levels off at high rates of output, but that for over half of the observations this is not the case and for only twelve to twenty-four percent of the cases (Figures 3-2a and perhaps 3-2e) does productivity actually appear to decline. This seems to be rather conclusive evidence that a production function with the usual constant or diminishing returns property is only infrequently observed in the short run, even at high rates of output.

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1. See the discussion in footnote 1 on page 63 for a further elaboration of this point.

CHAPTER 4

A THEORETICAL MODEL OF THE SHORT RUN DEMAND FOR PRODUCTION WORKERS

In this chapter a theoretical model of the short run demand for production workers is developed. In Chapter 5 the possible significance of inventory investment on short run employment demand is discussed, and in Chapter 6 a model of the short run demand for hours paid for per production worker is developed.

A necessary requirement for a theoretical model is that it explain to a reasonable degree of approximation empirical phenomena which are observed. Three basic facts which have been observed are that the rate of output fluctuates more than workers and hours in the short run, that even at high rates of output for the year productivity growth in the majority of cases does not decline, and that the basic model of short run employment demand outlined in Chapter 1 leads to unrealistically large estimates of the production function parameter a, even under the alternative assumption of fixed proportions. These are three of the facts which need to be explained.

The Theoretical Model

In the model developed here the concept of excess labor plays an important role and so does the concept of expected future rates of output.

A short run production function is postulated,

$$(4.1) \qquad Y_t = F(M_tH_t , K_tH_t^k , T_t)$$

where Y_t = the (assumed constant) rate of output during period t, M_tH_t = the number of production worker hours required to produce Y_t, $K_tH_t^k$ = the number of machine hours required, and T_t = the level of technical knowledge in existence during period t. M_t by itself denotes the number of production workers employed during period t and H_t by itself the average number of hours worked per worker during period t. Likewise, K_t by itself denotes the number of machines on hand during period t and H_t^k by itself the average number of hours each machine was used during period t.

When labor requirements increase, labor services M_tH_t can be increased either by increasing M_t or H_t (or both). Increasing H_t and keeping M_t constant need not require any additional machines used, for the existing machines can just be utilized more hours, i.e. H_t^k can increase with no increase needed in K_t.

Increasing M_t is a different matter. Either the new workers hired work with the workers already on hand on the same amount of capital stock (same number of machines) or the new workers hired work with machines which have previously been idle (including in this second case the possibility of second and third shift work). In like manner capital services can be increased either by increasing K_t (adding more machines) or by increasing H_t^k (running the existing machines longer).

Because of the different ways in which labor services and capital services can be increased and decreased, one must be careful in discussing substitution possibilities between capital services and labor services to specify exactly what he means. If, for example, for a particular production process there were no substitution possibilities between capital services and labor services in the sense that a fixed number of workers was required per machine per hour, it would still be possible to substitute workers for machines by, say, decreasing the number of machines, increasing the number of workers, and working each machine for a longer and each worker for a shorter period of time.

In what follows substitution possibilities between capital services and labor services will be said to exist if during a fixed period of time the same rate of output can be produced with differing numbers of workers and machines.[1]

There are two polar assumptions which can be made regarding short run substitution possibilities between capital services and labor services--either that the degree of substitutability is slight and can realistically be ignored or that it is of considerable significance and cannot be ignored. The assumption made in this thesis is that short run substitution possibilities are sufficiently limited so that they can be ignored. This assumption implies that when new workers are hired, they either work on a second or third shift or on the first shift using previously idle machines. It is difficult to verify this assumption empirically without a detailed study of each production process, a study which has not been undertaken here. It is the author's general impression that this assumption is a reasonable approximation of reality, but no empirical evidence is given to confirm this impression. It will be shown later to what extent the model developed in this thesis depends on this assumption.

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1. Substitution possibilities would be said to exist for a particular production process, for example, if, say, 10 units of output per hour could be produced by 20 workers working for one hour on 5 machines or 15 workers working for one hour on 6 machines.

This assumption still does not explain the phenomenon of increasing returns to labor services in the short run. The explanation of this phenomenon given here is based on the idea that during much of the year firms have on hand a considerable amount of excess labor and that only during the peak rates of output for the year can they be said to be holding no excess labor.

Let H_t continue to denote the average number of hours actually worked per worker during period t and let H_{pt} denote the average number of hours per worker paid for by the firm during period t. A firm is said to be holding excess labor during period t if H_{pt} is greater than H_t (ignoring the regularly paid for coffee breaks and the like).[1] For all practical purposes H_t is unobservable, although it could perhaps be observed in a time and motion study. The basic idea behind this explanation is that when the rate of output is low, workers can (and do) relax more and work less hard, with their effective working hours (as opposed to the number of hours paid for) being much less than during the higher rate of out put periods.

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1. A more precise definition of excess labor on hand will be given later. See the discussion on page 69.

There are a number of reasons why firms may knowingly allow this situation to occur. Given the large short run fluctuations in the rate of output which occur, large fluctuations in the number of production workers employed or in the number of hours paid for per production worker would be needed to keep H_{pt} always equal to H_t. Soligo[1] presents a comprehensive list of reasons why firms may be reluctant to allow large fluctuations in their work forces. The most important ones are: (1) Contractual commitments--such things as guaranteed annual wages, unemployment insurance compensation, severance pay, and seniority provisions where younger and perhaps more efficient workers must be laid off first. (2) Transactions costs--the size of the office space and the number of employees which must be used in the process of hiring and laying off workers will depend on the frequency and magnitude of layoffs and rehirings. (3) Retraining costs and loss of acquired skills. (4) Morale and public relation factors--qualified workers may not be attracted to a firm which has a reputation of poor job security; large layoffs may strain union-management relations and may affect the efficiency of the employees

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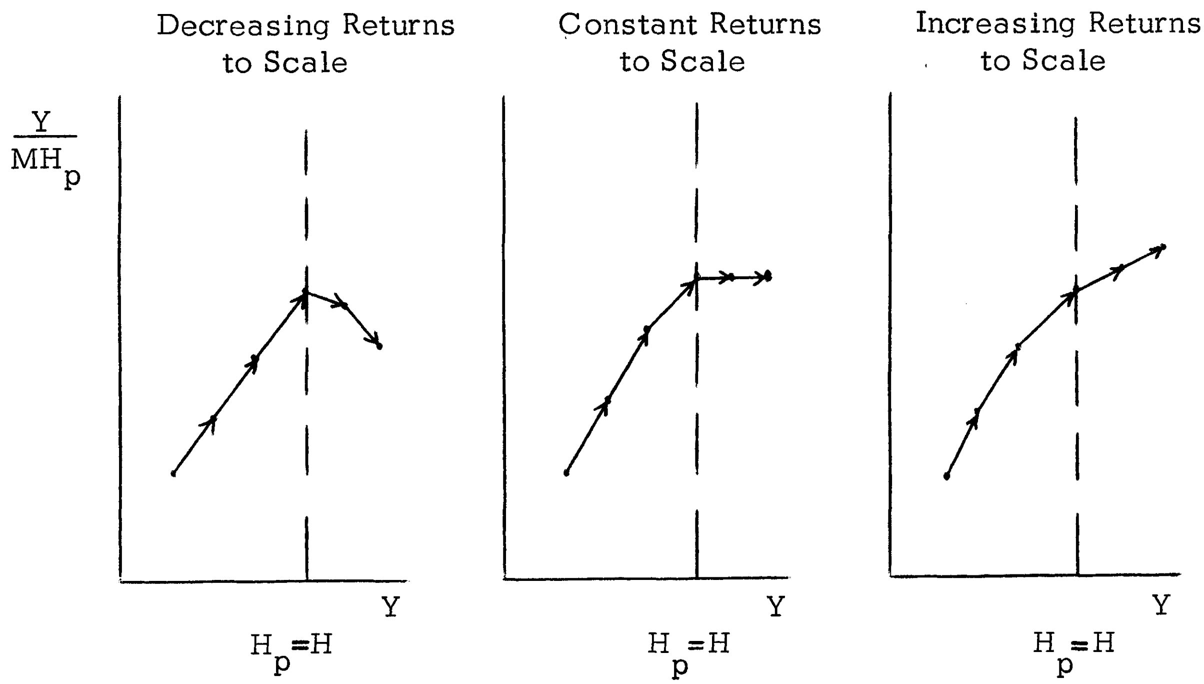
1. Soligo (1966), pp. 174-175.

remaining on the job; and large layoffs and rehirings may be harmful to its public image, which may be important to the firm. (5) Reorganization costs--large changes in the size of the work force may require considerable organizational changes which may lower efficiency in the short run.

These reasons pertain to fluctuations in M but not necessarily in H_p. Why do not firms allow more fluctuations in the number of hours paid for per worker, H_p, corresponding to fluctuations in the rate of output? Here again firms may be reluctant to do this for some of the same reasons they are reluctant to allow large fluctuations in M, namely reasons (1) and (4) listed above. Workers may expect, for example, a 40 hour work week, and firms may subject themselves to serious morale and public relation problems if they allow this standard hourly work week to fluctuate very extensively.

H_p is the variable actually observed rather than H and is the hours variable used in the scatter diagrams discussed in Chapter 3. Under the assumption of no substitution possibilities, the scatter diagrams should look like those depicted in Figure 4-1, corresponding to the alternative assumptions of decreasing, constant, and increasing returns to scale. Up to the point where

Figure 4-1



EXPECTED RELATIONSHIP BETWEEN OUTPUT PER PAID FOR MAN-HOUR AND OUTPUT

H_p equals H one should observe an increasing $Y/(MH_p)$ as Y increases, because, while H increases as the rate of output increases, H_p increases much less, if at all. At the point $H_p = H$ the production function constraint becomes binding on H_p and the scatter beyond this point should reveal properties about the production function, such as the returns to scale property.[1]

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1. One should at least expect this to be true for a continually increasing Y. For a drop in Y, even from a high rate, it is difficult to know whether H_p decreases as much as H during the same period or whether H_p is adjusted downward with a lag. For a continually increasing Y this problem is likely to be less serious since at points beyond $H_p = H$, H_p must increase at least as fast as H and is probably not likely to increase much faster than H. This is the reason why attention was concentrated in Chapter 3 on the points of the scatter diagrams where Y was increasing and why diagrams like Figure 3-2e were difficult to interpret. (See the discussion on page 54.)

It should be pointed out that the use of the phrase "returns to scale" here is not in accord with common usage. Here the quality of both the capital stock (the machines) and the workers can vary--e.g. the quality of the machines which are used only at high rates of output may differ from the quality of the machines which are used all of the time--and if, say, this quality is less at high rates of output, then decreasing returns to scale are said to exist, i.e. a certain percentage increase in both capital services and labor services (unadjusted for quality change) leads to a less than equal percentage change in output. In the normal usage of the phrase "returns to scale" the quality of the factor inputs is presumably constant, and the "returns to scale" phenomenon is due to things other than changing quality of factor inputs.

It is the author's general impression that there is not enough evidence from the results of the scatter diagrams to determine which one of the returns to scale hypotheses is the most realistic. The main reason for this is that it is difficult to know where the $H_p = H$ point begins, and it may be that in many cases the point is reached only at the peak rate of output for the year so that no scatter is observed beyond this point. It was mentioned on page 45 that on theoretical grounds the assumption of decreasing returns to scale appears to be more realistic than the assumption of increasing returns, since it is expected that previously idle capital stock is at least no more efficient than capital stock used all of the time and that overtime work and second and third shift work is not likely to be more efficient than standard first shift work. The assumption made in this thesis, however, is that of constant returns to scale. As was the case with the assumption of no short run substitution possibilities, no empirical evidence is given in this thesis to validate this assumption, other than any evidence which may be gleaned from the scatter diagrams. It was felt that it was better to make this assumption of constant returns to scale than to arbitrarily specify a certain degree of decreasing returns to scale. It will be shown later to what extent the model depends on this assumption.

It might be worthwhile at this point, before developing the model, to discuss briefly how the concept of excess labor developed above relates to the concepts used in previous studies. The idea that firms may during any one period of time employ more workers than they really need to produce the output of that period is, of course, not new. The lagged adjustment process (1.4), which is so widely used, implies that M_t, the number of workers employed, is not necessarily equal to M_t^*, the desired number of workers for the rate of output Y_t.[1] If M_t is greater than M_t^* then there are in effect too many workers employed for the current rate of output. Solow, for example, uses the term "labor-hoarding" "as a catch-phrase to stand for all the frictions involved in meeting transitory variations in output with variations in employment."[2]

What is not clear in much of the previous work is what happens to hours paid for per worker during the phases of adjustment. If the labor input variable in the production function is taken to be man-hours, then an M_t greater than M_t^* need not imply any "man-hours hoarding"

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1. The lagged adjustment process (1.4) is interpreted here as implying the adjustment of the number of workers employed, M_t, instead of, say, the adjustment of man-hours, since this is the consistent version of the basic model. See the discussion on pages 33-36.

2. Solow (1964), p. 8.

if hours paid for per worker are reduced sufficiently, i.e. to the point where M_tH_{pt}, total man-hours paid for, equals $(M_tH_t)^*$, total man-hour requirements. In the previous studies this aspect of the short run adjustment process has not been carefully examined.

Ball and St Cyr, working not within the context of a lagged adjustment model but with the production function directly, do postulate that measured man-hours $(M_tH_t)_m$ may differ from "productive man-hours".[1] Specifically, they postulate (1.16), which is repeated here,

$$(1.16) \qquad M_tH_t = (M_tH_t)_m \, (1 - U_t)^r$$

where U_t is a measure of labor market tightness. Using (1.16) they estimate the parameters of the Cobb-Douglas production function directly, assuming no lagged adjustment process, but assuming that true labor services differ from measured labor services in the manner depicted by (1.16). As stated on page 14, Ball and St Cyr remain agnostic as to whether this model or the lagged adjustment model is the more realistic. The postulate made in this thesis that

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1. See the discussion on pages 13-14.

the number of hours paid for per worker does not necessarily equal the number of hours effectively worked per worker is essentially the same as Ball and St Cyr's postulate that measured man-hours may differ from productive man-hours. What is significantly different in the model developed below is the way this postulate is used. The model will now be developed.

Let M_t denote the number of production workers on the payroll of the firm during the second week of month t.[1] The problem is to explain the behavior over time of $\log M_t - \log M_{t-1}$, the change in the number of production workers employed from the second week of month t-1 to the second week of month t.[2] One factor which should be significant is the expected increase or decrease in the rate of output from the second week of month t-1 to the second week of month t, $\log Y_t^e - \log Y_{t-1}$, where Y_t^e denotes the rate of output expected during the second week of month t, the expectation being made during the second week of month t-1. If, for example, the rate

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1. The theoretical model developed here is designed to be as consistent as possible with the data available for purposes of estimation. The BLS data on workers and hours are compiled from surveys taken during the week of the month which includes the 12th.

2. The functional form chosen for the model is the log-linear form, but to ease matters of exposition and where no ambiguity is involved, the difference of the logs of two variables (e.g. $\log M_t - \log M_{t-1}$) will be referred to as merely the difference of the variables.

of output is expected to decline, a certain number of production workers will probably be laid off, other things being equal, although for the reasons listed above this percentage drop in the number of workers will most likely be smaller than the percentage drop in the rate of output.

Expected future output changes may also influence the firm's current employment decision. If, for example, the rate of output is expected to increase for the next three or four months, the firm may begin to build up its stock of labor now in anticipation of higher man-hour requirements in the future (extremely rapid adjustments in the work force being costly) and conversely for expected future decreases in the rate of output. Therefore, $\log Y^e_{t+i} - \log Y^e_{t+i-1}$ for $i = 1, 2, \ldots, n$ may be significant factors in the determination of $\log M_t - \log M_{t-1}$, where Y^e_{t+i} is the rate of output expected during the second week of month t+i, all expectations being made during the second week of month t-1.

The basic idea of the model so far is that firms base their employment decisions on expected future man-hour requirements and thus on expected future rates of output. As yet no effect of the amount of excess labor on hand on the firms' employment decisions has been allowed for. One would expect that, other things being equal, the more excess labor on hand during the second week of month t-1, the larger would be the number of workers who would be laid off during the monthly decision period.

In the discussion of excess labor on page 59 a firm was said to be holding excess labor during, say, period t-1 if H_{pt-1} is greater than H_{t-1}, where H_{pt-1} denotes the average number of hours paid for by the firm per worker during the second week of month t-1 and H_{t-1} denotes the average number of hours per worker actually worked during that week. At the peak rates of output, however, with a lot of overtime being worked, H_{pt-1} and H_{t-1} will likely be very high and equal to one another; and in this case there is too little labor (too few workers) on hand in the sense that if the rate of output were to remain at this high rate, more workers would probably be hired and fewer hours would be worked per worker in order to decrease high overtime costs. Thus a good measure of excess (or too little) labor on hand during the second week of month t-1 is $\log H_{st-1} - \log H_{t-1}$, where H_{st-1} is the long run desired level of hours of work per worker for the second week of month t-1 (probably equal to the standard hourly work week).[1] $\log H_{st-1} - \log H_{t-1}$ is the difference between the desired level of hours of work per worker for the second week of month t-1 and the actual level of hours worked per worker for that week.

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1. As mentioned in footnote 1 on page 35, H_s may be changing slowly over time, and this is the reason for the time subscript.

Since H_{t-1} is unobservable at all but peak rates of output, where it probably equals H_{pt-1}, some approximation to the amount of excess labor on hand must be found. An estimate of the amount of excess labor on hand was made in the following manner. For each industry used in this study, output per (paid for) man-hour was plotted monthly for the period of estimation.[1] These "productivity" points were then interpolated from peak to the next higher peak and so on for the entire nineteen year period.[2] The points along these interpolation lines were taken as measures of potential productivity--the productivity which could have been achieved if the rate of output had been high enough.[3]

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1. 1947-1965. All data are non-seasonally adjusted.

2. The peaks in the productivity series occurred at the corresponding peaks in the rate of output series in most cases, as is of course implied by the results of the scatter diagrams. Many yearly productivity peaks were lower than the peaks of the previous years, and these peaks were not used in the interpolations. The "cyclical" productivity movements were quite noticeable for most industries, corresponding roughly to the cyclical movements of output. The long run productivity trends were upward for nearly all industries.

3. Remember "productivity" is defined as output per paid for man-hour. At the peaks used for the interpolations it is assumed that $H_p = H$ so that output per paid for man-hour equals output per worked man-hour at these peaks.

Let $(Y_{t-1}/(M_{t-1}H_{t-1}))^*$ denote this potential productivity for the second week of month t-1. The reciprocal of this, denoted as $((M_{t-1}H_{t-1})/Y_{t-1})^*$, is thus a measure of man-hour requirements per unit of output. When this is multiplied by Y_{t-1}, the actual rate of output during the second week of month t-1, the result gives the number of man-hours actually required during the second week of month t-1 to produce the output during that week, denoted as $(M_{t-1}H_{t-1})^*$.

Let H_{st-1} continue to denote the long run desired level of hours per worker for period t-1. When $(M_{t-1}H_{t-1})^*$ is divided by H_{st-1}, the result, denoted as M^*_{t-1}, can be considered to be the long run desired number of workers employed for the rate of output Y_{t-1}. The amount of excess labor on hand during the second week of month t-1 is then defined to be $\log M_{t-1} - \log M^*_{t-1}$.

The assumptions of no short run substitution possibilities and constant returns to scale are necessary for the construction of $(M_{t-1}H_{t-1})^*$. If these assumptions are not true, then $(M_{t-1}H_{t-1})^*$, being based on trend productivity interpolations, is a bad approximation of man-hour requirements for period t-1. The accuracy of $(M_{t-1}H_{t-1})^*$ as a measure of man-hour requirements also depends on the assumption that the productivity "peaks" used in the interpolations are accurate measures of true peak productivities, as well as on the assumption that potential productivity moves smoothly through time from peak to peak.

On page 69 $\log H_{st-1} - \log H_{t-1}$ was said to be a good measure of the amount of excess labor on hand during month t-1. It is easy to see that this measure of excess labor is equivalent to the measure $\log M_{t-1} - \log M^*_{t-1}$ constructed above, providing the assumptions made in the construction of $(M_{t-1}H_{t-1})^*$ are true. Since H_{t-1} is by definition equal to $(M_{t-1}H_{t-1})^*/M_{t-1}$, it follows that,

$$\log H_{st-1} - \log H_{t-1} = \log H_{st-1} - \log ((M_{t-1}H_{t-1})^*/M_{t-1})$$

$$= \log H_{st-1} - \log (M_{t-1}H_{t-1})^* + \log M_{t-1}$$

$$= \log M_{t-1} - \log ((M_{t-1}H_{t-1})^*/H_{st-1})$$

$$= \log M_{t-1} - \log M^*_{t-1}$$

and thus the two measures of excess labor are the same.

Regarding the measurement of the amount of excess labor on hand, there is another set of variables which is worth considering. Since man-hours paid for fluctuate much less than the rate of output and thus less than man-hour requirements, the past changes in the rate of output, $\log Y_{t-i} - \log Y_{t-i-1}$ for $i = 1, 2, \ldots, m$, may be useful proxies for the amount of excess labor on hand in the sense that if the rate of output has been declining in the past, there should be more excess labor on hand than if output has been rising in the past.[1] Of course, $\log M_{t-1} - \log M^*_{t-1}$ and the $\log Y_{t-i} - \log Y_{t-i-1}$ for $i = 1, 2, \ldots, m$ will be highly correlated, and to the extent that the assumptions made in this thesis are true, $\log M_{t-1} - \log M^*_{t-1}$ is the better measure of excess labor on hand.

It is not inconceivable, however, that both $\log M_{t-1} - \log M^*_{t-1}$ and the past rate of output changes are significant in the determination of $\log M_t - \log M_{t-1}$. Even though the variables $\log Y_{t-i} - \log Y_{t-i-1}$ for $i = 1, 2, \ldots, m$ are measuring part of $\log M_{t-1} - \log M^*_{t-1}$, the <u>reaction</u> of the firm to the two types of variables may be sufficiently different to make both types of variables significant. Assume, for example, that $\log M_{t-1} - \log M^*_{t-1}$ is a perfect measure of the amount of excess labor on hand. The firm may react in a specified way to this variable, other things being equal, but when the increase (decrease) of part of the excess labor comes in the immediate past month or two, the firm may react more strongly

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1. Y_{t-i} is the actual rate of output during the second week of month t-i.

(weakly) in eliminating this excess labor. In other words, the past two or three months' activities may have a stronger effect on a firm's employment decisions than effects which have been cumulating over a longer period of time.

In the development of the model some assumption has to be made regarding the influence of wage rate fluctuations on the short run demand for employment. As mentioned in Chapter 2, there are two different kinds of short run cost minimizing assumptions which can be made--one concerned with the optimal short run workers-hours worked per worker mix and the other concerned with the optimal short run capital services-labor services mix. Dhrymes (1966) has been the only one who has been concerned with this second assumption.

If there are no short run substitution possibilities between capital services and labor services, short run changes in the wage rate can have no effect on the short run capital services-labor services ratio. Since a firm holds excess labor during much of the year, however, an increase, say, in the wage rate will increase the cost of this excess labor. If adjustments costs do not increase proportionately with the wage rate, the firm may decide to hold less excess labor, other things being equal, because of the increased relative cost of holding this labor. Thus the short run changes in the wage rate may have a negative effect on the change in employment.

In the model developed here it is assumed that the short run employment decisions of firms are not significantly affected by short run wage rate changes.[1] This assumption does not appear too unreasonable, especially considering the fact that short run wage rate fluctuations are likely to be rather small and the fact that adjustment costs may increase nearly proportionately with the wage rate.

The long run effects of the growth of the capital stock and technology on the number of production workers employed have already been accounted for in the productivity interpolations. If productivity is increasing over time due to the growth of the capital stock and technology, then, other things being equal, M* is falling, and thus the amount of excess labor on hand is increasing. In the model developed here, therefore, the effects of the growth of the capital stock and technology on short run employment decisions are taken care of by the firm's reaction to the amount of excess labor on hand.

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1. It would have been better, of course, to test this assumption, but unfortunately data on standard hourly wage <u>rates</u> (as opposed to average hourly earnings, which reflect overtime earnings as well) are not available.

The following equation is the basic equation determining $\log M_t - \log M_{t-1}$:

$$(4.2) \quad \log M_t - \log M_{t-1} = a_1(\log M_{t-1} - \log M^*_{t-1}) + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

In equation (4.2) a_1 is the partial "reaction coefficient" to the amount of excess labor on hand, and it is expected to be negative. The reasons for the inclusion of the various output variables in equation (4.2) have been discussed above and require no further comment. One would expect that the b_i's would decrease as i increases (the more distant the change the smaller the effect on current behavior) and that the c_i's would decrease as i increases (the further in the future the expected change in the rate of output the smaller the effect on current behavior), with c_0 being the largest of the coefficients.

By the definition of M^*_{t-1}:

$$(4.3) \quad \log M_{t-1} - \log M^*_{t-1} = \log M_{t-1} - \log((M_{t-1}H_{t-1})^*/H_{st-1})$$

$$= \log M_{t-1} - \log(M_{t-1}H_{t-1})^* + \log H_{st-1}$$

The variable $(M_{t-1}H_{t-1})^*$ has been constructed in the manner described above, but in order to estimate equation (4.2) some assumption has to be made regarding H_{st-1}. It is assumed here that H_s is either a constant or a smoothly trending variable. Specifically, it is assumed that,

$$(4.4) \quad H_{st-1} = \bar{H} e^{ut}$$

where $\bar{H}$ and u are constants. On this assumption $\log H_{st-1}$ equals $\log \bar{H} + ut$ in (4.3), and the excess labor variable in (4.2) becomes,

$$(4.5) \quad a_1(\log M_{t-1} - \log M^*_{t-1}) = a_1(\log M_{t-1} - \log(M_{t-1}H_{t-1})^*)$$

$$+ a_1 \log \bar{H} + a_1 u t$$

which introduces a constant term and a time trend in equation (4.2).

The final form of the basic equation is:

$$(4.2) \quad \log M_t - \log M_{t-1} = a_1(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*) + a_1 \log \bar{H} + a_1 u\, t + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

There may be an additional factor in the constant term of equation (4.2) besides $a_1 \log \bar{H}$. The specification of equation (4.2) implies that the long run desired amount of excess labor on hand is zero. It may be possible, however, that a firm desires to hold a certain amount of excess labor at all times as insurance against, say, a sudden increase in demand or a sudden increase in absenteeism. If $\bar{E}$ denotes this long run desired amount of excess labor, then the excess labor term in equation (4.2) should be $a_1(\log M_{t-1} - \log M^*_{t-1} - \log \bar{E})$, which adds the (constant) term $- a_1 \log \bar{E}$ to the equation. The possibility that $\bar{E}$ is greater than zero will be ignored in the discussion below, but it should be kept in mind in the interpretation of the estimate of the constant term of equation (4.2)

Equation (4.2) is the basic equation determining the short run demand for production workers, and it has been estimated under various expectational hypotheses for each of the seventeen industries used in this study. Using equation (4.2) as a starting point, various tests have been made with respect to the possible influence of certain hours variables on short run employment decisions and of the possible significance of the unemployment rate on employment decisions. Tests have also been made to determine whether equation (4.2) predicts differently during general contractionary periods than during general expansionary periods and to determine whether the dynamic properties of the model are well specified. These various tests are discussed below. The results of these tests are presented in Chapter 8.

Expectational Hypotheses

Expectations play a crucial role in the model formulated above. In order for equation (4.2) to be estimated some assumption has to be made on how expectations are formed. Three expectational hypotheses have been tested in this study.

The first hypothesis is that expectations are perfect:

$$(4.6) \quad \log Y^{e}_{t+i} = \log Y_{t+i} \quad \text{for } i = 0, 1, \ldots, n.$$

The second hypothesis is that:

$$(4.7) \qquad \log Y^e_{t+i} = \log Y_{t+i-12} + q_i(\log Y_{t-1} - \log Y_{t-13})$$
$$\text{for } i = 0, 1, \ldots, n.$$

What this hypothesis says is that firms during the second week of month t-1 expect the rate of output during the second week of month t+i to be equal to what the rate of output was during the second week of the same month last year, plus a factor to take into account whether the rate of output has been increasing or decreasing in the current year over the previous year, $\log Y_{t-1} - \log Y_{t-13}$. If, for example, output has been increasing in the sense that $\log Y_{t-1} - \log Y_{t-13}$ is positive, the firm expects $\log Y_{t+i} - \log Y_{t+i-12}$ to be positive by a certain percentage based on the percentage increase of the past month. Similarly, if output has been declining, $\log Y_{t+i} - \log Y_{t+i-12}$ will be expected to be negative. The q_i may conceivably be different for different i, since as the rate of output to be predicted moves into the future, the firm may put less reliance on the immediate past behavior of the rate of output.

The third expectational hypothesis tested in this study is a combination of the first two. Specifically, it assumes that the hypothesis of perfect expectations holds for Y^e_t and the second hypothesis holds for Y^e_{t+i} , $i = 1, 2, \ldots, n$. It seems likely that a firm will have a rather good idea at what rate it is going to produce in the forthcoming month, but a less clear cut idea for more distant periods. If in fact employment decisions are made on less than a monthly basis, the hypothesis of perfect expectations for the current month appears quite reasonable.

The method used to test these hypotheses is as follows. For each expectational hypothesis the implied value of each Y^e_{t+i} is substituted into equation (4.2), and the equation is estimated. These equations can then be compared with respect to the goodness of fit criterion and with respect to the significance of the c_i coefficients. For the perfect expectational hypothesis the actual future values of the rates of output are used as measures of the expected future values of the rates of output. Under the second expectational hypothesis, the expectational part of equation (4.2) becomes (assuming n to be three):

$$(4.8) \quad c_0(\log Y^e_t - \log Y_{t-1}) = \sum_{i=1}^{3} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

$$+ \; c_0(\log Y_{t-12} - \log Y_{t-1}) + c_1(\log Y_{t-11} - \log Y_{t-12})$$

$$+ \; c_2(\log Y_{t-10} - \log Y_{t-11}) + c_3(\log Y_{t-9} - \log Y_{t-10})$$

$$+ \; (c_0q_0+c_1q_1-c_1q_0+c_2q_2-c_2q_1+c_3q_3-c_3q_2)(\log Y_{t-1} - \log Y_{t-13})$$

For this second expectational hypothesis, if all of the q_i's are equal (to, say, q), then the coefficient of $\log Y_{t-1} - \log Y_{t-13}$ becomes $c_0 q$, and q can be identified; otherwise the q_i's cannot be identified.

Under the third expectational hypothesis, the expectational part of equation (4.2) becomes (again assuming n to be three),

$$(4.9) \quad c_0(\log Y_t^e - \log Y_{t-1}) = \sum_{i=1}^{3} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

$$+ c_0(\log Y_t - \log Y_{t-1}) + c_1(\log Y_{t-11} - \log Y_t)$$

$$+ c_2(\log Y_{t-10} - \log Y_{t-11}) + c_3(\log Y_{t-9} - \log Y_{t-10})$$

$$+ (c_1q_1+c_2q_2-c_2q_1+c_3q_3-c_3q_2)(\log Y_{t-1} - \log Y_{t-13})$$

and again only if all of the q_i's are equal (to q) can q be identified.

The results of estimating these versions of equation (4.2) are presented in Chapter 8.

The Short Run Substitution of Hours for Workers

As was seen in Chapter 1, Kuh (1965b) has been the only one who has done any empirical work on the short run relationship between the number of workers employed and the number of hours worked per worker. Kuh adds the variable $\log H_{t-1} - \log H_{t-2}$ to an equation like (1.5) of the basic model of Chapter 1, arguing that a positive rate of change of hours in the previous period will have a positive effect on the number of workers employed in this period as firms try to reduce high overtime costs.

In this thesis the view has been presented that H_{t-1}, the actual number of hours effectively worked per worker per week, cannot be observed and that the observable H_{pt-1} is a poor measure of H_{t-1} during all but the peak rates of output. Since H_{t-1} cannot be observed, no tests can be made on the possible short run substitution of hours worked per worker and workers. In fact the model developed above <u>assumes</u> that the number of hours worked per worker is the major adjustment mechanism in the short run. The assumptions of no short run substitution possibilities and constant retruns to scale combined with the fact that output fluctuates more than man-hours in the short run implies that the number of hours worked per worker is the primary adjustment mechanism. H_{t-1} is by definition equal to $(M_{t-1}H_{t-1})^*/M_{t-1}$.

Due to this observational problem tests can only be performed on H_p. It was argued above that the amount of excess labor on hand, measured as $\log H_{st-1} - \log H_{t-1}$,[1] should be a significant factor affecting firms' employment decisions. The question arises whether a variable like $\log H_{st-1} - \log H_{pt-1}$ should be significant as well. H_p can never be less than H (hours actually worked per worker must be paid for by the firm), and when H_p equals H, the excess labor variable and $\log H_{st-1} - \log H_{pt-1}$ are equivalent. When H_p is greater than H, these two variables are not the same, and a priori there appears to be little reason why in this case $\log H_{st-1} - \log H_{pt-1}$ should be significant for employment decisions. If H_{pt-1} does not equal H_{st-1}, the obvious thing for the firm to do is to change H_p. As long as H_p is greater than H, the firm can lower H_p without the necessity of increasing M. The firm cannot do this if H_p equals H, and in this case it must increase M in order to lower H_p. This, however, is exactly what the excess labor variable implies the firm will do when H_{t-1} is greater than H_{st-1}. There thus

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1. In this discussion the measure of the amount of excess labor on hand is referred to as $\log H_{st-1} - \log H_{t-1}$ instead of the equivalent $\log M_{t-1} - \log M^*_{t-1}$.

seems to be little reason why log H_{st-1} - log H_{pt-1} should be a significant determinant of log M_t - log M_{t-1} other than at those times when $H_{pt-1} = H_{t-1}$.

There also seems little reason why, as Kuh's argument suggests, log H_{pt-1} - log H_{pt-2} should be a significant factor affecting employment decisions. It is the level of H_{pt-1} (whether or not H_{pt-1} is greater than H_{t-1} or H_{st-1}, etc.) which would seem to be appropriate for consideration and not the change in H_{pt-1} from whatever level last period.

In the empirical work log H_{pt-1} - log H_{pt-2} was added to equation (4.2) to see whether the coefficient of this variable is significant and positive, as Kuh suggests. In another run the variable log H_{st-1} - log H_{pt-1} was added to equation (4.2) to see if it has any significance, and specifically to see if its coefficient is significantly negative, as is to be expected for the excess labor variable, log H_{st-1} - log H_{t-1}. As argued above, neither log H_{pt-1} - log H_{pt-2} nor log H_{st-1} - log H_{pt-1} is expected to be significant in the determination of log M_t - log M_{t-1}.

Tests for Cyclical Variations in Short Run Employment Demand

The model has been formulated as a monthly one with seasonal fluctuations playing an important role. In most, but not all, of the industries the seasonal fluctuations in the rate of output are so large that they tend to swamp the cyclical fluctuations in output. An important question is whether the employment behavior of firms is different during general contractionary periods of output than during general expansionary periods. The hypothesis tested here is that during contractionary periods firms "hoard" labor in the sense that the model (equation (4.2)) predicts more workers fired (or fewer hired) than actually are during the period, and that during expansionary periods the model predicts fewer workers fired (or more hired) than actually are during the period. The idea behind this hypothesis is that firms expect contractionary and expansionary periods to be temporary and react to them in a temporary way by letting hours worked per worker adjust more than they would if these conditions were expected to be permanent.

Two tests of this hypothesis were made. For the first test the rate of output variable, Y_t, was regressed against twelve seasonal dummy variables[1] and time in an effort to eliminate the purely seasonal and trend fluctuations in Y_t. The residuals from this equation were then taken to be a measure of the cyclical fluctuation in Y_t, denoted as P_t. Since the cyclical effects on employment decisions may not be symmetrical for contractions and expansions, the following two variables were constructed: $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$. The variable $(\log P_t - \log P_{t-1})_+$ was set equal to $\log P_t - \log P_{t-1}$ when $\log P_t - \log P_{t-1}$ was positive and set equal to zero otherwise. The variable $(\log P_t - \log P_{t-1})_-$ was set equal to $\log P_t - \log P_{t-1}$ when $\log P_t - \log P_{t-1}$ was negative and set equal to zero otherwise. These two variables were then added to equation (4.2). If the above hypothesis is true these variables should have significantly negative, though not necessarily equal, coefficients, i.e. when $\log P_t - \log P_{t-1}$ is positive the model should predict too few hired or too many fired, and when $\log P_t - \log P_{t-1}$ is negative the model should predict too few fired or too many hired.

This test has the disadvantage that the variable P_t, the residual from the regression of Y_t on twelve seasonal dummies and time,

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1. Dummy variable one being set equal to one in January and zero otherwise, dummy variable two being set equal to one in February and zero otherwise, and so on.

includes the random error term in the Y_t series as well as the cyclical term. Taking first differences of the P_t series aggravates this problem, and it may be the case that the random error term in the $\log P_t - \log P_{t-1}$ series dominates the cyclical term.

Because of this possible difficulty, another test was made of the above hypothesis. The National Bureau of Economic Research has divided overall economic activity into upswings and downswings.[1] Using their definitions of peaks and troughs in the post-war period, a dummy variable, denoted as D_t, was constructed which was set equal to one for each month when overall economic activity was declining (NBER peak to trough) and zero otherwise. D_t was then added to equation (4.2), and if the above hypothesis is true the coefficient of D_t should be significantly positive (more workers hired or fewer fired during contractions than predicted). The disadvantage of this variable for testing the above hypothesis is that it relates to overall economic activity and not necessarily to the activity of the particular industry in question; but the variable may be a rough indicator of general tendencies in the industry.

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1. See, for example, U. S. Department of Commerce, Business Cycle Developments, July 1967, Appendix A.

The Effect of the Unemployment Rate on Short Run Employment Decisions

The hypothesis tested here is that a tight labor market (measured by a low unemployment rate) tends to damp short run changes in the number of production workers employed, i.e. that a tight labor market causes a firm to hire less (because workers are difficult and expensive to find) or fire less (because of fear of not being able to hire the workers back when needed). Conversely, the hypothesis states that a loose labor market (measured by a high unemployment rate) tends to increase the short run changes in the number of production workers employed because workers are easier to find and the firm need worry less about rehiring workers it has laid off.

Let $\bar{U}$ denote the unemployment rate at which, in the eyes of the firm, the labor market switches from being relatively tight to relatively loose, and let U_t denote the unemployment rate during the decision period, from the end of the second week of month t-1 to the second week of month t. According to the above hypothesis, the effect of a positive $\log U_t - \log \bar{U}$ on $\log M_t - \log M_{t-1}$ in equation (4.2) is expected to be positive for $\log M_t - \log M_{t-1}$ positive and negative for $\log M_t - \log M_{t-1}$ negative, and the effect of a negative $\log U_t - \log \bar{U}$ is expected to be negative for $\log M_t - \log M_{t-1}$ positive and positive for $\log M_t - \log M_{t-1}$ negative.

Because of this asymmetry of effects, $\log U_t - \log \bar{U}$ cannot be added to equation (4.2) in any simple linear way, and it is assumed to enter in the following way:

$$(4.10) \quad \log M_t - \log M_{t-1} = a_1(\log M_{t-1} - \log M^*_{t-1}) + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1}) + g(\log U_t - \log \bar{U})$$

where,

$$g = g_0(a_1(\log M_{t-1} - \log M^*_{t-1}) + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1}))$$

What equation (4.10) says is that the size and sign of the coefficient g of $\log U_t - \log \bar{U}$ are determined by the other determinates of $\log M_t - \log M_{t-1}$. If, for example, the other determinates imply that $\log M_t - \log M_{t-1}$ should be positive and large, then this implies that g will be positive and large; and if furthermore $\log U_t - \log \bar{U}$ is, say, negative, then equation (4.10) implies that the change in $\log M_t - \log M_{t-1}$ will be smaller (and in some cases perhaps even negative) than would have been the case if log U_t - log $\bar{U}$ had been zero or positive.

Equation (4.10) is non-linear in g_0 and $\bar{U}$ and a non-linear estimating technique must be used. An iterative technique was used to estimate (4.10). Equation (4.10) was linearized by means of a Taylor's series expansion around an initial set of guesses of the parameters.[1] From the resulting linear form the difference between the initial set of guesses and the true values of the parameters can be estimated by ordinary least squares, and then these differences can be used to correct the initial guesses and a new least squares estimate of the differences can be made. This iterative process can continue until the estimated differences are negligible. The asymptotic standard errors of the coefficients can be calculated. (The small sample properties of these estimates are not known.) If the unemployment rate has an influence on employment decisions, g_0 should be significantly positive in equation (4.10).[2] In practice it turned out to be impossible to estimate both g_0 and $\bar{U}$ due to multicollinearity problems, and so $\bar{U}$ was taken to be the average of U_t over the period of estimation.

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1. Fortunately in this case the least squares estimates of the coefficients of equation (4.2) could be used as initial guesses of the respective coefficients in equation (4.10).

2. The general rule of thumb used in the empirical work is that g_0 is said to be significant if it is more than twice the size of its asymptotic standard error.

The Relationship of the Excess Labor Model to a Lagged Adjustment Model

The empirical results, discussed on page 133 , regarding the expectational hypotheses indicate that the expectational hypothesis which assumes non-perfect expectations for Y_t^e is not realistic. Therefore, Y_t^e has been taken to be Y_t in all of the other empirical work. Assuming that $Y_t^e = Y_t$ in equation (4.2) and ignoring the $\log Y_{t-i} - \log Y_{t-i-1}$, $i = 1, 2, \ldots, m$ variables in equation (4.2) yields:

$$(4.11) \quad \log M_t - \log M_{t-1} = a_1(\log M_{t-1} - \log M^*_{t-1}) + c_0(\log Y_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

M^*_{t-1} is the long run desired number of workers for the rate of output Y_{t-1}. Since the variable M^* could be constructed by dividing $(MH)^*$ by some estimate of H_s and since M^*_t depends on Y_t, which it is assumed the firm knows in advance, the following "lagged adjustment" model could be constructed and estimated:

$$(4.12) \quad \log M_t - \log M_{t-1} = q(\log M^*_t - \log M_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

M_t^* is the long run desired number of workers for the rate of output Y_t. It might be said that this model is more in the spirit of the basic model of Chapter 1, with the expected future rate of output variables added. Of course, the basic difference between this model and the basic model of Chapter 1 is that here M_t^* is constructed under the assumptions of fixed proportions and constant returns to scale, whereas in the model of Chapter 1 M_t^* is assumed to be derived from a Cobb-Douglas production function, the parameters of which are assumed to be estimatable from the derived equation (1.5).

The relationship between equations (4.11) and (4.12) is easy to see. Since potential or trend productivity moves slowly over time, $((M_{t-1}H_{t-1})/Y_{t-1})^*$ approximately equals $((M_tH_t)/Y_t)^*$.[1] Call these potential productivities p_{t-1} and p_t respectively and assume that $p_{t-1} = p_t = p$. By definition, $(M_{t-1}H_{t-1})^* = pY_{t-1}$ and $(M_tH_t)^* = pY_t$. Assuming that $H_{st-1} = H_{st} = \bar{H}$,[2] it follows that $M_{t-1}^* = pY_{t-1}/\bar{H}$ and $M_t^* = pY_t/\bar{H}$. Now,

$$(4.13)\quad \log M_{t-1}^* = \log (p/\bar{H}) + \log Y_{t-1}$$

1. See page 71 for an explanation of the notation.

2. As mentioned on page 35, the variable H_s may be a slowly trending variable, but for purposes here this is ignored and it is assumed that the variable H_s is a constant, $\bar{H}$.

and

$$\text{(4.14)} \quad \log M_t^* = \log (p/\bar{H}) + \log Y_t$$

Therefore,

$$\text{(4.15)} \quad \log M_t^* - \log M_{t-1}^* = \log Y_t - \log Y_{t-1}$$

or

$$\text{(4.16)} \quad \log M_t^* = \log M_{t-1}^* + \log Y_t - \log Y_{t-1}$$

Substituting this value of $\log M_t^*$ into equation (4.12) yields:

$$\text{(4.17)} \quad \log M_t - \log M_{t-1} = q(\log M_{t-1}^* - \log M_{t-1}) + q(\log Y_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

Comparing equations (4.17) and (4.11) it is seen that the lagged adjustment model is equivalent to the excess labor model with the additional restriction that $|a_1|$ equal $|c_0|$ in equation (4.11). Also, regarding the lagged adjustment model, there does not seem to be any apparent reason why the log Y_{t-i} - log Y_{t-i-1}, i = 1, 2, ..., m variables should be added to equation (4.12), although as argued on page 73 there do appear to be reasons why they should be added to the excess labor equation (4.11).

The results of estimating the excess labor equation (4.11) (or (4.2)), presented in Table 8-1 of Chapter 8, suggest that $|a_1|$ does not equal $|c_0|$. In addition many of the log Y_{t-i} - log Y_{t-i-1}, i = 1, 2, ..., m variables are significant. Thus the model of short run employment demand appears to be better specified in terms of the "excess labor reaction" equation (4.11) than in terms of the "lagged adjustment" equation (4.12).

Alternative Distributed Lags

Ignoring for a moment the expected future rate of output variables and the log Y_{t-i} - log Y_{t-i-1}, i = 1, 2, ..., m variables, equation (4.2) implies that M_t is a distributed lag of past values of the desired number of workers, M*. Jorgenson (1966) has shown that any arbitrary distributed lag function can be approximated by a rational distributed lag function.[1] If M_t is an arbitrary distributed lag of M*, then by

1. Jorgenson (1966), p. 142.

Jorgenson's theorem the lag function can be approximated by,

$$(4.18) \quad \log M_t = \frac{u(L)}{v(L)} \log M^*_{t-1}$$

where $L^i M^*_t = M^*_{t-i}$ and $u(L) = u_0 + u_1 L + u_2 L^2 + u_3 L^3 + \ldots$ and $v(L) = v_0 + v_1 L + v_2 L^2 + v_3 L^3 + \ldots.$ Multiplying both sides by v(L) yields:

$$(4.19) \quad v(L) \log M_t = u(L) \log M^*_{t-1}$$

For equation (4.2) the assumptions that,

$$v(L) = 1 - (1 + a_1)L$$

and

$$u(L) = - a_1$$

are implied by the form of the equation.

A more complicated lag is implied by an equation like (4.2) with the added variable, $\log M_{t-2} - \log M^*_{t-2}$, the amount of excess labor on hand during the second week of month t-2. Adding the variable implies that in equation (4.18),

$$v(L) = 1 - (1 + a_1)L - a_2L^2$$

and

$$u(L) = -a_1 - a_2L$$

and M_t is seen to be a more complicated lag of past values of M^*.

In the empirical work the variable $\log M_{t-2} - \log M^*_{t-2}$ [1] was added to equation (4.2) to see if a more general lag structure than that specified in equation (4.2) is indicated. The results are discussed in detail in Chapter 8, but in general they suggest that the simple lag structure specified in equation (4.2) is sufficient for explaining the short run fluctuations in the number of production workers employed. Also, of course, the introduction of the past rate of output change variables, $\log Y_{t-i} - \log Y_{t-i-1}$, $i = 1, 2, \ldots, m$, in equation (4.2) complicates the distributed lag, and their possible significance has been interpreted in this thesis as implying different reactions on the part of the firm to the time stream of the cumulation of excess labor.[2]

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1. Actually, the variable $\log M_{t-2} - \log (M_{t-2} H_{t-2})^*$ was added to the equation, with the effects of $\log H_{st-2}$ being assumed to be absorbed in the constant term and the time trend. See the discussion on page 77.

2. That is, the reaction on the part of the firm in eliminating the excess labor may be stronger the more recent the build up of this excess labor. See the discussion on page 73.

It may also be possible that firms react differently depending on the size of the amount of excess labor on hand, i.e. they may react in a non-linear way to the amount of excess labor on hand. It is possible that the larger the amount of excess labor on hand the stronger the reaction in eliminating it and the larger the amount of too little labor[1] on hand the stronger the reaction in adding more workers. In an attempt to test for this possibility the variable $(\log M_{t-1} - \log M^*_{t-1})^2_{\mp}$ was added to equation (4.2).[2] The notation $\mp$ indicates that when $\log M_{t-1} - \log M^*_{t-1}$ was negative, the squared term was taken to be negative as well, as this is consistent with the hypothesis under examination. The results are described in Chapter 8, but in general the results indicate that here again this further complication of the firm's reaction behavior is not significant.

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1. $\log M_{t-1} - \log M^*_{t-1}$ can be negative and usually is during and near the peak output months when large amounts of overtime are being used.

2. For this test the variable M^*_{t-1} had to be constructed, and it was constructed in the following way. $\log H_p$ was regressed on a constant and time and the predicted values of this equation were taken to be the values of H_s. $(M_{t-1}H_{t-1})^*$ was then divided by H_{st-1} to yield M^*_{t-1}.

CHAPTER 5

THE POSSIBLE SIGNIFICANCE OF INVENTORY INVESTMENT ON THE SHORT RUN DEMAND FOR PRODUCTION WORKERS

An Alternative Model

The model developed in Chapter 4 has been formulated in terms of rates of output and expected future rates of output. The rates of output in the short run have been taken to be exogenous, i.e. it has been assumed that firms take their rates of output as given in the short run and adjust their employment accordingly. If in fact the production and employment decisions are made simultaneously, with sales as the exogenous variable in the short run, then the estimates of the coefficients of equation (4.2) are subject to simultaneous equation bias. This problem does not arise, of course, for those industries in which inventories are not held or held only in small amounts compared with short run changes in production rates.[1]

For industries 211, 212, 301, and 324 data on shipments and inventories (as well as, by definition, on production) are available,

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1. This appears to be true in varying degrees for industries 231, 232, 233, 271, 314, and 341. See Table 7-1 for the list of industries used in this study.

and alternative equations to (4.2) can be estimated. The following equation was estimated as an alternative to (4.2):

$$(5.1)\quad \log M_t - \log M_{t-1} = a_1'(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*)$$
$$+ a_1'\log \bar{H} + a_1' u t + \sum_{i=1}^{m} b_i'(\log Y_{t-i} - \log Y_{t-i-1})$$
$$+ c_0'(\log S_t^e - \log S_{t-1}) + \sum_{i=1}^{n} c_i'(\log S_{t+i}^e - \log S_{t+i-1}^e)$$
$$- r'(\log V_{t-1} - \log V_{t-2})$$

The excess labor variables have been left as they are; S_{t+i}^e, the rate of shipments expected to exist during the second week of month t+i, has replaced Y_{t+i}^e for all i; and S_{t-1}, the actual rate of shipments during the second week of month t-1, has replaced Y_{t-1}. In addition $\log V_{t-1} - \log V_{t-2}$ has been added to the equation, where V_{t-i} is the stock of inventories on hand during the second week of month t-i.[1] $\log V_{t-1} - \log V_{t-2}$ has been added to equation (5.1) on the hypothesis that, other things being equal, an increase, say, in inventories during the previous period will lead to a certain number of workers being laid off in the current period, since part of the expected rate of shipments

1. By definition, $Y_t = S_t + V_t - V_{t-1}$.

in the current period can come from drawing down inventories. In this case the rate of output need be less than otherwise and so then need be the number of workers employed.

Except for the excess labor variables, equation (5.1) is similar to an equation derived by Holt, Modigliani, Muth, and Simon (1960) in a path breaking study of production and inventory control. They specify a quadratic cost function for the firm and then minimize the sum of expected future costs with respect to the relevant decision variables, employment and production. Their approach will now be briefly outlined.[1]

The Holt, Modigliani, Muth, and Simon Model

Holt, Modigliani, Muth, and Simon (hereafter referred to as HMMS) take sales and prices as exogenous, so that minimizing costs is equivalent to maximizing profits. Their cost function is composed of the following items:

(5.2) Regular payroll cost $= w_1 M_t + A_0$

where M_t is the size of the work force, w_1 is the wage rate, and A_0 is the "fixed cost term."

1. See Holt, Modigliani, Muth, and Simon (1960), pp. 47-130.

(5.3) Cost of hiring and layoffs $= q_0(M_t - M_{t-1} - A_1)^2$

These are the costs associated with changing the size of the work force in any one period. The constant term A_1 provides for asymmetry in costs of hiring and firing.

(5.4) Expected cost of overtime (given M_t) $= q_1(Y_t - v_0M_t)^2 + v_1Y_t - v_2M_t + v_3Y_tM_t$

The cost of overtime depends both on the size of the work force M_t and the rate of output Y_t. The cost relation of which (5.4) is an approximation is presented in Figure 6-1. Given M_t and the average output per worker v_0, v_0M_t is the maximum rate of output which can be produced without working overtime. At rates higher than Y_t the cost of overtime rises, the cost depending on the size of the overtime premium. MHHS argue that random disturbances and discontinuities will smooth out the solid line in Figure 6-1. The dotted line in Figure 6-1 is the quadratic approximation given in (5.4). They point out that to the extent that production falls to a low rate of output relative to the work force the approximation becomes poor.[1]

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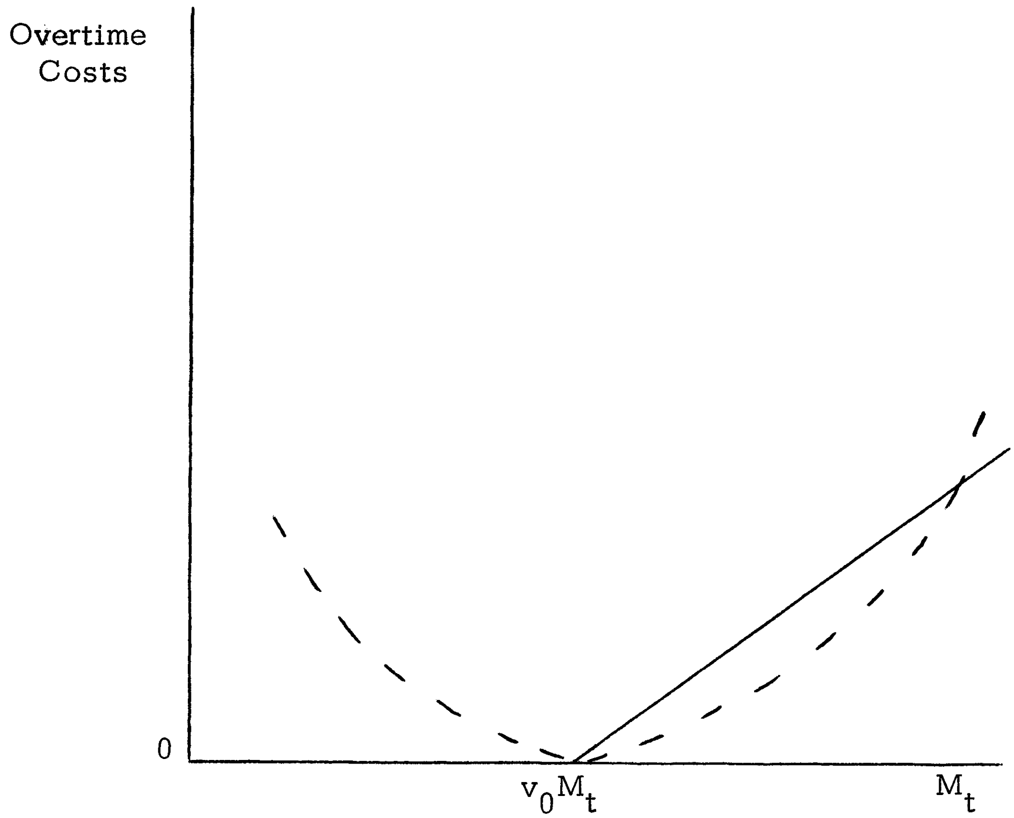
1. Holt, Modigliani, Muth, and Simon (1966), p. 55, n. 6.

Figure 6-1



HOLT, MODIGLIANI, MUTH, AND SIMON'S APPROXIMATION OF OVERTIME COSTS

Since (5.4) is based on a given size of the work force, M_t, there is a family of overtime cost curves, one for each value of M_t.

HMMS next define net inventories as inventories minus back orders and assume that,

$$\text{(5.5)} \quad \text{Optimal net inventory} = v_4 + v_5 S_t$$

where S_t is the aggregate order rate. As actual net inventory deviates from optimal in either direction, costs rise and they approximate:

$$\text{(5.6)} \quad \text{Expected inventory, back order, and set up costs} = q_2 (V_t - (v_4 + v_5 S_t))^2$$

where V_t is the level of net inventories.

Their cost function is the sum of (5.2), (5.3), (5.4), and (5.6). Since future orders are uncertain, the problem is to minimize the expected value of the sum of future costs with respect to the employment and production variables, subject to certain initial and terminal conditions.

This minimization procedure yields the linear equations:

$$(5.7)\quad Y_t = z_0 + z_1 M_{t-1} + \sum_{i=0}^{T} u_i S^e_{t+i} + z_2 V_{t-1}$$

$$(5.8)\quad M_t = k_0 + a_1'' M_{t-1} + \sum_{i=0}^{T} c_i'' S^e_{t+i} + r'' V_{t-1}$$

where S^e_{t+i} is the order rate expected for period t+i and T is the length of the decision period. Because of the quadratic nature of the cost function, the decisions reached by minimizing the sum of expected future costs using merely the expected values of the S^e_{t+i} are the same as the decisions which would be reached using complete knowledge of the distribution functions of the S^e_{t+i}.

Assuming the functional form of equation (5.8) to be log-linear instead of linear and taking first differences yields an equation similar to (5.1) except that the excess labor variables in equation (5.1) have been replaced by log M_{t-1} - log M_{t-2}:[1]

$$(5.9)\quad \log M_t - \log M_{t-1} = a_0'' + a_1''(\log M_{t-1} - \log M_{t-2})$$
$$+ c_0''(\log S^e_t - \log S_{t-1}) + \sum_{i=1}^{n} c_i''(\log S^e_{t+i} - \log S^e_{t+i-1})$$
$$+ r''(\log V_{t-1} - \log V_{t-2})$$

---

1. The constant term a_0'' has been added to allow for the possibiltiy of a time trend in log M_t.

a_1'' is expected to be positive and r'' is expected to be negative. Equation (5.9) can be estimated and compared with equation (5.1).

In like manner, if the inventory variable is not significant or if inventory costs are prohibitively high, an equation similar to equation (5.9) with expected sales replaced by expected production and the inventory variable eliminated,

$$(5.10) \quad \log M_t - \log M_{t-1} = a_0''' + a_1'''(\log M_{t-1} - \log M_{t-2}) + c_0'''(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i'''(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

can be compared with equation (4.2).[1]

The main drawback to the HMMS approach is their quadratic approximation to overtime costs, (5.4). They state that this approximation is poor to the extent that production falls to a low rate of output relative to the work force, but that the approximation may be good in the "relevant range."[2] It has been seen, however, that output does fall to a low rate relative to the work force in the course of the year, and if the assumptions made in this thesis are

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1. For those industries where the cost of holding inventories is prohibitively high, the HMMS equation (5.9) reduces to equation (5.10).

2. Holt, Modigliani, Muth, and Simon (1960), p. 55, n. 6.

true, firms hold a considerable amount of excess labor during much of the year. This implies that the approximation (5.4) is a very poor one indeed, and a model derived from this approximation is likely to be unrealistic. Fortunately the excess labor model developed in this study as exemplified by equations (4.2) or (5.1) can be tested against the HMMS model as exemplified by equations (5.9) or (5.10).

The results of estimating equation (5.1) and the HMMS equations (5.9) and (5.10) are presented in Chapter 9.

CHAPTER 6

A THEORETICAL MODEL OF THE SHORT RUN DEMAND FOR HOURS PAID FOR PER PRODUCTION WORKER

It has been pointed out above that in the model of the short run demand for production workers developed in Chapter 4 H_t is assumed to be the principle short run adjustment mechanism. Given $(M_tH_t)^*$, man-hour requirements, and M_t, the number of production workers employed, H_t is by definition equal to $(M_tH_t)^*/M_t$. The problem set forth here is to explain the determinates of $\log H_{pt} - \log H_{pt-1}$, the change in the number of hours paid for per production worker from the second week of month t-1 to the second week of month t. When $\log H_{pt} - \log H_{pt-1}$ is regressed against $\log M_t - \log M_{t-1}$, the coefficient of $\log M_t - \log M_{t-1}$ is nearly always significant and positive, which would seem to imply that at least some of the factors which determine $\log M_t - \log M_{t-1}$ also determine $\log H_{pt} - \log H_{pt-1}$. Indeed, on page 61 it was pointed out that a firm may view H_p in a similar manner as M with respect to short run fluctuations.

It would be expected, therefore, that an equation like (4.2) might be relevant for $\log H_{pt} - \log H_{pt-1}$ with $\log H_{pt} - \log H_{pt-1}$

replacing $\log M_t - \log M_{t-1}$ on the left hand side. There is, however, one main difference between hours paid for per worker per week and workers, which is probably best summarized by Kuh: "The main determinant of hours to be worked is a convention established through bargaining and a variety of social and institutional forces."[1] Unlike movements in M_t, which can be steadily upward or downward over time, movements in H_{pt} fluctuate around a relatively constant level of hours (such as 40 hours per week). Other things being equal, an H_{pt} greater than this level should bring into play forces causing H_{pt} to decline back to this level. Other things are of course never equal, and as mentioned above, these other factors may be some of the same factors influencing $\log M_t - \log M_{t-1}$.

The following equation is the basic equation determining the change in the hours paid for per week per worker:

$$(6.1) \quad \log H_{pt} - \log H_{pt-1} = a_1(\log M_{t-1} - \log M^*_{t-1}) + a_3(\log H_{pt-1} - \log H_{st-1}) + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

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1. Kuh (1965b), p. 253.

As an example, firms may be reluctant to drop H_{pt} below, say, the standard hourly work week because of such things as lower worker morale and the other factors discussed on page 60, but they may be more likely to do this if there is much excess labor on hand and if the rate of output is expected to decrease over the next few months than if there is little excess labor on hand and output is expected to increase over the next few months. In equation (6.1) both a_1 and a_3 are expected to be negative.

If it is continued to be assumed that H_{st-1} equals $\bar{H}e^{ut}$, then equation (6.1) is of the following form:

$$(6.1) \quad \log H_{pt} - \log H_{pt-1} = a_1(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*) + a_3\log H_{pt-1} + (a_1 - a_3)\log \bar{H} + (a_1u - a_3u)t + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

This is the form of the equation used in the empirical work.

There is one problem which may arise in estimating equation (6.1) for hours paid for per worker which does not arise in estimating equation (4.2) for workers. It was mentioned on page 84 that one constraint of the model of this thesis is that H_p can never be less than H. If H_{pt-1} is very large, greater than H_{st-1}, and equal to H_{t-1}, equation (6.1) may call for a negative $\log H_{pt} - \log H_{pt-1}$ if the negative effect of $\log H_{pt-1} - \log H_{st-1}$ is sufficiently stronger than the positive effect of the (negative) excess labor variable $\log H_{st-1} - \log H_{t-1}$[1] and if future rates of output are not expected to increase significantly. Depending on M_t and Y_t, equation (6.1) could call for an H_{pt} less than H_t, which cannot happen.

This constraint would not be taken into account if equation (6.1) were estimated directly. Another way of looking at this problem is the following. When H_p equals H, the production function constraint becomes binding on H_p and it is no longer free to fluctuate as much as it is when it is greater than H. When H_p equals H, it can only decrease as fast as H decreases, and it must increase if H increases and as fast as H increases. Since H_p is likely to equal H only when the levels of both variables are high, this constraint on H_p suggests that the behavior of $\log H_{pt} - \log H_{pt-1}$ may be significantly different when the level of H_p is high than when the level is low.

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1. Remember that the excess labor variable can be expressed in two equivalent ways.

A test of this possible difference of behavior of log H_{pt} - log H_{pt-1} was made in the following manner. For each industry the time series of H_p was plotted for the nineteen year period of estimation. When the levels of both H_{pt} and H_{pt-1} appeared to be large and when H_{pt} was greater than H_{pt-1}, a dummy variable, denoted as DP, was set equal to one for this observation of log H_{pt} - log H_{pt-1}. This was done for each case throughout the nineteen year period. DP was set equal to zero for all those cases where it was not set equal to one. Likewise, when the levels of both H_{pt} and H_{pt-1} appeared to be large and when H_{pt} was less than H_{pt-1}, another dummy variable, denoted as DM, was set equal to one for this observation of log H_{pt} - log H_{pt-1}. This was done for each case, and DM was set equal to zero for all those cases where it was not set equal to one. For each industry about 15 percent of the values of DP were set equal to one and about 15 percent of the values of DM were set equal to one.

DP and DM were then added to equation (6.1), and if the constraint on H_p is significant, the coefficients of these two variables should be positive. In addition, the coefficient a_3 of log H_{pt-1} - log H_{st-1} should be larger when DP and DM are included in the equation, since the firm has more freedom to react to an H_{pt-1} unequal to H_{st-1} when the constraint is not binding. Likewise, the coefficient c_0 of $\log Y_t - \log Y_{t-1}$ should be smaller when DP and DM are included, since H_p needs to respond less to current output changes when the constraint is not binding. The reason two dummy variables were constructed, one for positive changes and one for negative changes, was that the constraint may be more severefor positive changes than for negative changes of H_p.[1]

The degree of labor market tightness, as measured by the unemployment rate, may be a significant factor in determining the short run demand for hours paid for per worker. On page 90 it was seen that the unemployment rate (or more accurately $\log U_t - \log \bar{U}$) enters the equation determining the short run demand for production workers in a non-linear way.

According to the hypothesis discussed on page 89, a tight labor market (negative $\log U_t - \log \bar{U}$) leads to fewer workers hired and fewer workers fired in the short run, and a loose labor market (positive $\log U_t - \log \bar{U}$) leads to more

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1. When $H_{pt} - H_{pt-1}$ is negative and both levels are reasonably high, it may have been the case that H_t dropped even more, whereas for a positive $H_{pt} - H_{pt-1}$ with both levels high it cannot happen that H_t rises more than H_{pt}. There may thus be less of a constraint on H_p for a falling H_p than for a rising H_p, and if the coefficients of DP and DM are unequal, the coefficient of DP should be larger.

workers hired and more workers fired in the short run. In other words, in tight labor markets the short run fluctuations in the number of workers employed are damped, while in loose labor markets the fluctuations are increased. One of the basic postulates of this thesis is that many of the same factors which determine the short run demand for workers also influence the short run demand for hours paid for per worker, that firms view both variables in a similar manner with respect to short run movements. An important constraint of the model, as discussed above, is that H_p can never be less than H, and when H_p does equal H the production function constraint becomes binding on H_p. Considering all of these factors, an argument can be made why the variable $\log U_t - \log \bar{\bar{U}}$ should enter equation (6.1) in a simple linear way and have a negative effect on $\log H_{pt} - \log H_{pt-1}$.

Consider, first of all, what happens in a tight labor market. The number of workers hired and fired fluctuates less and so H fluctuates more. H_p is likely to equal H when the levels of both are high, and for these cases when H_p does equal H, H_p should increase more and decrease less when the labor market is tight since H increases more and decreases less. Since it is postulated that firms are reluctant to lay off workers or have workers quit during tight labor markets, an added inducement to keeping workers from moving to other jobs is to keep the level of hours paid for per worker high. This "inducement effect" should lead then to larger increases and smaller decreases in H_p when labor markets are tight. This "inducement effect" reinforces the "production function constraint effect" (i.e. the effect when H_p equals H) for increases in H_p, but runs counter to it for decreases in H_p. (The production function constraint implies that when H_p equals H, H_p should decrease more when labor markets are tight.) Since H_p is likely to be equal to H for only a few months out of the year, it seems likely that the counter influence of the production function constraint effect for decreases in H_p will be outweighed by the inducement effect. Thus in tight labor markets $\log H_{pt} - \log H_{pt-1}$ is likely to increase more and decrease less, and so $\log U_t - \log \bar{U}$ should have a negative influence on $\log H_{pt} - \log H_{pt-1}$.

A similar reasoning holds for loose labor markets. The production function constraint effect implies that, since H fluctuates less due to M fluctuating more, H_p should fluctuate less (increase less and decrease less) when H_p equals H. The inducement effect implies that H_p should increase less and decrease more (less inducement needed to keep the workers).

The conflict between the two effects occurs for decreases in H_p when H_p equals H. Again if this conflict is not significant, $\log U_t - \log \bar{U}$ should have a negative influence on $\log H_{pt} - \log H_{pt-1}$ during loose labor markets as well. Thus when $\log U_t - \log \bar{U}$ is added to equation (6.1), its coefficient should be significantly negative if the above hypothesis is valid.

One further test was performed on the hours paid for per worker equation, and this is the test to see if the equations predict differently during general contractionary periods of output than during general expansionary periods. As was the case for the production workers equation (4.2),[1] the variables $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$ have been added to the hours equation (6.1) to see if the coefficients of these variables are significantly negative (equation underpredicting for expansions and overpredicting for contractions). In another run the dummy variable D_t has been added to equation (6.1) to see if its coefficient is significantly positive. The discussion on page 88 of the problems associated with these two tests is relevant for the tests applied to the hours equation as well as to the workers equation.

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1. See the discussion on page 87.

It should be pointed out that both the production workers equation (4.2) and the hours paid for per production worker equation (6.1) may underpredict for expansions and overpredict for contractions, since it is assumed that the firms view H_p in a similar manner as M and may "hoard" hours paid for per worker during a contraction as well as workers. A priori it is expected that if a firm's behavior is different during contractions than during expansions, the difference in behavior would be more pronounced with respect to workers than with respect to hours paid for per worker, although the behavior may be significantly different with respect to both.

The results of estimating equation (6.1) and the results of the various tests described in this chapter are presented in Chapter 10. In Chapter 11 a comparison is made of the results of the workers equations and the hours paid for per worker equations, and the short run behavior of total man-hours paid for is examined. In the next chapter the data used in this study are examined.

CHAPTER 7

THE DATA

The basic model discussed in Chapter 1 and the model developed in this thesis take the firm as the basic behavioral unit. Data are not available by firm, however, and some degree of aggregation must be made. In many of the previous studies highly aggregated data have been used, such as all of manufacturing. The use of highly aggregated data tends to conceal certain relationships which may exist in the disaggregated data. Thor Hultgren (1960) has discovered in his work that the use of large statistical aggregates tends to conceal the disaggregate relationships between movements in output and output per man-hour.[1] The basic reason for this is that production cycles in different industries do not coincide with one another and to some extent tend to cancel each other out. Also, one would expect that hiring and firing practices would differ considerably across industries.

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1. Hultgren (1960), pp. 28-29.

The two studies of the United States which use two-digit industry data are those of Dhrymes (1966) and Kuh (1965b). Unfortunately, much of these data are nearly useless for the study of short run relationships between output and employment. The two-digit industry data have been constructed by interpolating annual two-digit industry data using the Federal Reserve Board (FRB) indices of industrial production. About half (by value added) of the FRB indices, however, are obtained by interpolating annual data using the Bureau of Labor Statistics (BLS) man-hour data and some assumption about how output per man-hour moves with production in the short run--and this is one of the very things the model is concerned with estimating. When these data are used, combined with the BLS data on employment, to estimate the relationship between employment and output in the short run, the net result is to estimate the estimating technique used by the FRB to construct the output data in the first place. There are only four two-digit industries in which the data are not based at least in part on man-hour interpolations--33 Primary Metals, 26 Paper and Allied Products, 21 Tobacco Manufacturing, and 29 Petroleum Refining and Related Industries.

Fortunately there are better United States data available, at a sacrifice, however, of complete coverage of all of United States manufacturing. There are seventeen three-digit industries for which FRB output data and BLS employment data are available monthly from 1947 to the present where the FRB output data are measured independently of BLS employment data. In addition there are about twenty four-digit industries for which these data are available monthly from 1958 to the present.[1] The seventeen three-digit manufacturing industries used in this study are listed in Table 7-1. These industries constitute about eighteen percent of manufacturing by value added.

There are other advantages of using these data in addition to the output estimates being independent of man-hour data. For the three-digit industries the degree of disaggregation is quite good, and many of the problems with using highly aggregated data should be mitigated. The three-digit industries are much more homogenous groups than even the two-digit industries. The use of monthly data in a short run study seems very desirable as some of the relationships between short run fluctuations in employment and output may be covered up in quarterly data.

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1. There are also three three-digit mining industries for which data are available from 1947 to the present.

Table 7-1

THE SEVENTEEN INDUSTRIES USED IN THE EMPIRICAL WORK

SIC Number	Description
201	Meat Products
207	Confectionery and Related Products
211	Cigarettes
212	Cigars
231	Men's and Boys' Suits and Coats
232	Men's and Boys' Furnishings
233	Women's, Misses', and Juniors' Outerwear
242	Sawmills and Planing Mills
271	Newspaper Publishing and Printing
301	Tires and Inner Tubes
311	Leather Tanning and Finishing
314	Footwear, Except Rubber
324	Cement, Hydraulic
331	Blast Furnance and Basic Steel Products
332	Iron and Steel Foundries
336	Nonferrous Foundries
341	Metal Cans

The BLS production worker data used in this study refer to persons on establishment payrolls who receive pay for any part of the pay period which includes the 12th of the month. Persons who are on paid sick leave, on paid holidays and vacations, or who work during part of the pay period and are on strike or unemployed during the rest of the period are counted as employed.

In all of the seventeen industries studied here except 201, 271, 324, and 341 a significant percentage of firms shut down for vacations in July (usually the first two weeks), and in industries 207, 211, 212, 231, 232, 233, and 314 a significant number of firms also shut down during the Christmas week in December.[1] In July and December many of these firms find demand at low levels anyway, and they find it to their advantage to shut the entire plant down for a week or two for vacations, rather than keeping the plant open and spreading the vacations over a longer period of time. For these shutdown periods production is clearly not exogenous, and thus it was decided to exclude in the empirical work the months in which shutdowns occurred. This means, for example, that for industries which shut down in July and December the values of $\log M_t - \log M_{t-1}$ for June to July, July to August,

1. This information was gathered mainly from industry and union officials.

November to December, and December to January were excluded.

The FRB output data are average daily rates of output for the month. The output variable, Y_t, used in the development of the theoretical model was defined to be the rate of output during the second week of the month. This variable can obviously differ from the average daily rate for the month and will certainly differ for the months of July and December when shutdowns occur. Since past and expected future changes in the rate of output are assumed to have an effect on employment decisions, excluding the four July and December observations when shutdowns occur does not exclude the July and December output figures from entering the estimated equation. For these figures the FRB data are not good approximations of the theoretically preferable Y_t variable. For the other months the assumption that the average daily rate of output for the month is a good approximation of the rate during the second week may not be too unrealistic.

What needs to be assumed for the July and December observations is that for these months the firm looks at the expected average daily rate rather than the rate expected during the second week (which is likely to be very low for July, for example) in formulating its current employment decisions. To the extent that without the shutdown in, say, July the average daily rate for July would have been larger and the June and August rates smaller, the log Y^e_{july} - log Y^e_{june} and the log Y^e_{august} - log Y^e_{july} variables (where these variables are now the average daily rates rather than the unobservable rates during the second week) are probably inadequate measures of the time stream of expected future output rates. This (hopefully slight) misspecification should be kept in mind when interpreting the estimates of the coefficients of the expected future output variables.[1,2]

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1. For the newspaper industry, 271, December was eliminated in the empirical work, since the average daily rate of output for this month was much lower than the rate during the second week, due to the heavy advertising before Christmas and the much lighter advertising after Christmas. The same problem still holds, of course, with respect to the December observations entering in the expected future rate of output variables.

2. Because of the fact that the output variable used in the empirical work is the average daily rate for the month rather than the rate during the second week, there is an additional reason why log Y_{t-1} - log Y_{t-2} may be significant in equation (4.2) in addition to it possibly serving as a proxy for excess labor on hand. Remember that log M_t - log M_{t-1} is the change in employment from the second week of month t-1 to the second week of month t. To the extent that the rate of output is, say, increasing throughout month t-1 and to the extent that employment responds to this increasing rate during the last half of month t-1, log M_t - log M_{t-1} will be influenced by the increase in the rate of output during the last two weeks of month t-1. It will therefore be influenced by log Y_{t-1} - log Y_{t-2}, since an increase in the rate of output in the last two weeks of month t-1 raises the average daily rate for the whole month, log Y_{t-1}.

In eight of the seventeen industries there were significant strikes (involving 10,000 workers or more) during the nineteen year period of estimation. In Table 7-2 these strikes are listed by industry, and the date of each strike and the number of workers involved are given. In the actual regressions these observations were omitted, as well as the two or three months before and after the strike. Some of the estimated equations had lags in output of up to 13 months, however, and an output variable had to be constructed to use for each strike month. In place of the actual number recorded during the strike month, the value of the output variable during the same month of the previous year was used multiplied by the ratio of the previous non-strike month's value to the same month of the previous year's value. (For example, if t were a strike month and t-1 were a normal month, the value of Y used for month t would be $Y_{t-12}(Y_{t-1}/Y_{t-13})$.) This variable is in effect trying to measure what output would have been if the strike had not taken place.[1]

Physical shipments and inventory data are available for industries 211, 212, 301, and 324--211 and 212 from the Internal Revenue Service (IRS), 301 from the Rubber Manufacturers Association (RMA), and

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1. For the strike ridden industries 301 and 331 this procedure was not used and all of the necessary observations were omitted.

Table 7-2

STRIKES INVOLVING 10,000 OR MORE WORKERS

Industry	Period of Strike		No. of Workers Involved
201	March 16, 1948	June 5, 1948	83,000
	September 4, 1959	October 24, 1959	18,000
233	February 17, 1948	February 19, 1948	10,000
242	April 29, 1952	May 31, 1952	45,000
	June 21, 1954	September 13, 1954	77,000
	June 5, 1963	August 18, 1963	29,000
271	December 8, 1962	March 31, 1963	20,000
	September 16, 1965	October 10, 1965	17,000
301	April 7, 1948	April 11, 1948	10,000
	August 27, 1949	September 30, 1949	15,000
	July 8, 1954	August 27, 1954	22,000
	August 13, 1954	September 5, 1954	21,000
	November 1, 1956	November 19, 1956	21,000
	April 1, 1957	April 16, 1957	14,000
	April 10, 1959	May 1, 1959	25,000
	April 16, 1959	June 10, 1959	13,000
	April 16, 1959	June 15, 1959	19,000
	June 2, 1965	June 9, 1965	22,000
324	May 15, 1957	September 16, 1957	16,000
331	October 1, 1949	December 1, 1949	500,000
	July 19, 1951	July 24, 1951	12,000
	April 29, 1952	August 15, 1952	560,000
	July 1, 1956	August 5, 1956	500,000
	July 15, 1959	November 8, 1959	519,000
341	December 2, 1953	January 12, 1954	30,000
	March 1, 1965	March 24, 1965	31,000

324 (ending in 1964) from the Bureau of the Mines. These data have been used to estimate the excess labor shipments equation (5.1) and the HMMS shipments equation (5.9).[1]

For industries 301 and 324 data on the rate of production, Y_t, and the level of inventories, V_t, are available, and from these the data on the rate of shipments $S_t = Y_t - (V_t - V_{t-1})$ can be constructed.[2] For industries 211 and 212 data on the rate of production, Y_t, and the rate of shipments, S_t, are available, but from these the level of inventories, V_t, cannot be constructed. Data on V_t is needed because the inventory variable entering equations (5.1) and (5.9) is $\log V_{t-1} - \log V_{t-2}$. For these two industries V_t was constructed in the following manner. For December, 1965, (denoted as 65.12) the dollar value of shipments—value of stock of inventories ratio, denoted as R, was computed using Bureau of Census data on the tobacco industry, 21. For each industry $S_{65.12}$ (IRS data) was multiplied by R, which gave a value of $V_{65.12}$ for each industry.

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1. All of the data gathered from sources other than the FRB were converted into average daily rates for the month using the FRB estimate of the number of working days in each month for each industry.

2. For industry 301 the RMA data on production and the FRB data on production are essentially the same since the FRB uses the RMA data to construct its production index. In this study the RMA data, adjusted for the number of working days in the month, has been used directly. Likewise, for industry 324 Bureau of Mines data have been used directly.

Using this figure as a base, the other values of V_t were constructed from the formula, $V_{t-1} = V_t + S_t - Y_t$, for each industry. Any errors resulting from this construction on log V_{t-1} - log V_{t-2} should be small.

For some three-digit industries (including 201, 301, 331, and 332) unpublished Bureau of the Census data on value of shipments and value of inventories and, in some cases, value of new orders are available monthly from 1948 or 1953 to the present. The basic disadvantage of these data is the fact that they are not based on physical magnitudes, but on dollar values. Price deflators could be used, but the deflators themselves are of questionable accuracy. Moreover, the Census data are based on sample surveys, whereas most of the data used in this study are based on the whole population. One of the reasons the three-digit Census data are not published is the questionable reliability of the estimates, particularly the estimates before 1960.

For industries 201, 301, 331, and 332 the Census data on production are used to estimate equation (4.2) and these results can be compared with the results using FRB or RMA data. These results are presented in Chapter 9, along with the results of estimating the shipments equation (5.1) using Census data. In addition, for industry 301 the results of estimating equation (5.1) using Census data can be compared with the results using RMA data. In every case the results using Census data are inferior to the results using FRB or RMA data.

Actually, the FRB data on production for industries 207, 332, 336, 341, and about 34 percent of 331 are really data on shipments. For industry 341 this is probably not very important since inventory changes are not likely to be very important, but for the others there may be serious problems involved in using the shipments data as if they were production data. Belsley (1966) has discovered in his work on production and inventory behavior of firms, however, that the effect of inventories on production decisions is significant but quite small in most cases, and if this is true for the industries used in this study, the bias resulting from using shipments data instead of production data should be small also.

The unemployment rate data used in this study are unpublished and were obtained from the BLS directly. Data are available on a monthly basis non-seasonally adjusted from 1948 to the present for durable good and non-durable good industries, as well as for the over-all economy and other categories. It seems that the most relevant measure of the tightness of the labor market facing any one firm is the unemployment rate in the durable and non-durable good industry, depending on which category the firm is in. Durable and non-durable is as fine a level of disaggregation as is available for the unemployment data, although with workers being able to move from one industry to another, it is not clear that the degree of data disaggregation should be any greater, even if it were possible to get more disaggregated data.

CHAPTER 8

THE RESULTS FOR PRODUCTION WORKERS

In the empirical work a large number of equations have been estimated and a large number of hypotheses have been tested. In this chapter the results of estimating the production workers equation (4.2) for each of the seventeen industries are presented, and the results of performing the various tests described in Chapter 4 are presented. In the next chapter the results of estimating the production workers equation (5.1), which takes the rate of shipments as exogenous in the short run instead of the rate of production, are presented, and the results of estimating the HMMS equations for both the shipments version and the production version are presented and compared with the results of the model of this thesis. In Chapter 10 the results of estimating the hours paid for per production worker equation (6.1) are presented, and the results of performing the tests described in Chapter 6 are presented. Since there is a considerable amount of detail in each of these chapters, a summary of the major conclusions derived form the results is given at the end of each chapter.

The Basic Results

The basic equation determining the short run demand for production workers is equation (4.2), and it is repeated here in the form in which it has been estimated:[1]

$$(4.2)\qquad \log M_t - \log M_{t-1} = a_1(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*)$$

$$+\; a_1 \log \bar{H} + a_1 u t + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1})$$

$$+\; c_0(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

Equation (4.2) is of course different depending on which expectational hypothesis is assumed. For the perfect expectational hypothesis the actual values of the Y_{t+i} are used, and for the other two hypotheses the expectational part of equation (4.2) takes the form presented (for n = 3) in equations (4.5) and (4.6). It was mentioned on page 82 that for these two "non-perfect" expectational hypotheses the q_i coefficients can be identified only if they are all equal. For all hypotheses, however, the c_i coefficients can be identified.

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1. See the discussion on page 77.

The expectational hypotheses are judged by the goodness of fit of the equation and by the significance of the c_i coefficients. The expectational hypothesis which assumed non-perfect expectations for Y_t^e proved to be substantially inferior in every industry to either of the other two hypotheses, and it was dropped from further consideration.

The results of estimating equation (4.2) for each of the seventeen industries are presented in Table 8-1. For each industry the expectational hypothesis which gave the better results has been used. For the non-perfect expectational hypothesis the coefficient of $\log Y_{t-1} - \log Y_{t-13}$ is denoted as d. The industries for which estimates of d are given are the industries in which the non-perfect expectational hypothesis proved to be better. In Table 8-2 the results of estimating equation (4.2) for each industry under the alternative expectational hypothesis to that assumed in Table 8-1 are presented, and a comparison of both hypotheses for each industry can be made. Before this comparison is made, however, the results presented in Table 8-1 are discussed.

The results presented in Table 8-1 appear to be quite good. For every industry the fit is better than the fit of the basic model of Chapter 1 and in most cases substantially so.[1] The coefficients are

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1. The results of estimating the equation of the basic model of Chapter 1 are presented in Table 2-2.

TABLE 8-1

PARAMETER ESTIMATES FOR EQUATION (4.2):

$$(4.2)\quad \log M_t - \log M_{t-1} = a_0 + a_1 (\log M_{t-1} - \log (M_{t-1} H_{t-1})^*) + a_2 t + \sum_{i=1}^{m} b_i (\log Y_{t-i} - \log Y_{t-i-1}) +$$

$$c_0 (\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i (\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
201	192	-1.039	-.178	-.077			.074	.067	.265	.171	.119	.138	.159	.087	.074	.039	.665	.0120	1.93
		(4.54)	(4.54)	(3.90)			(3.96)	(3.60)	(10.16)	(7.31)	(5.03)	(7.10)	(9.50)	(5.65)	(4.11)	(2.22)			
207	136	-.874	-.151	.121			.064	.091	.262	.182	.125	.080	.034			.056	.855	.0180	2.12
		(3.41)	(3.41)	(3.21)			(5.34)	(4.70)	(11.65)	(7.20)	(7.25)	(9.08)	(3.77)			(2.64)			
211	136	-.775	-.133	-.050					.086	.024	.043					-.010	.343	.0102	1.92
		(5.79)	(5.80)	(3.20)					(4.43)	(6.92)	(4.96)					(0.63)			
212	136	-.636	-.108	-.038				.053	.154								.454	.0159	2.63
		(4.76)	(4.73)	(1.52)				(4.57)	(7.76)										
231	136	-1.056	-.181	.085			.032	.065	.127	.021	.061	.035				-.017	.567	.0194	1.98
		(4.54)	(4.44)	(2.90)			(3.06)	(3.95)	(4.03)	(0.97)	(3.95)	(3.57)				(1.02)			
232	136	-.508	-.090	-.062				.021	.118	.091	.062	.018					.494	.0107	1.45
		(5.50)	(5.57)	(3.40)				(2.93)	(9.59)	(6.77)	(6.28)	(2.54)							
233	136	-.048	-.005	.041				.129	.164								.512	.0292	1.45
		(0.28)	(0.16)	(0.78)				(6.08)	(6.69)										
242	154	-.260	-.044	-.011	.060	.105	.146	.150	.218	.076	.065						.783	.0126	1.80
		(1.42)	(1.41)	(0.55)	(4.57)	(7.35)	(8.62)	(6.87)	(13.65)	(5.27)	(5.20)								
271	166	-.258	-.044	-.001					.120	.026	.044	.049	.013	.039			.552	.0048	2.12
		(2.57)	(2.60)	(0.09)					(7.58)	(1.68)	(3.37)	(4.26)	(1.34)	(4.06)					

TABLE 8-1 (continued)

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
301	134	-.626 (7.20)	-.108 (7.18)	-.062 (2.79)					.055 (2.88)	.059 (3.37)	.030 (1.83)	.036 (2.29)					.297	.0142	1.92
311	170	-1.021 (6.88)	-.174 (6.87)	-.056 (3.33)					.190 (8.12)	.082 (4.66)	.115 (7.51)	.084 (6.05)	.056 (4.52)	.038 (3.50)			.413	.0115	2.11
314	136	-.672 (2.51)	-.115 (2.50)	.042 (2.03)					.322 (10.73)	.109 (4.28)	.140 (8.04)	.052 (3.80)				.078 (3.34)	.661	.0143	2.19
324	187	-.653 (6.37)	-.110 (6.34)	.060 (2.44)					.224 (16.50)	.039 (2.40)	.026 (1.60)	.052 (3.36)	.051 (3.42)			.008 (0.47)	.639	.0177	2.01
331	128	-.209 (3.05)	-.035 (2.98)	.016 (1.01)	.044 (3.36)	0.67 (4.78)	.037 (2.48)	.121 (6.29)	.184 (9.89)								.790	.0101	1.86
332	170	-.734 (8.66)	-.123 (8.63)	.045 (2.04)					.172 (8.26)	.049 (3.46)	.058 (4.57)	.041 (3.45)	.033 (2.82)				.450	.0167	2.24
336	170	-.666 (5.61)	-.113 (5.59)	-.015 (0.62)				.090 (4.62)	.164 (6.53)	.086 (4.83)	.091 (6.00)	.076 (5.79)	.044 (3.42)	.027 (2.13)			.551	.0175	1.78
341	191	-.373 (3.60)	-.067 (3.62)	-.060 (2.38)				.038 (3.88)	.182 (15.32)	.067 (6.02)	.044 (4.64)	.036 (3.87)	.022 (2.45)				.771	.0180	1.99

t-statistics are in parentheses.

of the right sign except for two of the estimates of d, and most of them are highly significant.[1] The coefficient a_1 of the excess labor variable is always negative, and in all but two industries it is highly significant. One of these two industries is industry 242, where the past four changes in the rate of output are significant. Without these four variables included in the equation, a_1 is significant, but with these variables included it looses its significance.

For the most part the size of the coefficients decreases as the expected output changes move further away and as the past output changes move further back. The coefficient c_0 of $\log Y_t^e - \log Y_{t-1}$ is the largest of the output variable coefficients for all of the industries except 301, where c_1 is slightly larger.[2] The size of the reaction coefficient a_1 for each industry appears reasonable, with a range of .005 to .181. This implies, other things

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1. In estimating equation (4.2) the expected future output changes were carried forward until they lost their significance, and the past output changes were carried back until they lost their significance. In five of the industries--211,231,271,301, and 324--one or two of the expected future output change variables were not significant but the ones further out were. In these five cases the insignificant variables have been left in.

In what follows a coefficient is said to be significant if it is statistically significant at the five percent confidence level. A variable is said to be significant if its coefficient is significant.

2. .059 for c_1 vs .055 for c_0.

being equal, an elimination of the amount of excess labor on hand of between about one and twenty percent per month, excluding the effects of the past change in output variables.

The Durbin-Watson statistics presented in Table 8-1 are biased towards two because the excess labor variable ($\log M_{t-1} - \log (M_{t-1}H_{t-1})^*$) is of the nature of a lagged dependent variable. The bias can be significant,[1] and there may be serial correlation in the model even though the DW statistics do not indicate so except for industries 212, 232, and 233. What can be said regarding the DW statistics is that in general these results show much less evidence of serial correlation than do the results presented in Table 2-2 of estimating the basic model of Chapter 1, where there is strong evidence of serial correlation.

In a monthly model such as this one there is the possibility that the behavior of $\log M_t - \log M_{t-1}$ is significantly different during one specific month of the year than during the other eleven months. To the extent that the model is well specified this should not be the case, but there may be factors influencing $\log M_t - \log M_{t-1}$ in a systematic way during the same month each year which have not been taken into account in the model. One possible test to use to

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1. See Nerlove and Wallis (1966).

test whether this is true is the F test, testing the hypothesis that the coefficients for one specific month of the year are the same as the coefficients for all of the other months. A cruder test was in fact performed in this study. For each industry for each month the number of positive and negative residuals was calculated to see if there were a systematic tendency for the estimated equation to underpredict or overpredict for a specific month. Assuming that the probability of any one residual being negative is one-half, the hypothesis that the residuals for any one month come from a binomial population (with $p = 1/2$) was rejected (at the five percent confidence level) in 37 of the 162 cases, or in about 23 percent of the cases.[1]

Six of these cases occurred for the June-May period (where the model underpredicted) and seven for the October-September period (where the model overpredicted). The student influx in early June and outflow in late September probably account for this situation. Four of the cases occurred for the December-November period (where the model underpredicted), and there are probably accounted for by the fact that for December the average daily rate for the month is likely to be much less than the rate during the

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1. It should be emphasized that this test is crude and should be interpreted as indicating only general tendencies.

second week. Five of the cases occurred for the March-February period (where the model overpredicted), and here again the average daily rate of output for the month may be greater than the rate during the second week if the spring upturn begins during the last half of March. The other fifteen cases were about evenly distributed over the remaining months and showed no systematic tendency to underpredict or overpredict for a particular month.

For the 77 percent of the cases where the hypothesis was not rejected, the residuals appeared to be fairly random. The general conclusion of this test is that while there are some systematic tendencies by month which the model fails to account for, some of which can be explained by faulty data and some by student inflows and outflows, the model in general seems to do reasonably well.

Some people have conjectured that during the last few years employment has been more sluggish to output movements than previously, that firms are letting hours worked per worker adjust more in the short run. An F test was performed to test the hypothesis that the coefficients of equation (4.2) are equal for the subperiods 47.1-61.12 and 62.1-65.12. If the above conjecture is true, the hypothesis should be rejected. The hypothesis was rejected at the five percent confidence level for industries 201 and 332. Looking at the estimates for the two subperiods, it did appear that for 332 employment was less responsive to output changes during the second period, but for 201 the opposite appeared to be the case. For the other industries there appeared to be little evidence of a structural change in the second subperiod.

Capacity data were available for the Cement industry, 324, and a dummy variable was constructed which was set equal to one when the rate of capacity utilization was 95 percent or greater and zero otherwise. This variable was added to equation (4.2) on the hypothesis that, other things being equal, at high rates of capacity utilization more workers may be hired and fewer fired than at other times. The coefficient of this variable proved to be insignificant.

A Comparison of the Expectational Hypotheses

In Table 8-2 the results are presented of estimating equation (4.2) for each industry under the alternative (and inferior) expectational hypothesis to that assumed in Table 8-1.[1] These two sets of results

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1. As mentioned on page 125, for industry 301 none of the strike period observations on the rate of output was changed and all of the

TABLE 8-2

PARAMETER ESTIMATES FOR EQUATION (4.2) UNDER THE ALTERNATIVE EXPECTATIONAL HYPOTHESIS TO THAT ASSUMED IN TABLE 8-1

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
201	192	-.430	-.073	-.026			.064	.103	.201	.106	.046	.124	.140	.058	.042		.607	.0130	1.72
		(2.52)	(2.52)	(1.46)			(3.23	(5.68)	(8.74)	(5.07)	(2.05)	(6.70)	(8.09)	(3.42)	(2.08)				
207	136	-.775	-.134	.074			.064	.109	.245	.161	.126	.075	.034				.830	.0195	1.90
		(2.80)	(2.79)	(2.03)			(5.03)	(5.16)	(10.00)	(5.86)	(7.06)	(8.10)	(3.46)						
211	136	-.674	-.115	-.047			.079	.012	.039								.338	.0102	1.93
		(5.82)	(5.83)	(3.00)			(4.21)	(0.94)	(4.56)										
231	136	-.805	-.136	.084			.031	.066	.094	-.019	.037	.020					.562	.0194	2.13
		(6.27)	(6.04)	(2.88)			(2.90)	(4.05)	(4.08)	(0.99)	(2.60)	(2.03)							
232	136	-.385	-.068	-.031				.030	.088	.021	.023	.000				.013	.314	.0124	1.54
		(2.88)	(2.89)	(1.47)				(3.57)	(5.25)	(1.46)	(2.10)	(0.03)				(1.10)			
242	154	-.042	-.006	.006	.066	.111	.156	.166	.222	.052	.064					.034	.770	.0131	1.88
		(0.23)	(0.21)	(0.31)	(4.78)	(7.39)	(8.77)	(7.37)	(13.14)	(3.74)	(4.94)					(2.30)			
271	166	-.304	-.052	.005					.125	.035	.040	.048	.019	.030		.024	.517	.0050	2.13
		(2.11)	(2.12)	(0.55)					(5.51)	(1.75)	(2.23)	(3.33)	(1.59)	(2.85)		(2.03)			
311	170	-.911	-.155	-.044					.164	.028	.068	.049	.034	.023		-.010	.271	.0128	1.92
		(3.97)	(3.96)	(2.23)					(4.60)	(1.25)	(3.42)	(2.84)	(2.17)	(1.67)		(0.63)			
314	136	-.599	-.102	.043					.300	.114	.133	.040					.637	.0147	2.05
		(2.86)	(2.84)	(2.02)					(11.58)	(4.12)	(8.34)	(2.98)							
324	187	-.668	-.112	.066					.221	.042	.026	.046	.053				.630	.0179	2.03
		(6.28)	(6.29)	(2.53)					(13.99)	(1.81)	(1.31)	(2.37)	(2.86)						
332	170	-.367	-.061	.035					.133	-.027	.001	-.000	.001			-.006	.371	.0179	2.06
		(2.51)	(2.49)	(1.42)					(4.58)	(1.74)	(0.06)	(0.03)	(0.08)			(0.52)			

industry is made using these results.

TABLE 8-2 (continued)

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
336	170	-.228	-.038	-.001				.132	.126	-.032	.023	.032	.019	.017		-.019	.447	.0195	1.83
		(1.15)	(1.12)	(0.03)				(6.05)	(3.54)	(1.73)	(1.26)	(1.87)	(1.17)	(1.07)		(1.24)			
341	191	-.227	-.041	-.045				.038	.173	.047	.043	.025	.010			.038	.767	.0183	1.97
		(2.15)	(2.16)	(1.65)				(3.69)	(14.24)	(4.19)	(4.47)	(2.67)	(1.03)			(2.96)			
301	99	-.591	-.102	-.054					.059	.067	.049	.037					.212	.0151	2.06
		(4.41)	(4.36)	(1.68)					(2.23)	(2.93)	(2.37)	(1.85)							
	99	-.351	-.060	-.010					-.007	-.032	-.036	-.041				-.034	.180	.0155	2.14
		(1.80)	(1.78)	(0.31)					(0.22)	(1.56)	(1.41)	(1.74)				(1.84)			

t-statistics are in parentheses.

industry is made using these results.

are now compared. For industries 212, 233, and 331 none of the expected future output change variables were significant under either expectational hypothesis, and thus no comparison for these industries is needed.

For six industries, 201, 207, 211, 231, 314, and 324, the non-perfect expectational hypothesis is superior. Examining the results for these industries in the two tables reveals that the perfect expectational hypothesis works almost as well in all six industries. For the perfect expectational hypothesis the c_i coefficients are nearly as significant as for the other hypothesis and the fits are nearly as good. Industry 201 shows the most difference between the two hypotheses, but even in this case the perfect expectational hypothesis does not perform badly.

In three of the six industries where the non-perfect expectational hypothesis gives the better results, the coefficient d of $\log Y_{t-1} - \log Y_{t-13}$ is not significant, which, under the assumption

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necessary observations were omitted. Since the non-perfect expectational hypothesis involved longer lags, it was necessary to omit more observations under this hypothesis than under the perfect expectational hypothesis. To make the results for this industry comparible, the equation for the perfect expectational hypothesis was re-estimated using the same period of observation as was used to estimate the equation for the non-perfect expectational hypothesis. In Table 8-2 both of these results are given, and a comparison of the expectational hypotheses for this industry is made using these results.

that all of the q_i's are equal, implies that the rate of output in a specific future month is expected to be equal to what the rate of output was during the same month of the preceeding year. Expectations in this case are static.

For the remaining eight industries--232,242,271,301,311, 332,336, and 341--the perfect expectational hypothesis is superior. Examining the results for these industries in the two tables reveals that the non-perfect expectational hypothesis works almost as well for industries 242, 271, and 341. For the five industries 232, 301, 311, 332, and 336, however, the non-perfect expectational hypothesis yields substantially inferior results than the perfect expectational hypothesis does, both on grounds of goodness of fit and significance of the c_i coefficients. The fits are much worse[1] and most of the c_i coefficients are not significant.

One other comparison has been made of the two expectational hypotheses. In addition to the assumption that $Y_t^e = Y_t$, the following assumptions are made,

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1. For 232, .314 vs .494
For 301, .180 vs .212
For 311, .271 vs .413
For 332, .371 vs .450
For 336, .447 vs .551

$$(8.1a) \quad \log Y^e_{t+1} - \log Y_t = z_1(\log Y_{t-11} - \log Y_t) + (1-z_1)(\log Y_{t+1} - \log Y_t)$$

$$(8.1b) \quad \log Y^e_{t+2} - \log Y^e_{t+1} = z_2(\log Y_{t-10} - \log Y_{t-11}) + (1-z_2)(\log Y_{t+2} - \log Y_{t+1})$$

$$(8.1c) \quad \log Y_{t+3} - \log Y_{t+2} = z_3(\log Y_{t-9} - \log Y_{t-10}) + (1-z_3)(\log Y_{t+3} - \log Y_{t+2})$$

and so on. These assumptions are in a sense a weighted average of the two expectational hypotheses.[1] For the perfect expectational hypothesis all of the z_i's are zero, and for the non-perfect expectational hypothesis all of the z_i's are one and the $\log Y_{t-1} - \log Y_{t-13}$ variable is added.

Equation (4.2) was estimated under the assumptions made in (8.1) for each of the seventeen industries. For five industries--271,301,332,336, and 341--it was obvious that the z_i coefficients were not significantly different from zero. The output variables representing the perfect expectational hypothesis completely dominated the output variables representing the non-perfect expectational hypothesis. For four industries--201,211,231, and 324--it was obvious that the $(1-z_i)$ coefficients were not significantly different from zero. For these industries the output variables representing the

1. This type of assumption is similar to that made by Lovell in his study of inventory investment. See Lovell (1961), p. 305.

non-perfect expectational hypothesis completely dominated the output variables representing the perfect expectational hypothesis. These results are consistent with the results of estimating equation (4.2) under each expectational hypothesis separately. As was seen in Tables 8-1 and 8-2, for industries 271, 301, 332, 336, and 341 the perfect expectational hypothesis gave the better results, and for industries 201, 211, 231, and 324 the non-perfect expectational hypothesis performed better.

For the five remaining industries where future expectations are significant--207,232,242,311, and 314--one hypothesis likewise appeared to dominate the other, but since this domination was not quite as evident for these industries, it is worthwhile to examine the results more closely. In Table 8-3 the results of estimating equation (4.2) under the assumptions made in (8.1) are presented. The estimates are given only for the coefficients of the expectational variables, as the other coefficient estimates were little changed. Also presented in Table 8-3 are the derived values of the z_i coefficients.

The first thing to note is that the goodnesses of fit as measured by either the R^2's or the SE's are little changed over those in Table 8-1.

TABLE 8-3

PARAMETER ESTIMATES OF EQUATION (4.2) UNDER THE EXPECTATIONAL ASSUMPTIONS MADE IN (8.1). ESTIMATES GIVEN FOR THE COEFFICIENTS OF THE EXPECTATIONAL VARIABLES

Industry	No. of Obser.	$\widehat{c_1 z_1}$	$\widehat{c_2 z_2}$	$\widehat{c_3 z_3}$	$\widehat{c_4 z_4}$	$\widehat{c_5 z_5}$	$\hat{c}_1(1-z_1)$	$\hat{c}_2(1-z_2)$	$\hat{c}_3(1-z_3)$	$\hat{c}_4(1-z_4)$	$\hat{c}_5(1-z_5)$	R^2	SE	DW
207	136	.152	.089	.058	.029		.051	.055	.021	.007		.851	.0185	2.01
		(4.17)	(2.76)	(2.07)	(1.30)		(1.30)	(1.65)	(0.76)	(0.30)				
232	136	.002	.014	.015			.089	.050	.005			.507	.0106	1.46
		(0.19)	(1.28)	(1.46)			(6.45)	(4.05)	(0.52)					
242	154	.011	.032				.066	.041				.788	.0126	1.84
		(0.97)	(1.64)				(4.11)	(2.06)						
311	170	.018	.041	.028	.021	-.023	.089	.095	.073	.047	.061	.435	.0114	2.12
		(1.11)	(1.82)	(1.26)	(1.02)	(1.14)	(4.89)	(4.73)	(3.77)	(2.51)	(3.31)			
314	136	.046	.098	.047			.097	.060	.008			.666	.0143	2.12
		(2.08)	(3.29)	(1.65)			(3.49)	(2.09)	(0.29)					

Value of the z_i Coefficients

Industry	z_1	z_2	z_3	z_4	z_5
207	.749	.617	.734	.806	
232	.022	.219	.750		
242	.143	.438			
311	.168	.301	.277	.309	-.605
314	.322	.620	.855		

For industry 207 the coefficients of the output variables representing the non-perfect expectational hypothesis are larger and more significant than the coefficients of the other output variables (which are small and not significant). The size of z_i coefficients ranges between .617 and .806. For industries 232, 242, and 311 the coefficients of the output variables representing the perfect expectational hypothesis are in general larger and more significant, but there does appear to be a tendency for the coefficients of the output variables representing the non-prefect expectational hypothesis to become larger and more significant relative to the coefficients of the other output variables as the period for which the prediction is made moves further into the future. In other words, there seems to be a tendency for z_i to increase as i increases. This is definitely true for industries 232 and 242, and slightly true for 311 expect for the last coefficient, z_5, which is in fact negative. Industry 314 gives the best results for assumption (8.1). Except for the last period the coefficients of the output variables representing each hypothesis are significant. There is also clear evidence that z_i increases as i increases.

This slight evidence that z_i increases as i increases is consistent with theoretical notions, as one would expect that as the periods for which the predictions are made move further into the future, there will be less ability to predict accurately and more of a tendency to rely on past behavior. The results in general indicate, however, that the "weighted average" assumptions made in (8.1) are not an improvement over either the perfect expectational hypothesis or the non-perfect expectational hypothesis considered separately. The fits are little changed, and in general one set of output variables dominates the other set.

Results on the Short Run Substitution of Hours for Workers

As mentioned on page 85 of Chapter 4, the variable $\log H_{st-1} - \log H_{pt-1}$ was added to equation (4.2) to see if this variable had any of the properties of the excess labor variable $\log H_{st-1} - \log H_{t-1}$. On the assumption that $H_{st-1} = \bar{H} e^{ut}$, which is made throughout this study, this is equivalent to adding the variable $\log H_{pt-1}$ to equation (4.2). Since the sign of $\log H_{st-1} - \log H_{pt-1}$ is expected to be negative if this variable has any of the properties of the excess labor variable, the coefficient of $\log H_{pt-1}$, denoted as a_3, should be positive in the estimated equation.

The results of adding $\log H_{pt-1}$ to equation (4.2) are presented in Table 8-4. Since the addition of $\log H_{pt-1}$ to the equation had little effect on the other coefficient estimates, only the estimates of a_1 and a_3 are presented. As is clearly evident, the $\log H_{pt-1}$

TABLE 8-4

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERM $a_3 \log H_{pt-1}$.
ESTIMATES GIVEN FOR a_1 AND a_3.

Industry	Number of Observation	$\hat{a}_1$	$\hat{a}_3$	SE	DW
201	192	-.176 (4.50)	-.035 (0.69)	.0120	1.91
207	136	-.151 (3.37)	.044 (0.39)	.0181	2.14
211	136	-.127 (5.20)	.017 (0.69)	.0102	1.98
212	136	-.122 (4.08)	-.040 (0.71)	.0159	2.55
231	136	-.182 (4.39)	-.011 (0.18)	.0194	1.97
232	136	-.094 (5.69)	-.038 (1.13)	.0106	1.41
233	136	-.029 (0.94)	-.327 (3.57)	.0280	1.49
242	154	-.045 (1.42)	-.028 (0.57)	.0127	1.76
271	166	-.048 (2.60)	-.026 (0.58)	.0048	2.11
301	134	-.086 (4.86)	.074 (2.16)	.0140	1.95
311	170	-.169 (5.88)	.022 (0.36)	.0115	2.14
314	136	-.140 (2.73)	-.076 (1.11)	.0143	2.18
324	187	-.116 (6.14)	-.102 (0.83)	.0177	2.00
331	128	-.111 (4.29)	-.180 (3.27)	.0097	1.69
332	170	-.126 (6.22)	-.006 (0.15)	.0167	2.24
336	170	-.093 (4.64)	.214 (4.11)	.0167	2.10
341	191	-.072 (3.82)	-.104 (1.36)	.0180	1.92

t-statistics are in parentheses.

variable does not appear to be a significant determinant of $\log M_t - \log M_{t-1}$. In only two industries--301 and 336--is its coefficient significantly positive and in only five of the seventeen industries is it positive at all. Notice that in both industries 301 and 336 the absolute value of the excess labor variable coefficient a_1 has decreased in size (for 301, from .108 to .086 and for 336, from .113 to .093), which is as expected since the two variables are likely to be measuring the same thing during the peak output months. For twelve of the industries a_3 is negative and is significantly negative for two of these industries--233 and 331. No specific interpretation can be given for these negative signs, except that the results clearly indicate that hours paid for per worker are not a substitute for workers in the short run.

Most of the estimates of a_3 are not significantly different from zero, and it seems reasonable to conclude that the level of hours paid for per worker in the previous period is not a significant determinant of the number of workers hired or fired in the current period. This, of course, is as expected from the theory.[1]

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1. See especially the discussion on page 84.

In Table 8-5 the results of adding the variable $\log H_{pt-1} - \log H_{pt-2}$ to equation (4.2) are presented. The coefficient of this variable is denoted as a_4 and again only estimates of a_1 and a_4 are given, as the other estimates were not substantially affected. On the argument expounded by Kuh, a_4 is expected to be positive.[1]

For two industries--314 and 332--a_4 is significantly positive. In both of these industries the absolute value of a_1 has fallen (for 314, from .115 to .085 and for 332, from .123 to .111). For eleven of the industries a_4 is positive, and for the six industries where it is negative it is significantly negative for one of them--331. In fourteen industries a_4 is not significant. Again it seems safe to conclude that $\log H_{pt-1} - \log H_{pt-2}$ is not a significant determinant of $\log M_t - \log M_{t-1}$. This is also as expected since there seems to be little theoretical reason why this variable should be significant.

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1. See the discussion on page 83.

TABLE 8-5

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERM $a_4(\log H_{pt-1} - \log H_{pt-2})$. ESTIMATES GIVEN FOR a_1 AND a_4.

Industry	Number of Observation	$\hat{a}_1$	$\hat{a}_4$	SE	DW
201	192	-.177 (4.55)	.066 (1.26)	.0120	2.00
207	136	-.152 (3.39)	.017 (0.16)	.0181	2.12
211	136	-.117 (4.60)	.027 (1.45)	.0102	2.07
212	136	-.111 (4.72)	-.021 (0.49)	.0159	2.57
231	136	-.180 (4.46)	.114 (1.62)	.0192	2.04
232	136	-.090 (5.54)	.052 (1.07)	.0106	1.54
233	136	-.007 (0.23)	-.043 (0.50)	.0293	1.45
242	154	-.042 (1.34)	-.046 (0.77)	.0127	1.74
271	166	-.043 (2.52)	-.060 (1.47)	.0048	2.09
301	134	-.101 (6.54)	.068 (1.44)	.0141	1.94
311	170	-.164 (6.36)	.167 (1.94)	.0114	2.26
314	136	-.085 (1.91)	.221 (3.69)	.0136	2.05
324	187	-.109 (6.18)	.048 (0.37)	.0177	2.02
331	128	-.032 (2.77)	-.111 (2.10)	.0099	1.68
332	170	-.111 (7.43)	.206 (2.44)	.0164	2.42
336	170	-.109 (5.38)	.182 (1.59)	.0174	1.85
341	191	-.066 (3.58)	-.012 (0.18)	.0181	1.98

t-statistics are in parentheses.

The Results of the Tests for Cyclical Variations in Short Run Employment Demand

Two tests, described on pages 86-88, were performed to determine whether the behavior of firms is different with respect to hiring and firing practices during general contractionary periods than during general expansionary periods. For the first test the variable D_t was added to equation (4.2). The results are presented in Table 8-6. Estimates of the coefficient of D_t, denoted as a_5, are given, as well as the estimates of a_1 and c_0. a_5 is expected to be positive if firms do in fact "hoard" labor during contractions in the sense that during these periods they hire more workers or fire less than predicted.

a_5 is positive in only five industries, but is not significant for any of these five. For the remaining twelve industries where a_5 is negative, it is significant for three of them--301, 332, and 336. For these industries the coefficient c_0 of $\log Y_t^e - \log Y_{t-1}$ is smaller than it is when D_t is not included in the equation, and for 301 c_0 is no longer significant. There is also a slight tendency in the other industries for c_0 to be smaller when a_5 is negative. This phenomenon is probably due to the slight collinearity between D_t and $\log Y_t^e - \log Y_{t-1}$.

These results clearly give no indication that the model underpredicts during the contractions as defined by the NBER. The

TABLE 8-6

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERM $a_5 D_t$.

ESTIMATES GIVEN FOR a_1, c_0, AND a_5.

Industry	Number of Observation	$\hat{a}_1$	$\hat{c}_0$	$\hat{a}_5$	SE	DW
201	192	-.170 (4.38)	.259 (9.96)	-.002 (1.10)	.0120	1.95
207	136	-.159 (3.45)	.264 (11.51)	-.003 (0.64)	.0180	2.12
211	136	-.134 (5.79)	.086 (4.42)	-.001 (0.41)	.0103	1.93
212	136	-.110 (4.69)	.155 (7.72)	.001 (0.32)	.0159	2.64
231	136	-.181 (4.34)	.127 (3.98)	-.000 (0.06)	.0194	1.98
232	136	-.093 (5.40)	.119 (9.41)	.001 (0.49)	.0107	1.44
233	136	-.005 (0.15)	.163 (6.66)	.001 (0.13)	.0293	1.45
242	154	-.044 (1.41)	.215 (13.33)	-.003 (1.12)	.0126	1.79
271	166	-.047 (2.70)	.122 (7.58)	.001 (0.86)	.0048	2.14
301	134	-.070 (3.81)	.033 (1.68)	-.013 (3.35)	.0137	2.07
311	170	-.164 (6.32)	.183 (7.74)	-.004 (1.63)	.0114	2.21
314	136	-.121 (2.61)	.325 (10.76)	.003 (0.95)	.0143	2.18
324	187	-.110 (6.39)	.221 (16.04)	-.005 (1.32)	.0177	2.03
331	128	-.029 (2.31)	.174 (8.79)	-.004 (1.38)	.0101	1.81
332	170	-.106 (6.42)	.153 (6.77)	-.008 (2.02)	.0165	2.36
336	170	-.080 (3.74)	.137 (5.46)	-.014 (3.83)	.0168	2.13
341	191	-.062 (3.33)	.180 (15.03)	-.004 (1.01)	.0180	2.01

t-statistics are in parentheses.

insignificance of all but three of the a_5 coefficients implies that, according to this rather crude test, that firms do not behave differently during contractionary periods.

For the second test of the above hypothesis the variables $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$ were added to equation (4.2). The coefficients of these two variables, denoted as a_6 and a_7 respectively, are expected to be negative if firms hire more workers or fire fewer during contractions than the model predicts. In Table 8-7 the results are presented, with estimates of a_1 and c_0 presented as well as estimates of a_6 and a_7. The coefficient a_6 of $(\log P_t - \log P_{t-1})_+$ is negative for seven industries and positive for the other ten. It is significantly negative for two industries--212 and 233. It is significantly positive for three industries--301, 324, and 331--, and nearly so for three others--271, 311, and 332. The coefficient c_0 of $\log Y_t - \log Y_{t-1}$ is smaller for each of these six industries than it is when the two variables are not included. For the two industries--212 and 233--where a_6 is significantly negative, the estimates of c_0 are larger.

The coefficient a_7 of $(\log P_t - \log P_{t-1})_-$ is negative for nine of the industries and positive for the other eight. It is significantly negative for 212 and nearly so for 233 and 242. It is significantly positive for 331 and 336 and nearly so for 324. Again, the same sort

TABLE 8-7

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERMS $a_6(\log P_t - \log P_{t-1})_+$ AND $a_7(\log P_t - \log P_{t-1})_-$. ESTIMATES GIVEN FOR a_1, c_0, a_6, AND a_7.

Industry	No. of Obser.	$\hat{a}_1$	$\hat{c}_0$	$\hat{a}_6$	$\hat{a}_7$	SE	DW
201	192	-.177 (4.33)	.268 (7.89)	-.008 (0.16)	-.007 (0.13)	.0121	1.92
207	136	-.154 (3.44)	.264 (10.98)	.021 (0.44)	-.032 (0.65)	.0181	2.13
211	136	-.138 (5.87)	.099 (3.91)	.011 (0.23)	-.050 (1.16)	.0102	1.91
212	136	-.119 (5.01)	.230 (7.59)	-.128 (2.43)	-.116 (2.64)	.0154	2.55
231	136	-.169 (4.01)	.188 (3.38)	-.071 (1.15)	-.074 (1.15)	.0194	2.01
232	136	-.086 (5.08)	.116 (6.87)	-.022 (0.84)	.016 (0.65)	.0107	1.43
233	136	-.007 (0.25)	.239 (7.01)	-.170 (2.50)	-.098 (1.62)	.0284	1.59
242	154	-.031 (0.99)	.245 (11.69)	-.047 (0.94)	-.088 (1.82)	.0125	1.83
271	166	-.038 (2.24)	.113 (6.86)	.069 (1.71)	-.042 (0.82)	.0048	2.16
301	134	-.101 (6.63)	.009 (0.34)	.121 (2.17)	.045 (0.88)	.0140	1.98
311	170	-.169 (6.63)	.153 (3.56)	.102 (1.65)	.001 (0.01)	.0114	2.14
314	136	-.115 (2.50)	.309 (9.82)	.013 (0.17)	.085 (1.25)	.0143	2.23
324	187	-.120 (7.30)	.179 (11.89)	.204 (4.32)	.076 (1.65)	.0164	2.29
331	128	-.038 (3.35)	.071 (2.23)	.147 (4.05)	.142 (2.84)	.0094	2.15
332	170	-.119 (8.08)	.102 (2.28)	.110 (1.92)	.064 (0.99)	.0166	2.30
336	170	-.103 (4.65)	.105 (2.06)	.001 (0.02)	.140 (2.14)	.0174	1.84
341	191	-.068 (3.64)	.191 (13.21)	-.026 (0.84)	-.021 (0.84)	.0181	1.98

t-statistics are in parentheses.

of relationship holds between a_7 and c_0 as held between a_6 and c_0.

The over-all results indicate that for industries 212 and 231 the hypothesis that firms hire fewer workers or fire more than predicted during expansions and conversely during contractions is confirmed. For industries 301 and 332 and especially for industries 324 and 331, the opposite conclusion is suggested--that firms hire more workers and fire fewer than predicted during expansions and conversely during contractions. The general conclusion appears to be, however, that this test has not revealed any substantive evidence that firms behave differently during contractions than during expansions, that the model as exemplified by equation (4.2) appears to be adequately specified for "cyclical" short run employment behavior.

The Results of the Unemployment Rate Test

The results of estimating the non-linear equation (4.10) are presented in Table 8-8. Since the other coefficient estimates were not substantially changed, only the estimates of g_0 are presented. Under the hypothesis discussed on pages 89-91, g_0 is expected to be positive if in fact tight labor markets tend to damp short run fluctuations in the number of production workers employed and loose

TABLE 8-8

PARAMETER ESTIMATES FOR EQUATION (4.10)
ESTIMATES GIVEN FOR g_o.
A NON-LINEAR ESTIMATING TECHNIQUE HAS BEEN USED.

Industry	Number of Observation	g_o	SE
201	192	.133 (.163)	.0118
207	136	.073 (.113)	.0180
211	136	-.287 (.421)	.0102
212	136	-.022 (.378)	.0159
231	136	.607 (.207)	.0188
232	136	.466 (.243)	.0105
233	136	.254 (.235)	.0291
242	154	.075 (.099)	.0126
271	166	.138 (.171)	.0048
301	134	.650 (.421)	.0141
311	170	.330 (.313)	.0114
314	136	.013 (.186)	.0143
324	187	.149 (.164)	.0177
331	128	.284 (.164)	.0100
332	170	.591 (.257)	.0164
336	170	.720 (.190)	.0170
341	191	-.004 (.082)	.0181

Asymptotic standard errors are in parentheses.

labor markets tend to increase the fluctuations.

In all but three industries--211, 212, and 341--g_0 is positive. For three of these industries--231, 332, and 336--it is more than twice the size of its asymptotic standard error, and for five others--232, 233, 301, 311, and 331--it is larger than its asymptotic standard error. For each of these eight industries the SE for equation (4.10) is smaller than the SE for equation (4.2) presented in Table 8-1. For the nine other industries, including the three industries where g_0 is negative, g_0 is less than its asymptotic standard error, and except for industry 201 the SE is not improved.

The fact that all but three of the estimates of g_0 are positive and the fact that eight of the estimates are larger than their asymptotic standard error indicate that the degree of labor market tightness may affect short run employment decisions. The evidence is not strong and any conclusion must be tentative, but the hypothesis under consideration here appears to have some validity. Evidence on the significance of labor market tightness on the change in hours paid for per worker is given in Chapter 10, and these results will shed some further light on the possible validity of the hypothesis.

Tests of Different Reactions

It was mentioned on page 97 that adding the variable $\log M_{t-2} - \log M^*_{t-2}$ to equation (4.2) is a test for the existence of a more complicated distributed lag of $\log M_t$ on past values of $\log M^*$. The variable $\log M_{t-2} - \log M^*_{t-2}$ is the amount of excess labor on hand during the second week of month t-2. In Table 8-9 the results of estimating equation (4.2) with the variable $\log M_{t-2} - \log (M_{t-2}H_{t-2})^*$[1] added are presented. Only the coefficients of $\log M_{t-1} - \log M^*_{t-1}$ and $\log M_{t-2} - \log M^*_{t-2}$ are presented, the latter coefficient being denoted as a_8.

In only one industry--212--is a_8 significant, where it is significantly positive. In seven industries a_8 is negative and in the other ten it is positve. When a_8 is negative, a_1 is smaller in absolute value than it is when $\log M_{t-2} - \log M^*_{t-2}$ is not included in the equation; and when a_8 is positive, a_1 is larger in absolute value. There is also a strong tendency for the addition of $\log M_{t-2} - \log M^*_{t-2}$ to decrease the significance of a_1. The effects on the other coefficient estimates were small except for the coefficient b_1 of $\log Y_{t-1} - \log Y_{t-2}$. The introduction of $\log M_{t-2} - \log M^*_{t-2}$

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1. See footnote 1 on page 97 for the reason why this variable, $\log (M_{t-2}H_{t-2})^*$, has been used instead of some estimate of $\log M^*_{t-2}$.

TABLE 8-9

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERM $a_8(\log M_{t-2} - \log(M_{t-2} H_{t-2})^*)$.
ESTIMATES GIVEN FOR a_1 AND a_8.

Industry	Number of Observation	$\hat{a}_1$	$\hat{a}_8$	SE	DW
201	192	-.127 (1.81)	-.056 (0.84)	.0120	2.02
207	136	-.202 (2.85)	.055 (0.90)	.0180	2.04
211	136	-.131 (5.63)	-.004 (0.40)	.0103	1.93
212	136	-.325 (5.87)	.184 (4.25)	.0149	1.76
231	136	-.296 (3.89)	.135 (1.79)	.0192	1.89
232	136	-.092 (1.66)	.001 (0.03)	.0107	1.45
233	136	.105 (1.57)	-.116 (1.85)	.0289	1.57
242	154	-.014 (0.17)	-.032 (0.39)	.0127	1.85
271	166	-.033 (1.81)	-.021 (1.81)	.0048	2.22
301	134	-.093 (4.85)	-.022 (1.20)	.0142	1.99
311	170	-.176 (6.70)	.003 (0.26)	.0115	2.12
314	136	-.126 (2.68)	.022 (1.09)	.0143	2.09
324	187	-.104 (5.11)	-.012 (0.49)	.0177	2.02
331	128	-.156 (1.84)	.119 (1.44)	.0100	1.61
332	170	-.145 (6.77)	.024 (1.35)	.0166	2.22
336	170	-.128 (1.77)	.014 (0.22)	.0176	1.74
341	191	-.119 (1.68)	.049 (0.77)	.0180	1.89

t-statistics are in parentheses.

tended to decrease substantially the size and significance of b_1. This is due to the fact that log M^*_{t-2} approximately equals[1] log M^*_{t-1} - (log Y_{t-1} - log Y_{t-2}), and adding the variable log M_{t-2} - log M^*_{t-2} ($\approx$ log M_{t-2} - log M^*_{t-1} + log Y_{t-1} - log Y_{t-2}) to equation (4.2) is likely to lead to collinearity problems among log M_{t-2} - log M^*_{t-2}, log M_{t-1} - log M^*_{t-1}, and log Y_{t-1} - log Y_{t-2}.

Because of the insignificance of the a_8 coefficients and because the introduction of log M_{t-2} - log M^*_{t-2} had negligible effects on the standard errors, except for industry 212, there appears to be little evidence of the existence of a more complicated lag structure as exemplified by the addition of log M_{t-2} - log M^*_{t-2} to equation (4.2)

In Table 8-10 the results of estimating equation (4.2) with the variable $(\log M_{t-1} - \log M^*_{t-1})^2_{\pm}$ added are presented. The addition of this variable is a test to see whether firms react differently depending on the size of the amount of excess labor on hand. The coefficient of this variable, denoted as a_9, is expected to be negative if in fact the larger the amount of excess (or too little) labor on hand the stronger the reaction is. In Table 8-10

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1. See the discussion on page 94.

TABLE 8-10

PARAMETER ESTIMATES FOR EQUATION (4.2) WITH THE ADDITIONAL TERM $a_9(\log M_{t-1} - \log M^*_{t-1})^2_{\mp}$

ESTIMATES GIVEN FOR a_1 AND a_9

Industry	Number of Observation	$\hat{a}_1$	$\hat{a}_9$	SE	DW
201	192	-.135 (3.01)	-.196 (1.74)	.0119	1.93
207	136	-.072 (1.00)	-.154 (1.42)	.0179	2.12
211	136	-.161 (5.13)	.190 (1.31)	.0102	1.89
212	130	-.056 (1.32)	-.336 (1.48)	.0158	2.60
231	136	-.090 (1.57)	-.217 (2.19)	.0191	1.99
232	136	-.061 (1.75)	-.127 (0.96)	.0107	1.48
233	136	.150 (1.98)	-.405 (2.24)	.0288	1.50
242	154	-.079 (1.59)	.137 (0.90)	.0127	1.81
271	166	-.032 (1.26)	-.057 (0.64)	.0048	2.11
301	134	-.072 (2.20)	-.140 (1.22)	.0142	1.97
311	170	-.235 (3.60)	.298 (1.02)	.0115	2.14
314	136	-.191 (2.49)	.577 (1.25)	.0143	2.22
324	187	-.136 (4.01)	.052 (0.90)	.0177	2.02
331	128	-.052 (2.26)	.066 (0.88)	.0101	1.87
332	170	-.156 (4.62)	.103 (1.06)	.0167	2.20
336	170	-.167 (3.01)	.231 (1.04)	.0175	1.81
341	191	.009 (0.24)	-.106 (2.36)	.0178	2.02

t-statistics are in parentheses.

the estimates of the coefficients a_1 and a_9 are presented. The effects on the other coefficient estimates were minor.

In nine of the industries a_9 is negative, and in eight of the industries it is positive. For three industries a_9 is significant--231,233, and 341--and for all three of these industries it is negative. When a_9 is negative, a_1 decreases in absolute value compared with the estimate of a_1 without $(\log M_{t-1} - \log M^*_{t-1})^2_{\pm}$ included, and when a_9 is positive, a_1 increases in absolute value.[1] The introduction of $(\log M_{t-1} - \log M^*_{t-1})^2_{\pm}$ tends to decrease the significance of a_1. Except for perhaps industry 233, the effects on the standard errors are slight. The results suggest that the reaction to the amount of excess labor on hand is not stronger the larger the amount on hand.

It appears, therefore, that the introduction of the excess labor variable $\log M_{t-1} - \log M^*_{t-1}$ and the past change of output variables $\log Y_{t-i} - \log Y_{t-i-1}$, $i = 1, 2, \ldots, m$ to the equation determining the short run demand for workers adequately approximates the reaction of firms to the amount of excess labor on hand.

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1. It is interesting to note, although probably nothing very significant should be made of it, that industry 233, one of the three industries where a_9 is significant, is one of the two industries where a_1 is not significant in Table 8-1. In Table 8-10 a_1 is in fact significantly positive.

Summary

The results of estimating equation (4.2) determining the short run demand for production workers are quite good. The coefficients of the excess labor variables are highly significant and of the right sign, as are the coefficients of the expectational variables. For every industry the fit is better than the fit of the basic model of Chapter 1, and for most industries it is substantially better. The hypothesis of perfect expectations gives better results than the other "non-perfect" expectational hypothesis in eight of the fourteen industries where expectations are significant at all, and for the remaining six industries the non-perfect expectational hypothesis gives slightly better results. In general, future output expectations appear to be a significant determinant of short run employment demand.

Neither of the hours variables, $\log H_{pt-1}$ or $\log H_{pt-1} - \log H_{pt-2}$, appears to be a significant determinant of short run employment demand, which is as expected. The number of hours paid for per worker is not a substitute for the number of production workers employed in the short run in the sense that the level of hours paid for per worker in the previous period is not a significant determinant of the number of workers hired or fired in the current period. No evidence has been found that employment behavior is different during expansions than during contractions in that the model does not systematically underpredict or overpredict during these periods. The degree of labor market tightness appears to affect employment decisions, but the evidence on this point is not very strong. The tests of more complicated reaction behavior, such as adding the variables $\log M_{t-2} - \log M^*_{t-2}$ and $(\log M_{t-1} - \log M^*_{t-1})^{2}_{\pm}$ to equation (4.2), do not indicate the existence of a more complicated reaction than that specified in equation (4.2).

CHAPTER 9

THE RESULTS OF TESTING FOR THE SIGNIFICANCE OF INVENTORY INVESTMENT

Estimates of Equation (5.1)

For industries 211, 212, 301, and 324, where good data on shipments and inventories are available, equation (5.1) has been estimated. These results can be compared with the results of estimating equation (4.2) to determine whether the expected future rates of shipments are more significant for employment decisions than the expected future rates of production and to determine whether past inventory investment is a significant determinant of current employment decisions. The results are presented in Table 9-1.[1]

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1. Because the shipments data for industries 211 and 212 were collected only from 1953 on, equation (4.2) was re-estimated for the same period as equation (5.1) to insure a valid comparison. For industries 301 and 324 the estimates of equation (4.2) given in Table 9-1 are the same as those given in Table 8-1.

TABLE 9-1

PARAMETER ESTIMATES FOR EQUATIONS (4.2) AND (5.1):

$$(4.2)\quad \log M_t - \log M_{t-1} = a_0 + a_1(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*) + a_2 t + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

$$(5.1)\quad \log M_t - \log M_{t-1} = a_0' + a_1'(\log M_{t-1} - \log (M_{t-1}H_{t-1})^*) + a_a' t + \sum_{i=1}^{m} b_i'(\log Y_{t-i} - \log Y_{t-i-1}) + c_0'(\log S_t^e - \log S_{t-1}) + \sum_{i=1}^{n} c_i'(\log S_{t+i}^e - \log S_{t+i-1}^e) + r'(\log V_{t-1} - \log V_{t-2})$$

dustry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{d}$	R^2	SE	DW
211	96	-.470	-.081	-.061		.079	.024	.050			.002	.366	.0088	1.61
		(3.35)	(3.40)	(2.68)		(3.93)	(1.77)	(5.40)			(0.12)			
212	107	-.385	-.065	-.021	.057	.097						.318	.0171	2.77
		(2.61)	(2.58)	(0.56)	(4.47)	(4.69)								
301	134	-.626	-.108	-.062		.055	.059	.030	.036			.297	.0142	1.92
		(7.20)	(7.18)	(2.79)		(2.88)	(3.37)	(1.83)	(2.29)					
324	187	-.653	-.110	.060		.224	.039	.026	.052	.051	.008	.639	.0177	2.01
		(6.37)	(6.34)	(2.44)		(16.50)	(2.40)	(1.60)	(3.36)	(3.42)	(0.47)			

BLE 9-1 (continued)

dustry	No. of Obser.	$\hat{a}'_0$	$\hat{a}'_1$	1000 $\hat{a}'_2$	$\hat{b}'_1$	$\hat{c}'_0$	$\hat{c}'_1$	$\hat{c}'_2$	$\hat{c}'_3$	$\hat{c}'_4$	$\hat{d}'$	$\hat{r}'$	R^2	SE	DW
211	96	-.436	-.062	-.057		.066	.011	.053			.007	-.025	.351	.0089	1.75
		(2.87(	(2.53)	(2.45)		(3.03)	(0.78)	(4.99)			(0.39)	(1.24)			
212	107	-.306	-.018	.006	.063	.032						-.065	.212	.0184	2.76
		(1.57)	(0.73)	(0.16)	(4.45)	(1.31)						(1.88)			
301	134	-.566	-.086	-.049		.015	.009	-.015	.004			-.021	.250	.0147	1.69
		(5.16)	(5.90)	(2.20)		(1.50)	(0.82)	(1.48)	(0.40)			(1.21)			
324	187	-.679	-.087	.046		.085	.020	.041	.018	.017	.020	-.047	.285	.0250	1.71
		(4.42)	(3.78)	(1.34)		(6.94)	(1.39)	(3.19)	(1.47)	(1.44)	(1.07)	(3.15)			
	187	.064	.018	-.025	.144	.027	-.012	.032	-.002	-.006	-.003	-.012	.457	.0218	2.10
		(0.38)	(0.72)	(0.79)	(7.45)	(2.07)	(0.91)	(2.84)	(0.21)	(0.57)	(0.16)	(0.86)			

t-statistics are in parentheses.

For industry 211 the coefficient r' of the inventory variable in equation (5.1) is of the right sign but is not significant. The fit is slightly worse for equation (5.1) than for equation (4.2) (.341 vs .366). For industry 212 r' is of the right sign but not quite significant, and the coefficient c_0' of $\log S_t^e - \log S_{t-1}$ is not significant. The fit is substantially worse for equation (5.1) (.212 vs .318). For industry 301 r' is again of the right sign but not significant, and none of the c_i' coefficients is significant. The fit is likewise poorer for equation (5.1) (.250 vs .297). For industry 324 r' is significant and of the right sign without the $\log Y_{t-1} - \log Y_{t-2}$ variable included, but with this variable included it looses its significance.[1] Most of the c_i' coefficients are not significant, and the fit is substantially worse for equation (5.1) (.457 vs .639).

Although the sample is small, these results clearly indicate that the previous period's inventory investment is not a significant determinant of this period's employment decisions and that the model yields better results when specified in terms of production rates than in terms of shipments rates.

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1. $\log Y_{t-1} - \log Y_{t-2}$ was not significant in the estimation of equation (4.2).

Estimates of the Holt, Modigliani, Muth, and Simon Equations

In Table 9-2 the results of estimating the HMMS equation (5.9) for the four industries, 211, 212, 301, and 324, are presented.[1] For industry 211 the coefficient a''_1 of log M_{t-1} - log M_{t-2} is significantly positive (as expected), but the inventory variable coefficient r" is not significant and the fit is worse than the fit of either equation (4.2) or (5.1). For industry 212 a''_1 is negative and not significant, and neither c''_0 nor r" is significant. The fit is poorer than the fit of either equation (4.2) or (5.1). For industry 301 a''_1 is significantly positive, but none of the c''_i coefficients nor r" is significant and the fit is substantially worse than the fit of equation (4.2) or (5.1). For industry 324 with the log S_{t-1} - log S_{t-2} variable excluded a''_0 is significantly positive, r" is significantly negative, and the fit is better than the fit of equation (5.1) but still substantially inferior to the fit of (4.2). With the log S_{t-1} - log S_{t-2} variable included a''_0 is still significantly positive but r" is no longer significant, and the fit is substantially inferior to either the fit of

1. Because of the reasons given in footnote 2 on page 124on why log Y_{t-1} - log Y_{t-2} may be a significant determinant of log M_t - log M_{t-1} (other than as a proxy for excess labor on hand), log S_{t-1} - log S_{t-2} has been added to equation (5.9) when it proved to be significant. This was the case for industries 212 and 324.

TABLE 9-2

PARAMETER ESTIMATES FOR EQUATION (5.9):

$$(5.9)\quad \log M_t - \log M_{t-1} = a''_0 + a''_1(\log M_{t-1} - \log M_{t-2}) + b''_1(\log S_{t-1} - \log S_{t-2}) + c''_0(\log S^e_t - \log S_{t-1}) + \sum_{i=1}^{n} c''_i(\log S^e_{t+i} - \log S^e_{t+i-1}) + r''(\log V_{t-1} - \log V_{t-2})$$

Industry	No. of Obser.	$\hat{a}''_0$	$\hat{a}''_1$	$\hat{b}''_1$	$\hat{c}''_0$	$\hat{c}''_1$	$\hat{c}''_2$	$\hat{c}''_3$	$\hat{c}''_4$	$\hat{d}''$	$\hat{r}''$	R^2	SE	DW
211	96	-.081	.155		.042	-.009	.050			.019	-.028	.337	.0090	2.07
		(1.29)	(2.10)		(2.30)	(0.67)	(4.75)			(1.17)	(1.36)			
212	107	-.082	-.106	.090	.021						-.026	.190	.0187	1.64
		(0.78)	(1.84)	(3.84)	(0.84)						(0.76)			
301	134	-.023	.222		.003	.008	-.020	-.008			-.007	.095	.0162	2.01
		(0.39)	(2.68)		(0.26)	(0.67)	(1.76)	(0.76)			(0.36)			
324	187	-.139	.318		.056	-.003	.025	.007	.006	.025	-.040	.315	.0244	2.21
		(2.83)	(4.77)		(5.40)	(0.23)	(2.20)	(0.60)	(0.57)	(1.34)	(2.80)			
	187	-.004	.201	.056	.030	-.014	.025	.001	-.001	-.006	-.001	.378	.0234	2.08
		(0.07)	(2.90)	(4.22)	(2.56)	(1.15)	(2.28)	(0.05)	(0.10)	(0.31)	(0.07)			

t-statistics are in parentheses.

proved to be significant.

equation (5.2) with $\log Y_{t-1} - \log Y_{t-2}$ included or the fit of equation (4.2).

These results indicate that the HMMS model yields results inferior to both equations (5.1) and (4.2), and especially inferior to the latter. Since the expected future rates of production have proved to be more significant determinants of short run employment demand than expected future rates of shipments and past inventory investment, however, a more valid comparison of the HMMS model is to compare the results of estimating equation (5.10) (which is the HMMS model with the rate of production instead of the rate of shipments taken to be exogenous) with the results of estimating equation (4.2). In Table 9-3 the results of estimating equation (5.10) for each of the seventeen industries are presented.[1]

The coefficient a_1''' of $\log M_{t-1} - \log M_{t-2}$ is positive (as expected) in thirteen of the seventeen industries but is significantly positive in only eight of these. For the four industries where it is negative it is significantly negative for two of them. For every industry except 233 the fit is poorer than the fit of equation (4.2), and for all but about three industries--271, 314, and 341--the fit is substantially poorer. For industry 233 neither

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1. For the reasons given in footnote 2 on page 124 the variable $\log Y_{t-1} - \log Y_{t-2}$ has been added to equation (5.10) when it proved to be significant.

TABLE 9-3

PARAMETER ESTIMATES FOR EQUATION (5.10):

$$(5.10)\quad \log M_t - \log M_{t-1} = a_0''' + a_1'''(\log M_{t-1} - \log M_{t-2}) + b_1'''(\log Y_{t-1} - \log Y_{t-2}) + c_0'''(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i'''(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

ndustry	No. of Obser.	$\hat{a}_0'''$	$\hat{a}_1'''$	$\hat{b}_1'''$	$\hat{c}_0'''$	$\hat{c}_1'''$	$\hat{c}_2'''$	$\hat{c}_3'''$	$\hat{c}_4'''$	$\hat{c}_5'''$	$\hat{c}_6'''$	$\hat{d}'''$	R^2	SE	DW
201	192	-.001	.127	.097	.153	.066	-.004	.066	.098	.054	.027	.063	.582	.0133	2.21
		(0.66)	(1.93)	(4.81)	(9.01)	(4.77)	(0.25)	(3.86)	(6.11)	(3.34)	(1.57)	(3.34)			
207	136	-.001	.249	.105	.109	.063	.065	.054	.010			.049	.795	.0213	2.59
		(0.28)	(6.69)	(6.68)	(8.13)	(2.80)	(3.65)	(5.93)	(0.99)			(1.96)			
211	136	.001	.106		.026	-.013	.032					.024	.185	.0114	2.54
		(0.58)	(1.48)		(1.43)	(1.10)	(3.32)					(1.48)			
212	136	-.003	-.092	.077	.103								.379	.0169	1.74
		(1.83)	(1.96)	(6.45)	(5.44)										
231	136	-.012	-.063	.061	.032	-.035	.028	.020				.028	.435	.0219	1.93
		(5.11)	(0.85)	(4.50)	(1.18)	(1.82)	(1.73)	(1.78)				(1.63)			
232	136	.005	-.012	.036	.079	.065	.044	.006					.369	.0118	1.33
		(3.66)	(0.20)	(4.74)	(6.97)	(4.67)	(4.22)	(0.74)							
233	136	-.014	.110	.108	.181								.519	.0289	1.52
		(5.28)	(1.77)	(4.48)	(7.58)										
242	154	-.002	.555	.061	.147	.012	.043						.649	.0159	2.64
		(1.07)	(8.87)	(3.26)	(8.74)	(0.78)	(2.91)								
271	166	.002	-.159		.080	-.003	.024	.034	.008	.052			.546	.0048	1.84
		(4.55)	(2.85)		(7.60)	(0.25)	(2.41)	(3.41)	(0.83)	(4.68)					
301	134	-.002	.216		.001	.021	.001	.019					.062	.0164	2.02
		(0.64)	(2.62)		(0.03)	(1.09)	(0.08)	(1.05)							

BLE 9-3 (continued)

dustry	No. of Obser.	$\hat{a}_0'''$	$\hat{a}_1'''$	$\hat{b}_1'''$	$\hat{c}_0'''$	$\hat{c}_1'''$	$\hat{c}_2'''$	$\hat{c}_3'''$	$\hat{c}_4'''$	$\hat{c}_5'''$	$\hat{d}'''$	R^2	SE	DW
311	170	-.002	.164		.093	.011	.067	.052	.027	.029		.269	.0127	2.49
		(2.07)	(2.50)		(4.23)	(0.62)	(4.20)	(3.54)	(2.06)	(2.39)				
314	136	.002	.148		.270	.083	.127	.055			.083	.641	.0146	2.14
		(1.26)	(1.74)		(13.12)	(3.74)	(8.19)	(3.28)			(3.49)			
324	187	-.003	.145		.184	-.014	-.018	.021	.017		.023	.573	.0192	2.26
		(1.61)	(2.51)		(12.26)	(0.94)	(1.19)	(1.31)	(1.13)		(1.25)			
331	128	-.002	.343	.088	.156							.665	.0125	2.24
		(1.91)	(4.70)	(3.30)	(7.12)									
332	170	-.001	.201		.129	.010	.026	.016	.020			.235	.0195	2.40
		(0.43)	(2.94)		(5.38)	(0.60)	(1.85)	(1.13)	(1.42)					
336	170	-.001	.133	.105	.107	.057	.069	.063	.032	.026		.475	.0189	2.04
		(0.80)	(1.99)	(4.89)	(4.07)	(3.01)	(4.17)	(4.44)	(2.34)	(1.87)				
341	191	.000	.003	.059	.149	.038	.023	.017	.006			.754	.0186	1.98
		(0.05)	(0.05)	(4.69)	(18.21)	(4.79)	(2.95)	(2.15)	(0.78)					

t-statistics are in parentheses.

the excess labor variable $\log M_{t-1} - \log M^*_{t-1}$ in equation (4.2) nor $\log M_{t-1} - \log M_{t-2}$ in equation (5.10) is significant, and the standard error of (5.10) is slightly smaller than that of (4.2) (.0289 vs .0291).

There is also a tendency for the c_i''' coefficients of the expected future output variables to loose their significance in equation (5.10) compared with the significance of the c_i coefficients in equation (4.2). (Compare the results in Table 9-3 with those in Table 8-1.)

The HMMS model clearly yields inferior results compared with the model developed in this thesis. This is probably due to the HMMS overtime cost approximation exemplified in equation (5.4) and Figure 5.1, which, as mentioned on page 107, is likely to be very poor if in fact the rate of output falls to a low rate relative to the work force during the year. It does appear to be the case that the rate of output falls to a low rate relative to the amount of labor services paid for, and it is thus not surprising that the HMMS model yields poor results.

Estimates of Equations (4.2) and (5.1) Using Census Data

As mentioned in Chapter 7, Bureau of Census data on value of shipments and inventories are available for industries 201, 301, 331, and 332. These data are not likely to be very good, but it is at least worthwhile to compare the results using these data with the results already presented using the FRB data. In Table 9-4 results of estimating equation (4.2) using FRB data and Census data for industries 201, 331, and 332 are presented. Since the Census data were available for a shorter period of time, equation (4.2) was re-estimated using FRB data for the same period of estimation as was used for the Census data to insure a valid comparison. When Census data were used, the excess labor variable was constructed using Census data on production, and when FRB data were used, the excess labor variable was constructed using FRB data on production. The excess labor variables differ, therefore, depending on which data are used.

For industry 201 except for c_6 and d the coefficients are significant and of the right sign when Census data are used, but the fit using Census data is considerably worse than the fit using FRB data (.242 vs .643) and there is strong evidence of serial correlation when Census data are used. For industry 301 when

TABLE 9-4

PARAMETER ESTIMATES FOR:

a) EQUATION (4.2) USING FRB DATA
b) EQUATION (4.2) USING BUREAU OF CENSUS DATA
c) EQUATION (5.1) USING BUREAU OF CENSUS DATA

Industry	No. of Obser.		$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	$\hat{r}$	$\hat{s}$	R^2	SE	DW
201	182	a)	-.979	-.168	-.075			.066	.073	.259	.164	.109	.138	.153	.091	.064	.041			.643	.0120	1.86
			(4.02)	(4.02)	(3.31)			(3.36)	(3.77)	(9.25)	(6.53)	(4.43)	(6.84)	(8.71)	(5.58)	(3.45)	(2.12)					
	182	b)	-.422	-.073	-.042			.054	.087	.137	.126	.127	.126	.097	.049	.014	.021			.242	.0174	1.24
			(2.44)	(2.46)	(1.70)			(3.22)	(3.77)	(4.94)	(5.24)	(5.57)	(5.49)	(4.18)	(2.28)	(0.87)	(1.12)					
	182	c)	-.750	-.072	-.043			.046	.084	.087	.099	.120	.114	.079	.031	.012	.004	-.107		.212	.0179	1.29
			(3.42)	(2.35)	(1.71)			(2.56)	(3.29)	(2.49)	(2.94)	(3.61)	(3.21)	(2.37)	(1.08)	(0.63)	(0.16)	(4.21)				
331	118	a)	-.207	-.035	.006	.047	.067	.036	.124	.185										.794	.0103	1.90
			(2.93)	(2.89)	(0.33)	(3.39)	(4.63)	(2.37)	(6.17)	(9.61)												
	118	b)	-.010	-.016	.018	.034	.054	.062	.100	.133	.057	.030								.695	.0127	1.37
			(1.19)	(1.13)	(0.83)	(2.70)	(3.99)	(4.38)	(6.06)	(9.18)	(4.45)	(2.46)										
		c)	-.203	-.007	.022	.037	.061	.075	.138	.132	.045	.020						-.050	-.004	.694	.0128	1.46
			(1.40)	(0.48)	(1.00)	(2.86)	(4.36)	(5.09)	(6.70)	(7.09)	(3.00)	(1.55)						(1.56)	(0.57)			
332	120	a)	-.642	-.108	.045					.167	.027	.040	.019	.025						.381	.0178	2.51
			(6.28)	(6.18)	(1.14)					(5.87)	(1.44)	(2.31)	(1.15)	(1.52)								
		b)	-.640	-.108	.047					.082	.064	.071	.032	.018						.354	.0182	2.59
			(6.60)	(6.50)	(1.18)					(5.19)	(4.20)	(5.04)	(2.53)	(1.78)								
		c)	-.640	-.085	.020					.049	.050	.059	.032	.020				-.046	.047	.342	.0185	2.72
			(2.85)	(4.05)	(0.48)					(2.13)	(2.60)	(3.35)	(2.12)	(1.53)				(1.10)	(2.12)			

t-statistics are in parentheses.

Census data are used the excess labor variable coefficient a_1 is no longer significant. The coefficients c_1 and c_2 of the expected future rate of output variables are significant using Census data, but they were not significant when FRB data were used. The fit of the equation using Census data is worse than the fit using FRB data (.695 vs .794), and there is strong evidence of serial correlation when Census data are used. For industry 332 the results using Census data and FRB data are nearly the same, with the fit using Census data slightly worse than the fit using FRB data (.354 vs .381).[1]

In general the results using Census data are considerably poorer than the results using FRB data. It is also interesting to note that the square of the correlation coefficient between the first differences of the FRB output series and the first differences of the Census output series is only .353 for industry 331 and an

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1. It was pointed out in Chapter 7 that the FRB data for industry 332 are really data on shipments rather than on production, and so these two estimates are not strictly comparable. Census data on shipments were used to estimate equation (5.1), and perhaps a more valid comparison would be to compare the estimate of the equation using FRB data with this estimate. It is seen below that the fit of this equation using Census shipments data is slightly worse than the fit of the equation using Census production data (and *a fortiori* the fit using FRB data).

extremely low .002 for industry 201. For industry 332 the square of the correlation coefficient between the first differences of the FRB (shipments) series and the Census shipments series is .338.

For what they are worth, the results of estimating equation (5.1) for industries 201, 331, and 332 using Census data on shipments and inventories are presented in Table 9-4. r is the coefficient of $\log V_{t-1} - \log V_{t-2}$ in equation (5.1). In addition, for industries 331 and 332 data on value of new orders (denoted as R_t) were available, and the variable $\log R_{t-1} - \log S_{t-1}$, the change in unfilled orders during month t-1, was added to equation (5.1) on the hypothesis that the larger the (positive) change in unfilled orders in the previous period, other things being equal, the larger will be the number of workers hired in the current period.[1] The coefficient of $\log R_{t-1} - \log S_{t-1}$ is denoted as s, and it is expected to be positive.

For industry 201 the coefficients are of the right sign and are in general significant. The coefficient r of $\log V_{t-1} - \log V_{t-2}$ is significantly negative (as expected). The fit of equation (5.1) is worse than the fit of equation (4.2), however, and of course much

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1. Belsley (1966) has done extensive work on the relation between new orders, inventories, and production.

worse than the fit of equation (4.2) using FRB data. For industry 331 neither r nor s is significant and the fit is slightly worse for (5.1) than for (4.2). For industry 332 r is not significant but s is significant and positive (as expected), but again the fit is worse than the fit of equation (4.2) using the same data.

The same conclusion is reached here using Census data that was reached using FRB data--that expected future production rates are more significant for employment decisions than expected future shipment rates and past inventory investment (and for industries 331 and 332 the change in unfilled orders as well). The Census data have been seen to be poor, however, and probably not much reliance should be put on these results.

In Table 9-5 results of estimating equation (4.2) and (5.1) for industry 301 using Census data are presented. These results can be compared with the results of estimating these two equations using RMA data presented in Table 9-1. Here again the fits using Census data are worse than the fits using RMA data and the existence of serial correlation is more in evidence. The inventory variable coefficient r is significantly negative in equation (5.1) using Census data, but the fit is not improved from the fit of equation (4.2) using Census data. The square of the correlation coefficient between the first differences of the Census output series and the RMA output series is .402 and between the Census shipments series and RMA

TABLE 9-5

PARAMETER ESTIMATES FOR INDUSTRY 301 FOR:

a) EQUATION (4.2) USING BUREAU OF CENSUS DATA

b) EQUATION (5.1) USING BUREAU OF CENSUS DATA

Industry	No. of Obser.		$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{r}$	R^2	SE	DW
301	134	a)	-.483	-.083	-.017	.073	.057	.033	.038		.196	.0152	1.66
			(4.77)	(4.76)	(0.81)	(3.63)	(2.97)	(1.71)	(2.40)				
	134	b)	-.993	-.093	-.019	.038	.055	.026	.022	-.119	.201	.0152	1.64
			(5.05)	(5.07)	(0.87)	(2.12)	(3.16)	(1.55)	(1.41)	(3.34)			

t-statistics are in parentheses.

shipments series is .364.

Summary

The conclusions reached in this chapter are easy to summarize. The model of short run employment demand formulated in terms of expected future shipment rates and past inventory investment yields inferior results to the model formulated in terms of expected future production rates. Likewise, the HMMS model formulated either in terms of expected future shipments rates and past inventory investment or in terms of expected future production rates yields substantially inferior results to the model developed in this thesis.

CHAPTER 10

THE RESULTS FOR HOURS PAID FOR PER PRODUCTION WORKER

The Basic Results

In Chapter 6 it was argued that many of the factors which determine the short run demand for workers are likely to determine the short run demand for hours paid for per worker as well. Equation (6.1) is taken to be the basic equation determining the short run fluctuations in $\log H_{pt} - \log H_{pt-1}$. This equation is similar to equation (4.2) determining the short run fluctuations in $\log M_t - \log M_{t-1}$, except that equation (6.1) includes the term $\log H_{pt-1} - \log H_{st-1}$, which is expected to be significant for $\log H_{pt} - \log H_{pt-1}$ but not for $\log M_t - \log M_{t-1}$. The results presented in Chapter 8 indicate that $\log H_{pt-1}$ is not a significant determinant of $\log M_t - \log M_{t-1}$.

It was also mentioned in Chapter 6 that the unemployment rate variable, $\log U_t - \log \bar{U}$, may be a significant determinant of $\log H_{pt} - \log H_{pt-1}$, and, because of the restriction that H_p can never be less than H, that the dummy variables DP and DM described in Chapter 6 may be significant as well. In Table 10-1 the results of estimating equation (6.1) are presented. Two estimates for each industry are given. For the first estimate the $\log U_t - \log \bar{U}$ variable has been

TABLE 10-1

PARAMETER ESTIMATES FOR EQUATION (6.1):

$$(6.1)\quad \log H_{pt} - \log H_{pt-1} = a_0 + a_1(\log M_{t-1} - \log(M_{t-1}H_{t-1})^*) + a_2 t + a_3 \log H_{pt-1} + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y_t^e - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y_{t+i}^e - \log Y_{t+i-1}^e)$$

WITH THE ADDITIONAL TERMS: a) $v_0 \log u_t$ b) $v_0 \log u_t$, $v_1 DP_t$, AND $v_2 DM_t$

Industry	No. of Obser.		$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_3$	1000 $\hat{a}_2$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	$\hat{v}_0$	$\hat{v}_1$	$\hat{v}_2$	R^2	SE	DW
201	192	a)	2.119	-.113	-.458	-.028	.118	.051	.251	.064	.069	.058	.145	.015	.068	-.001	-.0068			.635	.0145	2.33
			(4.46)	(2.38)	(7.15)	(1.16)	(5.14)	(2.20)	(7.77)	(2.18)	(2.40)	(2.45)	(6.88)	(0.75)	(2.82)	(0.05)	(1.72)					
	192	b)	2.892	-.090	-.564	-.041	.094	.044	.213	.060	.068	.034	.126	.023	.040	*	-.0067	.024	.007	.693	.0134	2.41
			(6.23)	(2.12)	(8.54)	(1.82)	(4.35)	(2.07)	(7.16)	(2.24)	(2.73)	(1.58)	(6.43)	(1.24)	(1.77)		(1.85)	(5.72)	(1.43)			
207	136	a)	2.433	-.052	-.456	.034			.094	.023	.010	.039				.007	-.0027			.639	.0116	2.16
			(6.83)	(3.05)	(6.79)	(1.51)			(10.29)	(1.46)	(0.96)	(7.43)				(0.52)	(0.76)					
	136	b)	3.222	-.039	-.576	.036			.078	.025	.013	.034				.008	-.0026	.016	.008	.680	.0110	2.23
			(7.55)	(2.36)	(7.66)	(1.69)			(8.24)	(1.69)	(1.36)	(6.56)				(0.58)	(0.77)	(4.00)	(1.98)			
211	136	a)	1.330	-.387	-.612	.024			.503								.0071			.607	.0340	1.93
			(3.05)	(5.70)	(7.87)	(0.44)			(8.93)								(0.70)					
	136	b)	2.587	-.328	-.767	.027			.422								.0070	.040	.022	.654	.0321	1.95
			(4.78)	(4.95)	(8.99)	(0.52)			(7.46)								(0.72)	(4.15)	(2.34)			
212	136	a)	2.464	-.177	-.583	.103			.232								-.0174			.462	.0232	2.13
			(6.29)	(4.07)	(7.00)	(2.52)			(7.92)								(2.37)					
	136	b)	4.501	-.166	-.920	.152			.220								-.0160	.036	.034	.603	.0201	2.22
			(9.60)	(4.34)	(10.39)	(4.17)			(8.62)								(2.48)	(6.66)	(4.35)			
231	136	a)	1.129	-.264	-.439	.022			.183	.046	.047	.038				-.003	-.0132			.563	.0200	2.29
			(2.68)	(6.83)	(6.82)	(0.68)			(5.58)	(2.06)	(2.90)	(3.66)				(0.16)	(2.00)					
	136	b)	2.283	-.237	-.609	.013			.158	.043	.036	.027				.008	-.0142	.023	.012	.623	.0188	2.11
			(4.71)	(6.44)	(8.17)	(0.43)			(5.08)	(2.07)	(2.39)	(2.72)				(0.44)	(2.31)	(4.44)	(2.16)			

* with $- v_0 \log \bar{U}$ being absorbed in the constant term.

TABLE 10-1 (continued)

Industry	No. of Obser.		$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_2$	1000 $\hat{a}_2$	$\hat{b}_4$	$\hat{b}_3$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{v}_0$	$\hat{v}_1$	$\hat{v}_2$	R^2	SE	DW
232	136	a)	1.404	-.129	-.355	.007					.127	.095	.080	.046			-.0123			.479	.0145	1.88
			(4.35)	(6.10)	(6.58)	(0.25)					(7.55)	(5.38)	(6.20)	(4.71)			(2.47)					
	136	b)	2.688	-.114	-.560	.055					.108	.090	.069	.041			-.0131	.021	.013	.593	.0129	2.12
			(6.86)	(6.04)	(8.64)	(2.04)					(7.04)	(5.71)	(5.87)	(4.71)			(2.94)	(5.91)	(2.68)			
233	136	a)	3.839	-.084	-.733	-.057					.095						-.0100			.487	.0256	2.15
			(8.26)	(2.86)	(8.64)	(1.22)					(4.53)						(1.20)					
	136	b)	6.154	-.027	-1.083	.013					.051						-.0023	.047	.040	.692	.0200	2.10
			(13.87)	(1.12)	(14.09)	(0.34)					(2.92)						(0.35)	(8.05)	(7.03)			
242	154	a)	2.254	-.045	-.417	.005	.052	.031	.065	.021	.123						-.0067			.490	.0153	2.19
			(5.47)	(1.23)	(6.79)	(0.19)	(3.23)	(1.75)	(3.18)	(0.79)	(6.30)						(2.22)					
	154	b)	2.752	-.049	-.505	-.019	.044	.028	.051	.024	.109						-.0055	.017	.004	.536	.0147	2.21
			(6.19)	(1.39)	(7.36)	(0.74)	(2.86)	(1.70)	(2.57)	(0.95)	(5.68)						(1.90)	(3.68)	(0.79)			
271	166	a)	1.492	-.054	-.304	-.081					.081	.055	.023	.046	.017	.044	-.0005			.521	.0051	1.79
			(5.71)	(2.72)	(6.31)	(5.29)					(4.45)	(3.02)	(1.46)	(3.34)	(1.38)	(3.96)	(0.37)					
	166	b)	1.683	-.051	-.333	-.091					.075	.048	.028	.041	.015	.045	.0001	.004	-.002	.579	.0048	1.81
			(5.14)	(2.65)	(5.51)	(4.94)					(4.31)	(2.64)	(1.79)	(3.09)	(1.25)	(4.04)	(0.05)	(3.05)	(1.14)			
301	134	a)	1.294	-.169	-.370	.052					.149	.068	.033	.067			-.0199			.283	.0232	1.90
			(4.08)	(5.58)	(5.92)	(1.25)					(4.46)	(2.29)	(1.21)	(2.59)			(2.38)					
	134	b)	2.093	-.143	-.485	.128					.120	.061	.018	.059			-.0133	.034	.012	.418	.0211	1.85
			(5.70)	(5.10)	(7.32)	(2.83)					(3.87)	(2.27)	(0.73)	(2.48)			(1.73)	(5.20)	(1.68)			
311	170	a)	1.589	-.114	-.372	.035					.119	.043	.061	.032	.020	.018	-.0093			.369	.0097	2.04
			(5.35)	(4.69)	(6.80)	(2.16)					(5.80)	(2.80)	(4.68)	(2.69)	(1.90)	(1.93)	(3.25)					
	170	b)	2.360	-.109	-.498	.032					.109	.035	.049	.023	.016	.016	-.0073	.012	.002	.477	.0089	1.93
			(6.54)	(4.85)	(2.67)	(2.13)					(5.81)	(2.46)	(4.08)	(2.04)	(1.57)	(1.85)	(2.75)	(5.26)	(0.45)			

with $- v_0 \log \bar{U}$ being absorbed in the constant term.

TABLE 10-1 (continued)

Industry	No. of Obser.		$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_3$	1000 $\hat{a}_2$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{d}$	$\hat{v}_0$	$\hat{v}_1$	$\hat{v}_2$	R^2	SE	DW
314	136	a)	1.203	-.190	-.393	.061	.416	.141	.150	.092		.133	.0017			.737	.0169	1.84
			(2.39)	(3.12)	(4.53)	(2.25)	(11.43)	(4.56)	(6.15)	(4.24)		(4.60)	(0.30)					
	136	b)	1.555	-.171	-.434	.072	.392	.127	.143	.085		.127	.0016	.012	.013	.745	.0167	1.86
			(2.92)	(2.77)	(4.88)	(2.60)	(10.01)	(3.99)	(5.84)	(3.89)		(4.38)	(0.29)	(1.44)	(1.58)			
324	187	a)	3.290	-.032	-.574	-.034	.042						-.0057			.430	.0088	2.25
			(8.62)	(5.71)	(8.68)	(2.64)	(7.55)						(3.50)					
	187	b)	3.234	-.029	-.562	-.032	.040						-.0043	-.001	.009	.502	.0083	2.13
			(8.26)	(5.34)	(8.33)	(2.50)	(7.51)						(2.78)	(0.49)	(4.64)			
331	128	a)	2.764	-.182	-.633	.113	.192						-.0158			.532	.0137	2.39
			(7.88)	(6.82)	(8.18)	(4.66)	(9.09)						(3.89)					
	128	b)	2.378	-.153	-.542	.087	.183						-.0124	.010	-.008	.611	.0126	2.44
			(6.94)	(6.07)	(7.25)	(3.67)	(9.32)						(3.25)	(3.22)	(2.06)			
332	170	a)	.995	-.109	-.265	.063	.126	.033	.045	.040	.023		-.0132			.377	.0133	2.29
			(4.77)	(6.72)	(6.60)	(3.21)	(7.29)	(2.75)	(4.38)	(4.19)	(2.45)		(3.71)					
	170	b)	1.233	-.097	-.293	.054	.117	.033	.042	.040	.026		-.0139	.013	-.004	.472	.0123	2.15
			(5.05)	(6.36)	(6.47)	(2.88)	(7.29)	(2.97)	(4.34)	(4.47)	(2.99)		(4.14)	(4.20)	(0.89)			
336	170	a)	2.035	-.043	-.371	.050	.078	.034	.030	.035			-.0168			.347	.0111	2.26
			(6.51)	(3.23)	(6.79)	(2.92)	(5.33)	(3.10)	(3.06)	(4.34)			(5.50)					
	170	b)	2.033	-.023	-.353	.024	.069	.025	.018	.030			-.0132	.011	-.002	.482	.0099	2.08
			(5.69)	(1.85)	(5.87)	(1.51)	(5.13)	(2.46)	(1.93)	(4.07)			(4.58)	(4.72)	(0.83)			
341	191	a)	3.603	-.071	-.660	.092	.095	.022					-.0088			.595	.0159	1.91
			(10.07)	(6.37)	(10.02)	(3.84)	(13.09)	(3.02)					(3.23)					
	191	b)	4.340	-.051	-.765	.091	.070	.013					-.0083	.024	.005	.672	.0144	1.92
			(11.65)	(4.83)	(11.66)	(4.22)	(8.77)	(1.88)					(3.33)	(6.09)	(0.97)			

t-statistics are in parentheses.

*Variable was not included due to computer capacity restrictions.

with $- v_0 \log \bar{U}$ being absorbed in the constant term.

included, with its coefficient denoted as v_0,[1] and for the second estimate the variables DP_t and DM_t have been included as well, with their coefficients denoted as v_1 and v_2 respectively.

Examining the first estimate for each industry, it is seen that the coefficient a_3 of log H_{pt-1} is highly significantly negative for every industry. The coefficient a_1 of the excess labor variable is also significantly negative for every industry except industry 242, where the past four output changes are significant. The amount of excess labor on hand definitely appears to be a significant factor affecting the short run demand for hours paid for per worker, as well as the amount by which H_{pt-1} differs from the desired long run level of hours paid for and worked per worker, H_{st-1}.

The coefficient c_0 of log Y_t^e - log Y_{t-1} is significantly positive for every industry, and many of the c_i coefficients of the expected future rate of output variables are significant as well. The c_i's for the most part decrease as i increases.

Turning to the unemployment rate variable, the coefficient v_0 is negative for fifteen of the seventeen industries and significantly negative for eleven of these fifteen. For the two industries where v_0 is positive--211 and 314--it is not significant. These results

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1. Actually, only the variable log U_t was added to the equation, with - $v_0 \log \bar{U}$ being absorbed in the constant term.

definitely indicate that the degree of labor market tightness is a significant factor affecting the short run demand for hours paid for per worker--that the "inducement effect" does appear to exist. It is interesting to note that of the eight industries for which g_0 was larger than its asymptotic standard error in Table 8-8, in all but one of them, industry 233, v_0 in Table 10-1 is significantly negative. The results presented in Table 10-1 add support to the hypothesis that the degree of labor market tightness affects short run employment decisions.

Examining the second estimate for each industry, it is seen that the coefficient v_1 of DP_t is significantly positive for all but two industries--314 and 324. For 314 v_1 is positive but not significant and for 324 it is negative but not significant. The coefficient v_2 of DM_t is positive for thirteen of the seventeen industries and significantly so for seven of the industries. Of the remaining four where it is negative, it is significantly negative for one of them--331. For every industry except 314 and 324 v_1 is greater than v_2. Except for industry 314 the addition of these two variables improves the fit considerably.

For every industry the inclusion of the DP_t and DM_t variables has decreased the size of c_0, the coefficient of $\log Y_t^e - \log Y_{t-1}$. For every industry except for 324,331, and 336 the inclusion has increased in absolute value the size of the "reaction coefficient" a_3, and for every industry except 242 the inclusion has decreased in absolute value the size of the excess labor variable "reaction coefficient" a_1. For industries 242 and 301 the unemployment rate coefficient v_0 has lost its significance, but it remains significantly negative for the nine others where it was before. It remains negative for all but three of the industries--211, 271, and 314.

These results are very consistent with the theory developed above and appear to be an important confirmation of the overall model. The restriction that H_p can never be less than H implies that when H_p equals H the production function constraint becomes binding on H_p. This in turn implies that H_p has less freedom of action and must (at least in the upward direction) follow output movements more. The introduction of the DP and DM variables, therefore, would be expected to increase the absolute value of a_3, decrease the value of c_0, and yield positive coefficients estimates for DP and DM. In other words, for those periods when the production function constraint is not binding on H_p, the reaction to the current rate of output change should be (since it need be) smaller and the reaction in eliminating the discrepancy between H_p and H_s should be larger.

The reason why the excess labor variable coefficient a_1 decreases in absolute value with the addition of DP and DM is probably as follows. When H_p equals H, the excess labor variable is equivalent to the log H_{pt-1} - log H_{st-1} variable, and so at high levels of H_p the excess labor variable is picking up some of the effects of the log H_{pt-1} - log H_{st-1} variable. With the introduction of DP and DM this effect is lessened, and, since the coefficient of log H_{pt-1} - log H_{st-1} is larger than the coefficient of the excess labor variable in absolute value in equation (6.1) (the amount of excess labor on hand is less important in the short run demand for hours paid for per worker than the size of the discrepancy between H_p and H_s), the size of the excess labor variable coefficient decreases in absolute value.

The fact that the coefficient of DP is greater than DM for all but two industries is also to be expected on the above theory, as explained in footnote 1 on page 113.

An F test was performed on equation (6.1) testing the hypothesis that the coefficients of the equation are the same for the two sub-periods, 47.1-61.12 and 62.1-65.12. The hypothesis was rejected at the five percent confidence level in four of the seventeen industries--201, 311, 324, and 331. In 201 there appeared to be less reaction of hours paid for per worker to output changes in the second period, while in industries 311, 324, and 331 there appeared to be more reaction in the second period.

This completes the discussion of the results of estimating equation (6.1). In the remainder of this chapter the results of testing for cyclical variations in the short run demand for hours paid for per worker are discussed, and the ordinary least squares estimates of equations (4.2) and (6.1) are compared with estimates using Zellner's method of estimating seemingly unrelated equations. In the next chapter a comparison is made of the workers equation and the hours paid for per worker equation.

The Results of the Tests for Cyclical Variations in the Short Run Demand for Hours Paid For per Worker

As was done for equation (4.2), the variable D_t and then the variables $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$ were added to equation (6.1) to determine whether the equation overpredicts during contractions and underpredicts during expansions. In Table 10-2 the results of adding the variable D_t to equation (6.1) are presented. The coefficient of D_t, denoted as a_4, is presented along with the coefficient c_0 of $\log Y_t^e - \log Y_{t-1}$. a_4 is expected to be positive if firms do in fact decrease hours paid for per worker less or increase them more during contractions than the equation predicts.

TABLE 10-2

PARAMETER ESTIMATES FOR EQUATION (6.1) WITH THE ADDITIONAL TERMS $v_0 \log u_t$, $v_1\ DP_t$, $v_2\ DM_t$, AND $a_4\ D_t$. ESTIMATES GIVEN FOR c_0 AND a_4.

Industry	Number of Observation	$\hat{c}_0$	$\hat{a}_4$	SE	DW
201	192	.247 (7.66)	-.005 (1.94)	.0145	2.30
207	136	.085 (8.94)	-.008 (2.88)	.0107	2.17
211	136	.422 (7.42)	-.003 (0.40)	.0322	1.94
212	136	.217 (8.50)	-.005 (0.94)	.0201	2.26
231	136	.163 (5.16)	-.004 (0.76)	.0188	2.14
232	136	.105 (6.66)	-.003 (0.84)	.0130	2.13
233	136	.052 (2.96)	-.008 (1.65)	.0199	2.11
242	154	.108 (5.52)	-.002 (0.59)	.0148	2.23
271	166	.076 (4.15)	.001 (0.50)	.0048	1.86
301	134	.104 (3.22)	-.010 (1.63)	.0209	1.83
311	170	.106 (5.59)	-.003 (1.54)	.0089	1.97
314	136	.390 (9.91)	-.003 (0.82)	.0168	1.85
324	187	.040 (7.41)	-.002 (1.17)	.0083	2.23
331	128	.170 (7.72)	-.004 (1.20)	.0126	2.49
332	170	.095 (5.67)	-.011 (3.50)	.0119	2.31
336	170	.060 (4.43)	-.006 (2.39)	.0098	2.14
341	191	.070 (8.84)	-.005 (1.69)	.0143	1.99

t-statistics are in parentheses.

a_4 is positive for only one industry, 271, but is not significant. For the sixteen industries in which it is negative, it is significant for three of them--207, 332, and 336. For all industries the effects on the standard errors of the estimate are small.

These results indicate that, if anything, hours paid for per worker are decreased more or increased less than predicted during contractions rather than the opposite; but more likely the results of this test indicate that firms do not behave differently than predicted during the NBER defined contractions.

In Table 10-3 the results of adding the variables $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$ to equation (6.1) are presented. The coefficients of these two variables, denoted as a_5 and a_6 respectively, are presented along with the coefficient c_0 of $\log Y_t^e - \log Y_{t-1}$. a_5 and a_6 are expected to be negative under the hypothesis tested here.

a_5 is negative for seven industries, but is not significant for any of them. For the ten industries where it is positive, it is significantly so for four of them--207, 301, 311, and 332. For 301, 311, and 332 the coefficient c_0 decreases considerably in size and looses its significance when the two "cyclical" variables are added to the equation. a_6 is negative for six industries but is not significant for any of them. For the eleven industries where it is positive, it is

TABLE 10-3

PARAMETER ESTIMATES FOR EQUATION (6.1) WITH THE ADDITIONAL TERMS v_0 log u_t, v_1 DP_t, v_2 DM_t, $a_5(\log P_t - \log P_{t-1})_+$, AND $a_6(\log P_t - \log P_{t-1})_-$.
ESTIMATES GIVEN FOR c_0, a_5, AND a_6.

Industry	Number of Observation	$\hat{c}_0$	$\hat{a}_5$	$\hat{a}_6$	SE	DW
201	192	.280 (6.71)	-.057 (0.94)	-.011 (0.18)	.0147	2.33
207	136	.077 (8.07)	.055 (1.96)	-.001 (0.02)	.0110	2.34
211	136	.254 (3.35)	.222 (1.59)	.356 (2.76)	.0311	1.94
212	136	.223 (5.67)	-.018 (0.25)	.018 (0.31)	.0202	2.23
231	136	.190 (4.42)	-.010 (0.17)	-.053 (1.15)	.0188	2.14
232	136	.119 (5.68)	-.040 (1.18)	-.007 (0.24)	.0130	2.10
233	136	.064 (2.61)	-.057 (1.22)	.020 (0.47)	.0200	2.09
242	154	.069 (2.78)	.048 (0.84)	.131 (2.44)	.0145	2.19
271	166	.075 (4.06)	-.029 (0.69)	.040 (0.75)	.0048	1.85
301	134	-.020 (0.46)	.256 (3.24)	.222 (2.83)	.0197	2.08
311	170	.006 (0.19)	.149 (3.16)	.113 (2.55)	.0086	2.06
314	136	.392 (9.30)	-.024 (0.26)	.025 (0.30)	.0169	1.85
324	187	.038 (6.25)	.025 (1.12)	-.008 (0.35)	.0083	2.22
331	128	.143 (3.50)	.003 (0.06)	.090 (1.35)	.0126	2.48
332	170	.015 (0.43)	.141 (3.30)	.107 (2.27)	.0119	2.32
336	170	.021 (0.97)	.050 (1.38)	.091 (2.67)	.0097	2.13
341	191	.074 (7.45)	.006 (0.27)	-.017 (0.89)	.0144	1.97

t-statistics are in parentheses.

significantly so for six of them--211, 242, 301, 311, 332, and 336. For 336, as well as for 301, 311, and 332 mentioned above, the coefficient c_0 decreases in size and looses its significance when the variables are added. For 211 and 242 c_0 decreases in size but remains significant.

To the extent that industry seasonal patterns of output are not very pronounced, $\log Y_t - \log Y_{t-1}$ will tend to be correlated with $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$, and this is probably the reason for the decrease in the size of the c_0 coefficients in some of the industries. The fact that for industries 301, 311, 332, and 336 the $(\log P_t - \log P_{t-1})_+$ and $(\log P_t - \log P_{t-1})_-$ variables are significant while the $\log Y_t - \log Y_{t-1}$ variable is not may indicate that for these industries the purely "cyclical" factors influence $\log H_{pt} - \log H_{pt-1}$ more than seasonal factors.

The results in general indicate that for some industries the behavior of firms is different during contractions than expansions, but in the opposite direction as suggested above--i.e. for these industries the number of hours paid for per worker appears to be decreased more or increased less during contractions than predicted and conversely during expansions. For the majority of the industries, however, there does not appear to be any difference in behavior during the two periods.

Zellner Estimates

It seems likely that for each industry the residuals of equations (4.2) and (6.1) will be correlated--that a disturbance which makes the residual of equation (4.2) positive, for example, is also likely to affect the residual of equation (6.1) in a similar manner. It is also possible that disturbances which affect the residuals of the equations of one industry will affect the residuals of the equations of other industries in a similar manner. If these residuals are in fact correlated, Zellner's method of estimating seemingly unrelated equations will yield more efficient estimates.[1]

In Table 10-4 the results of estimating equations (4.2) and (6.1) (including the log U_t, DP_t, and DM_t variables) for industries 311, 332, and 336 using Zellner's method are presented. Comparing these estimates with the estimates using ordinary least squares presented in Tables 8-1 and 10-1, it is seen that the estimates are not substantially changed. There is a tendency for the size of the coefficient a_1 of the excess labor variable to decrease in absolute value in both the workers equation and the hours paid for per worker equation and for the size of the coefficient a_3 of log H_{pt-1} to decrease

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1. See Zellner (1962).

TABLE 10-4

PARAMETER ESTIMATES FOR EQUATIONS (4.2) AND (6.1) (WITH THE $v_0 \log u_t$, $v_1 DP_t$, AND $v_2 DM_t$ VARIABLES INCLUDED) FOR INDUSTRIES 311, 332, AND 336 USING ZELLNER'S METHOD OF ESTIMATING SEEMINGLY UNRELATED EQUATIONS

Industry	No. of Obser.	Equation	$\hat{a}_0$	$\hat{a}_1$		$1000\ \hat{a}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$			
311	170	(4.2)	-.999	-.170		0.055		.200	.076	.107	.079	.052	.036			
			(6.95)	(6.94)		(3.29)		(8.81)	(4.41)	(7.21)	(5.81)	(4.28)	(3.43)			
332	170	(4.2)	-.656	-.110		.043		.163	.051	.057	.036	.031				
			(8.35)	(8.32)		(1.94)		(8.38)	(3.70)	(4.72)	(3.10)	(2.72)				
336	170	(4.2)	-5.73	-.097		-.010	.090	.154	.080	.084	.068	.042	.022			
			(5.18)	(5.15)		(0.45)	(5.18)	(6.60)	(4.69)	(5.81)	(5.40)	(3.41)	(1.89)			
			$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_3$	$1000\ \hat{a}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{v}_0$	$\hat{v}_1$	$\hat{v}_2$
311	170	(6.1)	2.090	-.109	-.453	.029		.121	.029	.042	.019	.013	.015	-.0064	.009	.001
			(6.65)	(5.40)	(8.05)	(2.01)		(7.14)	(2.25)	(3.71)	(1.81)	(1.50)	(1.96)	(2.68)	(4.71)	(0.35)
332	170	(6.1)	1.056	-.082	-.250	.048		.116	.023	.033	.032	.020		-.0116	.009	-.004
			(5.13)	(6.27)	(6.64)	(2.65)		(8.08)	(2.24)	(3.67)	(3.83)	(2.62)		(3.87)	(3.43)	(1.22)
336	170	(6.1)	1.890	-.017	-.324	.026		.080	.019	.011	.025			-.0116	.008	-.003
			(6.08)	(1.53)	(6.23)	(1.71)		(6.61)	(2.07)	(1.23)	(3.49)			(4.42)	(3.84)	(1.05)

t-statistics are in parentheses.

in absolute value in the hours paid for per worker equation. None of the conclusions derived from the ordinary least squares estimates appears to be changed by the results obtained using Zellner's technique.

Summary

The results of estimating the hours paid for per worker equation (6.1) are quite good. Both the amount of excess labor on hand and the level of log H_{pt-1} appear to be significant determinants of log H_{pt} - log H_{pt-1}. The expected future rates of output are also in general important. The degree of labor market tightness does appear to have a significant influence on short run decisions regarding the number of hours paid for per worker. These results reinforce the results presented in Chapter 8 regarding the effect of the degree of labor market tightness on short run decisions regarding the number of workers employed.

The behavior of log H_{pt} - log H_{pt-1} definitely appears to be different when the level of H_p is high than when it is low, due to the restriction that H_p can never be less than H. The results achieved by adding DP and DM to equations (6.1) appear to be an important confirmation of the theoretical model developed in this thesis.

There appears to be little evidence that equation (6.1) predicts differently during general contractionary periods than during general expansionary periods, which is consistent with the results achieved for equation (4.2) for production workers. Zellner's method of estimating seemingly unrelated equations gives similar results to the ordinary least squares results. The size of the reaction coefficient a_1 decreases in absolute value, as does the size of the reaction coefficient a_3, but none of the conclusions reached using ordinary least squares estimates appears to be altered.

CHAPTER 11

A COMPARISON OF THE DEMAND FOR PRODUCTION WORKERS AND THE DEMAND FOR HOURS PAID FOR PER PRODUCTION WORKER

It is informative to compare the results presented in Table 8-1 of estimating the production workers equation (4.2) with the results presented in Table 10-1 of estimating the hours paid for per production worker equation (6.1) (with the log U_t, DP_t, and DM_t variables included).

In every case the coefficient of $\log H_{pt-1} - \log H_{st-1}$ in the hours equation is substantially larger in absolute value than the coefficient of the excess labor variable $\log M_{t-1} - \log M^*_{t-1}$ in the workers equation. This implies that the adjustment of hours paid for per worker back to the desired long run equilibrium level, H_s, is more rapid than the adjustment of workers back to the level where the number of workers employed equals the desired number of workers on hand, M^*.

It is interesting to note that the amount of excess labor on hand influences both the change in the number of production workers, $\log M_t - \log M_{t-1}$, and the change in the number of hours paid for per worker, $\log H_{pt} - \log H_{pt-1}$, whereas the amount that H_{pt-1} differs from H_{st-1} influences only $\log H_{pt} - \log H_{pt-1}$. It was argued on page 84 that there seemed to be little theoretical reason why $\log H_{st-1} - \log H_{pt-1}$ should influence $\log M_t - \log M_{t-1}$, and the empirical results confirm this view. What the above results suggest is that in the short run firms react to a positive amount of excess labor on hand by decreasing both the number of workers and the number of hours paid for per worker, and that they react to hours paid for per worker being greater than desired by decreasing hours paid for per worker but not by increasing the number of workers employed (unless of course H_{pt-1} equals H_{t-1} in which case the excess labor variable and $\log H_{st-1} - \log H_{pt-1}$ are the same).

The results presented in Tables 8-1 and 10-1 also suggest that expected future rates of output are more important in the determination of $\log M_t - \log M_{t-1}$ than in the determination of $\log H_{pt} - \log H_{pt-1}$. The size of the c_i coefficients is in general larger for the workers equation than for the hours equation, and fewer of the c_i coefficients are significant for the hours equation than for the workers equation. This is as expected since it seems likely that it would be less costly for a firm to allow rapid changes in H_p to occur than to allow rapid changes in M to occur. Expected future man-hour requirements (and thus expected future rates of output) should, therefore, have less significance for current hours decisions than for current employment decisions.

From the workers equation (4.2) and the hours paid for per worker equation (6.1) it is easy to derive the equation determining the change in total man-hours paid for, $\log M_t H_{pt} - \log M_{t-1} H_{pt-1}$. Since,

$$\text{(11.1)} \quad \log M_t H_{pt} - \log M_{t-1} H_{pt-1} = \log M_t - \log M_{t-1} + \log H_{pt} - \log H_{pt-1}$$

the equation determining $\log M_t H_{pt} - \log M_{t-1} H_{pt-1}$ can be derived by adding equations (4.2) and (6.1). For industry 232, for example, the equation is:

$$\begin{aligned} \text{(11.2)} \quad \log M_t H_{pt} - \log M_{t-1} H_{pt-1} = {} & 2.180 - .204(\log M_{t-1} - \log (M_{t-1} H_{t-1})^*) \\ & - .560 \log H_{pt-1} + .021(\log Y_{t-1} - \log Y_{t-2}) \\ & + .226(\log Y_t^e - \log Y_{t-1}) + .181(\log Y_{t+1}^e - \log Y_t^e) \\ & + .131(\log Y_{t+2}^e - \log Y_{t+1}^e) + .059(\log Y_{t+3}^e - \log Y_{t+2}^e) \\ & - .0131 \log U_t + .021 DP_t + .013 DM_t \end{aligned}$$

Notice that the coefficient of the excess labor variable, $\log M_{t-1} - \log (M_{t-1} H_{t-1})^*$ does not equal the coefficient of $\log H_{pt-1}$ because of the different reactions to the two variables in the two equations. One would thus be misspecifying the equation if he estimated an equation like (11.2) directly and used as the "excess man-hours variable" $\log M_{t-1}H_{pt-1} - \log (M_{t-1}H_{t-1})^*$.[1]

The coefficient of $\log Y_t^e - \log Y_{t-1}$ ($= \log Y_t - \log Y_{t-1}$) in equation (11.2) is less than one, and this is true for all of the other industries as well. Other things being equal, firms react in the short run to a certain percentage change in the rate of output by changing man-hours paid for by less than this percentage and in most cases by substantially less than this percentage. This is, of course, as expected from the results of the scatter diagrams discussed in Chapter 3.

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1. Notice that:

$$(11.3) \quad \log M_{t-1}H_{pt-1} - \log (M_{t-1}H_{t-1})^* = \log M_{t-1} - \log (M_{t-1}H_{t-1})^* + \log H_{pt-1}$$

Therefore, estimating a man-hours equation directly with the variable $\log M_{t-1}H_{pt-1} - \log (M_{t-1}H_{t-1})^*$ used as the excess man-hours variable is equivalent to assuming that the coefficients of $\log M_{t-1} - \log (M_{t-1}H_{t-1})^*$ and $\log H_{pt-1}$ in the equation are equal. As can be seen from the results presented in Tables 8-1 and 10-1, this is not true. For every industry the coefficient of $\log H_{pt-1}$ is larger than the sum of the coefficients of the two excess labor variables, excluding the effects of the past change of output variables.

In summary, when man-hours paid for, MH_p, do not equal man-hour requirements, $(MH)^*$, it makes a considerable difference with respect to the firm's reaction to this disequilibrium situation whether the difference is due to the number of hours paid for per worker, H_p, being unequal to the desired number of hours paid for per worker, H_s, or whether the difference is due to the number of workers employed, M, being unequal to the desired number of workers employed, M^*. The firm reacts much more rapidly in eliminating the discrepancy between $\log H_p$ and $\log H_s$ than between $\log M$ and $\log M^*$. If, for example, MH_p does not equal $(MH)^*$ but M equals $(MH)^*/H_s$ ($= M^*$), then the adjustment of MH_p to $(MH)^*$ will be more rapid than if MH_p does not equal $(MH)^*$ but H_p equals H_s. This is one of the major implications of the empirical results.

CHAPTER 12

A COMPARISON OF SHORT RUN EMPLOYMENT DEMAND ACROSS INDUSTRIES

How rapidly firms react to short run output changes is probably best measured by the size of the coefficient c_0 of $\log Y_t^e - \log Y_{t-1}$ in equation (4.2). The larger this coefficient the larger the change in the number of workers employed relative to the current change in the rate of output. It is interesting to examine whether the size of c_0 for an industry is related to such things as the average wage level in that industry, the degree of specific training required in that industry, and the degree of unionization in that industry.

It seems likely that the more specific training required the less the short run reaction will be, and the larger the degree of unionization the less the reaction. For the effects of the average wage level on the reaction size, there are two countervailing forces. The higher the wage level the more expensive it is to hold excess labor and thus the larger may be the reaction. On the other hand the higher the wage level the more skilled the workers are likely to be, and firms may be reluctant to lay these workers off for fear of not being able to get them back when they are needed again. These workers may require more specific training as well.

Average yearly wage levels for the seventeen three-digit industries used in this study are available, and a rank correlation was made between c_0 and the 1958 average industry wage level for the seventeen industries. The correlation coefficient is -.08, the sign of which implies that the higher the wage level the less the reaction. The coefficient is not significant, however, at even the ten percent confidence level, and the hypothesis that the wage level has no effect on the size of the industry reaction cannot be rejected.

From the work of Eckhaus (1964) data are available on specific industry training requirements measured in years (in 1950) for most of the industries used in this study.[1] Industries 231, 232, and 233 had to be grouped together and so did industries 211 and 212. Some of the other training figures are for industries slightly more aggregated than the three-digit industries used in this study, but these figures were used for lack of a better alternative. For the industries which were grouped together, a weighted average of their c_0 coefficients was taken to represent the grouped industry reaction, the weights

1. Hamermesh (1967) has used these data and the data on unionization described below for a related but quite different purpose.

being the percent of the production workers employed in the group in 1958. There were a total of 14 observations.

The rank correlation between the size of c_0 and the amount of specific training required is -.32, which is of the right sign (the more the training required the less the reaction) and significant at the ten percent level (but not at the five percent level). There is thus some slight indication that those industries which have higher specific training requirements have lower employment reactions.

From a study by Douty (1960) data are available at the two-digit industry level on the percent of workers employed in establishments in which the majority of workers are unionized (in 1958). The three-digit industries used in this study were grouped into their respective two-digit industries in the manner described above. This meant grouping 201 and 207 together, 211 and 212 together, 231,232, and 233 together, 311 and 314 together, and 331, 332, and 336 together. This gave a total of ten groups, and a rank correlation was made between the size of c_0 for the group and the percent of workers in establishments in which the majority of workers are unionized.

The correlation coefficient is -.20, which is of the right sign (the more the union pressure the less the reaction) but not significant at even the ten percent level. This result indicates that the hypothesis that union pressure in an industry has no effect on the size of the industry employment reaction cannot be rejected. The test is based on very few observations, however, and not too much reliance should be put on this result.

CHAPTER 13

THE SHORT RUN DEMAND FOR NON-PRODUCTION WORKERS

When the time series of the number of non-production workers employed is plotted monthly for each industry for the nineteen year period of estimation, it is seen that each series has very little variance in the short run and consists mostly of a smooth upward trend. This study is not concerned with explaining the long run movements of this series, but it is useful to examine the small short run fluctuations to see of they are related in any way to short run output fluctuations. Data on the number of hours paid for per non-production worker are not available, and attention has to be concentrated on merely the number of non-production workers employed. A model for non-production workers similar to the model developed for production workers has been developed and estimated. This model will now be discussed.

Let N_t denote the number of non-production workers employed during the second week of month t. The series Y_t/N_t, output per non-production worker, was plotted for the nineteen year period of estimation. This series was then interpolated from peak to next higher or lower[1] peak. It is assumed that the points on these lines measure potential output per non-production worker--the "productivity" which could have been achieved if the rate of output had been high enough. Denote this potential productivity by $(Y_t/N_t)^*$. When the reciprocal of this is multiplied by Y_t, the result is the number of non-production workers required to produce the rate of output Y_t, denoted as N_t^*. It is assumed that N_t^* is the desired number of non-production workers for period t.

This estimate of N_t^* is of course very crude, and many assumptions lie behind the construction of this variable--the assumptions that the peaks used in the interpolations are true measures of output per non-production worker, that at these peaks non-production workers are not working overtime, and that potential productivity does follow the smooth interpolation lines. The assumption that at the productivity peaks no non-production worker overtime is being worked is open to doubt. Since no data on hours paid for per non-production worker are available, output per (paid for) non-production worker hour could not be plotted and the cruder procedure described above had to be used.

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1. In some industries the trend in Y_t/N_t was downward--output per non-production worker decreasing through time--and the interpolations in these industries were slowly decreasing lines.

Notice, however, that if N* differs from the true desired number of non-production workers employed by the same percentage for each period of time, the results of estimating equation (13.1) below will not be affected except for the estimate of the constant term. Hopefully the variable N* is a rough approximation to the true desired number of non-production workers employed.

The variable $\log N_{t-1} - \log N^*_{t-1}$ is thus a measure of the amount of excess (non-production) labor on hand during the second week of month t-1. An equation for non-production workers similar to equation (4.2) for production workers has been estimated:[1]

$$(13.1) \quad \log N_t - \log N_{t-1} = a_1(\log N_{t-1} - \log N^*_{t-1}) + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) + c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

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1. In the equation estimated a constant term and a time trend have been added. The constant term has been included on the grounds that N* may differ from the true desired number of non-production workers by a constant percentage and that the desired amount of excess (non-production) labor on hand may not equal zero as is assumed in equation (13.1). The time trend has been included on the grounds that either the percentage error or the desired amount of excess labor held may have a trend in it.

The results of estimating equation (13.1) are presented in Table 13-1. The excess labor variable, $\log N_{t-1} - \log N^*_{t-1}$, appears to be a significant determinant of $\log N_t - \log N_{t-1}$. For every industry the coefficient a_1 of this variable is negative, and for all but four of the seventeen industries--212, 231, 232, and 233--it is significant. The coefficient c_0 of $\log Y^e_t - \log Y_{t-1}$, which is so significant in the production workers equation and the hours paid for per production worker equation, is much less significant in the non-production workers equation. For all but one of the seventeen industries c_0 is positive, but it is only significantly positive for eight of the industries. The size of c_0 is much smaller for the non-production worker equation than for the production worker equation. For a few industries future output expectations appear to be significant, but this tendency is much less pronounced here than it is for production workers. The existence of serial correlation also appears to be more pronounced for non-production workers.

Very little of the variance of $\log N_t - \log N_{t-1}$ has been explained. For all but industry 271 less than twenty percent has been explained.

What these results suggest is that the amount of excess (non-production) labor on hand is a significant (but small) determinant of the change in non-production workers employed and that the

TABLE 13-1

PARAMETER ESTIMATES FOR EQUATION (13.1):

$$\text{(13.1)}\quad \log N_t - \log N_{t-1} = a_0 + a_1(\log N_{t-1} - \log N^*_{t-1}) + a_2 t + \sum_{i=1}^{m} b_i(\log Y_{t-i} - \log Y_{t-i-1}) +$$

$$c_0(\log Y^e_t - \log Y_{t-1}) + \sum_{i=1}^{n} c_i(\log Y^e_{t+i} - \log Y^e_{t+i-1})$$

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
201	192	.014	-.036	-.050		.033	.034	.004	.048	.041	.023	.039	.047	-.046	.162	.0109	2.41
		(2.54)	(2.12)	(2.31)		(2.16)	(1.88)	(0.24)	(2.90)	(2.69)	(1.62)	(2.74)	(3.33)	(3.02)			
207	136	.014	-.046	.044			.027								.097	.0253	2.62
		(2.23)	(3.60)	(1.20)			(2.09)										
211	136	.046	-.187	-.079			.026	.064						-.026	.124	.0380	2.46
		(3.93)	(3.74)	(1.36)			(0.41)	(1.85)						(0.47)			
212	136	.020	-.073	-.089			.064								.028	.0453	2.52
		(1.39)	(1.88)	(1.11)			(1.18)										
231	136	.008	-.033	-.010			.007								.028	.0218	2.81
		(1.33)	(1.81)	(0.30)			(0.32)										
232	136	.008	-.025	-.003			.041								.063	.0161	2.52
		(1.53)	(1.28)	(0.13)			(2.87)										
233	136	.009	-.010	-.022			.038								.045	.0189	1.86
		(1.53)	(0.64)	(0.73)			(2.46)										
242	154	.021	-.071	-.075	.043	-.035	.062	.044	.031						.147	.0184	2.27
		(3.13)	(3.12)	(2.52)	(2.27)	(1.62)	(2.75)	(2.10)	(1.69)								
271	166	.007	-.045	-.001			-.006	.001	.030						.332	.0051	2.01
		(4.48)	(3.75)	(0.11)			(0.63)	(0.06)	(3.46)								

TABLE 13-1 (continued)

Industry	No. of Obser.	$\hat{a}_0$	$\hat{a}_1$	1000 $\hat{a}_2$	$\hat{b}_2$	$\hat{b}_1$	$\hat{c}_0$	$\hat{c}_1$	$\hat{c}_2$	$\hat{c}_3$	$\hat{c}_4$	$\hat{c}_5$	$\hat{c}_6$	$\hat{d}$	R^2	SE	DW
301	134	.008	-.023	-.029			.007								.062	.0088	2.03
		(2.63)	(2.87)	(1.97)			(0.61)										
311	170	.024	-.146	-.050			.017	.091	.057	.050	.042	.012			.159	.0222	2.36
		(3.49)	(4.56)	(1.59)			(0.38)	(2.79)	(1.88)	(1.81)	(1.67)	(0.55)					
314	170	.016	-.064	-.030			.080	.027	.055					-.030	.193	.0130	2.08
		(2.83)	(2.80)	(1.39)			(3.98)	(1.28)	(4.26)					(1.39)			
324	187	.008	-.032	.016			.040	.019	.024	.004	.029			-.019	.072	.0153	2.79
		(2.26)	(2.25)	(0.73)			(3.17)	(1.24)	(1.72)	(0.27)	(2.15)			(1.24)			
331	128	.003	-.060	.069			.023								.113	.0305	1.56
		(0.52)	(3.95)	(1.45)			(0.49)										
332	170	.006	-.037	.008			.046								.196	.0115	2.69
		(2.81)	(5.95)	(0.52)			(3.26)										
336	170	.034	-.082	-.124			.113								.098	.0393	3.98
		(3.31)	(3.80)	(2.22)			(2.30)										
341	191	.014	-.038	.029			.018	.038	.032						.120	.0209	2.57
		(2.70)	(3.96)	(1.11)			(1.94)	(3.90)	(3.24)								

t-statistics are in parentheses.

expected future rate of output changes (especially the current change) are in some industries significant (but small) as well. In general, however, the change in the number of non-production workers employed is only marginally influenced by the factors which influence the change in the number of production workers employed.

CHAPTER 14

SUMMARY AND CONCLUSIONS

Two major observations of this study are that the basic model of short run employment demand of previous studies, which centers around the concept of a short run production function and a simple lagged adjustment process, yields unrealistic estimates of the production function parameters, i.e. unrealistically large estimates of short run returns to labor, and that even at high rates of output, output per man-hour does not appear to decline with further increases in the rate of output. An explanation of this empirical phenomenon of increasing returns to labor services has been given in this study.

The explanation is based on the postulate that during much of the year firms have on hand a considerable amount of excess labor and that only during the peak rates of output can they be said to be holding no excess labor. In other words, it is postulated that during much of the year the (observed) number of hours paid for per week per worker, H_p, does not equal the (unobserved) number of hours effectively worked per week per worker, H. An estimate of the amount of excess labor on hand during any one period of time has been made for each of the seventeen industries used in this study. This estimate is based on trend productivity interpolations and thus on the assumptions of no short run substitution possibilities and constant short run returns to scale. At the interpolation peaks it is assumed that output per paid for man-hour equals output per effectively worked man-hour, so that the interpolation lines represent in some sense true potential productivity.

A model of the short run demand for production workers has been developed. The model centers around the ideas that firms base their employment decisions on expected future man-hour requirements (and thus on expected future rates of output) and that firms react to the amount of excess labor on hand by laying off a certain percentage of these workers each period. With respect to this model certain hypotheses have been tested--various expectational hypotheses have been tested; the hypothesis that the level of hours paid for per worker in the previous period has an influence on the current demand for workers has been tested; the hypothesis that firms react differently during general contractionary periods than during general expansionary periods has been tested; the hypothesis that the degree of labor market tightness affects employment decisions has been tested; and the hypothesis that the reaction behavior of firms is not adequately specified in the model has been tested.

The model has been tested against an alternative model in which the rate of shipments is taken to be the exogenous short run variable instead of the rate of production and where the amount of inventory investment in the previous period is assumed to have an effect on current employment decisions. The model has also been tested against two versions of the Holt, Modigliani, Muth, and Simon model, which are derived from quadratic cost minimizing assumptions.

A model of the short run demand for hours paid for per production worker has also been developed. The basic postulate regarding this model is that many of the same factors which determine the short run demand for workers also influence the short run demand for hours paid for per worker, i.e. that firms view both variables in a similar manner with respect to short run movements. One of the basic differences between the two variables, however, is that, unlike movements in the number of workers employed which can be steadily upward or downward over time, movements in the number of hours paid for per worker fluctuate around a relatively constant level of hours. Other things being equal, an H_p greater than this level should bring into play forces causing H_p to decline back to this level. The model of the short run demand for hours paid for per worker, therefore, centers around the ideas that firms base their decisions regarding the number of hours paid for per worker on expected future rates of output, on the amount of excess labor on hand, and on the discrepancy between the actual level of hours paid for per worker and the desired level.

The number of hours paid for per worker, H_p, can never be less than the number of hours actually worked, H; and when H_p equals H, the production function constraint becomes binding on H_p. Since H_p is likely to equal H only when the levels of both are high, these facts suggest that the behavior of the change in the number of hours paid for per worker may be different when the level of H_p is high than when the level is low. A test of this possible difference in behavior has been made. Tests have also been made of the hypothesis that labor market tightness has an effect on hours paid for per worker decisions and of the hypothesis that firms react differently regarding the demand for hours paid for per worker during general contractionary periods than during general expansionary periods.

Three-digit U. S. manufacturing industry monthly non-seasonally adjusted data have been used in this study for the period, 1947-1965. There are seventeen industries for which these data are available, constituting about eighteen percent of U. S. manufacturing by value added. The output data are compiled by the Federal Reserve Board and the employment and hours data by the Bureau of Labor Statistics.

The empirical results are quite good. For the equation determining the change in the number of production workers employed, the estimates of the coefficients of the excess labor variables are highly significant and of the right sign, as are the estimates of the coefficients of the expectational (output) variables. For every industry the fit is better than the fit of the basic model of previous studies and for most industries substantially better. For fourteen of the seventeen industries future output expectations appear to be significant determinants of short run employment demand. For eight of these industries the hypothesis of perfect expectations gives better results than the other "non-perfect" expectational hypothesis, and for the other six the non-perfect expectational hypothesis gives slightly better results.

Regarding the various hypotheses tested--the level of hours paid for per worker in the previous period does not appear to be a significant determinant of the current demand for workers; firms do not appear to react differently during contractions than during expansions; there is some slight evidence that the degree of labor market tightness has an effect on employment decisions; and the reaction behavior of firms appears to be adequately specified in the model, as tests of more complicated reaction behavior do not yield significant results.

The alternative model in which the rate of shipments is taken to be the exogenous variable and where the previous period's inventory investment is assumed to have an effect on current employment decisions yields results inferior to the model developed in this study in every industry tested. Likewise, both versions of the Holt, Modigliani, Muth, and Simon model yield substantially inferior results.

For the equation determining the change in the number of hours paid for per production worker the results are also very good. Both the amount of excess labor on hand and the difference between the actual level of hours paid for per worker and the desired level appear to be highly significant determinants of the demand for hours paid for per worker. Expected future output changes are also in general important.

The behavior of the change in the number of hours paid for per worker definitely appears to be different when the level of H_p is high than when it is low. At high levels H_p has less freedom of movement and must respond to output movements more. The empirical results bear this out completely. The degree of labor market tightness appears to have a significant influence on the short run demand for hours paid for per worker, and these results reinforce the results achieved for workers. Firms do not appear to react differently during contractions than during expansions with respect to their demand for hours paid for per worker.

Comparing the demand for production workers with the demand for hours paid for per worker it is seen that the adjustment of hours paid for per worker back to the desired level is more rapid than the adjustment of workers back to the desired level. The empirical results indicate that the amount of excess labor on hand influences both the demand for production workers and the demand for hours paid for per worker, whereas the difference between the actual level of hours paid for per worker and the desired level influences only the demand for hours paid for per worker. These results are as expected from the theoretical model. Expected future output changes appear to be more important in the determination of the change in the number of workers employed than of the change in the number of hours paid for per worker, which also is as expected on theoretical grounds.

From the equations determining the change in the number of workers employed and the change in the number of hours paid for per worker, the change in total man-hours paid for can be derived. It is seen that firms react to a certain percentage change in the current rate of output by changing man-hours paid for by much less than this percentage. It is also seen that when man-hours paid for do not equal man-hour requirements, it makes a considerable difference with respect to the firm's reaction to this situation whether the difference is due to the level of hours paid for per worker being unequal to the desired level or whether the difference is due to the number of workers employed being unequal to the desired number employed. As mentioned above, firms react much more rapidly in eliminating the discrepancy between the actual level of hours paid for per worker and the desired level than in eliminating the discrepancy between the actual number of workers employed and the desired number.

Comparing industry differences in short run employment demand, it is seen that there is some evidence that industries which have higher specific training requirements have lower short run employment reactions. There is little evidence that either the average industry wage level or the degree of union pressure has an effect on short run employment reactions. All of these results are based on a small sample, however, and not too much reliance should be put on the conclusions.

Short run fluctuations in the number of non-production workers employed are quite small, but a model similar to the model developed for production workers has been developed for non-production workers to see if the small short run fluctuations in the number of non-production workers employed can be explained by any of the same factors which explain the fluctuations in the number of production workers employed.

The empirical results suggest that the amount of excess (non-production) labor on hand is a significant determinant of the change in the number of non-production workers employed and that expected future output changes (especially the current change) in some industries are significant as well. The change in the number of non-production workers employed is only marginally influenced by these factors, however, and for most industries only a small amount of the variance of this series has been explained.

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