CHAPTER 5

TESTS OF VARIOUS HYPOTHESES REGARDING THE SHORT-RUN DEMAND FOR PRODUCTION WORKERS

5.1 Introduction

Eq. (3.9)′, which was developed in ch. 3 and estimated in ch. 4, appears to be an adequate specification of the short-run demand for production workers. Both the amount of excess labor on hand and the time stream of expected future output changes appear to be significant factors in the determination of a firm's demand for production workers. In table 4.3 the results of estimating eq. (3.9)′ for each of the seventeen industries under the best expectational hypothesis for that industry were presented. In this chapter various hypotheses regarding other possible determinants of the short-run demand for production workers are discussed, and using the estimates in table 4.3 as a base of reference, these hypotheses are tested. As was the case for the tests of the expectational hypotheses in ch. 4, the validity of these tests depends on the assumption that eq. (3.9)′ is an adequate specification of the short-run demand for production workers to begin with.

5.2 The short-run substitution of hours for workers

As was seen in ch. 2, KUH (1965b) has been the only one who has done any empirical work at all on the short-run relationship between the number of workers employed and the number of hours worked per worker. Kuh adds the variable $\log H_{t-1} - \log H_{t-2}$ (using the notation of ch. 2) to an equation like (2.37) of the basic model, 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 the current period as firms try to reduce high overtime costs. The hours variable which Kuh uses is an hours paid-for variable.

In this study the view has been presented that H_{2wt}, the actual number of hours effectively worked per worker during the second week of month t, is not observed and that the observed number of hours paid-for per worker during the second week of month t, HP_{2wt}, is likely to be a poor measure of H_{2wt} during all but the peak output periods. Since H_{2wt} 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 *assumes* 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 of constant returns to scale, combined with the fact that output fluctuates more than the number of workers employed in the short run, imply that the number of hours worked per worker is the primary adjustment mechanism. From eq. (3.6) H_{2wt} is equal to $Y_{2wt}/\alpha_{2wt}M_{2wt}$,[1] and since α_{2wt} is fairly constant in the short run, if Y_{2wt} changes by a larger percentage than M_{2wt}, H_{2wt} must adjust accordingly.

Due to this observational problem, tests can only be performed on HP_{2wt}. It was seen above that the amount of excess labor on hand during the second week of month $t-1$, measured as $\log HS_{2wt-1} - \log H_{2wt-1}$,[2] definitely appears to be a significant factor affecting firms' employment decisions. The question arises whether a variable like $\log HS_{2wt-1} - \log HP_{2wt-1}$, which is the difference between the standard (or long-run equilibrium) number of hours of work per worker and the actual number of hours paid-for per worker, should be significant as well. HP_{2w} can never be less than H_{2w} (hours actually worked per worker must be paid for by the firm), and when HP_{2w} equals H_{2w}, the excess labor variable and $\log HS_{2wt-1} - \log HP_{2wt-1}$ are equivalent. When HP_{2w} is greater than H_{2w}, these two variables are not the same, and *a priori* there appears to be little reason why in this case $\log HS_{2wt-1} - \log HP_{2wt-1}$ should be a significant factor affecting employment decisions. If HP_{2wt-1} does not equal HS_{2wt-1}, the obvious thing for the firm to do (if it wants to make any adjustment at all) is to change HP_{2w}. It can raise HP_{2w} at will, and as long as HP_{2w} is greater than H_{2w}, the firm can also lower HP_{2w} without the necessity of increasing M_{2w}. The firm cannot, however, lower HP_{2w} at will if HP_{2w} equals H_{2w}, and in this case it must increase M_{2w} in order to lower HP_{2w}. This, however, is exactly what the excess labor variable implies the firm will do when H_{2wt-1} is greater than HS_{2wt-1}. There thus seems to be little reason why $\log HS_{2wt-1} - \log HP_{2wt-1}$ should be a significant determinant of $\log M_{2wt} - \log M_{2wt-1}$ other than at those times when HP_{2wt-1} equals H_{2wt-1}.

[1] Eq. (3.6) is actually expressed in terms of $M^*_{2wt}H^*_{2wt}$ rather than $M_{2wt}H_{2wt}$, but since these two variables are equal to one another (both of them being equal to the total number of man hours worked), eq. (3.6) can be expressed in terms of $M_{2wt}H_{2wt}$, which then implies that H_{2wt} is equal to $Y_{2wt}/\alpha_{2wt}M_{2wt}$.

[2] In this discussion the measure of the amount of excess labor on hand is referred to as $\log HS_{2wt-1} - \log H_{2wt-1}$ instead of the equivalent $\log M_{2wt-1} - \log M^d_{2wt-1}$.

There also seems little reason why, as Kuh's argument suggests, log HP_{2wt-1} − log HP_{2wt-2} should be a significant factor affecting employment

TABLE 5.1

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_2 \log HP_{2wt-1}$. Estimates presented for α_1 and α_2 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\alpha}_2$	SE	DW
201	192	−.176	−.035	.0120	1.91
		(4.50)	(0.69)		
207	136	−.151	.044	.0181	2.14
		(3.37)	(0.39)		
211	136	−.127	.017	.0102	1.98
		(5.20)	(0.69)		
212	136	−.122	−.040	.0159	2.55
		(4.08)	(0.71)		
231	136	−.182	−.011	.0194	1.97
		(4.39)	(0.18)		
232	136	−.094	−.038	.0106	1.41
		(5.69)	(1.13)		
233	136	−.029	−.327	.0280	1.49
		(0.94)	(3.57)		
242	154	−.045	−.028	.0127	1.76
		(1.42)	(0.57)		
271	166	−.048	−.026	.0048	2.11
		(2.60)	(0.58)		
301	134	−.086	.074	.0140	1.95
		(4.86)	(2.16)		
311	170	−.169	.022	.0115	2.14
		(5.88)	(0.36)		
314	136	−.140	−.076	.0143	2.18
		(2.73)	(1.11)		
324	187	−.116	−.102	.0177	2.00
		(6.14)	(0.83)		
331	128	−.111	−.180	.0097	1.69
		(4.29)	(3.27)		
332	170	−.126	−.006	.0167	2.24
		(6.22)	(0.15)		
336	170	−.093	.214	.0167	2.10
		(4.64)	(4.11)		
341	191	−.072	−.104	.0180	1.92
		(3.82)	(1.36)		

t-statistics are in parentheses.

decisions. It is the *level* of HP_{2wt-1} (whether or not HP_{2wt-1} is greater than H_{2wt-1} or HS_{2wt-1}, etc.) which would seem to be appropriate for consideration and not the change in HP_{2wt-1} from whatever level last period.

For each of the seventeen industries the variable $\log HS_{2wt-1} - \log HP_{2wt-1}$ was added to eq. (3.9)′ to see if this variable had any of the same properties of the excess labor variable, $\log HS_{2wt-1} - \log H_{2wt-1}$. On the assumption that $\log HS_{2wt-1}$ equals $\log \bar{H} + \mu t$, which was made in eq. (3.11), this is equivalent to adding the variable $\log HP_{2wt-1}$ to eq. (3.9)′. Since the sign of the coefficient of $\log HS_{2wt-1} - \log HP_{2wt-1}$ is expected to be negative if this variable has any of the same properties of the excess labor variable, the estimate of the coefficient of $\log HP_{2wt-1}$ should be positive in the estimated equation. The coefficient of $\log HP_{2wt-1}$ is denoted as α_2.

The results of adding $\log HP_{2wt-1}$ to eq. (3.9)′ are presented in table 5.1. The same equation was estimated for each industry (same period of estimation, same expectational variables, etc.) as was estimated in table 4.3, except that $\log HP_{2wt-1}$ was added to the equation. The results in table 5.1 are thus directly comparable with the results in table 4.3. Since the addition of $\log HP_{2wt-1}$ to the equation had little effect on the other coefficient estimates, only the estimates of α_1 and α_2 are presented. As is clearly evident in table 5.1, $\log HP_{2wt-1}$ does not appear to be a significant determinant of $\log M_{2wt} - \log M_{2wt-1}$. In only two industries – 301 and 336 – is its coefficient estimate 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 estimate of the coefficient α_1 of the excess labor variable has decreased in size from the absolute value of the estimate in table 4.3 (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 part of each year (the peak output months). For twelve of the industries the estimate of α_2 is negative, and it 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 seem to be inconsistent with the idea that a high level of hours paid-for per worker in the previous period leads to more workers hired in the current period (other than at those times when HP_{2wt-1} equals H_{2wt-1}).

Most of the estimates of α_2 are not significantly different from zero and the fit in table 5.1 for most of the industries has not been improved from the fit in table 4.3, and it seems reasonable to conclude that the level of hours paid-for per worker in the previous period is not a significant determinant

TABLE 5.2

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_3(\log HP_{2wt-1} - \log HP_{2wt-2})$. Estimates presented for α_1 and α_3 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\alpha}_3$	SE	DW
201	192	−.177	.066	.0120	2.00
		(4.55)	(1.26)		
207	136	−.152	.017	.0181	2.12
		(3.39)	(0.16)		
211	136	−.117	.027	.0102	2.07
		(4.60)	(1.45)		
212	136	−.111	−.021	.0159	2.57
		(4.72)	(0.49)		
231	136	−.180	.114	.0192	2.04
		(4.46)	(1.62)		
232	136	−.090	.052	.0106	1.54
		(5.54)	(1.07)		
233	136	−.007	−.043	.0293	1.45
		(0.23)	(0.50)		
242	154	−.042	−.046	.0127	1.74
		(1.34)	(0.77)		
271	166	−.043	−.060	.0048	2.09
		(2.52)	(1.47)		
301	134	−.101	.068	.0141	1.94
		(6.54)	(1.44)		
311	170	−.164	.167	.0114	2.26
		(6.36)	(1.94)		
314	136	−.085	.221	.0136	2.05
		(1.91)	(3.69)		
324	187	−.109	.048	.0177	2.02
		(6.18)	(0.37)		
331	128	−.032	−.111	.0099	1.68
		(2.77)	(2.10)		
332	170	−.111	.206	.0164	2.42
		(7.43)	(2.44)		
336	170	−.109	.182	.0174	1.85
		(5.38)	(1.59)		
341	191	−.066	−.012	.0181	1.98
		(3.58)	(0.18)		

t-statistics are in parentheses.

of the number of workers hired or fired in the current period. This, of course, is as expected from the argument given above.

In table 5.2 the results of adding the variable $\log HP_{2wt-1} - \log HP_{2wt-2}$ to eq. (3.9)′ are presented. The coefficient of this variable is denoted as α_3, and again only estimates of α_1 and α_3 are presented, as the other estimates were not substantially affected. On the argument expounded by Kuh, α_3 is expected to be positive.

For eleven of the industries the estimate of α_3 is positive, and for two of these industries – 314 and 332 – the estimate of α_3 is significant. In both of these industries the absolute value of the estimate of α_1 has fallen from that presented in table 4.3 (for 314 from .115 to .085, and for 332 from .123 to .111). For the six industries where the estimate of α_3 is negative, it is significantly negative for one of them – 331. In fourteen industries the estimate of α_3 is not significant. The fits in table 5.2 are little changed from those in table 4.3, and it seems safe to conclude from these results that $\log HP_{2wt-1} - \log HP_{2wt-2}$ is not a significant determinant of $\log M_{2wt} - \log M_{2wt-1}$. This is also as expected, since there seems to be little theoretical reason why this variable should be significant.

5.3 Tests for cyclical variations in the short-run demand for production workers

The model developed in this study has been formulated as a monthly one, with seasonal fluctuations playing an important role. In most, but not all, of the industries seasonal fluctuations in output are so large that they tend to swamp the cyclical fluctuations. 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 which is tested here is the hypothesis that during contractionary periods firms "hoard" labor in the sense that the model [eq. (3.9)′] predicts more workers fired (or fewer hired) than actually are during the period and that during expansionary periods firms "dishoard" labor in the sense that the model predicts fewer workers fired (or more hired) than actually are during the period. The idea behind this hypothesis is that firms might 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 each industry. For the first test the output variable, $\log Y_{dt}$, was regressed against twelve seasonal dummy variables[1] and time in an effort to eliminate the purely seasonal and trend fluctuations in log Y_{dt}. The residuals from this equation, denoted as log P_{dt}, were then taken to be a measure of the cyclical fluctuation in log Y_{dt}. Since the cyclical effects on employment decisions may not be symmetrical for contractions and expansions, the following two variables were constructed: $(\log P_{dt} - \log P_{dt-1})_+$ and $(\log P_{dt} - \log P_{dt-1})_-$. The variable $(\log P_{dt} - \log P_{dt-1})_+$ was set equal to $\log P_{dt} - \log P_{dt-1}$ when $\log P_{dt} - \log P_{dt-1}$ was positive and was set equal to zero otherwise. The variable $(\log P_{dt} - \log P_{dt-1})_-$ was set equal to $\log P_{dt} - \log P_{dt-1}$ when $\log P_{dt} - \log P_{dt-1}$ was negative and set equal to zero otherwise. These two variables were then added to eq. (3.9)′. If the above hypothesis is true, these variables should have significantly negative, though not necessarily equal, coefficient estimates. When $\log P_{dt} - \log P_{dt-1}$ is positive (expansionary period), the model on the above hypothesis should predict too few workers hired or too many fired, and when $\log P_{dt} - \log P_{dt-1}$ is negative (contractionary period), the model should predict too few workers fired or too many hired.

In table 5.3 the results of adding $(\log P_{dt} - \log P_{dt-1})_+$ and $(\log P_{dt} - \log P_{dt-1})_-$ to eq. (3.9)′ are presented. The coefficients of these two variables are denoted as α_4 and α_5 respectively. In table 5.3 estimates of α_1, γ_0, α_4, and α_5 are presented; the effects on the other coefficient estimates were slight. Comparing the SE's in table 5.3 with those in table 4.3, it is seen that only in industries 212, 233, 324, and 331 has the fit been noticeably improved by adding the two variables. For 212 and 233 the estimates of α_4 and α_5 are negative, as expected, but for 324 and 331 the estimates are positive. For the other thirteen industries, only in 301 and 336 is the estimate of either α_4 or α_5 significant, and in both cases the estimate is of the wrong positive sign. Of the 34 estimates of α_4 and α_5, 16 are negative and 18 are positive.

For industries 212 and 233, where the fit is improved and the estimates of α_4 and α_5 are negative, the estimate of the coefficient γ_0 of $\log Y^e_{dt} - \log Y_{dt-1}$ is larger than it was in table 4.3 without the inclusion of the two variables. This is consistent with the above hypothesis, since presumably with the inclusion of the two variables the "hoarding" phenomenon is explicitly taken account of and is not erroneously included in the $\log Y^e_{dt} - \log Y_{dt-1}$ variable. For industries 324 and 331, where the fit is also improved but where

[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.

TABLE 5.3

Parameter estimates for eq. (3.9)′ with the additional terms $\alpha_4(\log P_{at} - \log P_{at-1})_+$ and $\alpha_5(\log P_{at} - \log P_{at-1})_-$. Estimates presented for α_1, γ_0, α_4, and α_5 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\gamma}_0$	$\hat{\alpha}_4$	$\hat{\alpha}_5$	SE	DW
201	192	−.177	.268	−.008	−.007	.0121	1.92
		(4.33)	(7.89)	(0.16)	(0.13)		
207	136	−.154	.264	.021	−.032	.0181	2.13
		(3.44)	(10.98)	(0.44)	(0.65)		
211	136	−.138	.099	.011	−.050	.0102	1.91
		(5.87)	(3.91)	(0.23)	(1.16)		
212	136	−.119	.230	−.128	−.116	.0154	2.55
		(5.01)	(7.59)	(2.43)	(2.64)		
231	136	−.169	.188	−.071	−.074	.0194	2.01
		(4.01)	(3.38)	(1.15)	(1.15)		
232	136	−.086	.116	−.022	.016	.0107	1.43
		(5.08)	(6.87)	(0.84)	(0.65)		
233	136	−.007	.239	−.170	−.098	.0284	1.59
		(0.25)	(7.01)	(2.50)	(1.62)		
242	154	−.031	.245	−.047	−.088	.0125	1.83
		(0.99)	(11.69)	(0.94)	(1.82)		
271	166	−.038	.113	.069	−.042	.0048	2.16
		(2.24)	(6.86)	(1.71)	(0.82)		
301	134	−.101	.009	.121	.045	.0140	1.98
		(6.63)	(0.34)	(2.17)	(0.88)		
311	170	−.169	.153	.102	.001	.0114	2.14
		(6.63)	(3.56)	(1.65)	(0.01)		
314	136	−.115	.309	.013	.085	.0143	2.23
		(2.50)	(9.82)	(0.17)	(1.25)		
324	187	−.120	.179	.204	.076	.0164	2.29
		(7.30)	(11.89)	(4.32)	(1.65)		
331	128	−.038	.071	.147	.142	.0094	2.15
		(3.35)	(2.23)	(4.05)	(2.84)		
332	170	−.119	.102	.110	.064	.0166	2.30
		(8.08)	(2.28)	(1.92)	(0.99)		
336	170	−.103	.105	.001	.140	.0174	1.84
		(4.65)	(2.06)	(0.02)	(2.14)		
341	191	−.068	.191	−.026	−.021	.0181	1.98
		(3.64)	(13.21)	(0.84)	(0.84)		

t-statistics are in parentheses.

the estimates of α_4 and α_5 are positive, the estimate of γ_0 is smaller than it was in table 4.3; adding the two variables took away some of the influence of the $\log Y^e_{dt} - \log Y_{dt-1}$ variable.

In summary, then, the results for industries 212 and 231 are consistent with the hypothesis that firms hire fewer workers or fire more than predicted during expansions and conversely during contractions, while the results for industries 324 and 331 are consistent with the counter hypothesis – that firms hire more workers or fire fewer than predicted during expansions and conversely during contractions. Considering all of the industries together, however, the general conclusion appears to be that this test has not revealed any substantive evidence that firms behave differently than the model predicts they should during contractions or during expansions, that the model as exemplified by eq. (3.9)′ appears to be adequately specified for "cyclical" short-run employment behavior.

The above test has the disadvantage that the variable $\log P_{dt}$, the residual from the regression of $\log Y_{dt}$ on twelve seasonal dummies and time, includes the random error term in the $\log Y_{dt}$ series as well as the cyclical term. Taking first differences of the $\log P_{dt}$ series aggravates this problem, and it may be the case that the random error term in the $\log P_{dt} - \log P_{dt-1}$ 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 over-all economic activity into upswings and downswings.[1] Using their definitions of peaks and troughs in the post-war period, a dummy variable, denoted at D_t, was constructed which was set equal to one for each month when over-all economic activity was declining (NBER peak to trough) and zero otherwise. D_t was then added to eq. (3.9)′, and if the above hypothesis is true, the estimate of 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 over-all 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.

The results of adding D_t to eq. (3.9)′ are presented in table 5.4. The coefficient of D_t is denoted as α_6, and estimates of α_1, γ_0, and α_6 are presented in the table. The other coefficient estimates were little affected.

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1 See, for example, US DEPARTMENT OF COMMERCE (1967a).

TABLE 5.4

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_6 D_t$. Estimates presented for α_1, γ_0, and α_6 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\gamma}_0$	$\hat{\alpha}_6$	SE	DW
201	192	−.170	.259	−.002	.0120	1.95
		(4.38)	(9.96)	(1.10)		
207	136	−.159	.264	−.003	.0180	2.12
		(3.45)	(11.51)	(0.64)		
211	136	−.134	.086	−.001	.0103	1.93
		(5.79)	(4.42)	(0.41)		
212	136	−.110	.155	.001	.0159	2.64
		(4.69)	(7.72)	(0.32)		
231	136	−.181	.127	−.000	.0194	1.98
		(4.34)	(3.98)	(0.06)		
232	136	−.093	.119	.001	.0107	1.44
		(5.40)	(9.41)	(0.49)		
233	136	−.005	.163	.001	.0293	1.45
		(0.15)	(6.66)	(0.13)		
242	154	−.044	.215	−.003	.0126	1.79
		(1.41)	(13.33)	(1.12)		
271	166	−.047	.122	.001	.0048	2.14
		(2.70)	(7.58)	(0.86)		
301	134	−.070	.033	−.013	.0137	2.07
		(3.81)	(1.68)	(3.35)		
311	170	−.164	.183	−.004	.0114	2.21
		(6.32)	(7.74)	(1.63)		
314	136	−.121	.325	.003	.0143	2.18
		(2.61)	(10.76)	(0.95)		
324	187	−.110	.221	−.005	.0177	2.03
		(6.39)	(16.04)	(1.32)		
331	128	−.029	.174	−.004	.0101	1.81
		(2.31)	(8.79)	(1.38)		
332	170	−.106	.153	−.008	.0165	2.36
		(6.42)	(6.77)	(2.02)		
336	170	−.080	.137	−.014	.0168	2.13
		(3.74)	(5.46)	(3.83)		
341	191	−.062	.180	−.004	.0180	2.01
		(3.33)	(15.03)	(1.01)		

t-statistics are in parentheses.

The estimate of α_6 is positive as expected in only five industries, and it is not significant for any of these five. For the remaining twelve industries where the estimate of α_6 is negative, it is significant for three of them – 301, 332, and 336. For these three industries the estimate of the coefficient γ_0 of $\log Y^e_{dt} - \log Y_{dt-1}$ is smaller than it was in table 4.3 with D_t not included in the equation, and for 301 the estimate of γ_0 in table 5.4 is no longer significant. This phenomenon is probably due to collinearity between D_t and $\log Y^e_{dt} - \log Y_{dt-1}$ in the equation.

These results clearly give no indication that the model underpredicts during the contractions as defined by the NBER. The insignificance of all but three of the estimates of α_6 implies, according to this rather crude test, that firms do not behave differently than predicted during contractionary periods.

The two tests together thus indicate that firms do not appear to behave differently than predicted during general contractionary periods of output or during general expansionary periods.

5.4 The effect of the unemployment rate on short-run employment decisions

So far the effect of possible supply constraints on the number of workers employed has not been considered. It has been implicitly assumed that a firm has no trouble in the short run in finding and hiring the number of workers that it wants. In tight labor markets, of course, this may not be the case.

The hypothesis which is tested here is the hypothesis 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), and that a loose labor market (measured by a high unemployment rate) tends to increase 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 being relatively loose, and let U_{2wt} denote the unemployment rate during the decision period, from the end of the second week of month $t-1$ to the end of the second week of month t. According to the above hypothesis, the effect of a positive $\log U_{2wt} - \log \bar{U}$ (loose labor market) on $\log M_{2wt} - \log M_{2wt-1}$ in eq.

(3.9)′ is expected to be positive for $\log M_{2wt} - \log M_{2wt-1}$ positive and negative for $\log M_{2wt} - \log M_{2wt-1}$ negative, and the effect of a negative $\log U_{2wt} - \log \bar{U}$ (tight labor market) is expected to be negative for $\log M_{2wt} - \log M_{2wt-1}$ positive and positive for $\log M_{2wt} - \log M_{2wt-1}$ negative.

Because of this asymmetry of effects, $\log U_{2wt} - \log \bar{U}$ cannot be added to eq. (3.9)′ in any simple linear way, and it is assumed to enter in the following way:

$$\begin{aligned}\log M_{2wt} - \log M_{2wt-1} = {} & \alpha_1(\log M_{2wt-1} - \log M^*_{2wt-1}H^*_{2wt-1}) \\ & + \alpha_1 \log \bar{H} + \alpha_1 \mu t \\ & + \sum_{i=1}^{m} \beta_i(\log Y_{dt-i} - \log Y_{dt-i-1}) + \gamma_0(\log Y^e_{dt} - \log Y_{dt-1}) \\ & + \sum_{i=1}^{n} \gamma_i(\log Y^e_{dt+i} - \log Y^e_{dt+i-1}) + \psi(\log U_{2wt} - \log \bar{U}) + \varepsilon_t,\end{aligned} \tag{5.1}$$

where

$$\begin{aligned}\psi = \psi_0 \Bigg[& \alpha_1(\log M_{2wt-1} - \log M^*_{2wt-1}H^*_{2wt-1}) + \alpha_1 \log \bar{H} \\ & + \alpha_1 \mu t + \sum_{i=1}^{m} \beta_i(\log Y_{dt-i} - \log Y_{dt-i-1}) \\ & + \gamma_0(\log Y^e_{dt} - \log Y_{dt-1}) + \sum_{i=1}^{n} \gamma_i(\log Y^e_{dt+i} - \log Y^e_{dt+i-1})\Bigg].\end{aligned}$$

The error term ε_t is explicitly introduced in eq. (5.1) to avoid possible ambiguity as to how it is assumed to enter in the specification of the equation.

What eq. (5.1) says is that the size and sign of the coefficient ψ of $\log U_{2wt} - \log \bar{U}$ are determined by the other determinates of $\log M_{2wt} - \log M_{2wt-1}$. If, for example, the other determinates imply that $\log M_{2wt} - \log M_{2wt-1}$ should be positive and large, then this implies that ψ will be positive and large; and if furthermore $\log U_{2wt} - \log \bar{U}$ is, say, negative, then eq. (5.1) implies that $\log M_{2wt} - \log M_{2wt-1}$ will be smaller than it would have been if $\log U_{2wt} - \log \bar{U}$ had been zero or positive. The specification of this equation is consistent with the above hypothesis that tight labor markets damp fluctuations in log M_{2wt} − log M_{2wt-1} while loose labor markets tend to increase these fluctuations.

Eq. (5.1) is non-linear in the parameters and thus cannot be estimated by ordinary least squares. It is also the case that the parameter $\bar{U}$ in eq. (5.1) is not identified. $\bar{U}$ is supposed to be the unemployment rate which divides loose from tight labor markets. Since $\bar{U}$ could not be estimated simultaneously with the other coefficients in eq. (5.1), it was rather arbitrarily taken to be the average of U_{2wt} over the sample period. Hopefully this measure is a rough approximation to the unemployment rate in the "average" (from the point of view of the firm) labor market.

The coefficients in eq. (5.1) were estimated by minimizing the sum of the squared residuals of the equation. The sum was minimized by the use of the quadratic hill-climbing technique of GOLDFELD *et al.* (1966).[1] On the assumption that ε_t in eq. (5.1) is normally distributed, the estimates attained by this procedure are maximum likelihood estimates,[2] and so an estimate of the asymptotic variance-covariance matrix of the parameter estimates can be obtained as $[-\partial^2 \log L/\partial\boldsymbol{\phi}^2]^{-1}$, where L is the likelihood function, $\boldsymbol{\phi}$ is the vector of parameters, and where the derivatives are evaluated at the coefficient estimates.[3] In the present context the asymptotic variance-covariance matrix of the parameters other than σ^2 is $2\sigma^2[\partial^2\ \boldsymbol{\varepsilon}'\boldsymbol{\varepsilon}/\partial\boldsymbol{\theta}^2]^{-1}$, where $\boldsymbol{\varepsilon}$ is the $T \times 1$ vector of errors ε_t, σ^2 is the variance of ε_t, and $\boldsymbol{\theta}$ is the vector of parameters other than σ^2. The maximum likelihood estimate of σ^2 is $\hat{\boldsymbol{\varepsilon}}'\hat{\boldsymbol{\varepsilon}}/T$, where $\hat{\boldsymbol{\varepsilon}}$ is the vector of calculated residuals and T is the number of observations. For present purposes, however, the estimate of σ^2 was taken to be $\hat{\boldsymbol{\varepsilon}}'\hat{\boldsymbol{\varepsilon}}/(T-K)$, where K is the number of coefficients estimated. Both of these estimates of σ^2 are consistent, and the estimate of σ^2 used here has the advantage of being more comparable with the ordinary least squares results in table 4.3. The estimate of asymptotic variance-covariance matrix

[1] See also GOLDFELD, QUANDT, and TROTTER (1968).

[2] Note that eq. (5.1) includes the log M_{2wt-1} − log $M^*_{2wt-1}H^*_{2wt-1}$ variable, which is of the nature of a lagged dependent variable. For equations with no lagged dependent variables the properties of the maximum likelihood estimates are well established (e.g., consistency and asymptotic efficiency), but the properties are less established for equations with lagged dependent variables. The results which have been achieved for a few cases (see KOOPMANS and HOOD, 1953, pp. 146–147), however, indicate that for equations with lagged dependent variables the maximum likelihood estimates retain their desirable properties.

[3] See, for example, GOLDBERGER (1964, p. 131).

which was finally calculated was, therefore, $2(\hat{\varepsilon}'\hat{\varepsilon}/(T - K))\ [\partial^2\ \varepsilon'\varepsilon/\partial\theta^2]^{-1}$, where the derivatives are evaluated at $\theta = \hat{\theta}$.

The unemployment rate data used for U_{2w_t} were unpublished and were obtained from the BLS directly. Data were available on a monthly basis seasonally unadjusted from 1948 to the present for durable goods and non-durable goods industries, as well as for the over-all economy and other categories. Given these data, 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 or non-durable goods 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 rate data, although with workers being able to move from one industry to another, it is not clear that the degree of disaggregation should be any greater even if it were possible to get more disaggregated data. Thus the durable–non-durable breakdown was used for the unemployment rate data.

Prior to 1955 the BLS unemployment data refer to the week containing the 8th day of the month, and since 1955 they refer to the week containing the 12th day of the month. Ideally the U_{2w_t} variable above should refer to the state of the labor market from the end of the second week of month $t - 1$ to the end of the second week of month t. The U_{2w_t} actually observed relates approximately to the second week of month t, or a little earlier before 1955. On theoretical grounds U_{2w_t} would appear to be a closer approximation to the relevant decision period than, say, $U_{2w_{t-1}}$, which actually relates to the week before the decision period. U_{2w_t} was thus chosen as the more relevant variable.

There is a possible simultaneous equation bias which could creep into the estimates of eq. (5.1), since a firm's employment policy obviously affects the number of workers unemployed. Since each of the three-digit industries studied here is a relatively small part of total durable or non-durable manufacturing, this bias is not likely to be serious, and the unemployment rate has been taken to be exogenous to each industry.

The results of estimating eq. (5.1) are presented in table 5.5. Since the other coefficient estimates were not substantially changed, only the estimate of ψ_0 is presented. Under the hypothesis discussed above, ψ_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 labor markets tend to increase the fluctuations. The "t-statistic" presented in table 5.5 is the absolute value of the ratio of the coefficient estimate to its

TABLE 5.5

Parameter estimates for eq. (5.1). Estimates presented for ψ_0 only

Industry	No. of obs.	$\hat{\psi}_0$	SE
201	192	.431 (2.73)	.0118
207	136	.072 (0.65)	.0180
211	136	−.252 (0.57)	.0102
212	136	−.049 (0.14)	.0159
231	136	.594 (2.93)	.0188
232	136	.451 (1.80)	.0106
233	136	.271 (1.19)	.0292
242	154	.079 (0.80)	.0127
271	166	.074 (1.21)	.0048
301	134	.087 (1.57)	.0141
311	170	.356 (1.09)	.0114
314	130	.022 (0.12)	.0143
324	187	.147 (0.90)	.0177
331	128	.275 (1.66)	.0100
332	170	.583 (2.37)	.0164
336	170	.693 (3.33)	.0170
341	191	−.009 (0.10)	.0181

t-statistics are in parentheses.

asymptotic standard error, the latter being computed from the asymptotic variance-covariance matrix discussed above.

In all but three industries – 211, 212, and 341 – the estimate of ψ_0 is positive. For four of these industries – 201, 231, 332, and 336 – the t-statistic is larger than two, and for six others it is larger than one. For about half of the industries the SE for eq. (5.1) is smaller than the SE for eq. (3.9)′ presented in table 4.3.

The fact that all but three of the estimates of ψ_0 are positive and the fact that ten 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. Some evidence on the significance of labor market tightness for the change in hours paid-for per worker will be given in ch. 7, and these results will shed some further light on the possible validity of the above hypothesis.

5.5 The relationship of the excess labor model to a lagged adjustment model

The empirical results which were discussed in ch. 4 regarding the expectational hypotheses indicated that the expectational hypothesis which assumes non-perfect expectations for Y^e_{2wt} is not realistic,[1] and this hypothesis was dropped from further consideration. Assuming, then, that Y^e_{2wt} equals Y_{2wt} in eq. (3.9) and ignoring for the moment the past change in output variables, the equation can be written

$$\log M_{2wt} - \log M_{2wt-1} = \alpha_1(\log M_{2wt-1} - \log M^d_{2wt-1})$$

$$+ \gamma_0(\log Y_{2wt} - \log Y_{2wt-1}) + \sum_{i=1}^{n} \gamma_i(\log Y^e_{2wt+i} - \log Y^e_{2wt+i-1}). \quad (5.2)$$

M^d_{2wt-1} is the desired number of workers employed for the second week of month $t-1$ for the output Y_{2wt-1}. Since the firm is assumed to know Y_{2wt} in advance (perfect expectations for Y_{2wt}), it can also be assumed to

[1] For sake of consistency with the discussion in ch. 3, the discussion in this section is couched in terms of Y_{2wt} instead of the observed Y_{at}.

know M^d_{2wt} in advance. Therefore, the following "lagged adjustment" model could be constructed and estimated:

$$\log M_{2wt} - \log M_{2wt-1} = \lambda(\log M^d_{2wt} - \log M_{2wt-1}) + \sum_{i=1}^{n} \gamma_i(\log Y^e_{2wt+i} - \log Y^e_{2wt+i-1}). \quad (5.3)$$

M^d_{2wt} is the desired number of workers employed for the second week of month t, desired as of the second week of month $t-1$. Using the definition of M^d_{2wt} in eq. (3.7) and the assumptions made about HS_{2wt} in eq. (3.11), eq. (5.3) could be estimated in a manner analogous to eq. (3.9)′, the basic equation of the "excess labor" model.

The lagged adjustment model as exemplified by eq. (5.3) appears to be more in the spirit of the basic model of ch. 2, with the expected future change in output variables being added. Of course, the basic difference between this model and the basic model of ch. 2 is that here M^d_{2wt} is constructed, under the assumptions of no substitution possibilities and constant returns to scale, from the interpolations discussed in § 3.6, whereas in the basic model of ch. 2, M^d_{2wt} is assumed to be derived from a Cobb–Douglas production function, the parameters of which are assumed to be estimatable from the derived equation (2.37).

The relationship between the excess labor equation (5.2) and the lagged adjustment equation (5.3) is easy to see. Since in eq. (3.6) [which is derived from the production function (3.2)] the production function parameter α_{2wt} is assumed to move slowly through time from peak to peak, for short-run considerations α_{2wt} can be approximated by a constant, say $\bar{\alpha}$. If it is assumed that the standard number of hours of work per worker per week is constant over time so that $HS_{2wt-1} = HS_{2wt} = \bar{H}$, which is approximately true in the short run even if HS is a slowly trending variable as assumed in eq. (3.11), then from eqs. (3.6) and (3.7)

$$M^d_{2wt} = \frac{1}{\bar{\alpha}} \frac{Y_{2wt}}{\bar{H}} \quad (5.4)$$

and

$$M^d_{2wt-1} = \frac{1}{\bar{\alpha}} \frac{Y_{2wt-1}}{\bar{H}}. \quad (5.5)$$

Therefore,

$$\log M^d_{2wt} - \log M^d_{2wt-1} = \log Y_{2wt} - \log Y_{2wt-1}, \tag{5.6}$$

or

$$\log M^d_{2wt} = \log M^d_{2wt-1} + \log Y_{2wt} - \log Y_{2wt-1}. \tag{5.7}$$

Substituting this value of log M^d_{2wt} into the lagged adjustment equation (5.3) yields

$$\log M_{2wt} - \log M_{2wt-1} = \lambda(\log M^d_{2wt-1} - \log M_{2wt-1})$$

$$+ \lambda(\log Y_{2wt} - \log Y_{2wt-1}) + \sum_{i=1}^{n} \gamma_i(\log Y^e_{2wt+i} - \log Y^e_{2wt+i-1}). \tag{5.8}$$

Comparing eqs. (5.8) and (5.2), it is seen that the lagged adjustment model is equivalent to the excess labor model with the additional restriction that $|\alpha_1|$ equals $|\gamma_0|$ in eq. (5.2). In other words, the lagged adjustment model can be considered to be special case of the excess labor model. The results of estimating the excess labor equation, which were presented in table 4.3, strongly indicate that $|\alpha_1|$ does not equal $|\gamma_0|$ (even considering the fact that for some of the industries the past output change variables are taking away some of the influence of the excess labor variable and thus are decreasing the size of $|\alpha_1|$), so that the model of the short-run demand for production workers appears to be better specified in terms of the "excess labor reaction" equation (5.2) than in terms of the "lagged adjustment" equation (5.3).

5.6 Alternative distributed lags

Eq. (3.9) implies that log M_{2wt} is a distributed lag of past values of the desired number of workers employed, log M^d_{2w}, and of the past values of the various change in output variables in the equation. Jorgenson has shown that any arbitrary distributed lag function can be approximated by a rational distributed lag function.[1] Let the lag operator L be defined such that $L^i X_t = X_{t-i}$, and let $\mu(L)$ and $\nu(L)$ be polynomials in L. Then eq. (3.9) can be written

$$\nu(L) \log M_{2wt} = \mu(L) \log M^d_{2wt-1} + \sum_{i=1}^{m} \beta_i(\log Y_{2wt-i} - \log Y_{2wt-i-1})$$

[1] Jorgenson (1966, p. 142).

$$+ \gamma_0(\log Y^e_{2wt} - \log Y_{2wt-1}) + \sum_{i=1}^{n} \gamma_i(\log Y^e_{2wt+i} - \log Y^e_{2wt+i-1}), \tag{5.9}$$

where

$$v(L) = 1 - (1 + \alpha_1) L \tag{5.10}$$

and

$$\mu(L) = -\alpha_1. \tag{5.11}$$

Eq. (5.9) can be divided through by $v(L)$ to give log M_{2wt} as a rational distributed lag of past values of log M^d_{2w} and past values of the change in output variables.

A more complicated lag than that implied by eq. (3.9) is implied by an equation like (3.9) with the variable log M_{2wt-2} − log M^d_{2wt-2} added to it. This variable is a measure of the amount of excess labor on hand during the second week of month $t-2$, and adding it to eq. (3.9) (with coefficient α_7) implies that in eq. (5.9)

$$v(L) = 1 - (1 + \alpha_1)L - \alpha_7 L^2 \tag{5.12}$$

and

$$\mu(L) = -\alpha_1 - \alpha_7 L. \tag{5.13}$$

In an effort to test for a more complicated lag structure than that specified in eq. (3.9), the variable log M_{2wt-2} − log M^d_{2wt-2} was added to eq. (3.9)′. From eq. (3.7) M^d_{2wt-2} equals $M^*_{2wt-2}H^*_{2wt-2}/HS_{2wt-2}$, and if it is assumed that the effects of log HS_{2wt-2} can be absorbed in the constant term and time trend in the equation, then adding log M_{2wt-2} − log M^d_{2wt-2} to eq. (3.9)′ is equivalent to adding log M_{2wt-2} − log $M^*_{2wt-2}H^*_{2wt-2}$ to the equation. The results of adding log M_{2wt-2} − log $M^*_{2wt-2}H^*_{2wt-2}$ to eq. (3.9)′ are presented in table 5.6. Only the estimates of the coefficients of log M_{2wt-1} − log $M^*_{2wt-1}H^*_{2wt-1}$ and log M_{2wt-2} − log $M^*_{2wt-2}H^*_{2wt-2}$ are presented, the coefficient of the latter being denoted as α_7.

In only one industry – 212 – is the estimate of α_7 significant, where it is significantly positive. In seven industries the estimate of α_7 is negative and in the other ten it is positive. When the estimate of α_7 is negative, the estimate of α_1 is smaller in absolute value than it was in table 4.3 when log M_{2wt-2} − log $M^*_{2wt-2}H^*_{2wt-2}$ was not included in the equation; and when the estimate of α_7 is positive, the estimate of α_1 is larger in absolute

TABLE 5.6

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_7(\log M_{2wt-2} - \log M^*_{2wt-2} \cdot H^*_{2wt-2})$. Estimates presented for α_1 and α_7 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\alpha}_7$	SE	DW
201	192	−.127	−.056	.0120	2.02
		(1.81)	(0.84)		
207	136	−.202	.055	.0180	2.04
		(2.85)	(0.90)		
211	136	−.131	−.004	.0103	1.93
		(5.63)	(0.40)		
212	136	−.325	.184	.0149	1.76
		(5.87)	(4.25)		
231	136	−.296	.135	.0192	1.89
		(3.89)	(1.79)		
232	136	−.092	.001	.0107	1.45
		(1.66)	(0.03)		
233	136	+.105	−.116	.0289	1.57
		(1.57)	(1.85)		
242	154	−.014	−.032	.0127	1.85
		(0.17)	(0.39)		
271	166	−.033	−.021	.0048	2.22
		(1.81)	(1.81)		
301	134	−.093	−.022	.0142	1.99
		(4.85)	(1.20)		
311	170	−.176	.003	.0115	2.12
		(6.70)	(0.26)		
314	136	−.126	.022	.0143	2.09
		(2.68)	(1.09)		
324	187	−.104	−.012	.0177	2.02
		(5.11)	(0.49)		
331	128	−.156	.119	.0100	1.61
		(1.84)	(1.44)		
332	170	−.145	.024	.0166	2.22
		(6.77)	(1.35)		
336	170	−.128	.014	.0176	1.74
		(1.77)	(0.22)		
341	191	−.119	.049	.0180	1.89
		(1.68)	(0.77)		

t-statistics are in parentheses.

value. There is also a strong tendency for the addition of $\log M_{2wt-2} - \log M^*_{2wt-2}H^*_{2wt-2}$ to decrease the significance of the estimate of α_1. The effect on the other coefficient estimates was small except on the estimate of the coefficient β_1 of $\log Y_{dt-1} - \log Y_{dt-2}$. The introduction of $\log M_{2wt-2} - \log M^*_{2wt-2}H^*_{2wt-2}$ tended to decrease substantially the significance of the estimate of β_1 (for those industries, that is, where the estimate of β_1 was significant to begin with). This is probably due to the fact that $\log M^d_{2wt-2}$ approximately equals[1] $\log M^d_{2wt-1} - (\log Y_{dt-1} - \log Y_{dt-2})$, and adding the variable $\log M_{2wt-2} - \log M^d_{2wt-2}$,[2] which approximately equals $\log M_{2wt-2} - \log M^d_{2wt-1} + \log Y_{dt-1} - \log Y_{dt-2}$, to eq. (3.9)′ is likely to lead to collinearity problems between this variable and $\log Y_{dt-1} - \log Y_{dt-2}$.

Because of the insignificance of all but one of the estimates of α_7 and because the introduction of $\log M_{2wt-2} - \log M^*_{2wt-2}H^*_{2wt-2}$ 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 adding this variable to eq. (3.9)′.

Regarding the reaction of firms to the amount of excess labor on hand, it may be the case that firms react differently depending on the *size* of the amount of excess labor on hand, i.e., firms may react in a non-linear way to the amount of excess labor on hand. The hypothesis which is tested here is the hypothesis that the larger the amount of positive excess labor on hand the stronger is the reaction of firms in eliminating it and the larger the amount of negative excess labor on hand the stronger is the reaction of firms in adding more workers. The hypothesis was tested by adding the variable $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$ to eq. (3.9)′.[3] The notation $\pm$ indicates that when $\log M_{2wt-1} - \log M^d_{2wt-1}$ was negative, the squared term was taken to be negative as well. This is consistent with the idea that $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$ should be positive when there is a positive amount of excess labor on hand and negative when there is a negative amount of excess labor on hand.

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[1] See eq. (5.7).

[2] Remember that adding the variable $\log M_{2wt-2} - \log M^*_{2wt-2}H^*_{2wt-2}$ to the equation (which was actually done) is equivalent to adding $\log M_{2wt-2} - \log M^d_{2wt-2}$, under the assumption made about $\log HS_{2wt-2}$ above.

[3] For this variable, M^d_{2wt-1} had to be constructed, and it was constructed in the following way. $\log HP_{2wt}$ was regressed against a constant and time for the basic period of estimation for each industry, and the predicted values of this equation were taken to be the values of $\log HS_{2wt}$. The already constructed $M^*_{2wt-1}H^*_{2wt-1}$ was then divided by HS_{2wt-1} to yield M^d_{2wt-1}.

TABLE 5.7

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_8(\log M_{2ut-1} - \log M^d_{2ut-1})^2_{\pm}$. Estimates presented for α_1 and α_8 only

Industry	No. of obs.	$\hat{\alpha}_1$	$\hat{\alpha}_8$	SE	DW
201	192	−.135	−.196	.0119	1.93
		(3.01)	(1.74)		
207	136	−.072	−.154	.0179	2.12
		(1.00)	(1.42)		
211	136	−.161	.190	.0102	1.89
		(5.13)	(1.31)		
212	130	−.056	−.336	.0158	2.60
		(1.32)	(1.48)		
231	136	−.090	−.217	.0191	1.99
		(1.57)	(2.19)		
232	136	−.061	−.127	.0107	1.48
		(1.75)	(0.96)		
233	136	.150	−.405	.0288	1.50
		(1.98)	(2.24)		
242	154	−.079	.137	.0127	1.81
		(1.59)	(0.90)		
271	166	−.032	−.057	.0048	2.11
		(1.26)	(0.64)		
301	134	−.072	−.140	.0142	1.97
		(2.20)	(1.22)		
311	170	−.235	.298	.0115	2.14
		(3.60)	(1.02)		
314	136	−.191	.577	.0143	2.22
		(2.49)	(1.25)		
324	187	−.136	.052	.0177	2.02
		(4.01)	(0.90)		
331	128	−.052	.066	.0101	1.87
		(2.26)	(0.88)		
332	170	−.156	.103	.0167	2.20
		(4.62)	(1.06)		
336	170	−.167	.231	.0175	1.81
		(3.01)	(1.04)		
341	191	.009	−.106	.0178	2.02
		(0.24)	(2.36)		

t-statistics are in parentheses.

In table 5.7 the results of adding $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$ to eq. (3.9)′ are presented. The coefficient of this variable, denoted as α_8, is expected to be negative if in fact the larger the amount of excess labor on hand the stronger the reaction is. In table 5.7 only the estimates of α_1 and α_8 are presented; the effects on the other coefficient estimates were minor.

In nine of the industries the estimate of α_8 is negative (as expected), and in three of these industries – 231, 233, and 341 – the estimate is significant. When the estimate of α_8 is negative, the estimate of α_1 decreases in absolute value compared with the estimate of α_1 in table 4.3 without $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$ included, and when the estimate of α_8 is positive, the estimate of α_1 increases in absolute value. The introduction of $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$ tends to decrease the significance of the estimate of α_1. Except for perhaps industry 233, the effects on the standard errors are slight. The results rather strongly suggest that the reaction to the amount of excess labor on hand is not stronger the larger the amount held.

It appears, therefore, from the two tests performed here that the introduction of the excess labor variable, $\log M_{2wt-1} - \log M^d_{2wt-1}$, and (for a few industries) the past change in output variables to the equation determining the short-run demand for workers adequately approximates the reaction of firms to the amount of excess labor on hand.

5.7 Possible capacity constraints

By specifying the short-run production function as one of fixed proportions and constant returns to scale, it is implied that when new workers are hired they work on previously idle machines (or on a previously non-existence second or third shift).[1] Labor services (measured in this study as man hours) can, of course, be increased by increasing the number of hours worked per worker without having to add more machines, since the existing machines can just be utilized more hours. At high rates of output firms are not likely to have idle machines on hand, and if they want to increase the rate of output even more from an already high rate, they may have no choice but to increase labor services by increasing the number of hours worked per worker rather than by adding new workers. This would imply that for further increases in the rate of output from an already high rate $\log M_{2wt} - \log M_{2wt-1}$ should be smaller, other things being equal, than for the same

[1] See the discussion in § 3.5.

TABLE 5.8

Parameter estimates for eq. (3.9)′ with the additional term $\alpha_9 DK_t$. Estimates presented for γ_0 and α_9 only

Industry	No. of obs.	$\hat{\gamma}_0$	$\hat{\alpha}_9$	SE	DW	%[a]
201	192	.261	.0005	.0120	1.94	6.8
		(9.84)	(0.11)			
207	136	.261	.0002	.0181	2.12	9.6
		(10.09)	(0.02)			
211	136	.084	.0007	.0103	1.93	6.6
		(4.15)	(0.17)			
212	136	.158	−.0018	.0159	2.61	13.2
		(7.22)	(0.41)			
231	136	.129	−.0017	.0194	1.98	7.4
		(3.95)	(0.24)			
232	136	.125	−.0051	.0106	1.46	11.8
		(9.58)	(1.58)			
233	136	.173	−.0107	.0292	1.49	9.6
		(6.67)	(1.09)			
242	154	.223	−.0056	.0126	1.79	7.1
		(13.63)	(1.32)			
271	166	.124	−.0039	.0046	2.13	19.3
		(8.13)	(3.59)			
301	134	.070	−.0101	.0140	1.88	11.2
		(3.53)	(2.25)			
311	170	.188	.0014	.0115	2.12	5.3
		(7.89)	(0.31)			
314	136	.324	−.0016	.0143	2.19	7.4
		(10.21)	(0.29)			
324	187	.224	.0020	.0177	2.01	12.3
		(16.46)	(0.45)			
331	128	.189	−.0040	.0101	1.89	10.2
		(9.94)	(1.24)			
332	170	.176	−.0046	.0167	2.22	8.2
		(8.24)	(0.91)			
336	170	.158	.0036	.0176	1.78	10.6
		(6.02)	(0.69)			
341	191	.176	.0095	.0180	1.97	6.8
		(14.34)	(1.51)			

t-statistics are in parentheses.

[a] Percentage of observations for which DK_t was set equal to one.

increase in the rate of output from a lower rate, since hours worked per worker would take up more of the adjustment at high rates of output.

This hypothesis that $\log M_{2wt} - \log M_{2wt-1}$ is smaller, other things being equal, at high rates of output was tested in the following manner. For each industry, output Y_{dt} was plotted monthly for the nineteen-year period, and a dummy variable, denoted as DK_t, was set equal to one for those observations where $Y_{dt} - Y_{dt-1}$ was positive and Y_{dt-1} appeared to be large relative to surrounding observations, and was set equal to zero otherwise. On the above hypothesis the coefficient of DK_t should be negative. This test is of course somewhat subjective in that the construction of DK_t is subjective, but the test should give a general indication whether $\log M_{2wt} - \log M_{2wt-1}$ behaves differently, other things being equal, when the rate of output is high and increasing.

The results of adding DK_t to eq. (3.9)′ are presented in table 5.8. The coefficient of DK_t is denoted as α_9, and estimates of γ_0 and α_9 are presented in the table. Presented also in the table for each industry is the percentage of observations for which DK_t was set equal to one. For ten of the seventeen industries the estimate of α_9 is negative, as expected, but significantly so for only two of them – 271 and 301. The estimates of γ_0 are little affected by the introduction of DK_t and the other coefficient estimates were little affected either. Only for industries 232, 271, and 301 has the standard error gone down even slightly compared with the standard error in table 4.3. It is rather clear that DK_t is not a significant variable, and at least on this test the behavior of $\log M_{2wt} - \log M_{2wt-1}$ does not appear to be different when the rate of output is high and increasing.

If the above assumptions about the short-run production function are true, these results indicate that at least for rates of output which are actually observed there does not appear to be machine capacity problems at high rates of output. The crude nature of the above test should be emphasized, however, and perhaps not too much weight should be put on the results.

5.8 Summary

In this chapter various hypotheses regarding the short-run demand for production workers were proposed and tested. For the most part these hypotheses were rejected. Neither the past level of hours paid-for per worker, $\log HP_{2wt-1}$, nor the past change in the number of hours paid-for per worker, $\log HP_{2wt-1} - \log HP_{2wt-2}$, appears to be a significant determinant of the change in the number of workers employed, although as was seen in ch. 4, the amount of excess labor on hand, which is measured as $\log HS_{2wt-1} - \log H_{2wt-1}$, definitely appears to be significant. These results are as expected from the theory discussed above.

Since seasonal fluctuations are quite pronounced in many of the industries, two tests were made to see whether the behavior of firms is different than the model predicts it should be during general contractionary periods of output and general expansionary periods. The hypothesis that firms "hoard" labor during contractions and "dishoard" labor during expansions (in the sense that the model predicts more workers fired or fewer hired than actually are during contractions and conversely during expansions) was tested. Although the tests were rather crude, there did not seem to be any evidence that this hypothesis is true.

The one hypothesis which appeared to have some evidence in its favor is the hypothesis that labor market conditions (as measured by the unemployment rate) affect the employment behavior of firms. The hypothesis that tight labor markets tend to damp fluctuations in the number of workers employed and that loose labor markets tend to increase these fluctuations was tested by the means of a non-linear estimating technique, and the results were such that the hypothesis could not be completely rejected. Some further results will be presented in ch. 7 which add indirect support to this hypothesis.

The relationship between the "excess labor" model developed in this study and a "lagged adjustment" model which is more in the tradition of previous models was discussed, and the lagged adjustment model was seen to be (approximately) a special case of the excess labor model. From the results presented in table 4.3 the lagged adjustment model appears to be unduely restrictive. With respect to the excess labor model, a more complicated distributed lag equation was estimated in which the variable $\log M_{2wt-2} - \log M^d_{2wt-2}$, which is the amount of excess labor on hand during the second week of month $t-2$, was added to eq. (3.9). This variable was not significant, and there was no evidence of a more complicated distributed lag on this score. In another test the variable $(\log M_{2wt-1} - \log M^d_{2wt-1})^2_{\pm}$, which is the square (adjusted for negative signs) of the amount of excess labor on hand during the second week of month $t-1$, was added to eq. (3.9) to see whether firms react in a non-linear way to the amount of excess labor on hand. This also does not appear to be the case, since the variable was not significant. From the results of these last two tests, the reaction of firms to the amount of excess labor on hand appears to be adequately specified by eq. (3.9).

Finally, a test was made to see whether possible machine capacity problems cause the behavior of firms to be different, other things being equal, at high rates of output. The hypothesis that the change in the number of production workers employed is smaller, other things being equal, at high rates of output was tested, and the results indicated that this is not the case.