NBER WORKING PAPER SERIES

LABOR PRODUCTIVITY DURING THE GREAT DEPRESSION

Michael D. Bordo

Charles L. Evans

Working Paper No. 4415

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 1993

We have benefitted from comments by Ben Bernanke and Robert Margo. The views expressed in this paper do not necessarily reflect the views of the Federal Reserve Bank of Chicago or the Federal Reserve System. This paper is part of NBER's research programs in Historical Factors in Long Run Growth and Monetary Economics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #4415
August 1993

LABOR PRODUCTIVITY DURING THE GREAT DEPRESSION

ABSTRACT

In a recent paper, Bernanke and Parkinson (1991) studied interwar U.S. manufacturing data with the objective of assessing competing theories of the business cycle. An important finding was that short-run increasing returns to Labor (SRIRL), or procyclical labor productivity, was at least as strong during the Great Depression as in the postwar period. The authors conclude that this information casts further doubt on the real business cycle explanation of economic fluctuations.

The purpose of this note is to point out that, within the data set analyzed by Bernanke and Parkinson (20% of the manufacturing sector), labor productivity during the Great Depression (1928:III to 1933:I) was procyclical in some industries and countercyclical in others. Furthermore, our measure of labor productivity for the entire manufacturing sector during this period was countercyclical. We conclude that the evidence is not favorable toward the hypothesis that large, negative aggregate demand shocks pushed the 1929-33 economy down a static, neoclassical production function. Another possibility is that firms which typically hoarded labor during recessions chose not to do so during the 1929-33 period.

Michael D. Bordo
Department of Economics
Rutgers University
New Brunswick, NJ 08903
and NBER

Charles L. Evans
Research Department
Federal Reserve Bank of Chicago
P.O. Box 834
Chicago, IL 60690

In a recent paper, Bernanke and Parkinson (1991) studied interwar U.S. manufacturing data with the objective of assessing competing theories of the business cycle. An important finding was that short-run increasing returns to labor (SRIRL), or procyclical labor productivity, was at least as strong during the Great Depression as in the postwar period. The authors conclude that this information casts further doubt on the real business cycle explanation of economic fluctuations. Their argument can be summarized as follows. Suppose that the Great Depression was not caused by a series of technology shocks; instead, suppose that the cause was a series of aggregate demand shocks. This is a plausible identifying assumption. In this situation, a refutable implication of many neoclassical models with static production technologies is that labor productivity should be countercyclical.[1] A finding of procyclical labor productivity during this period is problematic for these theories. As Bernanke and Parkinson describe the implications of their analysis, "this [procyclical labor productivity] constitutes a strong rejection of the technological shock theory of SRIRL and, consequently, of the real business cycle approach [p. 441]." This leaves theories of labor hoarding and increasing returns as the prime remaining candidates.[2]

---

[1]For example, Christiano and Eichenbaum (1992) find the introduction of stochastic government purchases shocks leads to countercyclical labor productivity (in the absence of technology shocks).

[2]A theoretical difficulty with this line of argument is that labor hoarding and increasing returns can be accomodated within equilibrium models of the business cycle, as in Burnside, Eichenbaum, and Rebelo (1993) and Braun and Evans (1991). In each of these models, the researchers study a demand shock which leads to procyclical productivity. Presumably, the evidence against the real business cycle approach refers to models of the type popularized by Kydland and Prescott (1982), Prescott (1986), Hansen (1985), and Christiano and Eichenbaum (1992); explicit mention is also made to Lucas and Rapping (1969).

The purpose of this note is to point out that, within the data set analyzed by Bernanke and Parkinson (20% of the manufacturing sector), labor productivity during the Great Depression (1929:III to 1933:I) was procyclical in some industries and countercyclical in others. Furthermore, our measure of labor productivity for the entire manufacturing sector during this period was countercyclical. We conclude that the evidence is not unfavorable toward the hypothesis that large, negative aggregate demand shocks pushed the 1929-33 economy down a static, neoclassical production function. Another possibility is that firms which typically hoarded labor during recessions chose not to do so during the 1929-33 period.

While labor hoarding is likely to be an important factor in explaining procyclical labor productivity during relatively brief economic downturns, it is less likely to be important during deep and prolonged reductions in economic activity. Labor hoarding during a recession is often defined as a firm holding "excess labor" temporarily until the economy rebounds, in an effort to mitigate the costs of adjusting employment rapidly in both directions.[3] While this phenomena seems imminently plausible for postwar recessions, the length and severity of the Great Depression (1929-33) suggests that the costs of adjusting employment and honoring implicit long-term employment contracts were second-order relative to the losses that many firms and industries experienced. If this was the case, labor hoarding mechanisms would merely mitigate the countercyclical effects on productivity, not eliminate them. Thus, a finding that labor productivity was countercyclical during this brief period need not refute the hypothesis that firms tended to hoard labor at other times during the interwar period.

[3]The term "excess labor" is relative to some target level of employment which the firm would desire in the absence of adjustment costs. Textbook definitions of labor hoarding can be found in Dornbusch and Fischer (1987, pp 478-479) and Hall and Taylor (1991, p. 96).

Increasing returns theories can generate a positive correlation between output and labor productivity in response to aggregate demand shocks, but the initial response will not necessarily be procyclical. For example, suppose that the production function is Cobb-Douglas, the factors of production are labor and capital, and that within a period the capital stock is fixed. Then, if the production function is concave with respect to the labor input, a negative demand shock which reduces labor and output will lead to an increase in labor productivity (countercyclical). However, if the increasing returns are sufficiently large, so that the production function is not concave in labor, then productivity will fall (procyclical). Therefore, a finding of procyclical labor productivity during the 1929-33 period is more likely to be a strong indication of increasing returns rather than labor hoarding.

Firms' behavior during the period 1929-33 is critical because the identifying assumption that technology shocks did not cause the Great Depression is a statement about 1929-33, not pre-1929 and probably not post-1933. Our method of assessing the cyclicality of labor productivity differs from the analysis in Bernanke and Parkinson. Bernanke and Parkinson infer that labor productivity is procyclical from production function estimates. Assuming a Cobb-Douglas production function, they estimate the following equation:

$$\Delta y_t = \theta \, \Delta n_t + \varepsilon_t$$

where Δy and Δn are the growth rates of output and labor hours, ε_t is an error term, and a constant term has been suppressed. Table 1 reports Bernanke and Parkinson's Ordinary Least Squares estimates of θ for eight manufacturing industries which collectively account for 20% of total manufacturing during this period (from their Table 2, column 1, p. 447).[4] Under the identifying assumption that technology shocks are approximately negligible during this period, the procyclicality of labor productivity can be inferred from the estimates of θ: $\theta>1$ implies productivity is positively correlated with labor hours (and output), $\theta<1$ implies countercyclical productivity. Using this method of analysis, over the period 1929-39, six of the eight industries exhibited procyclical productivity (Petroleum and Leather exhibited countercyclical productivity).

Computing the correlation between output and labor productivity provides a more direct perspective on these data's comovements. Alternative definitions of trend and cycle are easily accomodated and a simple assessment of the immediate period of interest (1929-33) is facilitated. To compute the correlations, the output and labor productivity data are detrended. Our detrending procedures place more weight on business cycle frequency movements than Bernanke and Parkinson. Their use of the first-difference filter tends to place more weight on high frequency movements in the data. We detrended the logarithms of output and average labor productivity data[5] using either the Hodrick-Prescott filter or a linear deterministic trend.[6] Both filters place more weight on lower, business-cycle frequency movements than the first difference

[4]As Bernanke and Parkinson report, their results are not sensitive to whether θ is estimated by OLS or Instrumental Variables, nor whether or not the growth rate of capital is included in the production function. Two other industries studied by Bernanke and Parkinson (Stone-Clay-Glass and Nonferrous metals) are omitted from our study since the data do not cover the period of interest, 1929-33.

[5]The original Bernanke-Parkinson data are seasonally unadjusted. We seasonally adjusted the output and labor productivity data using the RATS implementation of the Census X-11 filter (EZ-X11).

[6]For many series, the Hodrick-Prescott trend series turns down during the Great Depression. The linear trend does not. The correlations across each filter are quite similiar, indicating that the Hodrick-Prescott filter per se is not the reason for these results.

filter. Computing standard errors for these correlations requires taking into account the serial correlation properties of the error terms which are implicit in these calculations.[7] Table 1 reports the contemporaneous correlations and standard errors for three sample periods: 1924-1939, 1929-1939, and 1929:3-1933:1. In addition to the eight industries which account for only 20% of manufacturing, we also have examined data for total manufacturing.[8] First, notice that for the periods 1924-39 and 1929-39, the HP filter correlations agree qualitatively with the correlations implied by Bernanke and Parkinson's OLS estimates: six of the eight industries exhibit substantial procyclical productivity, with Petroleum and Leather being either acyclical (1924-39) or countercyclical (1929-39). Second, during the Great Depression four of the eight industries exhibited countercyclical labor productivity: Petroleum, Leather, Rubber, and Paper/Pulp. For our measure of the total manufacturing sector, labor productivity was also countercyclical. Third, despite the small number of observations for this period, the estimated standard errors indicate that labor productivity was significantly countercyclical in the Petroleum, Leather, Paper/Pulp, and total Manufacturing sectors. For the Rubber industry, the hypothesis of acyclicality cannot

[7] The estimator of the correlation is a just-identified GMM estimator. The error term in the GMM estimation which identifies the correlation ρ is given by $w_t=[(y_t-\mu_y)(x_t-\mu_x)/\sigma_y\sigma_x]-\rho$, where y and x are the output and labor productivity data. The parameters μ_y, μ_x, σ_y, and σ_x are estimated simultaneously with ρ: μ_y and μ_x are the means of y and x; σ_y and σ_x are the standard deviations of y and x. The instrument used to identify ρ in the w_t equation is unity. Standard errors are estimated with a Newey-West covariance estimator with four lags.

[8] The output data are industrial production from the Federal Reserve, and labor hours are from BLS (employment) and the NICB (average hours worked per week). Bernanke and Parkinson choose not to consider the total manufacturing data: their choice is motivated by an attempt to avoid aggregation bias and those industries whose production indices are based on scaled-up input measures (p. 444-445). If the measured manufacturing output is simply proportional to the labor input plus a measurement error term, then our estimated output-labor productivity correlation will be biased upward. In this situation, the bias would make it more difficult to find evidence of countercyclical productivity.

be rejected. For each of these five industry definitions, the degree of countercyclicality during this period appears to be greater than during the longer period of 1929-39. Recall that Bernanke and Parkinson concluded that labor productivity was at least as procyclical during this period as the postwar period.

Figures 1 and 2 display the cyclical behavior of output and labor productivity for each of the nine industrial sectors. Figures 1 and 2 display time series of output and labor productivity which have been detrended with the Hodrick-Prescott and linear filters, respectively. The shaded regions correspond to recessions as dated by the National Bureau of Economic Research. During the 1929-33 period, productivity is clearly countercyclical in the Petroleum, Leather, Paper/Pulp, Manufacturing, and (to a lesser extent) Rubber sectors. Productivity is below trend at or shortly after the business cycle peak in the third quarter of 1929. In each of these sectors, as output falls productivity rises above trend during this period. For these sectors the cyclical behavior of productivity is strikingly similar across the two detrending filters.

To examine the relative cyclicality of labor productivity in the subperiod 1929:3-1933:1 versus the full sample period 1924-39, we conducted a Chow test. The null hypothesis is that the output-labor productivity is the same over the entire sample 1924-39 versus the alternative hypothesis that the correlation during 1929:3-1933:1 differs from the correlation in 1924:1-1929:2 and 1933:2-1939:4 periods.[9] The final column of the table reports the marginal significance level

[9]For this test the error term in the GMM estimation which identifies the correlation(s) is given by $w_t=[(y_t-\mu_y)(x_t-\mu_x)/\sigma_y\sigma_x]-\rho_1-\rho_2 d_t$, where d_t is a dummy variable which takes on the value 1 during the period 1929:3 to 1933:1 and zero otherwise. The instruments used to identify ρ_1 and ρ_2 are unity and the dummy variable d_t. The parameters μ_y, μ_x, σ_y, and σ_x are estimated simultaneously with ρ_1 and ρ_2. Under the null hypothesis that the correlations are equal across both sample periods, $\rho_2=0$. This is the Chow test.

for rejecting the hypothesis that the correlations are equal during the period 1929-33 and the period 1924-39 (excluding 1929-33). The interesting cases are the five industries which appear to exhibit countercyclical productivity during the Great Depression period. For Petroleum, Paper/Pulp, and total Manufacturing, the null hypothesis of equal cyclicality can be rejected for both detrending filters at marginal significance levels ranging from 10% to 1%. For Leather the null hypothesis cannot be rejected: since the full sample correlation was negative, this indicates that labor productivity was equally countercyclical across the interwar period. For Rubber, the null hypothesis cannot be rejected, but the question remains as to whether this correlation is positive or negative. The evidence for the Rubber industry seems to indicate acyclical labor productivity.

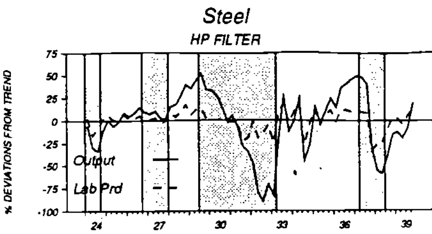
Other studies of this period provide corroborating evidence on the countercyclicality of labor productivity during the Great Depression. First, according to Margo (1993), real wages rose 16% from 1929-32. This would suggest that firms are moving up their marginal product of labor schedule and average productivity is rising (for a Cobb-Douglas technology). In arguing that the data are not collected in a way which is consistent with a homogeneous labor market, Margo notes that less productive workers with lower wages were laid off first. This observation alone, if true, would indicate that measured productivity was rising during this period. Second, Bernanke and Powell (1986) studied eight industrial labor markets during the interwar period and found that labor productivity at the trough (1933:1) was higher than at the peak (1929:3) for three of the five industry definitions considered in Table 1: Paper, Leather, and Lumber (Bernanke-Powell, Table 10.13, p. 615). A fourth industry, Petroleum, was not covered in the Bernanke and Powell study. For the fifth industry definition, total manufacturing, labor productivity was lower at the trough than the peak, but its behavior during that period was not detailed. On balance, these studies tend to support our findings.

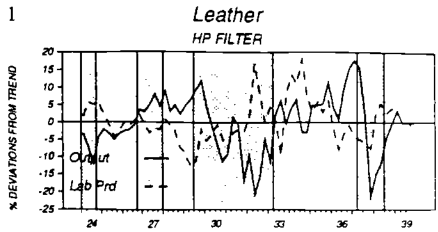
A finding that labor productivity was countercyclical during the period 1929-33 should not be viewed as surprising even if firms tended to hoard labor periodically during the period of 1924-39. In response to a large and persistent demand shock, firms may be quite willing to incur the costs of adjusting their workforce. In this case, the implications of a labor hoarding model may not be too different from a more standard neoclassical model. On the other hand, if increasing returns is an important factor in generating procyclical productivity from aggregate demand shocks in general, the countercylicality in total manufacturing is surprising. The practical significance of these findings is that researchers wishing to account for this turbulent period in the context of a dynamic economic model may find it useful to initially explore standard neoclassical production structures, and focus on the source of the demand and supply shocks.

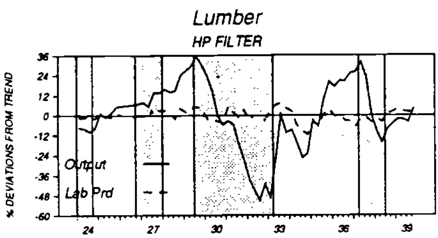
Table 1
Correlations of Output and Labor Productivity
Bernanke-Parkinson Data, Seasonally Adjusted (Census X-11)
Detrended by: (1) HP filter, (2) Linear Time Trend

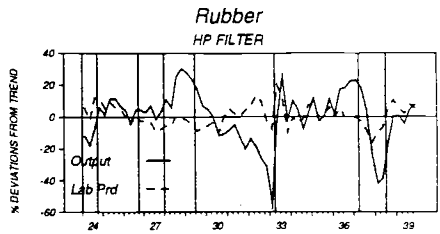
		BP Estimates of θ (OLS)	Correlation (y, y/n)			Chow Test Significance Levels
Industy	Filter	1924-39	1924-39	1929-39	1929:3-33:1	
Steel	HP filter	1.53	.79 (.03)	.77 (.05)	.61 (.24)	.39
	TS filter		.81 (.05)	.79 (.08)	.51 (.24)	.15
Lumber	HP filter	1.11	.20 (.19)	.14 (.19)	.24 (.22)	.77
	TS filter		.41 (.17)	.38 (.20)	.35 (.21)	.85
Auto	HP filter	1.26	.62 (.05)	.65 (.04)	.69 (.17)	.01
	TS filter		.63 (.04)	.67 (.03)	.62 (.19)	.03
Petroleum	HP filter	0.36	.04 (.26)	-.11 (.24)	-.48 (.18)	.01
	TS filter		.26 (.25)	-.06 (.21)	-.46 (.19)	.01
Textiles	HP filter	1.03	.88 (.03)	.87 (.04)	.54 (.11)	.59
	TS filter		.88 (.03)	.86 (.04)	.39 (.10)	.73
Leather	HP filter	0.61	-.27 (.15)	-.24 (.16)	-.56 (.16)	.25
	TS filter		-.24 (.15)	-.24 (.17)	-.50 (.16)	.52
Rubber	HP filter	1.21	.14 (.16)	.17 (.18)	-.18 (.27)	.41
	TS filter		-.09 (.17)	-.05 (.20)	-.31 (.26)	.44
Paper/Pulp	HP filter	1.10	.03 (.22)	-.03 (.24)	-.47 (.25)	.10
	TS filter		-.08 (.23)	-.08 (.22)	-.46 (.28)	.01
MFG	HP filter	not considered	-.08 (.22)	-.11 (.24)	-.67 (.15)	.01
	TS filter		-.42 (.21)	-.48 (.12)	-.40 (.17)	.10

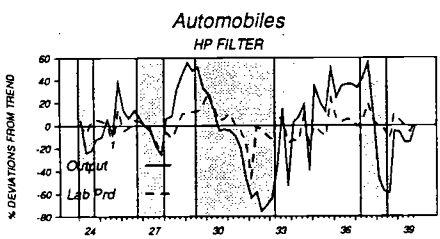
Figure 1

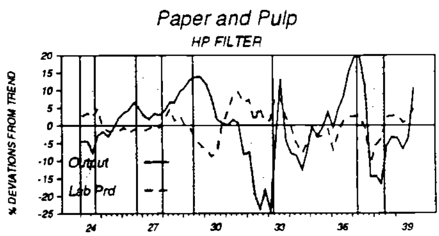

Steel
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd

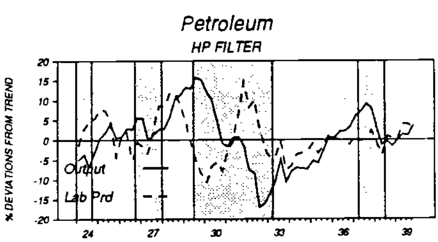

Leather
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd

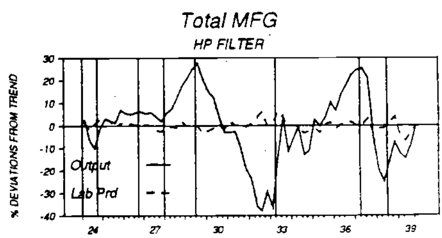

Lumber
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd


Rubber
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd


Automobiles
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd


Paper and Pulp
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd


Petroleum
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd


Total MFG
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd

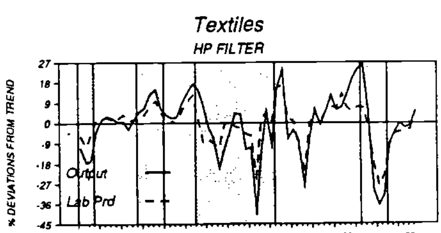
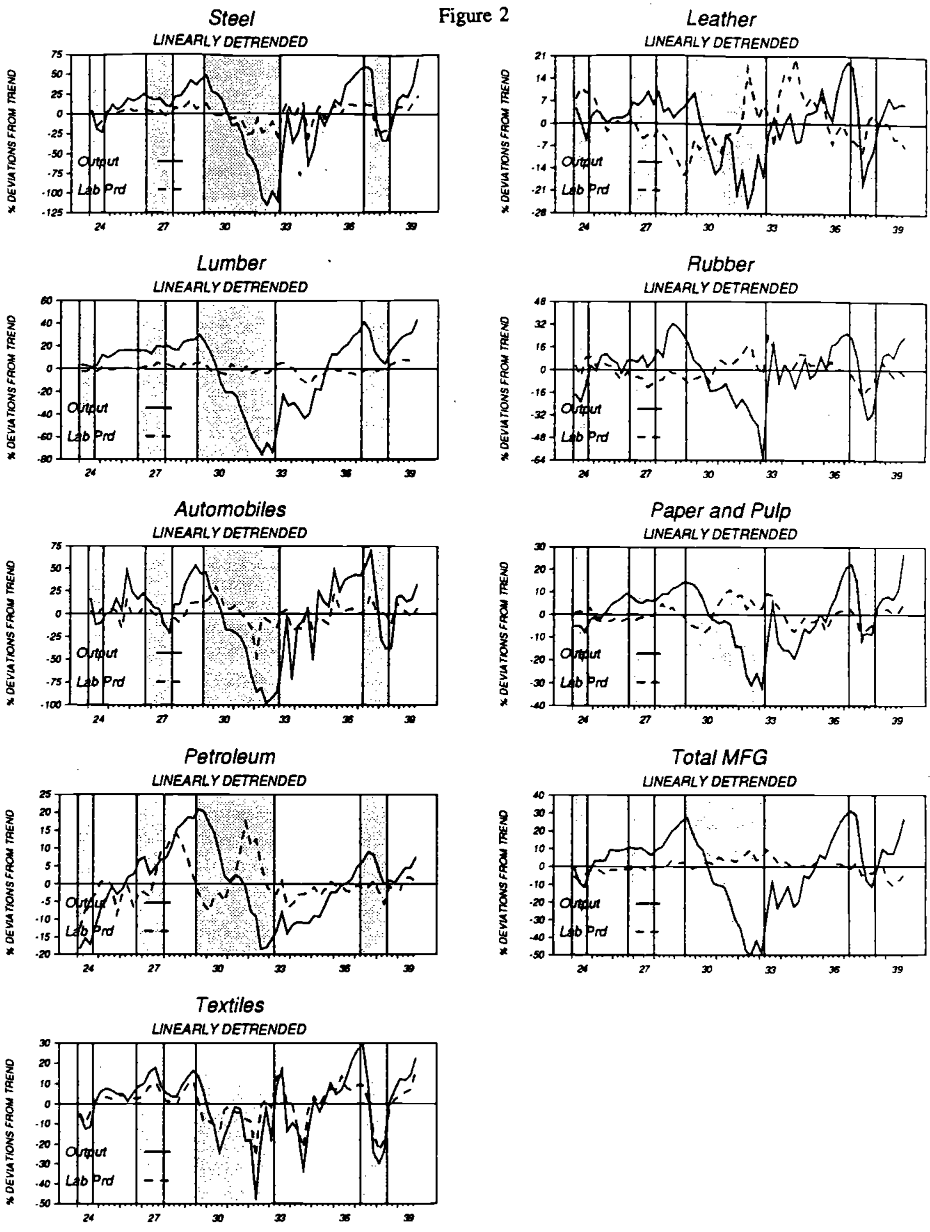

Textiles
HP FILTER
% DEVIATIONS FROM TREND
Output
Lab Prd

Figure 2


Steel
LINEARLY DETRENDED
Leather
LINEARLY DETRENDED
Lumber
LINEARLY DETRENDED
Rubber
LINEARLY DETRENDED
Automobiles
LINEARLY DETRENDED
Paper and Pulp
LINEARLY DETRENDED
Petroleum
LINEARLY DETRENDED
Total MFG
LINEARLY DETRENDED
Textiles
LINEARLY DETRENDED
% DEVIATIONS FROM TREND
Output
Lab Prd
24
27
30
33
36
39

References

Bernanke, B. and M. Parkinson, 1992, Procyclical Labor Productivity and Competing Theories of the Business Cycle: Some Evidence from Interwar U.S. Manufacturing Industries, *Journal of Political Economy 99*, 439-459.

Bernanke, B. and J. Powell, 1986, The Cyclical Behavior of Industrial Labor Markets: A Comparison of the Prewar and Postwar Eras, in: R. Gordon (editor), The American Business Cycle: Continuity and Change. Chicago: University of Chicago Press (for NBER).

Braun, R. and C. Evans, 1991, Seasonal Solow Residuals and Christmas: A Case for Labor Hoarding and Increasing Returns, Federal Reserve Bank of Chicago, WP-91-20.

Burnside, C., M. Eichenbaum, and S. Rebelo, 1993, Labor Hoarding and the Business Cycle, *Journal of Political Economy* 101, 245-273.

Caballero, R. and R. Lyons, 1992, External effects in U.S. procyclical productivity, *Journal of Monetary Economics 29*, 209-226.

Christiano, L. and M. Eichenbaum, 1992, Current Real Business Cycle Theories and Aggregate Labor Market Fluctuations, *American Economic Review* 82, 430-450.

Dornbusch, R. and S. Fischer, 1987, Macroeconomics, McGraw-Hill, Fourth Edition.

R. Hall and J. Taylor, 1991, Macroeconomics, Norton, Third Edition.

Hansen, G., 1985, Indivisible Labor and the Business Cycle, *Journal of Monetary Economics* 16, 309-327.

Hansen, L., 1982, Large Sample Properties of Generalized Method of Moments Estimators, *Econometrica* 50, 1029-1054.

Hodrick, R. and E. Prescott, 1980, Post-war U.S. Business Cycles: An Empirical Investigation, manuscript, Carnegie-Mellon University.

Kydland, F. and E. Prescott, 1982, Time to Build and Aggregate Fluctuations, *Econometrica* 50, 1345-1370.

Lucas, R. and L. Rapping, 1969, Real Wages, Employment and Inflation, *Journal of Political Economy 77*, 721-754.

Margo, R., 1993, Employment and Unemployment in the 1930s, *Journal of Economic Perspectives* 7, 41-59.

Newey, W. and K. West, 1987, A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, *Econometrica 55*, 703-708.

Prescott, E., 1986, Theory Ahead of Business Cycle Measurement, Carnegie-Rochester conference series on Public Policy 25, 11-44.