Excess Labor and the Business Cycle

By RAY C. FAIR*

In a remarkable empirical study of 168 U.S. manufacturing plants, James Medoff and Jon Fay (1985) have examined the magnitude of labor hoarding during economic contractions. They found that during its most recent trough quarter, the typical plant paid for about 8 percent more blue-collaf hours than were needed for regular production work. Some of these hours were used for other worthwhile work, and after taking account of this, 5 percent of the blue-collar hours was estimated to be hoarded for the typical plant.

The hypothesis that firms may hold "excess labor" during contractions was explored in my 1969 study, using monthly three-digit industry data. A model of labor demand was developed that is based on the idea that firms may at times hold excess labor. This model was originally estimated using the monthly three-digit industry data, and it was later estimated using aggregate quarterly data. The aggregate labor demand equations are part of my U.S. macro model. The latest discussion of the aggregate equations is in chapter 4 in my 1984 study. Both the monthly industry estimates and the quarterly macro estimates support the excess labor hypothesis.

The purpose of this paper is to see if the quantitative estimates of Medoff and Fay are consistent with the aggregate estimates. If this is the case, which the results in this paper show, it provides a strong argument in favor of the excess labor hypothesis. Essentially the same conclusion has been reached using two very different data sets. This is one of the few examples in macroeconomics where a hypothesis has been so strongly confirmed using detailed micro data.

*Department of Economics, Yale University, New Haven, CT 06520. I am indebted to a referee for helpful comments.

I. Review of the Aggregate Labor Demand Equations

The latest discussion of the theoretical model upon which the labor demand equations are based is in chapter 3 of my 1984 study. Only a few features of this model will be reviewed here. The technology is assumed to be putty-clay, where at any one time there are a number of different types of machines that can be purchased. The machines differ in price, in the number of workers that must be used with each machine per unit of time, and in the amount of output that can be produced per machine per unit of time. The worker-machine ratio is assumed to be fixed for each type of machine. Adjustment costs are postulated for changes in the size of the work force and for changes in the size of the capital stock. Firms behave by maximizing the present discounted value of expected future after-tax cash flow. The main decision variables of a firm are its price, production, investment, labor demand, and wage rate. Because of the adjustment costs, it may sometimes be optimal for a firm to operate "off" its production function and hold excess labor and/or excess capital.

The transition from a theoretical to an econometric model is always difficult in macroeconomics, and the present case is no exception. This transition is discussed in chapter 4 of my 1984 study, and again only a few features will be discussed here. For the empirical work the production function is postulated to be one of fixed proportions:

$$(1) \quad Y = \min\{\lambda(J \cdot H^J), \mu(K \cdot H^K)\},$$

where Y is production, J is the number of workers employed, H^J is the number of hours worked per worker, K is the stock of capital, H^K is the number of hours each unit of K is utilized, and λ and μ are coefficients that may change over time due to technical progress. The variables Y, J, and K are observed; H^J and H^K are not. This production function is only an approximation to the technology of the theoretical model. It does not allow for the existence of more than one type of machine, and it treats technical progress in an inappropriate way. Even if there were only one type of machine in existence, technical progress would take the form of machines having different λ and μ coefficients depending on when they were purchased. In order to account for technical progress in this way, one would have to keep track of when each machine was purchased and what the coefficients were for that machine. This kind of detail is not possible with aggregate data, and one must resort to simpler specifications.

Given the production function, the next step is to measure the number of worker hours required to produce the output each period. This was done as follows. Output per paid-for worker hour, $Y/(J \cdot H)$, was first plotted for the 1952:I–1982:III period. (Data on hours paid for, H, exist, whereas data on hours worked, H^J, do not.) The peaks of this series were assumed to correspond to cases where the number of hours worked equals the number of hours paid for (i.e., where $H^J = H$), which implies that values of λ in equation (1) are observed at the peaks. The values of λ other than those at the peaks were then assumed to lie on straight lines between the peaks. Given an estimate of λ for a particular quarter and given the production function (1), the estimate of the number of worker hours required to produce the output of the quarter (denoted $JHMIN$) is simply Y/λ. The peaks that were used for the interpolations are 1952:I, 1953:II, 1955:I, 1966:I, 1973:I, and 1977:I. The line connecting 1973:I and 1977:I was extrapolated beyond 1977:I to fill out the series through 1982:III.

In the theoretical model, a firm's price, production, investment, labor demand, and wage rate decisions are made simultaneously in the sense that all are derived from the solution of the firm's maximization problem. For the empirical work the decisions are assumed to be made sequentially, where the sequence is price, production, investment, labor demand, and wage rate. The labor demand equations are thus based on the assumption that the production decision has already been made. Were it not for the adjustment costs of changing employment, the optimal level of employment would merely be the amount needed to produce the output of the period, but, because of these costs, excess labor may be held during certain periods. In the theoretical model there was no need to postulate explicitly how employment deviates from the amount required to produce the output, but this must be done for the empirical work.

The estimated demand-for-workers equation is based on the following three equations:

$$(2) \qquad \Delta \log J = \alpha_0 \log \frac{J_{-1}}{J^*_{-1}} + \alpha_1 \Delta \log Y + \alpha_2 \Delta \log Y_{-1} + \alpha_3 \Delta \log Y_{-2},$$

$$(3) \qquad J^*_{-1} = JHMIN_{-1}/H^*_{-1},$$

$$(4) \qquad H^*_{-1} = \overline{H} e^{\delta t},$$

where $JHMIN$ is the number of worker hours required to produce the output of the period, H^* is the average number of hours per worker that the firm would like to be worked if there were no adjustment costs, and J^* is the number of workers the firm would like to employ if there were no adjustment costs. The term $\log(J_{-1}/J^*_{-1})$ in equation (2) will be referred to as the (logarithmic) "number of excess workers" on hand. Equation (2) states that the change in the demand for workers is a function of the number of excess workers on hand and three change-in-output terms (all changes are changes in logs). If output has not changed for three periods and if there are no excess workers on hand, the change in workers employed is zero. The change-in-output terms are means in part to be proxies for expected future output changes. Equation (3) defines the desired number of workers, which is simply equal to the required number of worker hours divided by the desired number of hours worked per worker. Equation (4) postulates that the desired number of hours worked is a smoothly trending variable, where $\overline{H}$ and δ are constants.

Combining equations (2)–(4) yields

$$\text{(5)}\quad \Delta\log J = \alpha_0\log\overline{H} + \alpha_0\log\frac{J_{-1}}{JHMIN_{-1}} + \alpha_0\delta t + \alpha_1\Delta\log Y + \alpha_2\Delta\log Y_{-1} + \alpha_3\Delta\log Y_{-2}.$$

This equation was estimated by two-stage least squares under the assumption of first-order serial correlation of the error term for the 1954:I–1982:III period. The estimated equation is (t-statistics in absolute value are shown in parentheses):[1]

$$\text{(6)}\quad \Delta\log J = \underset{(3.76)}{-.885} - \underset{(3.75)}{.141}\log\frac{J_{-1}}{JHMIN_{-1}} + \underset{(4.28)}{.000176t} + \underset{(8.33)}{.281}\Delta\log Y + \underset{(3.03)}{.119}\Delta\log Y_{-1} + \underset{(1.02)}{.033}\Delta\log Y_{-2} - \underset{(2.70)}{.00967}D593 + \underset{(0.50)}{.00174}D594$$

$$SE = .00355,\ R^2 = .780,\ D\text{-}W = 2.04,\ \hat{\rho} = \underset{(4.44)}{.447}$$

where $D593$ and $D594$ are dummy variables for the 1959 steel strike. The estimated value of α_0 is $-.141$, which means that, other things being equal, 14.1 percent of the number of excess workers on hand is eliminated each quarter. The implied value of $\overline{H}$ is 531.97, which at a weekly rate is 40.92 hours. The implied value of δ is $-.00125$. The trend variable t is equal to 9 for the first quarter of the sample period (1954:I), and so the implied value of H^*_{-1} for 1954:I at a weekly rate is $40.92\cdot\exp(-.00125\times 9) = 40.46$. For 1982:III, t is equal to 123, and so the implied value for this quarter is $40.92\cdot\exp(-.00125\times 123) = 35.09$. In general these numbers seem reasonable.

The estimated demand-for-hours equation is based on equations (3), (4), and the following equation:

$$\text{(7)}\quad \Delta\log H = \lambda\log(H_{-1}/H^*_{-1}) + \alpha_0\log(J_{-1}/J^*_{-1}) + \alpha_1\Delta\log Y.$$

The first term on the right-hand side of equation (7) is the (logarithmic) difference between the actual number of hours paid for per worker in the previous period and the desired number. The reason for the inclusion of this term in the demand-for-hours equation but not in the demand-for-workers equation is that, unlike J, H fluctuates around a slowly trending level of hours. This restriction is captured by the first term in (7). The other two terms are the number of excess workers on hand and the current change in output. Both of these terms have an important effect on the demand-for-workers decision, and they should also affect the demand-for-hours decision since the two decisions are closely related. Past output changes might also be expected to affect the demand-for-hours decision, but these were not found to be significant and so are not included in (7).

Combining (3), (4), and (7) yields

$$\text{(8)}\quad \Delta\log H = (\alpha_0-\lambda)\log\overline{H} + \lambda\log H_{-1} + \alpha_0\log\frac{J_{-1}}{JHMIN_{-1}} + (\alpha_0-\lambda)\delta t + \alpha_1\Delta\log Y.$$

The estimated equation is

$$\text{(9)}\quad \Delta\log H = \underset{(4.95)}{1.37} - \underset{(5.16)}{.284}\log H_{-1} - \underset{(3.55)}{.0659}\log\frac{J_{-1}}{JHMIN_{-1}} - \underset{(4.94)}{.000250t} + \underset{(4.40)}{.120}\Delta\log Y$$

$$SE = .00285,\ R^2 = .398,\ D\text{-}W = 2.18.$$

The estimated value of λ is $-.284$, which

[1] The first-stage regressors that were used for this work are presented in Table 6-1 in my earlier study (1984). The same holds for equation (9) below.

means that, other things being equal, actual hours per worker are adjusted towards desired hours by 28.4 percent per quarter. The excess workers variable is significant, with an estimated value of α_0 of $-.0659$. The implied value of $\bar{H}$ is 534.60, which is 41.12 hours at a weekly rate. This compares closely to the value of 40.92 implied by equation (6). The implied value of δ is $-.00115$, which compares closely to the value of $-.00125$ implied by equation (6). No attempt was made to impose the restriction that $\bar{H}$ and δ are the same in equations (6) and (9). Given the closeness of the estimates, it is unlikely that imposing this restriction would make much difference.

The significance of the excess workers variable in equations (6) and (9) provides support for the excess labor hypothesis. It seems unlikely that a variable like this would be significant if firms never or seldom held excess labor.

II. Comparison

The main concern of this paper is whether the above aggregate empirical results are consistent with the Medoff-Fay micro results. Before making this comparison, various concepts of "excess" labor need to be reviewed. Medoff and Fay distinguish between regular production work and other work. Much of the other work is maintenance. They find that at its trough in output the typical plant paid for about 8 percent more hours than were needed for regular production work. About 3 of this 8 percent was used for worthwhile other work, which means that about 5 percent of the hours was truly hoarded. Firms appear to shift at least some maintenance work from high-output to low-output periods.

For the aggregate work above there is no distinction between regular production work and other work. Within this framework there are two concepts of excess labor. One is J/J^*, which is the ratio of the actual number of workers to the long-run desired number. The other is $(J \cdot H)/JHMIN$, which is the ratio of total worker hours paid for to the total number required to produce the output. Note that J/J^* equals $(J \cdot H^*)/JHMIN$, where H^* is the long-run desired number of hours worked per worker. J/J^* measures how far the firm is from its long-run desired number of workers. It seems to be the appropriate "excess labor" variable to use in the labor demand equations, and it has been so used. $(J \cdot H)/JHMIN$, on the other hand, measures the number of hours paid for but not worked, and it seems to be the appropriate variable to compare to the Medoff-Fay estimates. It will be called the "percentage of excess hours."

If maintenance work is shifted from high- to low-output periods, then $JHMIN$ is a misleading estimate of worker hour requirements. In a long-run sense, $JHMIN$ is too low because it has been based on the incorrect assumption that the peak productivity values could be sustained over the entire business cycle. This error is not a serious one from the point of view of estimating the labor demand equations (6) and (9) above. If the same percentage error has been made at each peak, which is likely to be approximately the case, the error will merely be absorbed in the estimates of the constant term in the two equations. It does mean, however, that $(J \cdot H)/JHMIN$ should not be compared to the Medoff-Fay concept of hoarded hours (i.e., to the 5 percent number). It is likely to be closer to the Medoff-Fay concept of hours in excess of regular production work (i.e., to the 8 percent number). The 8 percent number, like the peak-to-peak interpolation work, does not account for maintenance that is shifted from high- to low-output periods.

One final point should be noted before making the comparison. The aggregate estimates are based on the assumption of constant short-run returns to labor. If there are in fact decreasing short-run returns, then, other things being equal, $JHMIN$ will overestimate worker-hour requirements in low-output periods. This is because in off-peak output periods the values of λ estimated from the peak-to-peak interpolations will be lower than the true values. The Medoff-Fay results show some evidence in favor of decreasing returns to labor. The results are not very strong, however, and they do not put any stress on them. There is no obvious way

TABLE 1—ACTUAL AND PREDICTED VALUES OF $(J \cdot H)/JHMIN$

Quarter	Actual	Predicted	Quarter	Actual	Predicted	Quarter	Actual	Predicted
54:I	1.022	1.020	63:III	1.026	1.026	73:I	1.000	1.009
54:II	1.021	1.026	63:IV	1.024	1.026	73:II	1.013	1.018
54:III	1.008	1.020	64:I	1.012	1.022	73:III	1.015	1.019
54:IV	1.006	1.016	64:II	1.019	1.024	73:IV	1.014	1.018
55:I	1.000	1.008	64:III	1.022	1.027	74:I	1.033	1.031
55:II	1.003	1.013	64:IV	1.026	1.029	74:II	1.031	1.031
55:III	1.011	1.015	65:I	1.018	1.019	74:III	1.042	1.038
55:IV	1.028	1.021	65:II	1.021	1.020	74:IV	1.045	1.046
56:I	1.033	1.033	65:III	1.013	1.019	75:I	1.044	1.058
56:II	1.042	1.035	65:IV	1.007	1.014	75:II	1.023	1.042
56:III	1.047	1.041	66:I	1.000	1.012	75:III	1.011	1.027
56:IV	1.043	1.037	66:II	1.008	1.021	75:IV	1.018	1.027
57:I	1.038	1.038	66:III	1.012	1.024	76:I	1.013	1.020
57:II	1.044	1.044	66:IV	1.013	1.026	76:II	1.012	1.022
57:III	1.047	1.044	67:I	1.020	1.032	76:III	1.013	1.024
57:IV	1.049	1.057	67:II	1.013	1.032	76:IV	1.011	1.023
58:I	1.054	1.071	67:III	1.015	1.030	77:I	1.000	1.013
58:II	1.047	1.062	67:IV	1.015	1.029	77:II	1.009	1.011
58:III	1.037	1.046	68:I	1.014	1.030	77:III	1.003	1.009
58:IV	1.032	1.035	68:II	1.010	1.024	77:IV	1.015	1.017
59:I	1.038	1.036	68:III	1.010	1.025	78:I	1.016	1.018
59:II	1.048	1.029	68:IV	1.015	1.029	78:II	1.017	1.006
59:III	1.055	1.034	69:I	1.028	1.028	78:III	1.019	1.011
59:IV	1.053	1.034	69:II	1.031	1.031	78:IV	1.017	1.009
60:I	1.043	1.028	69:III	1.038	1.035	79:I	1.024	1.014
60:II	1.065	1.041	69:IV	1.048	1.043	79:II	1.031	1.021
60:III	1.076	1.045	70:I	1.053	1.046	79:III	1.031	1.016
60:IV	1.084	1.052	70:II	1.051	1.045	79:IV	1.032	1.021
61:I	1.075	1.048	70:III	1.037	1.041	80:I	1.030	1.022
61:II	1.049	1.038	70:IV	1.046	1.051	80:II	1.044	1.044
61:III	1.052	1.037	71:I	1.025	1.033	80:III	1.043	1.037
61:IV	1.043	1.027	71:II	1.028	1.036	80:IV	1.045	1.031
62:I	1.044	1.028	71:III	1.024	1.037	81:I	1.030	1.019
62:II	1.043	1.028	71:IV	1.032	1.035	81:II	1.039	1.030
62:III	1.038	1.030	72:I	1.028	1.026	81:III	1.037	1.028
62:IV	1.033	1.033	72:II	1.018	1.021	81:IV	1.046	1.040
63:I	1.038	1.033	72:III	1.015	1.022	82:I	1.055	1.048
63:II	1.035	1.029	72:IV	1.011	1.017	82:II	1.050	1.041
						82:III	1.047	1.040

Note: Root mean squared error = .011. The predicted values are from a dynamic simulation that begins in 1954:I. The model consists of equations (6) and (9). Y and $JHMIN$ ($= Y/\lambda$) are exogenous.

to test the constant returns hypothesis using the aggregate data, and so it has simply been assumed to be true. One should be aware, however, that $JHMIN$ will be biased upward if there are decreasing returns.

One thing that can be done to compare the results is simply look at the actual values of $(J \cdot H)/JHMIN$ over the business cycle. Another is to see what the model predicts these values to be. This information is presented in Table 1. The model consists of equations (6) and (9). Y and $JHMIN$ ($= Y/\lambda$) are exogenous. The predicted values in Table 1 are for a dynamic simulation for the 1954:I–1982:III period. The results in Table 1 show, first of all, that the model fits the data well. The predicted values are based on a dynamic simulation of 115 quarters in length, and the root mean squared error over the entire period is only .011.

Consider now the actual values in Table 1. There are two possible troughs that are rele-

TABLE 2—PREDICTED VALUES OF $(J \cdot H)/JHMIN$ FOR ALTERNATIVE OUTPUT PATHS

Quarter	Output Change	$\frac{J \cdot H}{JHMIN}$ Change	Output Change	$\frac{J \cdot H}{JHMIN}$ Change	Output Change	$\frac{J \cdot H}{JHMIN}$ Change
78:I	−1.0	.61	−2.0	1.22	−4.0	2.48
78:II	−2.0	.97	−4.0	1.99	−8.0	4.12
78:III	−3.0	1.26	−6.0	2.58	−8.0	2.67
78:IV	−4.0	1.49	−8.0	3.10	−8.0	2.08
79:I	−4.0	1.07	−8.0	2.20		

Notes: Output Change$=100 \cdot ((\text{new } Y/\text{old } Y)-1)$;
$(J \cdot H)/JHMIN$ Change$=100 \cdot (\text{new } J \cdot H/JHMIN/\text{old } J \cdot H/JHMIN-1)$.

vant for the Medoff-Fay study, the one in mid-1980 and the one in early 1982. The first survey upon which the Medoff-Fay results are based was done in August 1981, and the second (larger) survey was done in April 1982. A follow-up occurred in December 1982. The plant managers were asked to answer the questionnaire for the plant's most recent trough. For the last responses the trough might be in 1982, whereas for the earlier ones the trough is likely to be in 1980. Table 1 shows that in 1980 the percentage of excess hours reached a high of 4.5 percent in the fourth quarter. In 1982 it reached a high of 5.5 percent in the first quarter. The percentages in earlier troughs are 5.4 in 1958:I, 8.4 in 1960:IV, 5.3 in 1970:I, and 4.5 in 1974:IV.

The Medoff-Fay estimate of 8 percent is thus compared to the 4.5 and 5.5 percent values in Table 1 for the two most recent trough quarters. These two sets of results seem consistent. There are at least two reasons for expecting the Medoff-Fay estimate to be somewhat higher. First, the trough in output for a given plant is on average likely to be deeper than the trough in aggregate output, since not all troughs are likely to occur in the same quarter across plants. (In the aggregate model, other things being equal, the deeper the trough, the larger will be the predicted percentage of excess hours, and the comparison of the two sets of results has not adjusted for different size troughs.) Second, the manufacturing sector may on average face deeper troughs than do other sectors, and the aggregate estimates in Table 1 are for the total private sector, not just manufacturing. One would thus expect the Medoff-Fay estimate to be somewhat higher than the aggregate estimates, and 8 percent versus a number around 5 percent seems consistent with this.

With respect to the predicted values in Table 1, in 1980 the predicted percentage of excess hours reached a high of 4.4 percent in the second quarter, and in 1982 it reached a high of 4.8 percent in the first quarter. These values compare fairly closely to the actual values.

One cannot get from the Medoff-Fay results estimates of the timing of the response of excess hours to output fluctuations. This can be done, however, with the aggregate equations. The results of three experiments are reported in Table 2. These experiments were performed as follows. First, the estimated residuals were added to equations (6) and (9) and treated as exogenous. This means that when the model is solved using the actual values of Y, perfect fits are obtained for J and H (and thus $J \cdot H$). Second, Y was changed and the model was solved for the new values of Y. Third, the new (predicted) values of $J \cdot H/JHMIN$ were compared to the old (actual) values to see the response of excess hours to the output changes. The simulation period began in 1978:I. All three simulations were dynamic. For the first experiment Y was lowered (from its actual value) by 1.0 percent in the first quarter, 2.0 percent in the second, 3.0 percent in the third, and 4.0 percent in the fourth and fifth. The second experiment was the same as the first except that the decreases were twice as large. For the third experiment Y was lowered by 4.0 percent in the first quarter and 8.0 percent in the second, third, and fourth.

The results in Table 2 show that, for the first experiment, excess hours reached a high of 1.49 percent in the fourth quarter. For the second experiment, the high was 3.10 percent in the fourth quarter. The values for the second experiment are only slightly more than twice as large as the values for the first, which means that the excess-hours response to output fluctuations is not very nonlinear with respect to the size of the changes. The response is, however, quite nonlinear with respect to the timing of the changes. For the third experiment compared to the second experiment, output was 8 percent lower by the second quarter rather than by the fourth quarter. Excess hours reached a high of 4.12 percent for the third experiment compared to a high of 3.10 percent for the second experiment.

Remember, of course, that these results are based on the particular specification of the aggregate model. If there are, for example, decreasing short-run returns to labor, then the increase in excess labor due to the fall in output will have been underestimated. Also, the model does not account for the possibility that the response of firms in eliminating excess labor is larger the larger is the fall in output. If firms begin to decrease employment drastically for very large downturns, the percentage of excess labor may actually fall as downturn size increases, and the model is not capable of capturing this. It is unlikely that one would be able to pick up a response shift like this in the aggregate data.

III. Conclusion

The Medoff-Fay results seem consistent with the aggregate estimates, which is further evidence in favor of the excess labor hypothesis. This hypothesis has important implications for the production function and investment literature. Much of this literature is based on the assumption that firms are always "on" their production functions. If they are not and if in fact the amount of worker hours hoarded during contractions, even after adjusting for worthwhile nonproduction work, is as much as 5 percent of total worker hours, it is not clear that estimates of production parameters and investment behavior that are based on the assumption of no hoarding are trustworthy.

REFERENCES

Fair, Ray C., *The Short-Run Demand for Workers and Hours*, Amsterdam: North-Holland, 1969.

______, *Specification, Estimation, and Analysis of Macroeconometric Models*, Cambridge: Harvard University Press, 1984.

Medoff, James L. and Jon A. Fay, "Labor and Output over the Business Cycle: Some Direct Evidence," *American Economic Review*, forthcoming 1985.