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ARE BUSINESS CYCLES SYMMETRIC?

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ABSTRACT

This note shows that contrary to widespread belief there is little evidence that the business cycle is asymmetric. Using American data for the pre- and post-war periods and data on five other major OECD nations for the post-war period, we are unable to support the hypothesis that contractions are shorter and sharper than expansions. We conclude that there is not much basis for preferring some version of traditional cyclical techniques to more modern statistical methods.

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The dating of peaks and troughs and the concommitant emphasis on the different qualitative mechanisms involved in cyclical expansions and contractions have been major features of the NBER program on business cycle research. Asymmetry between expansions and contractions has long been a focus of such business cycle research. Thus Wesley Mitchell wrote in 1927, "the most violent declines exceed the most considerable advances. . . . Business contractions appear to be a briefer and more violent process than business expansions." Keynes wrote in the General Theory that "the substitution of a downward for an upward tendency often takes place suddenly and violently . . . no such sharp turning point occurs when an upward is substituted for a downward tendency." Indeed, Neftci (1984) states that "the claim that major economic time series are asymmetric over different time phases of the business cycle arises in almost all major works on business cycles."

In many respects the techniques of modern statistics and econometrics surely supersede earlier methods of cyclical analysis. They make possible the application of techniques of statistical estimation and inference. They remove the need for judgment in data description. And they provide a rigorous basis for non-judgmental forecasting. Yet, statistical models of the sort used in economics--whether built in the structural spirit of the Cowles Commission or in the more modern time series tradition--are entirely unable to capture cyclical asymmetries. If, as Keynes, Mitchell, and others believed, cyclical asymmetries are of fundamental importance, then standard statistical techniques are seriously deficient. Something like traditional business cycle analysis may then be necessary to provide an adequate empirical basis for theorizing about cyclical behavior.

Hence, the question of the magnitude of cyclical asymmetries seems to be of substantial methodological importance. Yet, with the exception of the work of Neftci (1984), it appears to have attracted relatively little attention. This paper

examines the extent of cyclical asymmetries using American data for the pre-war and post-war periods and data on five other major OECD nations for the post-war period. We find no evidence of asymmetry in the behavior of GNP or industrial production. For the U.S. only, we find evidence of some asymmetry in the behavior of unemployment. We conclude that asymmetry is probably not a phenomenon of first order importance in understanding business cycles. It appears that there is not much basis for preferring some version of traditional cyclical techniques of analysis and forecasting to more modern statistical methods.

Section II of this note describes our methods and presents the results of our analysis of GNP and industrial production. Section III follows Neftci (1984) in considering unemployment. We note some methodological problems we have with his analysis and then show that his conclusions about the behavior of unemployment appear to be invalid outside the U.S. Section IV provides some brief conclusions.

II. Asymmetries in Output?

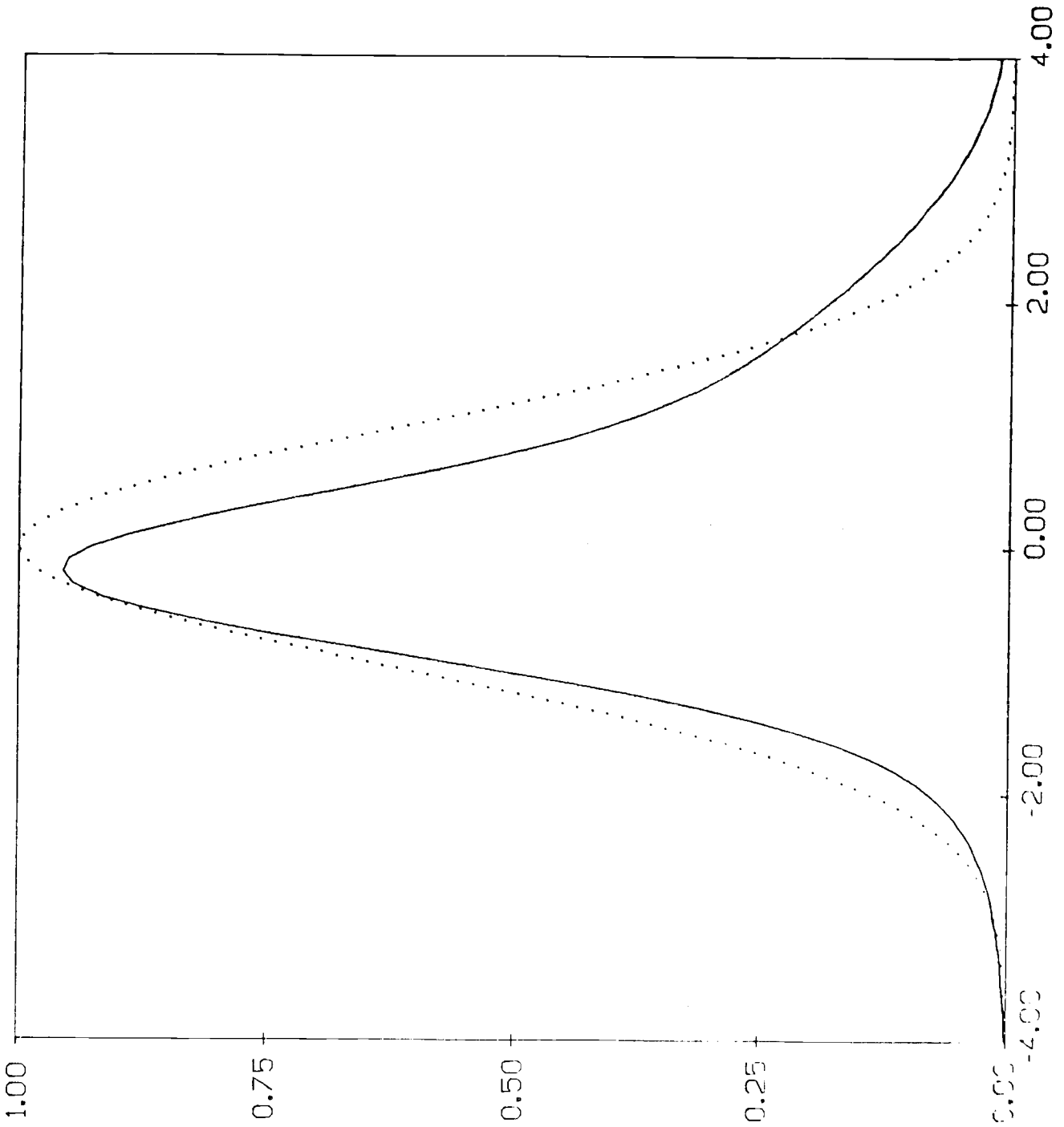
The essence of the claims of Keynes and Mitchell quoted in the previous section was that economic downturns are brief and severe relative to trend, while upturns are longer and more gradual. This hypothesis has a clear implication: there should be significant skewness in a frequency distribution of periodic growth rates of output. That is, the distribution should have significantly fewer than half its observations below its mean; and the average deviation from the mean of the observations below the mean should be significantly more than the average deviation of the observations above the mean. The median output growth rate should exceed the mean by a significant amount. Figure 1 depicts the predicted frequency distribution of output growth under the null hypothesis of symmetry and under the alternative hypothesis of Keynes and Mitchell.

Our procedure is simple: it is to calculate the coefficient of skewness of the distribution of output growth rates for a variety of output measures and time intervals. The coefficient of skewness is defined as the ratio of the third centered moment to the cube of the standard deviation. For a symmetric distribution, the coefficient of skewness is zero, and the mean equals the median.

Evaluation of the statistical significance of any measured deviations from symmetry clearly requires an estimate of the sampling variability in our estimates of skewness. Standard statistical works such as Kendall and Stuart (1969) note that under the null hypothesis of zero skewness, the estimated skewness of a set of n independent random normal observations is normally distributed with a standard error of $(6/n)^{\frac{1}{2}}$. Unfortunately, the observations on growth rates considered here are highly serially correlated, and so this formula is inapplicable. We therefore used the following Monte Carlo procedure for each series and sample period considered. First, a third-order autoregressive process was estimated for

Figure 1

Standardized (Zero Mean and Unit Variance) Distributions
with Zero and Unit Skewness, Respectively



the time series of growth rates. It was then used to generate 300 artificial series for the sample period under the assumption that the shocks to the autoregressive process were normally distributed. The standard deviation of the estimated skewness under the null hypothesis was then used calculated as the standard deviation of the skewnesses of the artificially generated series.[1]

Table 1 presents some evidence on skewness in quarterly and annual growth rates of U.S. GNP and industrial production for various sample periods. We use industrial production as well as GNP because the latter contains a greater number of imputed series, and because cyclicality is most apparent in the manufacturing sector of the economy. Because quarterly data is complicated by the need for seasonal adjustment and by high-frequency movements that might render existing skewness undetectable, both annual and quarterly data are examined.

Very little evidence of significant asymmetries emerges. Before World War II, quarterly GNP growth rates exhibit positive skewness, the opposite of that implied by the hypotheses of Keynes and Mitchell. The failure of the steep 1929-1933 decline to dominate the interwar period is somewhat surprising. We expected significant skewness to be most apparent around the Great Depression. Similar conclusions are obtained with annual GNP data and with data on annual industrial production for the pre-war period. Asymmetries do not appear to be substantial enough to be important. The difference between the median and mean growth rates reaches a maximum of .3% using quarterly data on industrial production for the post-war period. This difference is only 2% of the interquartile range of the distribution of quarterly growth rates: it is a very small number.

There is a little bit of evidence in favor of skewness in post-war data. All the estimated skewnesses are negative, as predicted by Keynes and Mitchell. In the case of annual GNP data, the estimated skewness approaches statistical significance. However, no equivalent result is found with either quarterly GNP or

Table 1

Skewness of U.S. GNP and Industrial Production Growth Rates

		Annual Data		Quarterly Data	
Variable	Period	Skewness	Standard Error	Skewness	Standard Error
GNP	1891-1915	-.47	.73	.55	.29
GNP	1923-1940	-.70	1.12	.04	.42
GNP	1949-1983	-1.37	.74	-.33	.29
IP	1949-1983	-.55	.68	-.58	.40

Data from Gordon (1982) and from the 1984 Business Conditions Digest.

annual industrial production data. Hence we are inclined to discount its significance. It is of course possible that with longer time series significant asymmetries would emerge--the estimate of skewness would become sharper. But as Figure 2 reveals, the observed skewness does not appear to be substantively important. The naked eye cannot easily judge the direction of asymmetry.

As a further check, Table 2 reports estimated skewnesses of quarterly GNP and industrial production for other major OECD countries for the post-war period. Skewness is noticeably negative for only two of the five countries--for only Canada and Japan--using either industrial production or GNP data. There is no significant evidence of asymmetry for any country. The only natural grouping suggested by the data is a possible division into the U.S., Canada, and Japan on the one hand and the U.K., France, and West Germany on the other. But this possible difference between "non-European" and "European" business cycles is not strongly enough present in the data to give us any confidence that it is anything more than the workings of chance.

How has the picture of recessions as short violent interruptions of the process of economic growth emerged? Part of the answer lies in the way economic data are frequently analyzed. Figures 3 and 4 depict the NBER reference cycles and growth cycles of the post-war period. Using reference cycles, contractions are definitely shorter than expansions, confirming the judgments of Keynes and Mitchell. But this is a statistical artifact. The superposition of the business cycle upon a trend of economic growth implies that only the most severe portions of the declines relative to trend will appear as absolute declines and thus as reference cycle contractions. Even a symmetric business cycle superimposed on a rising trend would generate reference cycles for which the recessions would be short and severe relative to trend, even though the growth cycles--the cycles in detrended indices--would be symmetric. As this argument suggests, there is little difference

Figure 2

Histogram of Quarterly GNP Growth Rates
1949-1982

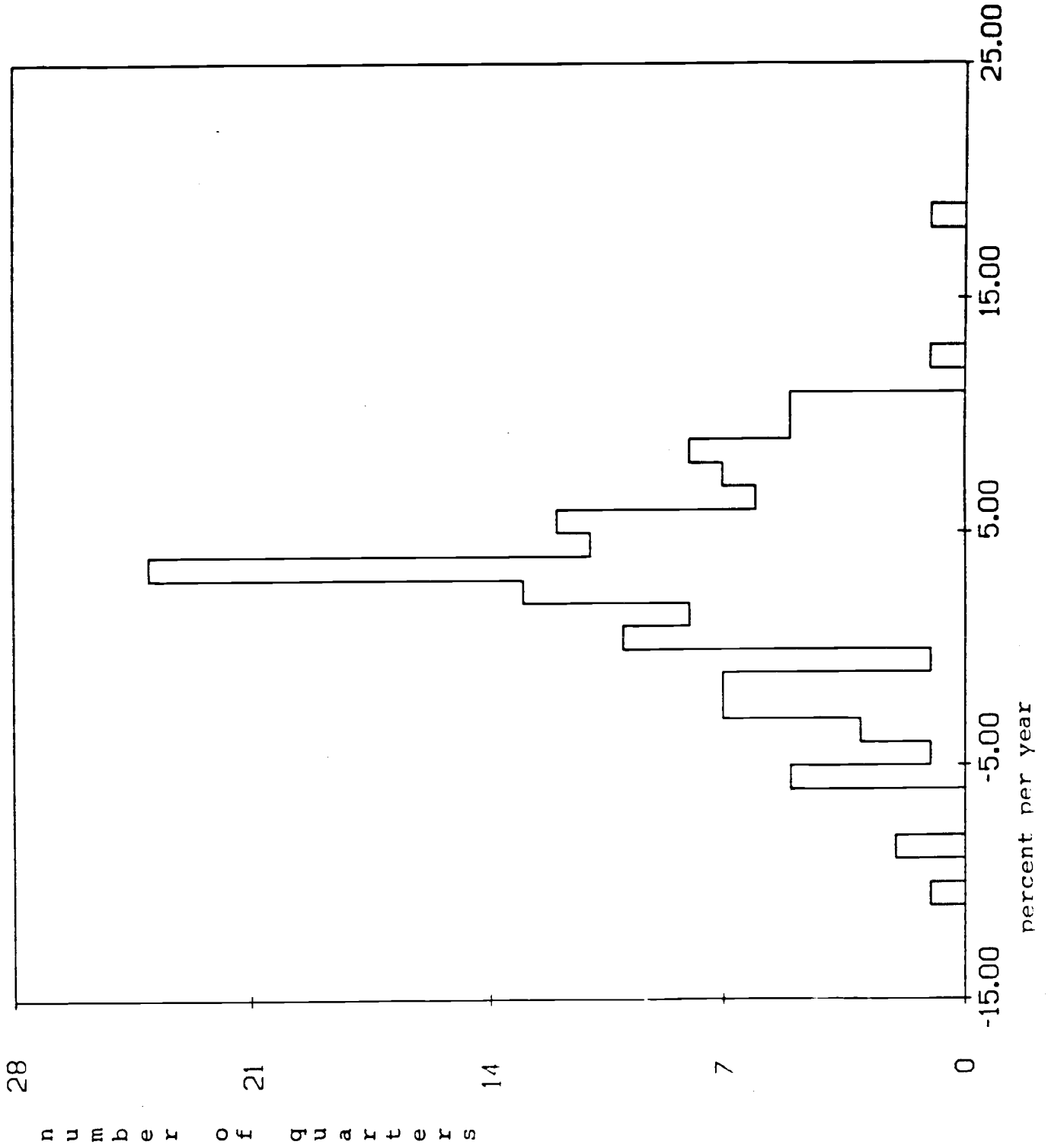


Table 2

Skewness of Quarterly Changes in GNP and Industrial Production 1950-1979

Country	Ind. Pdn. Skewness	S.E.	GNP Skewness	S.E.
U.S.	-.61	.42	-.33	.29
Japan	-.66	.40	-.43	.29
Canada	-.52	.39	-.42	.30
W. Germany	-.01	.34	-.11	.26
U.K.	.13	.35	.61	.27
France	.27	.33	-.03	.24

Data from the OECD Historical Statistics and from the 1984 Business Conditions Digest.

Figure 3

Deviation of U.S. GNP from its Natural Rate
NBER Reference-Cycle Recessions Shaded

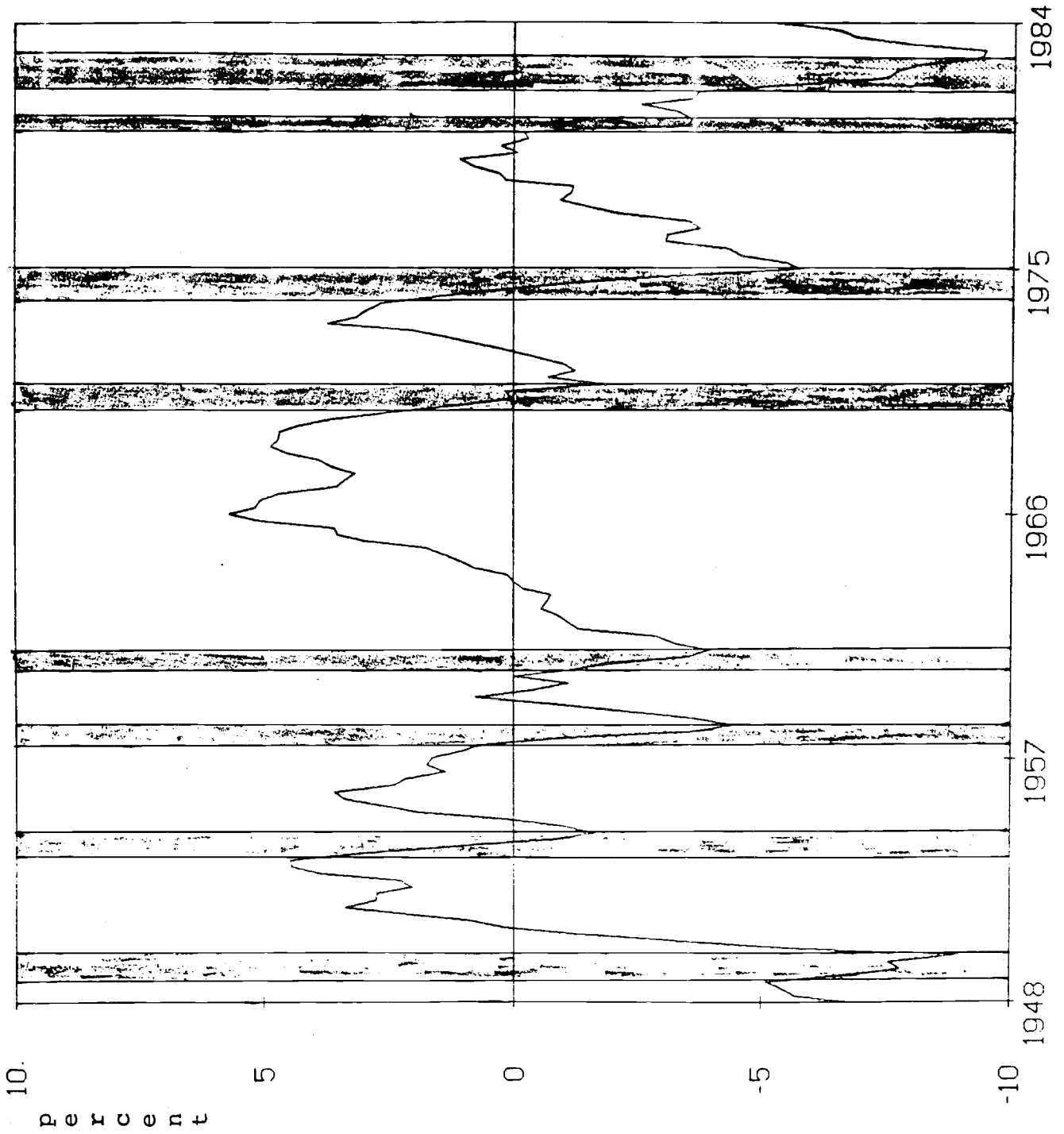
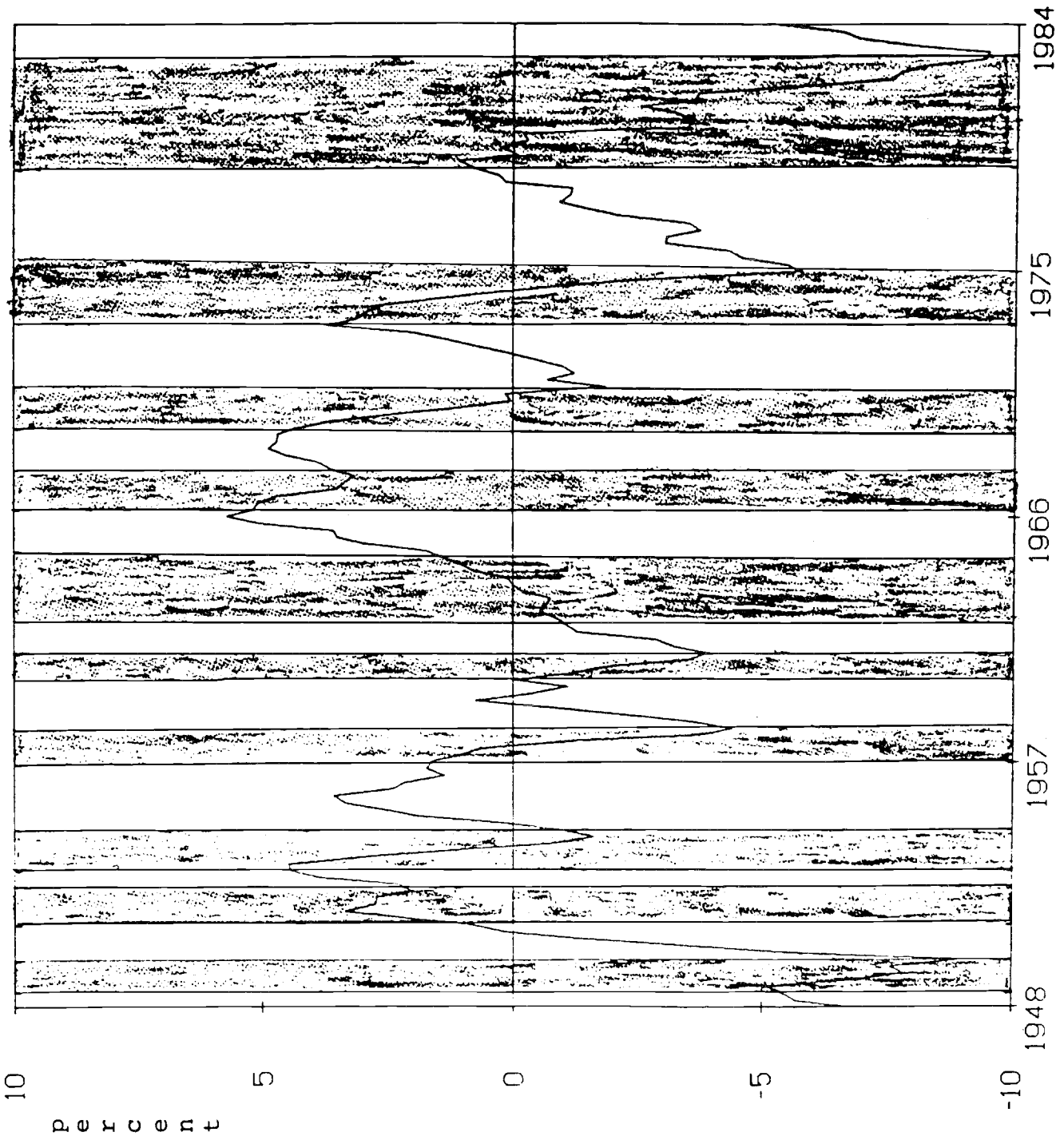


Figure 4

Deviation of U.S. GNP from its Natural Rate
NBER Growth-Cycle Recessions Shaded



between the lengths of growth cycle expansions and contractions. The difference in length between expansions and contractions for the nine growth cycles averaged .9 quarters; the standard deviation of this estimate of the average is 1.4 quarters.[2] By contrast, the average length of the seven reference cycle expansions was 11.4 quarters longer than the length of the subsequent contractions.[3]

We conclude from this investigation that once one takes proper account of trend growth--either using our skewness-based approach or the traditional NBER cycle-dating approach--little evidence of cyclical asymmetry in the behavior of output remains. The impression to the contrary that we used to hold seems to result from a failure to take account either impressionistically or quantitatively of the effects of long-run economic growth. Few extant theories suggest that business cycles should depend on the rate of underlying growth of either productivity or population.[4] The next section considers whether similar conclusions are obtained using data on unemployment.

III. Asymmetries in Unemployment?

Our conclusions so far contradict those of Neftci (1984), who examines the behavior of the unemployment rate and finds evidence against the null of symmetry at the .80 level. Neftci's statistical procedure seems inappropriate to us: eliminating the quantitative information in the data by reducing it to a series of 1's (unemployment increasing) and 0's (unemployment decreasing) cannot lead to a test of maximum power.

Table 3 presents estimates of the skewness in detrended unemployment rates for the U.S. and other major OECD countries for the post-war period. We examine only the post-war data because earlier unemployment estimates are, in general, not derived independently from output data. For the U.S., we confirm Neftci's conclusion. Indeed, we are able to reject the null hypothesis of symmetry at the .95 level. Annual data suggest as much skewness as quarterly data, but the skewness in annual data is not statistically significant.

None of the other OECD countries, however, have statistically significant skewnesses in their detrended unemployment rates.[5] This suggests that skewness in the U.S. is either a statistical accident or a result of a peculiarity in the U.S. labor market. Asymmetry in changes in unemployment rates is not a strong general feature of business cycles.

We have briefly attempted to examine the reasons for asymmetry in American unemployment rates. Skewness does not arise from the behavior of labor force participation: labor force participation rates exhibit no noticeable skewness, and skewness is present in detrended unemployment numbers as strongly as in detrended unemployment rates. Moreover, quarterly changes in employment over the 1949-1982 period exhibit a skewness coefficient of -1.90, significant at the .95 level. Skewness in employment and unemployment but not in GNP clearly indicates a breakdown in Okun's law. In figure 5, inverted deviations of industrial production

Table 3

Skewness of Quarterly Changes in Unemployment Rates
1950-1979

Country	Skewness	Standard Error
U.S.	1.02	.30
Japan	.40	.28
Canada	.55	.29
W. Germany	-.13	.27
U.K.	.27	.30
France	.14	.33

Data from the 1984 Business Conditions Digest.

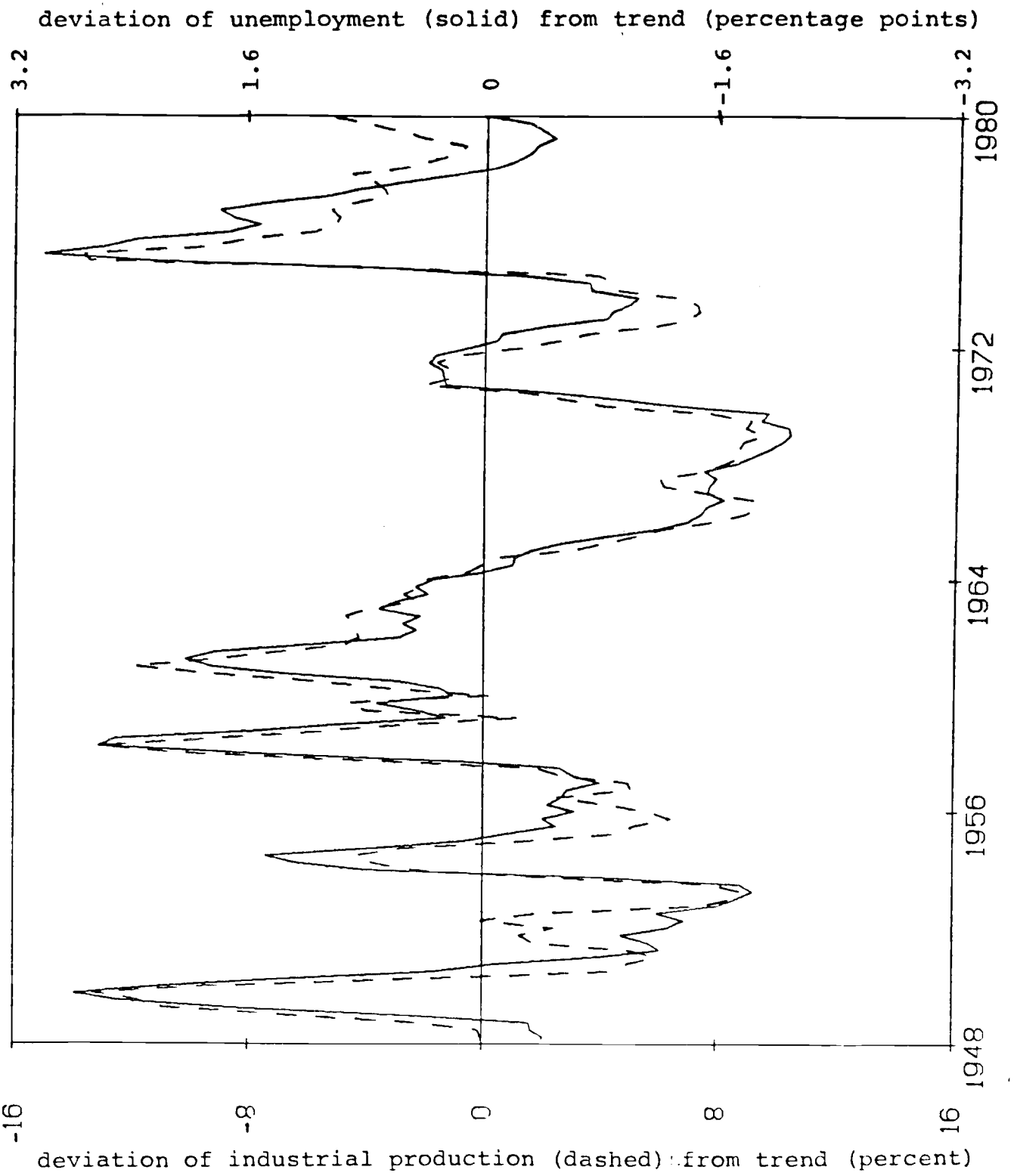


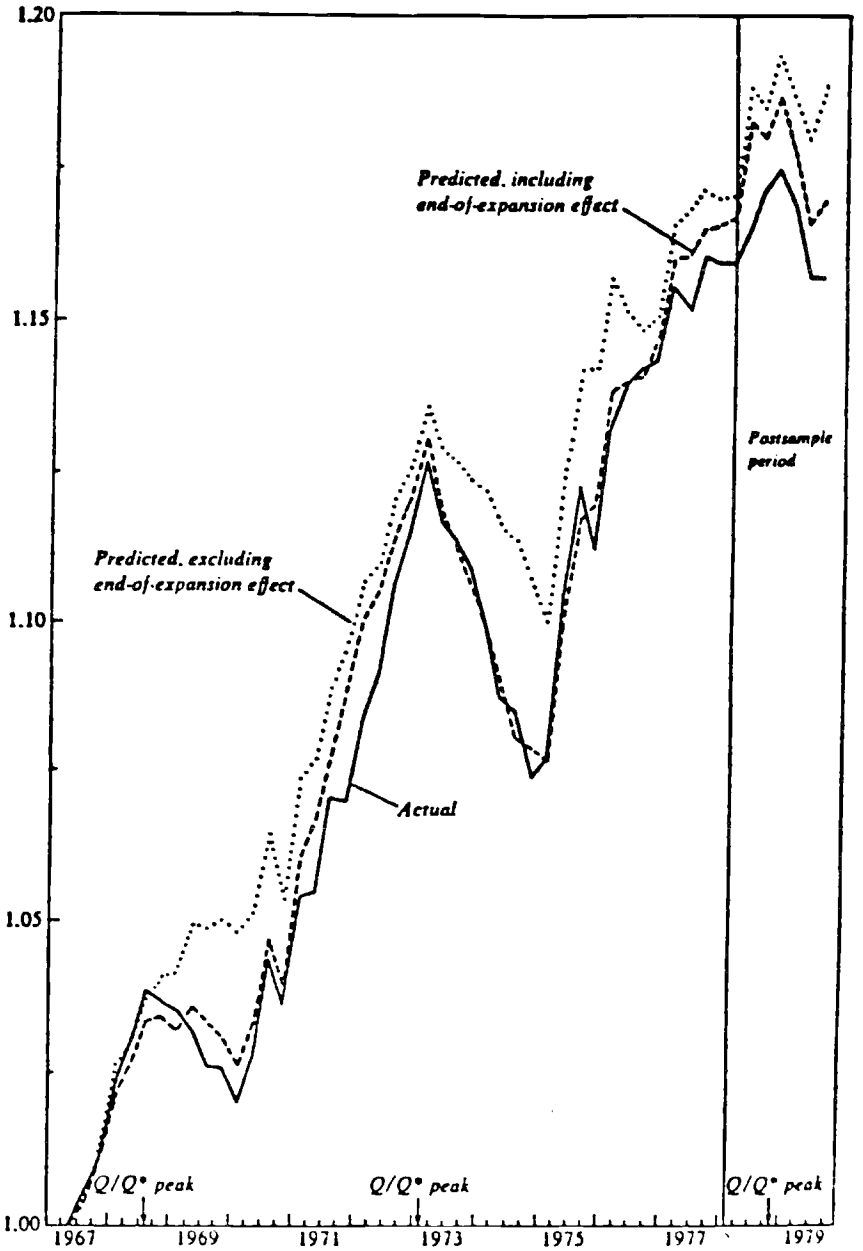
Figure 5
U.S. Industrial Production and Unemployment
1948-1980

from trend are plotted alongside the detrended unemployment rate. At business cycle peaks--unemployment troughs--the unemployment rate lags behind output measures. Output measures start to decline relative to trend before unemployment starts to rise. There is a period of time, after the growth cycle peak and before the reference cycle peak, during which output is falling relative to trend and employment is still rising relative to trend. This discrepancy in timing appears only near business cycle peaks. At business cycle troughs, the unemployment rate peaks within one quarter of the trough of output measures.

The significant coefficient of skewness found in the U.S. unemployment rate is apparently another manifestation of the "end of expansion" productivity effect documented in Gordon (1979). According to Gordon, normal equations for raw labor productivity go awry in the quarters after output reaches its maximum relative to trend. The magnitude of this effect can be seen in Gordon's figure 1 (reprinted as figure 6). Output has begun to fall relative to trend; employment is still rising relative to trend; and so raw labor productivity naturally declines sharply. Firms are able to expand their work forces rapidly after business cycle troughs in order to keep pace with rising aggregate demand. Why don't they contract their work forces relative to trend after growth cycle peaks? We suspect that there is an explanation related to the burgeoning literature on labor hoarding (see Medoff and Fay (1983) or Fair (1984), for example), but it is beyond our competence to suggest here what the explanation might be.

Figure 6

Output per Hour in the Nonfarm Business Sector, Actual and Predicted from Alternative Equations 1969:2-1979:3



*Peak of real over potential output

Reprinted from Gordon (1979)

IV. Conclusion

Our investigation into the possible asymmetry of the business cycle has, in our estimation, failed to turn up significant evidence that the econometric model-building approach to business cycles is misguided. We could not find the skewness coefficients that we had thought we would find; and we therefore conclude that it is reasonable to, in a first approximation, model business cycles as symmetric oscillations about a rising trend. GNP growth rates and industrial production growth rates do not provide significant evidence of asymmetry. We therefore think that the main advantage of the econometric model-building approach--the body of statistical theory behind it--makes it the methodology of choice for analyzing macroeconomic fluctuations.

Our results call into question at least one possible justification for using reference cycles in studying macroeconomic fluctuations. An alternative justification for the reference-cycle approach stresses the commonality of the patterns of comovements in variables across different business cycles. Blanchard and Watson's paper in this volume challenges this proposition. Studies of macroeconomic fluctuations using the reference-cycle approach are the foundation of empirical macroeconomics. But, given the availability of modern statistical methods, there appears to be no scientific basis for the use of reference cycles in either macroeconomic analysis or forecasting. As yet, no phenomenon or regularity has been adduced which can be studied using the reference-cycle approach, but is inconsistent with the assumptions of standard time series methods. Until such a demonstration is provided, there is little justification for the continued use of reference cycles in studying or forecasting macroeconomic fluctuations.

Notes

1. We verified that the estimated skewnesses were approximately normally distributed. Coefficients of kurtosis were less than ten percent away from their value of three under the null hypothesis. Note that our test of asymmetry is appropriate if output is stationary either when detrended or when differenced. Our standard errors are calculated under the second assumption, which is weakly supported by Nelson and Plosser (1982). Because they include periods in their analysis like the Great Depression and World War II during which no one would expect the underlying rate of growth of the economy to stay constant, it is hard to interpret how their warnings against the practice of detrending apply to analyses that deal only with periods for which one has good reason to suspect that the underlying growth of potential output has been approximately constant.

   For the U.S. industrial production index, estimated skewnesses for subperiods of the post-World War II period are very variable--more variable than the stochastic errors calculated under the assumption of an AR(3) generating process would suggest. Apparently, modelling the generating process as an AR(3) does not capture all of the serial dependence in the series and leads to estimated standard errors that are presumably too low. Therefore the standard errors reported in this paper are probably below their actual values.

2. Assuming that each post-war business cycle is an independent draw from a population characterized partly by the difference in length between the expansion and the recession phase. Cycle dates are taken from Moore and Zarnowitz's "The Development and Role of the National Bureau's Business Cycle Chronologies." Note that, as Moore and Zarnowitz report, it was not always the case that expansions were as a rule longer than contractions.

3. With a standard error of the mean of 3.3 quarters. Excluding the highly anomalous 1961-1970 reference cycle, the mean difference is 8.1 quarters and its standard error is 1.8 quarters.

4. But see Schumpeter (1939) for arguments that the cyclical variance of output is itself positively related to the rate of long-run growth.

5. Detrending European unemployment rates is not easy: there appears to have been an enormous rise in structural unemployment rates all over Europe in the last ten years. The results reported used a second degree polynomial to detrend the data. The results were effectively unchanged when a third or a fourth degree polynomial was used, or when a piecewise linear trend with a breakpoint in 1973 was used. If the rise in unemployment is attributed entirely to cyclical factors--if the skewness of raw changes is calculated--then changes in European unemployment rates since 1970 appear strongly skew.

Bibliography

BURNS, Arthur F. and Wesley C. Mitchell (1946). Measuring Business Cycles. New York: Columbia.

FAIR, Ray C. (1984). "Excess Labor and the Business Cycle." Cambridge: NBER Working Paper 1292.

GORDON, Robert J. (1979). "The 'End-of-Expansion' Phenomenon in Short-Run Productivity Behavior." Brookings Papers on Economic Activity 79:2.

_____ (1982). "Price Inertia and Policy Ineffectiveness in the U.S., 1890-1980." Journal of Political Economy 90:6.

KENDALL, Maurice and Alan Stuart (1969). The Advanced Theory of Statistics (3 vol. ed.). London: McGraw-Hill.

KEYNES, J. Maynard (1936). The General Theory of Employment, Interest and Money. London: Macmillan.

MITCHELL, Wesley C. (1927). Business Cycles: The Problem and Its Setting. New York: NBER.

MEDOFF, James L. and John A. Fay (1983). "Labor and Output over the Business Cycle: Some Direct Evidence." Cambridge: mimeo.

MOORE, Geoffrey, ed. (1961). Business Cycle Indicators. New York: National Bureau of Economic Research.

NEFTCI, Salih N. (1984). "Are Economic Time-Series Asymmetric Over the Business-Cycle? Journal of Political Economy 92:21.

NELSON, C.R. and C.I. Plosser (1982). "Trends and Random Walks in Macroeconomic Time Series." Journal of Monetary Economics 10:2.

SCHUMPETER, Joseph A. (1939). Business Cycles.