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10 The Cyclical Behavior of Industrial Labor Markets: A Comparison of the Prewar and Postwar Eras

Ben S. Bernanke and James L. Powell

10.1 Introduction

This paper compares the cyclical behavior of a number of industrial labor markets of the prewar (1923–39) and postwar (1954–82) eras. The methodology follows that of the traditional Burns and Mitchell (1946) business cycle analysis in at least two ways. First, the data employed are relatively disaggregated (we use monthly data at the two- or three-digit industry level). Second, we have not formulated or tested a specific structural model of labor markets during the cycle but instead concentrate on measuring qualitative features of the data. As did Burns and Mitchell, we see descriptive analysis of the data as a useful prelude to theorizing about business cycles. Thus, although the research reported here permits *no* direct structural inferences, it should be useful in restricting the class of structural models or hypotheses that may subsequently be considered.

The principal questions we study are also two in number. First, what are the means by which labor input is varied over the business cycle? We consider the intensity of utilization (as measured by gross labor productivity), hours of work per week, and number of workers employed. Both the timing and the relative magnitudes of the changes in these quantities over the cycle are examined. Second, what are the relationships over the cycle of output and labor input to measures of

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labor compensation? We look at the cyclical behavior of product wages and real weekly earnings as well as of real wages.

As might be expected, many of our findings are not novel; rather, they tend to support and perhaps refine existing perceptions of cyclical labor market behavior. However, we do reveal some interesting differences between the prewar and postwar periods in the relative use of layoffs and short hours in downturns and in cyclical movements of the real wage. Another finding is that labor productivity may behave in an anomalous manner in more severe recessions. Finally, a number of the familiar regularities are documented in a previously little-used data set, over an unusually long sample period, and by means of some alternative methods.

The paper is organized as follows: Section 10.2 reviews previous empirical work on the cyclical behavior of labor market variables. Sections 10.3 and 10.4 introduce and describe the data set used here. The behavior of key variables over the business cycle is analyzed by frequency domain methods in section 10.5 and by a time domain approach in section 10.6. Section 10.7 focuses on labor market phenomena in four particularly severe recessions. Results are summarized and conclusions drawn in section 10.8.

10.2 Previous Work: Some Regularities and Some Puzzles

There has been a great deal of empirical work that relates, sometimes directly and sometimes tangentially, to the cyclical behavior of labor markets. Without attempting an exhaustive survey, in this section we will try to summarize the major empirical findings of the literature. We will also include some brief discussion of how various authors have interpreted these findings. However, because the focus of this paper is description rather than structural analysis, the results we will present later do little to resolve existing disputes about interpretation.

The discussion of this section will be organized around the two questions of interest raised in section 10.1: the means by which labor input is varied over the cycle and the cyclical relationship of labor input and labor compensation. It might be said that by concentrating on these two questions, rather than on such phenomena as the frequency and duration of unemployment spells or cyclical variations in participation rates, we are emphasizing the "demand side" of the labor market at the expense of the "supply side." This imbalance is unfortunate but is dictated by the nature of the available prewar data.[1]

10.2.1 The Cyclical Pattern of Labor Utilization

The earliest empirical work on the variation of labor input over the cycle was done in the context of NBER business cycle research. Among

1. This is not to say that no empirical work on cyclical aspects of labor supply exists for the prewar period; for a fascinating example, see Woytinsky 1942.

the hundreds of data series whose business cycle patterns were painstakingly analyzed by Wesley Mitchell, and later by Mitchell and Arthur Burns, were a number of labor market variables. For example, Mitchell (1951) documented the high conformity of employment and weekly hours with output. (However, Mitchell was perhaps more interested in labor cost measures; see below.)

An early NBER finding was the strong tendency of weekly hours (that is, the length of the average workweek) to lead output and employment over the cycle (Moore 1955; Bry 1959). Weekly hours subsequently became a component of the NBER's well-known index of leading indicators. (For a relatively recent discussion and updating of this index, see Zarnowitz and Boschan 1975.) Other labor market variables identified as leading the cycle by the NBER included accession and layoff rates and initial claims for unemployment insurance (Shiskin 1961). Employment and unemployment were found to be coincident with the cycle.

Arguably the most important contribution of the NBER research program in this area was the classic paper by Hultgren (1960). With the purpose of investigating a hypothesis of Mitchell's about labor cost, Hultgren collected monthly data on output, aggregate hours worked, and payrolls for twenty-three industries. (The sample period was 1932–58.) With these and other data, Hultgren discovered that output per worker-hour is procyclical (or equivalently, that employment and hours worked vary relatively less over the cycle than does output).

The finding of procyclical labor productivity, or "short-run increasing returns to labor" (SRIRL), spawned a voluminous literature. Important early contributions were made by Kuh (1960, 1965), Okun (1962), Eckstein and Wilson (1964), and Brechling (1965). (Okun's famous "law" is, of course, SRIRL applied to the aggregate economy.) These and numerous other studies (including, notably, Ball and St. Cyr 1966; Masters 1967; Brechling and O'Brien 1967; and Ireland and Smyth 1967) found the SRIRL phenomenon to be ubiquitous: it occurs at both high and low levels of output aggregation, for both production and nonproduction workers, and in virtually all industrial countries.

Because of the neoclassical presumption of diminishing marginal returns to factors of production, SRIRL originally was perceived (and to some extent still is) as a deep puzzle. One favored explanation was that, because of the existence of specific human capital, firms "hoard" labor during downturns (Oi 1962; Solow 1968; Fair 1969); the hoarded labor is utilized more fully as demand recovers, giving the illusion of increasing returns. For empirical purposes, the labor hoarding model has become closely identified with a model in which increasing marginal costs of adjusting the labor stock induce the firm to move toward the desired level of employment only gradually (Brechling 1965; Coen and Hickman 1970); conceptually, however, the two models are not quite the same. Another popular explanation of SRIRL is that it is a reflection of unobserved (by the econometrician) variations in capital utilization rates that are associated with changes in labor input (Ireland and Smyth 1967; Lucas 1970; Solow 1973; Nadiri and Rosen 1973; Tatom 1980).

What is probably the most general current view is that SRIRL is the outcome of a complex dynamic optimization problem solved by the firm, in which labor is only one of a number of inputs, each with a possibly different degree of quasi-fixity. For example, Nadiri and Rosen (1973) emphasized that the rate at which employment will be varied depends not only on the costs of adjusting labor stocks but also on the costs of adjusting all other inputs (including inventories and rates of utilization); Morrison and Berndt (1981) showed that these interactions could result in the SRIRL phenomenon even if labor itself were a perfectly variable factor.

Overall, the research that followed Hultgren's original paper has made two valuable contributions to knowledge. First, from Brechling (1965) to Nadiri and Rosen (1973) to Sims (1974), there has been generated a wealth of empirical material on the sluggish short-run response of employment to output change and on the relationship over the cycle of employment to hours worked, inventories, and other factors of production. Second, the general dynamic optimization model of firm input utilization developed in this literature has proved to be a most useful and flexible research tool. (For example, it has permitted the incorporation of rational expectations; see Sargent 1978 or Pindyck and Rotemberg 1982.)

We may summarize the received findings on the cyclical behavior of labor inputs as follows: Employment and weekly hours are procyclical. Productivity is also procyclical; that is, employment and worker-hours vary less than output over the cycle. Finally, weekly hours lead output, while employment coincides with or possibly lags output over the cycle.

10.2.2 Labor Compensation over the Cycle

Although the qualitative behavior of labor inputs over the business cycle seems relatively well established, there is very little agreement about how to characterize the cyclical movements of labor compensation, especially of real wages. The debate about real wages began when Keynes (1936) conjectured that, again because of diminishing marginal returns, labor's marginal productivity and hence the real wage should be countercyclical.[2] Empirical studies by Dunlop (1938) and Tarshis (1939) purported to show that this conjecture was false; but these studies were in turn disputed (see Bodkin 1969 for references).

2. Bodkin 1969 notes that the French economist Rueff made the same prediction in 1925.

The debate prompted Keynes (1939) to aver that countercyclical real wages were in fact not an essential implication of his theory.

Postwar research has done little to resolve the question of the cyclical behavior of real wages. One can find papers supporting procyclicality (Bodkin 1969; Stockman 1983), countercyclicality (Neftci 1978; Sargent 1978; Otani 1978; Chirinko 1980), and acyclicality (Geary and Kennan 1982). Altonji and Ashenfelter (1980) have argued that the best statistical model of the real wage is the random walk. It would not be much help for us to present a detailed comparison of these papers here. Instead, we simply list some of the major methodological issues that have arisen in this literature.

First, researchers have typically found that these results are sensitive to whether the nominal wage is deflated by an index of output prices, such as the wholesale price index or the producer price index or by a cost-of-living index such as the consumer price index. (See Ruggles 1940; Bodkin 1969; or Geary and Kennan 1982.) This does not seem unreasonable, since the wage divided by the output price (henceforth the "product wage") corresponds conceptually to the "demand price" of labor, while the wage deflated by the cost of living (henceforth the "real wage") corresponds to the "supply price"; it is not difficult to think of conditions under which the short-run behaviors of these two variables might differ. Unfortunately, however, the difference in behavior does not seem to vary systematically across studies.

Second, there is some dispute over whether the contemporaneous correlation of the real wage and output (or employment) is an interesting measure of the real wage's cyclical pattern. Neftci (1978) and Sargent (1978) have argued that, because of the complex dynamics of the wage/employment relationship, it is necessary to look at correlations at many leads and lags. (See also Clark and Freeman 1980.)

Finally, it has been founded that empirical results concerning the short-run behavior of wages may be particularly sensitive to aggregation biases, both when the aggregation is over individuals (Stockman 1983) and when it is over industries (Chirinko 1980).

The apparently very weak relationship of real wages and the business cycle has posed a problem for some prominent theories of cyclical fluctuations (or at least for simple versions of those theories; see, for example, Altonji and Ashenfelter 1980 and Ashenfelter and Card 1982). However, attempts to reconcile the low correlation of wages and the cycle with theories of short-run employment fluctuations have also led to a number of interesting lines of research: these include disequilibrium modeling of the cycle (Solow and Stiglitz 1968; Barro and Grossman 1971), contracting approaches that divorce wage payments and short-run labor allocations (see Hall 1980 for a discussion), Lucas's (1970) theory of capacity and overtime, and others.

Real and product wages are not the only measures of labor compensation whose cyclical behavior has been studied, although they have absorbed a large part of the research effort. Mitchell theorized in very early work that unit labor costs might play an important role in the business cycle; Hultgren's (1960, 1965) studies found that, in reasonably close correspondence to Mitchell's prediction, labor costs lag the cycle. Various other compensation measures were studied by the NBER analysts: nominal labor income, for example, was reported by Shiskin (1961) to be coincident with the cycle.

Another variable that has commanded some attention is the nominal wage. In an NBER Occasional Paper, Creamer (1950) studied monthly wage rates in a number of industries for 1919–31. (His aggregate wage rate series extended to 1935.) Creamer's most important conclusion was that nominal wage rates lagged business activity by nine months or more, a finding that some subsequent authors viewed as supporting the "stickiness" of wages. (Creamer also showed that the cyclical behaviors of an index of wage rates and of average hourly earnings were similar, a very useful result given the paucity of direct information on wage rates.) "Stickiness" was also a major issue for later students of the nominal wage: for example, Sachs (1980) has argued that wages became relatively more rigid after World War II, and Gordon (1982) has found United States postwar wages to be stickier than those of the United Kingdom and Japan. Gordon's result is the opposite of earlier characterizations by Sachs (1979) and others.

Overall, the question of how to characterize the cyclical behavior of labor compensation remains rather unsettled. This is unfortunate, given the central role of wages in much of macroeconomic theory.

10.3 The Data

This paper reassesses the qualitative empirical findings described in the previous section, with particular attention to possible differences between the prewar and postwar eras. This section introduces our data set and compares it briefly with what has been employed by others.

The data we use are monthly, roughly at the level of the "industry," and cover the time periods 1923–39 and 1954–82. We felt that the high-frequency data were necessary if short-run relationships were to be distinguished; the industry-level data were used both to reduce aggregation bias and to avoid reliance on the aggregate production indexes, which are poorly constructed for our purpose (see below). In contrast to our approach, few studies since Hultgren have used monthly, industry-level data (Fair 1969 is an important exception). Also, little recent work has used prewar data; the exceptions have typically looked only at annual, highly aggregated numbers.

There were many variables we could have chosen to study. Considerations of data availability and economic relevance led to the following short list (with mnemonic abbreviations):

IP	Industry output or production
EMP	Employment (number of production workers)
HRS	Hours of work per week (per production worker)
PROD	Gross labor productivity = $IP/(EMP \times HRS)$
WR	Average hourly earnings (nominal) divided by a cost-of-living index; the "real wage."
WP	Average hourly earnings divided by the industry wholesale output price; the "product wage"
EARN	Real weekly earnings per production worker = $HRS \times WR$.

In the analysis below, we concentrate not on the levels of these variables but on the log differences (roughly, the monthly growth rates). From now on, therefore, the mnemonic names just defined should be understood to denote log differences.

The variables above were collected for eight prewar manufacturing, eight postwar manufacturing, and three postwar nonmanufacturing industries. These industries are listed in table 10.1. Note that the eight prewar and postwar manufacturing industries are approximately a "matched set." This was done to facilitate comparison of the two eras. We did not have com-

Table 10.1 Industries Included in Data Set

Prewar Industry Title	Postwar Industry Title (SIC code)
Manufacturing Industries (prewar and postwar data)	
1. Iron and steel (STEEL)	Blast furnaces and steel mills (331)
2. Automobiles (AUTOS)	Motor vehicles and equipment (371)
3. Meat-packing (MEAT)	Meat-packing plants (201)
4. Paper and pulp (PAPER)	Paper and allied products (26)
5. Boots and shoes (SHOES)	Footwear, except rubber (314)
6. Wool textiles (WOOL)	Weaving and finishing mills, wool (223)
7. Leather tanning and finishing (LEATH)	Leather tanning and finishing (311)
8. Lumber and millwork (excluding furniture (LUMBR)	Lumber and wood products (24)
9. All manufacturing industries (ALL MFG)	All manufacturing industries
Nonmanufacturing Industries (postwar data only)	
10. NA (COAL)	Bituminous coal and lignite mining (12)
11. NA (ELECT)	Electric services (491)
12. NA (CONST)	Construction (no code)

parable prewar data for the three nonmanufacturing industries. However, we included these industries because they represent major sectors of the economy (mining, utilities, and construction) and because it seemed to us that nonmanufacturing industries have been slighted somewhat (relative to manufacturing industries) by students of the business cycle.

Some explanation should be given for the rather miscellaneous character of the manufacturing industries chosen. For the prewar period, the eight industries included represent the largest class for which complete and reasonably consistent data were available. In particular, our desire to have series on hours of work restricted us to industries regularly surveyed, beginning in the early 1920s, by the National Industrial Conference Board. The Bureau of Labor Statistics, which surveyed many more industries, did not collect hours data before 1932. Also, we included only industries whose output indexes were based on direct measures of physical output (e.g., number of automobiles) rather than on scaled-up input measures (e.g., man-hours). A wider selection of industries is available for the postwar period, of course, but because of the burden of collecting and entering the data, only those manufacturing industries "matching" the available prewar industries were used. In terms of employment or value added, the industries here studied made up about one-fifth of total manufacturing in the prewar era and about one-sixth of total manufacturing after the war.

A nice fringe benefit of using the Conference Board data rather than that from the Bureau of Labor Statistics (BLS) is that it gives us a prewar data set that has not been previously analyzed, except in a partial and desultory way by some earlier NBER studies. In particular, it is quite different from the data set used by Hultgren (1960).

A potential problem with studying only manufacturing industries that have more or less continuous identities since the 1920s is that it biases the sample toward older, often declining industries at the expense of new and growing fields. However, for the purpose of studying cyclical (as opposed to trend) behavior of labor market variables, this sample bias is probably not important. In particular, our informal comparisons of the declining manufacturing industries with the expanding manufacturing and nonmanufacturing industries did not reveal obvious differences in cyclical behavior.

For the purposes of comparison with the industry-level findings, we also analyzed prewar and postwar monthly data for aggregate manufacturing. Although these data obviously have broader coverage than the industry data, we have less confidence in the results using aggregates, for three reasons: (1) aggregation across industries introduces well-known cyclical biases; (2) the aggregate production indexes are heavily contaminated with input-based measures of output; and (3) the prewar output, price, and labor input series are not perfectly mutually consistent. (See the data appendix to this chapter for an explanation and for a more detailed discussion of all the data and their sources.)

10.4 Some Basic Statistics

Most of the analysis below follows the application of a deseasonalization process and the removal of means from the log-differenced series. As a preliminary step, this section looks at some features of the raw log differences.

Tables 10.2 and 10.3 present the means of the variables for each industry and for the prewar and postwar periods separately. The means are multiplied by 100 and thus can be interpreted approximately as percentage rates of growth *per month*.

Considering first the productivity column in table 10.2, we note that average prewar rates of productivity growth compared well with those of the postwar era. Rates of productivity growth were higher during 1923–39 than during 1954–82 in five of the eight manufacturing industries, as well as in aggregate manufacturing. The prewar rate of pro-

Table 10.2 Monthly Rates of Growth (%) of Output, Employment, Weekly Hours, and Productivity

Industry	Period	*IP*	*EMP*	*HRS*	*PROD*
STEEL	1923–39	0.18	0.07	−0.25	0.35
	1954–82	−0.12	−0.26	−0.01	0.14
AUTOS	1923–39	0.34	0.07	−0.14	0.42
	1954–82	0.16	−0.09	0.00	0.25
MEAT	1923–39	0.04	0.05	−0.08	0.07
	1954–82	0.18	0.02	−0.01	0.17
PAPER	1923–39	0.33	0.06	−0.12	0.39
	1954–82	0.33	0.03	0.00	0.29
SHOES	1923–39	0.01	−0.07	−0.14	0.22
	1954–82	−0.13	−0.22	−0.01	0.10
WOOL	1923–39	0.04	−0.08	−0.12	0.24
	1958–82	−0.14	−0.43	0.01	0.28
LEATH	1923–39	−0.09	−0.14	−0.10	0.15
	1954–82	−0.17	−0.29	0.00	0.12
LUMBR	1923–39	−0.07	−0.14	−0.10	0.17
	1954–82	0.18	−0.06	0.01	0.23
ALL	1923–39	0.22	−0.01	−0.12	0.34
MFG	1954–82	0.27	−0.02	0.00	0.29
COAL	1954–82	0.18	−0.13	0.06	0.26
ELECT	1954–82	0.48	0.11	0.00	0.36
CONST	1954–82	0.13	0.11	0.02	0.00

ductivity growth reached rather exceptional levels in automobiles, paper and pulp, and iron and steel. The rapid expansion of prewar productivity observed in these data supports the view that the period between the world wars (particularly the 1920s) was a time of transformation of industrial technologies, leading to sharp reductions in costs; see Jerome (1934) and Bernstein (1960). In the postwar period, the best productivity performance among our manufacturing industries was by paper and allied products; best overall in the postwar sample was by electric services.

Productivity growth is, of course, definitionally equal to output growth minus the sum of employment and hours growth. Examining these constituents of productivity, we note first that the fastest prewar growth in output was experienced by automobiles and by paper and pulp; in the postwar period, paper took the output growth honors for manufacturing, with electric services again doing best overall. It appears that the high-output industries were also the high-productivity industries; the rank correlation between output growth and productivity growth is .945 for the eight prewar industries, .913 for the eleven postwar industries.

Despite the depression of the 1930s, employment growth in the prewar manufacturing industries studied tended to exceed that in their post-war counterparts (seven of eight cases); this was also true for the aggregates. This difference largely reflects serious long-term declines by a number of the postwar industries: in wool textiles, leather tanning and finishing, and footwear, prewar tendencies toward decline accelerated after the war; in iron and steel, prewar growth in employment changed to postwar shrinkage. The strongest employment growth in the sample took place in two postwar nonmanufacturing industries (electric services and construction). As a whole, the employment column of table 10.2 is consistent with the often-noted secular fall in the fraction of total employment absorbed by manufacturing.

The behavior of the last component of productivity, hours of work, was quite different in the two sample periods. Weekly hours declined steadily during the prewar period in all industries, most precipitously in iron and steel (a notorious "long-hours" industry during the early 1920s, in which eighty-four-hour workweeks were not uncommon). This fall reflected changes in work organization during the 1920s (in a few cases as a response to the pressure of public opinion against long hours) and the "work sharing" of the depressed 1930s (sometimes initiated by employers, sometimes the result of New Deal legislation or union demands); see Zeisel (1958) for further discussion. In contrast, the postwar workweek was almost perfectly stable.

Finally, we may consider the mean rates of growth of the alternative measures of production worker compensation (table 10.3). It is inter-

Table 10.3 Monthly Rates of Growth (%) of Real Wages, Product Wages, and Real Weekly Earnings

Industry	Period	*WR*	*WP*	*EARN*
STEEL	1923–39	0.31	0.29	0.06
	1954–82	0.16	0.10	0.15
AUTOS	1923–39	0.31	0.30	0.17
	1954–82	0.11	0.16	0.11
MEAT	1923–39	0.29	0.29	0.21
	1954–82	0.06	0.15	0.04
PAPER	1923–39	0.24	0.24	0.12
	1954–82	0.13	0.15	0.13
SHOES	1923–39	0.11	−0.01	−0.03
	1954–82	0.03	0.05	0.02
WOOL	1923–39	0.21	0.20	0.08
	1958–82	0.05	0.31[a]	0.06
LEATH	1923–39	0.27	0.25	0.17
	1954–82	0.05	0.03	0.05
LUMBR	1923–39	0.28	0.27	0.17
	1954–82	0.09	0.13	0.10
ALL MFG	1923–39	0.26	0.27	0.14
	1954–82	0.09	0.10	0.09
COAL	1954–82	0.12	−0.04	0.18
ELECT	1958–82	0.13	0.05[b]	0.13
CONST	1954–82	0.09	0.03	0.11

[a]Sample period is 1958–75.
[b]Sample period is 1958–82.

esting that, though productivity gains during the prewar period were larger than during the postwar period in only five of the eight manufacturing industries studied, real wage growth was significantly larger during the prewar in *all* eight industries, as well as in the aggregate. Prewar product wages also rose sharply, except in boots and shoes. Within the major sample periods, the rank correlation of real wage growth with productivity growth was .815 for the eight prewar industries, .864 for the eleven postwar industries. (Although these correlations are high, note that they are somewhat lower than the correlations of productivity and output growth reported above.) The large prewar growth in real wages was not fully reflected in increases in worker buying power, as the last column of table 10.3 shows; because of the sharp declines in hours of work, real weekly earnings rose much more slowly than real wages.

Turning from the first to the second moments, tables 10.4 and 10.5 contain the standard deviations of the raw log differences, multiplied by 100 so they can be interpreted as percentages. We will not comment on these figures except to note, first, how surprisingly large the vari-

Table 10.4 Standard Deviations (%) of Monthly Growth Rates of Output, Employment, Weekly Hours, and Productivity

Industry	Period	*IP*	*EMP*	*HRS*	*PROD*
STEEL	1923–39	13.40	4.70	6.85	8.00
	1954–82	16.09	11.53	2.25	7.06
AUTOS	1923–39	30.12	10.37	8.13	22.47
	1954–82	7.80	9.69	4.14	8.69
MEAT	1923–39	9.91	4.03	3.16	7.95
	1954–82	2.82	1.80	1.84	3.87
PAPER	1923–39	5.71	1.83	2.47	5.15
	1954–82	1.83	1.06	0.98	2.06
SHOES	1923–39	11.87	3.18	5.39	10.08
	1954–82	4.05	2.86	2.58	5.63
WOOL	1923–39	12.04	6.09	4.93	8.64
	1958–82	9.30	2.71	2.01	10.17
LEATH	1923–39	5.52	2.93	3.52	5.46
	1954–82	3.39	2.32	1.71	4.82
LUMBR	1923–39	6.80	5.63	4.88	6.79
	1954–82	2.85	2.47	1.87	3.62
ALL MFG	1923–39	4.70	2.36	2.59	2.92
	1954–82	3.28	1.36	1.17	2.58
COAL	1954–82	14.00	16.05	8.18	11.74
ELECT	1954–82	1.45	0.91	0.91	1.94
CONST	1954–82	7.88	6.17	2.87	5.25

ability of the industry data often is and, second, that aggregation seems to reduce measured variability somewhat. To see how much of total variability was attributable to business cycles, we used a frequency domain technique to wipe out the variance associated with the high-frequency (seasonal) and the low-frequency (trending or long-wave) bands. The resulting standard deviations for five key variables are in table 10.6. Three facts are obvious from the table. First, the share of total variability of the data to be associated with business cycles is relatively small in both the prewar and postwar periods. Second, the business cycle has dampened considerably during the postwar period. Third, in most industries the cyclical variance of hours of work per week has, between the prewar and postwar periods, been reduced relatively more than that of employment.

This last observation, which is also confirmed in the raw data (table 10.4) and in section 10.7 below, is worth remarking on a bit further. Why have postwar employers relied relatively more heavily on layoffs, rather than on short workweeks, to reduce labor input in downturns? Two possible sources of the change are the greater postwar importance of unions and the advent of unemployment insurance programs. Union objective functions might be such that layoffs of a relatively small

Table 10.5 **Standard Deviations (%) of Monthly Growth Rates of Real Wages, Product Wages, and Real Weekly Earnings**

Industry	Period	*WR*	*WP*	*EARN*
STEEL	1923–39	2.14	2.24	7.02
	1954–82	1.32	1.50	2.96
AUTOS	1923–39	1.90	2.24	8.32
	1954–82	1.69	1.87	5.21
MEAT	1923–39	2.24	4.81	3.25
	1954–82	1.29	4.05	2.43
PAPER	1923–39	1.30	2.14	2.43
	1954–82	0.83	3.61	1.36
SHOES	1923–39	2.70	2.47	5.41
	1954–82	0.95	1.80	2.60
WOOL	1923–39	2.14	2.97	4.79
	1958–82	1.06	1.48[a]	2.37
LEATH	1923–39	1.47	3.03	3.37
	1954–82	0.92	2.96	2.12
LUMBR	1923–39	4.14	4.74	5.25
	1954–82	1.32	1.99	2.37
ALL MFG	1923–39	1.24	1.48	2.55
	1954–82	2.30	2.34	2.69
COAL	1954–82	1.95	2.19	9.04
ELECT	1954–82	0.90	1.11[b]	1.44
CONST	1954–82	1.05	1.02	2.80

[a]Sample period is 1958–75.
[b]Sample period is 1958–82.

number of junior workers are preferred to a general reduction of hours. (Cross-sectional evidence that unions prefer layoffs was presented in Medoff 1979. Medoff also cited a study by Slichter, Healy, and Livernash 1960 claiming that unions, which initially approved of some work sharing, moved toward a preference for layoffs in the early postwar period.) Perhaps more important than unionism is the fact that in the United States, fully unemployed workers can receive government compensation but the partially unemployed cannot. See Baily (1977) for a formal analysis.

10.5 Analysis in the Frequency Domain

We turn now to the study of these variables over the business cycle. To obtain characterizations of "typical" cyclical patterns, we subjected the data to both frequency domain and time domain analysis. In the frequency domain work we followed the approach suggested by Granger and Hatanaka (1964); in the time domain our analysis is in the spirit of Sims (1980). (There are, of course, close formal connections between

Table 10.6 **Standard Deviations (%) of Monthly Growth Rates of Five Variables: Business Cycle Frequencies (Twelve to Ninety-Six Months) Only**

Industry	Period	*IP*	*EMP*	*HRS*	*PROD*	*WR*
STEEL	1923–39	3.96	1.59	1.73	1.53	0.59
	1954–82	2.28	1.05	0.48	1.15	0.27
AUTOS	1923–39	4.54	2.72	1.46	2.93	0.36
	1954–82	1.85	1.43	0.47	0.77	0.31
MEAT	1923–39	1.66	1.05	0.49	1.01	0.49
	1954–82	0.46	0.27	0.19	0.36	0.21
PAPER	1923–39	1.33	0.60	0.65	0.76	0.36
	1954–82	0.56	0.30	0.16	0.27	0.14
SHOES	1923–39	1.26	0.47	0.94	0.78	0.68
	1954–82	0.71	0.39	0.38	0.60	0.17
WOOL	1923–39	3.16	1.69	1.06	0.99	0.67
	1954–82	1.56	1.01	0.61	1.74	0.22
LEATH	1923–39	1.19	0.97	0.77	0.82	0.47
	1954–82	0.59	0.49	0.22	0.52	0.14
LUMBR	1923–39	1.75	1.48	0.85	1.19	0.70
	1954–82	0.87	0.61	0.21	0.44	0.23
ALL MFG	1923–39	1.53	0.97	0.67	0.48	0.33
	1954–82	0.60	0.39	0.15	0.21	0.20
COAL	1954–82	0.92	0.71	0.61	0.84	0.25
ELECT	1954–82	0.22	0.16	0.10	0.28	0.13
CONST	1954–82	0.69	0.75	0.21	0.77	0.15

these two approaches; this is evidenced by the similarity of the results obtained.) The results from the frequency domain will be discussed here. Those from the time domain are presented in section 10.6.

The data used in the frequency domain work (as well as in the time domain) were the deseasonalized log differences of the basic series. (Deseasonalization was done by the use of seasonal dummies; see our data appendix.) Each variable was analyzed separately by industry and for the prewar and postwar sample periods.

Spectra of these data showed power in the business cycle frequency range, but rarely were clear peaks apparent in that range. (Sargent 1979, 254, warns that this is to be expected.) We decided to investigate the properties of cycles with periods exceeding one year (so as to exclude remaining seasonal and other high-frequency influences) but shorter than eight years. (According to the NBER chronology, the longest business cycle in our sample—the one extending from 1929 to 1937—was eight years long.) For each industry/sample period, we calculated the coherences and phase relationships of the variables over the one- to eight-year band.

The coherences of six variables (the rates of growth of employment, weekly hours, productivity, real wages, product wages, and real weekly earnings) with the rate of growth of industry output over the business cycle range are reported in table 10.7. (Standard errors of the coherence estimates are also included. See the appendix for a description of how these were calculated.) Coherence is a measure of the degree of association of a pair of variables over a prescribed set of frequencies; a coherence of zero indicates the minimum association, a coherence of one the maximum. The table suggests that employment and hours bear the strongest relation to output over the business cycle. Productivity and earnings also are strongly related to output for most industries. The connection between the two wage measures and output is erratic across industries and, on the whole, is weaker; this is especially true in the postwar period. Note, however, that the coherences of wages and output appear to be statistically significant in both periods.

A particularly informative exercise in the frequency domain is the calculation of phase relationships. For a given frequency, think of variables as tracing out sine curves over time. Then the "phase lead" of variable A with respect to variable B is the number of months after A reaches a given point on its sinusoidal path that B reaches the corresponding point. We shall say a variable that has a phase lead with respect to output of near zero is "procyclical"; a variable whose phase lead with respect to output is approximately half the period of the full cycle is "countercyclical." (There are, however, some caveats to this interpretation of phase leads; see Hause 1971.)

The phase leads of six variables with respect to output growth, plus standard errors, are given in table 10.8. The phase leads are evaluated at the frequency with period of fifty-four months, the period at the center of the range considered. (See the appendix for more discussion.) We find that employment, hours, and earnings are roughly procyclical. Productivity is procyclical but slightly leading in the postwar period; its lead over output is greater in the prewar period. Hours typically leads, though by less than productivity, while employment consistently lags a few months behind output. Earnings is approximately coincident.

The interrelation of productivity, hours, output, and employment is essentially stable between the prewar and postwar periods and, except for the introduction of some subtleties in timing, is consistent with earlier findings. In conjunction with the dynamic model of the firm discussed in section 10.2, this interrelation suggests a simple economic interpretation: cycles are dominated by demand changes. Firms anticipating an increase in demand respond first by increasing nonlabor inputs and asking for more work effort; this increases productivity. As demand strengthens, hours of work expand. Finally, as the increase in demand assumes greater permanence, firms make the hiring and training investments needed to add to the work force. This story is hardly original (see, for example, Baily 1977), and we emphasize again that

Table 10.7 Coherences of Growth Rates of Six Variables with Growth Rate of Output

Industry	*EMP*	*HRS*	*PROD*	*WR*	*WP*	*EARN*
			Prewar Data			
STEEL	.828	.883	.915	.272	.230	.854
	(.060)	(.042)	(.031)	(.175)	(.179)	(.051)
AUTOS	.854	.583	.692	.252	.271	.568
	(.051)	(.125)	(.099)	(.177)	(.175)	(.128)
MEAT	.773	.657	.836	.541	.330	.292
	(.076)	(.107)	(.057)	(.134)	(.168)	(.173)
PAPER	.661	.870	.721	.610	.507	.836
	(.106)	(.046)	(.091)	(.119)	(.140)	(.057)
SHOES	.717	.836	.651	.098	.142	.794
	(.092)	(.057)	(.109)	(.187)	(.185)	(.070)
WOOL	.934	.878	.783	.449	.429	.797
	(.024)	(.043)	(.073)	(.151)	(.154)	(.069)
LEATH	.754	.742	.341	.473	.634	.823
	(.082)	(.085)	(.167)	(.147)	(.113)	(.061)
LUMBR	.749	.784	.276	.354	.659	.638
	(.083)	(.073)	(.175)	(.165)	(.107)	(.112)
ALL MFG	.935	.916	.567	.567	.607	.902
	(.024)	(.031)	(.128)	(.128)	(.119)	(.035)
			Postwar Data			
STEEL	.898	.895	.863	.527	.180	.829
	(.027)	(.028)	(.036)	(.102)	(.137)	(.044)
AUTOS	.912	.724	.479	.733	.578	.809
	(.024)	(.067)	(.109)	(.065)	(.094)	(.049)
MEAT	.592	.585	.618	.430	.706	.648
	(.092)	(.093)	(.087)	(.115)	(.071)	(.082)
PAPER	.911	.771	.856	.360	.735	.672
	(.024)	(.057)	(.038)	(.123)	(.065)	(.078)
SHOES	.714	.594	.503	.159	.094	.590
	(.069)	(.092)	(.106)	(.138)	(.140)	(.092)
WOOL	.418	.295	.586	.252	.573	.294
	(.127)	(.141)	(.101)	(.144)	(.123)	(.141)
LEATH	.620	.412	.416	.164	.368	.385
	(.087)	(.117)	(.117)	(.138)	(.122)	(.120)
LUMBR	.881	.845	.658	.378	.489	.779
	(.032)	(.040)	(.080)	(.121)	(.108)	(.056)
ALL MFG	.941	.839	.684	.378	.314	.693
	(.016)	(.042)	(.075)	(.121)	(.128)	(.073)
COAL	.603	.710	.331	.371	.063	.676
	(.090)	(.070)	(.126)	(.122)	(.141)	(.077)
ELECT	.290	.359	.734	.287	.203	.413
	(.129)	(.123)	(.065)	(.130)	(.148)	(.117)
CONST	.568	.344	.384	.274	.507	.397
	(.096)	(.125)	(.121)	(.131)	(.105)	(.119)

Note: Bandwidth is twelve to ninety-six months. Standard errors are given in parentheses.

Table 10.8 Phase Leads of Growth Rates of Six Variables with Respect to Growth Rate of Output, in Months

Industry	*EMP*	*HRS*	*PROD*	*WR*	*WP*	*EARN*
			Prewar Data			
STEEL	−4.7	1.8	2.3	−5.3	−0.3	1.2
	(1.11)	(0.9)	(0.7)	(5.7)	(6.9)	(1.0)
AUTOS	−0.5	10.4	−2.9	−10.6	−6.0	9.8
	(1.0)	(2.3)	(1.7)	(6.2)	(5.8)	(2.4)
MEAT	−6.0	2.2	4.6	−22.2	−7.6	−5.1
	(1.3)	(1.9)	(1.1)	(2.5)	(4.7)	(5.3)
PAPER	−7.3	2.4	2.3	−19.3	26.5	−0.5
	(1.8)	(0.9)	(1.6)	(2.1)	(2.8)	(1.1)
SHOES	−6.3	−2.4	9.0	−11.5	9.0	−3.0
	(1.6)	(1.1)	(1.9)	(16.6)	(11.3)	(1.2)
WOOL	−2.6	2.1	2.7	−15.8	24.7	−0.6
	(0.6)	(0.9)	(1.3)	(3.2)	(3.4)	(1.2)
LEATH	−5.7	2.8	11.1	−14.6	26.5	−0.7
	(1.4)	(1.5)	(4.5)	(3.0)	(1.9)	(1.1)
LUMBR	−3.8	2.0	11.2	−19.1	27.0	−0.7
	(1.4)	(1.3)	(5.7)	(4.3)	(1.9)	(2.0)
ALL MFG	−3.9	2.3	9.3	−11.6	−19.5	−0.3
	(0.6)	(0.7)	(2.4)	(2.4)	(2.1)	(0.8)
			Postwar Data			
STEEL	−2.8	1.1	2.2	3.1	9.3	1.6
	(0.6)	(0.6)	(0.7)	(2.0)	(6.6)	(0.8)
AUTOS	−2.5	4.5	5.0	3.6	3.9	4.1
	(0.5)	(1.2)	(2.2)	(1.1)	(1.7)	(0.9)
MEAT	−4.1	2.3	1.8	0.1	−1.6	1.3
	(1.7)	(1.7)	(1.6)	(2.6)	(1.2)	(1.4)
PAPER	−4.4	2.1	3.9	7.2	10.0	3.5
	(0.6)	(1.0)	(0.7)	(3.2)	(1.1)	(1.3)
SHOES	−5.9	1.6	3.8	−7.6	11.9	0.8
	(1.2)	(1.7)	(2.1)	(7.6)	(12.9)	(1.7)
WOOL	−3.4	−1.0	1.5	4.9	24.3	0.5
	(2.8)	(4.1)	(1.8)	(4.9)	(2.0)	(4.1)
LEATH	−2.3	3.5	1.7	−5.4	12.4	1.8
	(1.5)	(2.7)	(2.7)	(7.3)	(3.1)	(2.9)
LUMBR	−3.9	2.0	6.4	−1.2	25.7	1.0
	(0.7)	(0.8)	(1.4)	(3.0)	(2.2)	(1.0)
ALL MFG	−2.4	2.1	4.4	0.7	8.4	1.6
	(0.5)	(0.8)	(1.3)	(3.0)	(3.7)	(1.3)
COAL	−5.1	−0.1	9.1	−10.4	−21.3	−1.7
	(1.6)	(1.2)	(3.5)	(3.0)	(19.2)	(1.3)
ELECT	−16.0	−0.3	1.9	2.8	−5.4	1.3
	(4.0)	(3.2)	(1.1)	(4.1)	(4.9)	(2.7)
CONST	−4.2	4.2	5.0	11.6	12.3	6.7
	(1.8)	(3.3)	(2.9)	(4.3)	(2.0)	(2.8)

Note: Bandwidth is twelve to ninety-six months. Standard errors are given in parentheses.

we have done no explicitly structural test. Still, it is interesting that this interpretation seems at least to be consistent with the facts for so many disparate industries, and for both the prewar and postwar eras.

This stability across industries and sample periods is not shared by the relationship of wages and output. There seems to be a definite difference between the prewar and postwar behavior of wages. Let us concentrate on real, rather than product, wages. During the prewar period, real wages lagged output significantly—not quite enough to be called countercyclical, but still "half out of phase."[3] (A well-known example of this is the positive growth of real wages in 1931–32, even as output and employment plunged.) In contrast, during the postwar period real wages were nearly in phase (procyclical), even leading the cycle in some industries.

Why did the cyclical behavior of real wages change between the prewar and postwar periods? A satisfactory answer to this question would require an explicit structural model, which we do not attempt in this paper. However, we do present a simple heuristic example suggesting that this change may be related to one of our earlier findings, that layoffs have become relatively more important than work sharing in the postwar period.

Suppose that, because of fixed costs, workers can hold only one job at a time. (This example will generalize as long as an individual's work effort is not infinitely divisible among employers.) Then the labor market is cleared not by the hourly wage, but by the total utility available to the worker in a job. Assume that workers get utility from total real compensation Y and disutility from hours of work per week H. If, for simplicity, the marginal utilities of income and leisure are taken to be constant, then instantaneous utility at time t, U_t, can be written as

$$U_t = Y_t - \alpha H_t, \qquad (1)$$

where α is a parameter.

To retain their labor forces, firms must provide workers with (Y_t, H_t) combinations such that workers' utility equals or exceeds $\bar{U}$, the (exogenous) utility level obtainable elsewhere in the economy. Assuming for purposes of this example that business cycles are regular sine waves and that $\bar{U}$ is procyclical, we can write

$$\bar{U}_t = \bar{U}_0 (1 + a \sin t), \qquad (2)$$

where $\bar{U}_0$ is average obtainable utility and a is a positive parameter measuring the cyclical sensitivity of $\bar{U}$.

3. This is reminiscent of Creamer's (1950) result for nominal wage rates. See section 10.2.

Firms' choices about which (Y_t, H_t) combinations to offer (from among those combinations that satisfy the external utility constraint) will arise from a maximization calculation that takes into account the nature of the production function, the existence of specific human capital or adjustment costs, and so forth. For this heuristic example we do not explicitly specify the firm's maximization problem but simply assume (realistically) that its outcome will imply a procyclical workweek:

$$H_t = H_0 (1 + b \sin t), \tag{3}$$

where H_O is the average workweek over the cycle and b measures the workweek's cyclical sensitivity. Equation (3) is to be interpreted as a reduced form; the parameter b may well depend on the other parameters in the problem.

The three equations just given, plus the assumption that real earnings are just high enough to meet the external utility constraint, imply that the cyclical behavior of real earnings per worker is

$$Y_t = (\bar{U}_0 + \alpha H_0) + (a + \alpha b) \sin t. \tag{4}$$

Average earnings Y_0 equal $\bar{U}_0 + \alpha H_0$.

In this example, the measured "real wage" W_t is just Y_t/H_t. Under what conditions will the measured wage be procyclical (i.e., have a positive sensitivity to the exogenous cycle)? It is easy to show that the necessary and sufficient condition for real wage procyclicality is

$$a > b. \tag{5}$$

That is, wages are procyclical if reservation utility has a greater sensitivity to the cycle than do hours of work.

It is difficult to say what has happened over time to the cyclical sensitivity of reservation utility; perhaps reservation utility has become less cyclical in the postwar period, which would work against the present argument. However, in section 10.4 we introduced evidence that b, the cyclical sensitivity of hours, has fallen in the postwar era. The example shows that, everything else being equal, reduced cyclical sensitivity of hours tends to be associated with greater observed procyclicality in real wages. Thus, two of the novel findings of this paper—that hours have become less procyclical and that real wages more procyclical in the postwar period—may be related.

An important question is whether the cyclical relationships described in tables 10.7 and 10.8 are the same in long and short business cycles. Closely related is whether it is useful to study "reference cycles." Burns and Mitchell frequently measured timing relationships in terms of "stages" of a standard "reference cycle" instead of in calendar times. For this to be worthwhile, it must be the case that cyclical lead/

lag relationships are roughly constant fractions of the cycle length rather than constant when measured in calendar time; that is to say, phase angles must be constant across business cycle frequencies.

Some insight on this question is provided by table 10.9. That table gives the estimates of the phase leads of the six variables for the deseasonalized high-frequency band (two to twelve months); for short cycles (one to two years); and for long cycles (two to eight years). (The business cycle band was broken up in that particular way because there are approximately as many frequencies with periods between twelve and twenty-four months as there are with periods between twenty-four and ninety-six months.) Also reported for each variable are the results of a statistical test for constancy of phase angles between short and long business cycles. Inspection of table 10.9 suggests two observations.

First, while not much systematic emerges in the high-frequency band, the qualitative pattern of leads and lags is the same in the short and long business cycles ranges (the b and c rows in the table). For example, productivity still leads the cycle, employment still lags.

Second, there appears to be a bit of support for the "reference cycle" construction (and, by implication, for the "time deformation" approach to cycles recently suggested by Stock 1983). The hypothesis of constant phase angles between short and long business cycles, which is implied by the reference cycle approach, is not usually rejected by the data. (Exceptions are the prewar meat-packing industry and, to some extent, aggregate manufacturing in both the prewar and postwar periods.) Thus, assuming that leads and lags are proportional to cycle length does not seem unreasonable. On the other hand, it should be noted that this evidence in favor of reference cycles may possibly be spurious: as an example in Hause (1971) shows, two variables with a fixed distributed lag relationship in the time domain may also exhibit a phase relationship that is roughly proportional to the period of the cycle.

The observations we have made so far apply to more or less all the industries in the sample, with a few distinctions drawn between the patterns visible in the prewar period and those in the postwar era. We had hoped to be able to make more cross-sectional distinctions (e.g., like the finding of Nadiri and Rosen 1973 that input responses are much more rapid in durable goods industries). Unfortunately, much less cross-sectional variation than we expected was evident when we grouped the industries in the obvious ways.

To see if the industries might be grouped by the nature of their cyclical behavior, we estimated the coherences and phases between industry outputs and the aggregate index of output, for the prewar and postwar periods separately. These are presented in table 10.10. An odd result is that almost all the phase leads are positive; this may be due to the inclusion of input-based measures of output in the aggregate index.

Table 10.9 Phase Leads of Growth Rates of Six Variables with Respect to Growth Rate of Output, in Months

Industry		*EMP*	*HRS*	*PROD*	*WR*	*WP*	*EARN*
				Prewar Data			
	(a)	−0.4	0.0	0.2	−1.9	2.5	−0.1
STEEL	(b)	−1.6	0.6	0.8	2.2	2.4	0.8
	(c)	−5.0	2.1	2.5	−13.8***	−13.5***	−0.4
	(a)	0.3	0.5	−0.2	−1.4	−1.2	0.4
AUTOS	(b)	−0.3	4.1	−0.9	−2.2	−1.2	4.0
	(c)	0.1	6.6	−3.6	−15.3	−9.4	5.0*
	(a)	−1.0	−0.1	0.2	−2.0	−1.2	−0.2
MEAT	(b)	−2.2	0.6	1.1	−8.2	−5.5	0.2
	(c)	−5.8	23.9***	10.4***	−16.1	0.3***	−18.9***
	(a)	−1.4	−0.6	0.3	−3.0	−2.4	−0.9
PAPER	(b)	−3.1	0.7	0.8	−7.1	−8.9	0.1
	(c)	−4.5	3.4	2.7	−18.1	27.8	−2.7
	(a)	−0.3	−0.1	0.1	2.8	2.6	0.1
SHOES	(b)	−1.9	−0.9	3.0	−7.4	4.4	−1.1
	(c)	−8.6	−1.1	9.8	−5.0	0.6	−2.3
	(a)	−0.6	−0.1	0.4	−2.6	−3.4	−0.3
WOOL	(b)	−0.6	0.6	0.6	−5.3	−8.9	0.2
	(c)	−4.4	2.9	5.3	−17.5	25.6	−3.5
	(a)	0.0	−0.1	0.0	1.9	−3.3	0.2
LEATH	(b)	−2.4	0.8	3.5	−4.9	8.8	0.1
	(c)	−3.2	4.0	18.7	−15.9	29.5	−4.0
	(a)	−0.4	0.6	−0.1	−2.6	−3.0	0.4
LUMBR	(b)	−1.8	0.4	4.6	−7.4	−8.8	−0.5
	(c)	−1.3***	5.7	−0.9*	−5.7	28.8	0.8
	(a)	−0.5	−0.1	0.6	3.4	−3.2	−0.1
ALL MFG	(b)	−1.7	0.6	2.3	−3.9	−7.2	0.0
	(c)	−3.3*	3.4	19.9***	−12.8	−20.0	−0.7
				Postwar Data			
	(a)	−0.4	0.0	0.1	0.7	0.9	0.1
STEEL	(b)	−0.9	0.1	0.5	0.8	0.8	0.3
	(c)	−3.3	2.9***	4.4*	4.7	17.6	3.4
	(a)	−0.2	−0.1	1.7	−0.2	−0.1	−0.1
AUTOS	(b)	−0.8	1.5	1.6	1.2	2.0	1.4
	(c)	−2.7	4.6	6.1	3.9	−0.7*	4.3
	(a)	−1.3	0.1	0.0	−0.6	−0.4	−0.1
MEAT	(b)	−1.3	0.9	0.5	1.0	−0.2	0.9
	(c)	−4.9	1.9	2.4	−5.6*	−2.4	−1.5
	(a)	0.4	−0.6	0.0	2.7	−2.0	−0.4
PAPER	(b)	−1.2	0.3	1.0	−2.8	3.1	0.1
	(c)	−5.5	3.6	5.8*	8.7	12.0	5.8*
	(a)	0.3	0.5	0.1	1.0	1.2	0.5
SHOES	(b)	−1.9	0.9	0.6	−3.5	5.3	0.5
	(c)	−6.7	0.8	8.3	−5.6	10.9	0.1

Table 10.9 (continued)

Industry		*EMP*	*HRS*	*PROD*	*WR*	*WP*	*EARN*
	(a)	0.0	0.1	0.0	0.5	2.5	0.1
WOOL	(b)	−1.9	−1.9	0.5	1.0	−5.2	0.5
	(c)	−2.2	3.7	0.8	7.1	25.2**	4.6
	(a)	0.7	0.7	−0.1	0.7	1.8	0.7
LEATH	(b)	−0.4	1.5	−0.1	−3.3	−8.5	0.7
	(c)	−3.2	3.0	4.2	−2.6	13.3	1.7
	(a)	−0.2	0.1	0.0	0.4	1.2	0.3
LUMBR	(b)	−1.4	0.7	1.3	−2.6	−7.7	0.2
	(c)	−6.2	0.8	18.7***	−8.5	29.1	0.2
	(a)	−0.0	0.2	0.1	0.6	0.7	0.1
ALL MFG	(b)	−0.7	0.0	1.0	−1.8	2.8	−0.7
	(c)	−2.9	4.7***	9.5**	5.7**	9.3	9.5**
	(a)	−0.2	−0.2	0.1	−2.7	−1.6	−0.2
COAL	(b)	−1.1	−0.3	0.7	−3.7	−3.2	−1.1
	(c)	−6.2	0.8	18.7***	−8.5	29.0	0.2
	(a)	2.1	0.7	−0.1	−2.2	0.6	0.3
ELECT	(b)	−5.7	1.1	0.3	−3.3	−4.4	−0.8
	(c)	−16.5	−9.0*	3.1	8.5***	−0.1	5.2
	(a)	0.0	0.2	0.0	−3.4	−3.1	0.2
CONST	(b)	−0.8	1.6	0.6	7.0	5.6	3.2
	(c)	−6.7	1.5	8.5	4.9***	10.3**	4.0

Note: Asterisks denote significance of *t*-tests of difference of phase angles between frequency bands (b) and (c), at marginal significance levels of .10 (*), .05 (**), and .01 (***).

(a) Bandwidth: two to twelve months.

(b) Bandwidth: twelve to twenty-four months.

(c) Bandwidth: twenty four to ninety-six months.

The coherence estimates suggest that cyclical influences became relatively less important for the industries in the postwar period. There is also a tendency in the postwar sample for durable goods industries to exhibit a relatively higher coherence with the cycle than nondurable goods industries. However, except for meat-packing, there is surprisingly little evidence of this pattern in the prewar period. Overall, cross-sectional differences still seem less significant than cross-sectional similarities.

10.6 Analysis in the Time Domain

To complement the frequency domain analysis of the data, we employed time domain methods, primarily vector autoregressions (VARs). Separate VARs, using twelve monthly lags of four variables (output, hours, employment, and real wages), were estimated for each of the

Table 10.10 Coherences and Phase Leads of Growth Rates of Output in Each Industry with Respect to Growth Rate of "All Manufacturing" Output

Industry	Period	Coherence (SE)	Phase Lead (SE)
STEEL	1923–39	94.7 (2.0)	1.3 (0.6)
	1954–82	64.6 (8.2)	0.2 (1.4)
AUTOS	1923–39	78.0 (7.4)	−4.1 (1.3)
	1954–82	78.6 (5.4)	0.2 (1.0)
MEAT	1923–39	19.5 (18.2)	1.2 (8.2)
	1954–82	26.2 (13.2)	4.8 (4.5)
PAPER	1923–39	86.7 (4.7)	2.3 (0.9)
	1954–82	79.7 (5.2)	1.2 (0.9)
SHOES	1923–39	73.9 (8.6)	6.7 (1.5)
	1954–82	46.4 (11.1)	4.9 (2.3)
WOOL	1923–39	80.1 (6.8)	3.5 (1.2)
	1954–82	31.9 (13.9)	1.4 (3.9)
LEATH	1923–39	75.0 (8.3)	0.6 (1.4)
	1954–82	38.8 (12.0)	3.7 (2.9)
LUMBR	1923–39	88.0 (4.3)	1.0 (0.9)
	1954–82	73.9 (6.4)	5.3 (1.1)
COAL	1954–82	28.4 (13.0)	−5.4 (4.1)
ELECT	1954–82	44.7 (11.3)	−2.1 (2.4)
CONST	1954–82	57.4 (9.5)	6.3 (1.7)

Note: Bandwidth is twelve to ninety-six months.

prewar and postwar industries and for the aggregates. The data were the same centered and seasonalized log differences described in section 10.5. As in Sims (1980), the estimated VARs were used to do three things. First, we looked at the statistical significance of blocks of coefficients in order to search for patterns of causality (in the Granger sense). Second, we calculated the percentages of the forecast errors attributable to (triangularized) innovations in the right-hand-side variables, for four forecast horizons. Finally, the implied impulse/response diagrams were examined for systematic timing relationships among the variables. We briefly discuss each of these exercises.

Table 10.11 summarizes the results of the Granger-causality F-tests. There is one matrix for each dependent variable. In each matrix, the rows designate the industry to which the VAR applies, the columns give the block of independent variables being tested. One, two, or three asterisks in a given cell of a matrix implies that the twelve monthly lags of the independent variable jointly "explain" the dependent variable (for the given industry and period) at the .10, .05, or .01 level of significance. No asterisks in a cell implies that the joint contribution of all lags of the given regressor is not significant at the .10 level.

Table 10.11 VAR *F*-Tests

		Independent Variables			
Dependent Variables	Industry	*IP*	*HRS*	*EMP*	*WR*
		Prewar Data			
IP					
	STEEL	**	*		***
	AUTOS	***		***	
	MEAT		**		**
	PAPER			**	
	SHOES	***	**		*
	WOOL	*		***	
	LEATH		*		
	LUMBR	***	***		***
	ALL MFG	***			
HRS					
	STEEL	***	***	***	***
	AUTOS		***		
	MEAT		**	*	*
	PAPER	***	*		*
	SHOES	***	***	***	
	WOOL	***	**	***	
	LEATH	***	***	***	
	LUMBR	**	***		
	ALL MFG	***	*	***	
EMP					
	STEEL	*			
	AUTOS	***	***	**	*
	MEAT	**	**		
	PAPER	**		**	
	SHOES	**	**	***	
	WOOL	***		***	
	LEATH	***		**	
	LUMBR	**		**	
	ALL MFG	**	*		
WR					
	STEEL				
	AUTOS		**		
	MEAT				
	PAPER			**	
	SHOES	**	**		
	WOOL				
	LEATH	**			
	LUMBR	***	*	*	***
	ALL MFG			*	
		Postwar Data			
IP					
	STEEL	*			
	AUTOS	*		***	
	MEAT	***	**		*
	PAPER	***		**	***
	SHOES	***	***	**	
	WOOL	***	***		
	LEATH	***	**		
	LUMBR	***		***	***

Table 10.11 (continued)

		Independent Variables			
Dependent Variables	Industry	*IP*	*HRS*	*EMP*	*WR*
	ALL MFG	***	**	***	
	COAL	***		*	
	ELECT	***			***
	CONST	***			**
HRS					
	STEEL	**	***	**	
	AUTOS		***		
	MEAT	**	***		**
	PAPER	***	***	*	
	SHOES	***	***	***	
	WOOL	*	***	***	***
	LEATH		***	**	*
	LUMBR		***		
	ALL MFG	***	***	**	
	COAL	***	***	*	**
	ELECT		***		
	CONST		***		
EMP					
	STEEL	***	**		
	AUTOS	***	**	***	
	MEAT	***		**	
	PAPER	***	***	***	
	SHOES	**	***	***	
	WOOL	***	***	***	***
	LEATH		***	***	
	LUMBR	***		***	**
	ALL MFG	***		**	
	COAL	*		***	
	ELECT		**	***	
	CONST			***	
WR					
	STEEL				***
	AUTOS	***		***	***
	MEAT	*			**
	PAPER				***
	SHOES		**		***
	WOOL		*		***
	LEATH				***
	LUMBR			**	
	ALL MFG				***
	COAL				***
	ELECT	**		***	***
	CONST				***

Note: *F*-tests whose outcomes are reported are tests of the joint significance of all twelve lags of the independent variable in the explanation of the dependent variable. (All variables are in growth rates.)

*F-test significant at .10 level.

**F-test significant at .05 level.

***F-test significant at .01 level.

Table 10.11 suggests that, for all industries taken together:

1. Output growth tends to be relatively exogenous (in the Granger sense), at least in comparison with the growth rates of employment and hours. (Thus hours may be a "leading indicator" without having incremental predictive value for output. See Neftci 1979.) Output seemed to be much more "persistent" in the postwar period, in the sense that lagged growth rates of output became much stronger predictors of the current growth rate.

2. Hours and employment are rarely found to be Granger exogenous; they respond both to each other and to output. The two variables are also found to be persistent, in the sense just defined, in both the prewar and postwar samples. The persistence of employment will be an appealing finding for supporters of the view that there are "adjustment costs" to changing employment. Are there also adjustment costs to changing hours of work? The data seem consistent with this.

3. The real wage seems to vary nearly independently of the three other variables, neither consistently predicting nor being predictable by them. A remarkably strong finding about the real wage is that, like output, its persistence significantly increased between the prewar and postwar periods.

The results of the forecast error decomposition exercise are given in Table 10.12. To save space, we report results for three industries only: iron and steel (a durable goods industry), paper and pulp (nondurables), and leather tanning and finishing (semidurables). Results for the manufacturing aggregates are also reported. The prewar and postwar forecast error decompositions are placed side by side in the table, for easier comparison. Also note that, since the growth in productivity is just a linear combination of the growth in output, hours, and employment (all of which were included in the VARs), it is possible to report decompositions for this variable as well.

As the reader familiar with these methods is aware, the attribution of forecast error at different horizons to the (triangularized) innovations in the regressors is not invariant to the ordering of the variables. The ordering used here (and for the construction of the impulse/response diagrams below) is as follows: (log differences of) output, hours, employment, real wages. Given that the data are monthly and that forecast horizons up to forty-eight months are studied, the choice of ordering is not likely to be crucial to the results.

The pattern of relationships suggested by table 10.12 is, perhaps not surprisingly, very similar to that revealed by the F-tests reported in table 10.11. Note, for example, that the relatively exogenous output variable (IP) is shown in table 10.12 to be largely "self-caused," even at the four-year forecast horizon. (This tendency seems to be even

Table 10.12 Percentages of Forecast Error *k* Months Ahead Produced by Each Innovation (Prewar/Postwar)

Forecast Error	Triangularized Innovation				
	k	*IP*	*HRS*	*EMP*	*WR*
		Iron and Steel			
IP	6	89/91	2/3	3/5	6/1
	12	79/87	5.4	4/6	13/2
	24	66/85	8/5	5/8	21/2
	48	63/85	8/5	6/8	23/2
EMP	6	31/55	1/1	63/41	5/3
	12	29/52	4/6	59/39	8/4
	24	29/51	5/7	53/38	12/4
	48	29/51	6/7	51/38	15/4
HRS	6	40/43	40/52	19/4	2/1
	12	41/41	34/50	19/7	7/2
	24	40/41	31/49	17/8	12/2
	48	39/41	31/49	17/8	13/2
WR	6	3/4	3/8	6/1	88/86
	12	6/6	5/9	7/4	82/82
	24	8/6	6/9	8/4	78/81
	48	8/6	7/9	8/4	77/81
PROD	6	57/76	29/10	3/12	11/2
	12	49/74	30/10	5/13	16/2
	24	40/73	30/11	7/14	24/3
	48	39/73	30/11	7/14	24/3
		Paper and Pulp			
IP	6	83/92	3/2	10/5	4/0
	12	75/83	6/3	11/7	8/7
	24	71/80	8/3	12/7	10/9
	48	71/80	8/3	12/7	10/9
EMP	6	21/31	1/5	72/62	6/2
	12	19/30	5/6	68/57	8/7
	24	19/30	5/6	65/55	11/10
	48	19/30	5/6	65/54	11/10
HRS	6	30/11	61/86	3/2	6/2
	12	32/14	56/80	4/3	8/3
	24	32/14	54/79	4/4	10/4
	48	32/14	54/79	4/4	10/4
WR	6	9/1	10/2	2/2	80/96
	12	13/2	10/3	8/3	69/93
	24	13/3	10/4	10/3	67/91
	48	13/3	10/4	10/3	66/91
PROD	6	50/64	26/18	19/17	5/1
	12	45/60	27/16	20/18	8/6
	24	43/58	26/17	19/18	12/8
	48	43/58	26/17	19/18	12/8

Table 10.12 (continued)

Forecast Error	Triangularized Innovation				
	k	*IP*	*HRS*	*EMP*	*WR*
		Leather Tanning and Finishing			
IP	6	84/90	5/3	8/5	3/2
	12	80/87	8/5	7/5	4/3
	24	78/85	10/7	8/5	5/4
	48	78/85	10/7	8/5	5/4
EMP	6	21/8	8/9	69/82	2/2
	12	23/8	9/10	65/78	4/4
	24	29/8	9/10	58/78	4/4
	48	29/8	10/10	56/78	5/4
HRS	6	19/3	69/89	7/3	6/5
	12	21/5	65/84	8/6	6/6
	24	23/5	61/82	9/6	7/7
	48	24/5	60/81	9/6	7/7
WR	6	8/3	12/1	7/3	72/92
	12	14/4	14/3	8/5	64/88
	24	16/5	16/3	9/5	59/87
	48	16/5	16/3	9/5	58/87
PROD	6	24/58	36/14	37/26	3/1
	12	33/55	34/17	30/25	4/3
	24	34/54	34/17	28/25	4/4
	48	35/53	34/17	28/25	4/4
		All Manufacturing Firms			
IP	6	94/93	1/2	3/4	2/1
	12	77/86	8/4	8/7	7/3
	24	71/82	12/6	10/9	7/3
	48	70/80	12/6	11/10	7/4
EMP	6	64/59	1/2	33/39	2/0
	12	57/57	9/3	31/39	3/2
	24	54/57	11/4	30/38	5/2
	48	53/56	11/4	31/38	5/2
HRS	6	51/22	38/74	9/4	1/1
	12	47/21	38/71	12/5	2/3
	24	46/22	37/68	14/6	4/4
	48	46/22	37/68	14/6	4/4
WR	6	7/2	5/3	11/1	77/94
	12	7/3	9/3	14/2	70/92
	24	13/4	9/3	15/2	62/91
	48	14/4	9/3	16/2	61/91
PROD	6	22/18	41/47	36/34	2/1
	12	22/18	39/44	34/35	5/3
	24	20/19	39/42	35/36	5/3
	48	21/19	39/42	35/36	5/3

greater in the postwar period than in the prewar.) Hours and employment are fairly sensitive to output innovations except, for some reason, in the postwar leather industry. The "persistence" of both hours and employment is apparent; this persistence increases markedly for hours in the postwar era. The productivity variable is largely driven by innovations in output, especially in the postwar period, although productivity's other components (employment and hours) also play a role.

Again, a most striking finding is the relationship (or lack of a relationship) between real wages and the other variables. Innovations in the real wage appear to have virtually no predictive power for output, employment, and weekly hours; and in the other direction, no variable except the real wage itself is of much use in forecasting the real wage. This essential independence of the real wage and the other variables is more pronounced in the postwar period.

The final exercise in the time domain was the use of the estimated VARs to generate impulse/response (IR) diagrams. These diagrams show the movement over time of each variable in the VAR in response to a (triangularized) innovation to one of the regressors. (The response of productivity to innovations in the other variables was also analyzed.) The ordering of the variables was the same as in the forecast error decompositions above. Since the data are in log differences, we printed out cumulative response diagrams; this allowed us to interpret the patterns in terms of log levels. These diagrams were useful for gaining a qualitative appreciation of "typical" short-run patterns in the data.

The number of industries, variables, and sample periods meant that there were potentially hundreds of IR diagrams to study. We chose to look carefully only at the three representative industries (iron and steel, paper, leather); we also looked closely at construction. The reader will be burdened with only a few sample IR diagrams (see figs. 10.1 and 10.2). These show the forty-eight month response pattern of (the log levels of) output, hours, employment, real wages, and productivity to a one standard deviation innovation in output growth in the iron and steel industry. Figure 10.1 *a–d* cover the prewar period; figure 10.2 *a–d* cover the postwar period. The path of output is included in each diagram, for reference.

From our examination of all the IR diagrams, we drew the following conclusions:

1. Generally, the IRs reinforce the characterization of the cycle obtained in the frequency domain. For example, the conclusion of section 10.5 that productivity is highly coherent with output and that it tends to lead the cycle by a few months emerges distinctly from the IR diagrams; this is true no matter which disturbance term provides the initial shock. Similarly, the high coherence and the lead/lag patterns

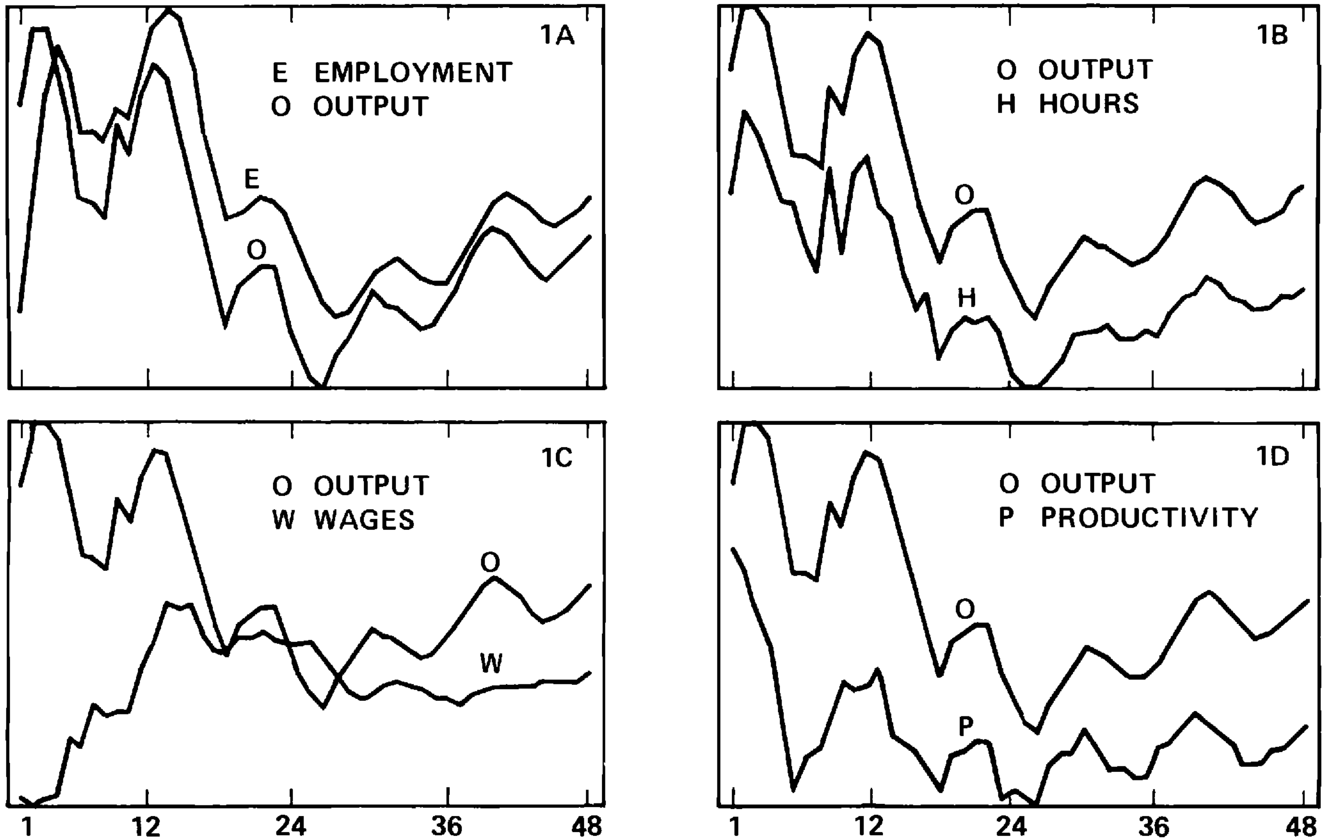

Fig. 10.1 Response of log levels to innovation in output growth: prewar, iron and steel.

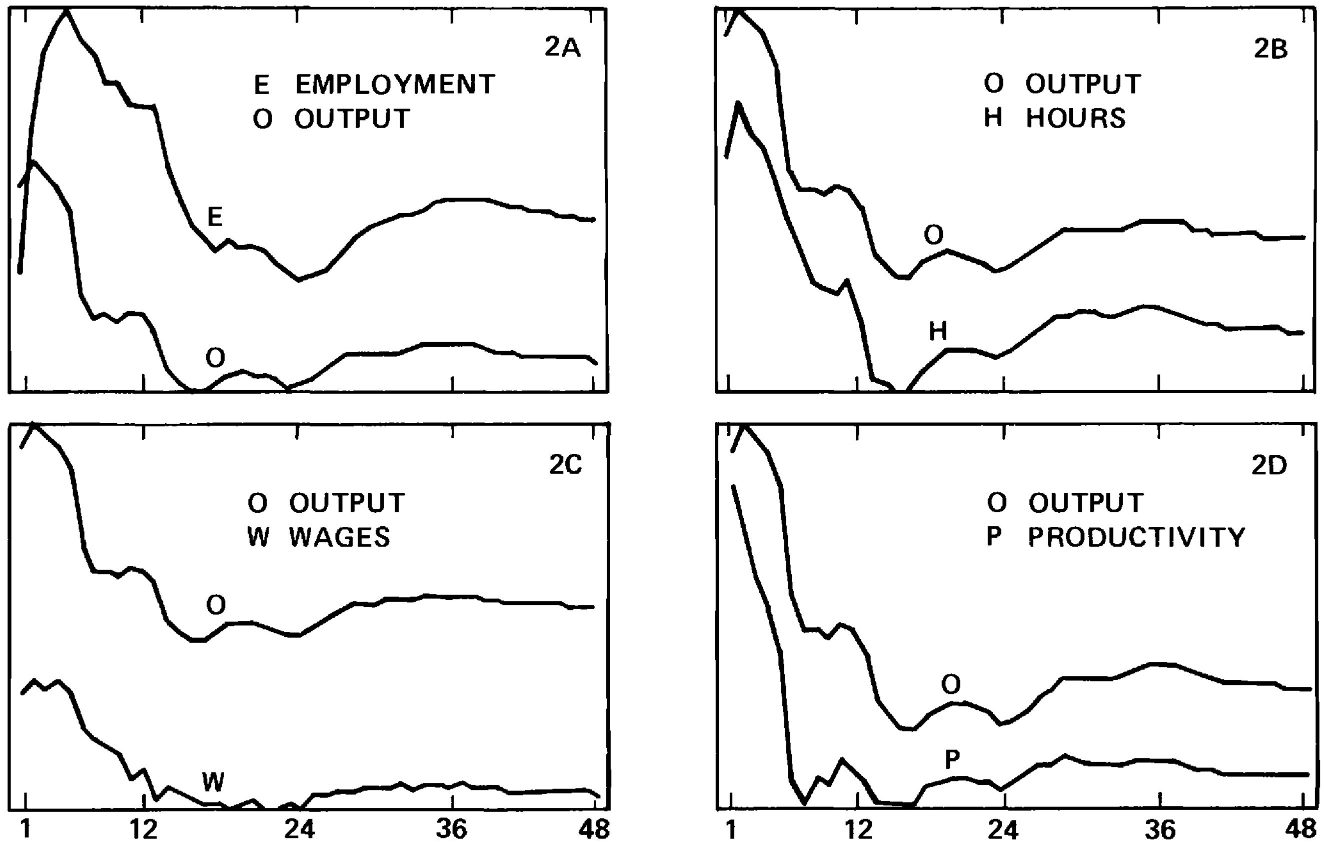

Fig. 10.2 Response of log levels to innovation in output growth: postwar, iron and steel.

for hours and employment found by frequency domain techniques recur almost exactly in the IRs. Figures 10.1*a*, *b*, *d* and 10.2*a*, *b*, *d* are here perfectly representative.

2. As the frequency domain analysis was less clear about the cyclical characteristics of the real wage, so it is the case in the time domain. The pictures show a real wage behavior that is not very stable across industries and that is also sensitive to the source of the initial shock, especially in the prewar sample. However, as in section 10.4, there still appear to be noticeable differences between prewar and postwar wage movements. (See figs. 10.1*c* and 10.2*c*.) During the postwar period, in the cases when there is a visible relationship between output and wages, the IRs show the real wage to be a roughly coincident, procyclical variable. In the prewar data, the real wage is usually "half out of phase," either lagging (the typical response to output shocks; see fig. 10.1*c*) or leading (when there is an employment shock). There is also an interesting contrast between the prewar and postwar periods with regard to the effect of a wage shock on the rest of the system: a prewar wage shock tends to result in declining output and employment, whereas a wage shock in the postwar sample typically has just the opposite effect.

3. Finally, the diagrams show a postwar decline in cyclical variability (given a "typical" shock), which is consistent with several findings already discussed. Output and real wages in particular (reflecting their increased "persistence"?) are much less prone to gyrations in the postwar sample.

10.7 Four Major Recessions

The analysis so far has been "democratic" in its use of the data, allowing every sample observation equal weight in the calculations. This is consistent with the view that business cycles are realizations of stationary stochastic processes. An alternative view is that serious recessions or depressions are "special" occurrences, governed by different laws of probability than the "normal" parts of the sample. (This idea is investigated more formally by the Blanchard/Watson paper in this volume.) In the spirit of this alternative view, this section looks briefly at the behavior of labor market variables during four major downturns—two prewar and two postwar.

The four downturns studied are 1929:3 to 1933:1, 1937:2 to 1938:2, 1973:4 to 1975:1, and 1981:3 to 1982:4. Note that, except for the first, the recessions are of comparable length. (The peak and trough quarters are from the official NBER chronology.) For each of the four downturns, table 10.13 gives (for each of the seven labor market variables studied) the ratio of the average value of the *level* of the variable in

Table 10.13 Trough-to-Peak Ratios of Seven Variables for Four Selected Recessions

Industry	Cycle	*IP*	*EMP*	*HRS*	*PROD*	*WR*	*WP*	*EARN*
STEEL	I	.17	.50	.56	.62	.91	.84	.50
	II	.36	.72	.65	.77	.95	.92	.62
	III	.87	.96	.95	.95	1.00	.81	.95
	IV	.57	.68	.96	.87	.99	1.05	.94
AUTOS	I	.18	.40	.76	.58	.99	.88	.75
	II	.36	.49	.85	.86	1.02	.90	.87
	III	.60	.74	.93	.88	.95	.92	.88
	IV	.96	.87	1.01	1.10	.97	.97	.97
MEAT	I	.91	.77	.95	1.25	.95	1.50	.90
	II	1.07	.93	1.03	1.12	.99	1.12	1.02
	III	.97	.98	.99	1.00	1.01	1.17	1.00
	IV	.90	.96	1.00	.94	.94	.94	.94
PAPER	I	.59	.74	.79	1.01	.99	.87	.79
	II	.71	.87	.86	.95	1.06	1.13	.91
	III	.74	.88	.95	.89	.96	.82	.91
	IV	.98	.95	.99	1.05	1.02	1.02	1.01
SHOES	I	.79	.89	.92	.96	.99	.95	.91
	II	.82	.93	.73	1.20	1.00	1.02	.73
	III	.81	.87	.91	1.03	.95	.98	.86
	IV	.87	.91	.98	.97	1.00	1.01	.98
WOOL	I	.62	.73	.88	.95	.94	1.23	.83
	II	.44	.68	.80	.80	1.01	1.21	.81
	III	.47	.57	.71	1.16	.91	1.23	.65
	IV	.77	.77	.82	1.22	.99	NA	.82
LEATH	I	.76	.80	.91	1.04	.98	1.43	.89
	II	.71	.79	.85	1.06	1.03	1.23	.87
	III	1.03	.99	.99	1.06	.95	1.24	.94
	IV	.88	.90	1.01	.97	1.02	1.07	1.03
LUMBR	I	.32	.42	.74	1.04	.92	1.13	.68
	II	.67	.86	.87	.89	1.02	1.22	.88
	III	.75	.78	.94	1.01	.96	1.21	.91
	IV	1.10	.99	1.02	1.09	1.01	1.06	1.02
ALL MFG	I	.50	.72	.79	.89	.96	1.01	.76
	II	.62	.73	.81	1.05	.97	1.04	.78
	III	.81	.88	.96	.96	.97	.88	.93
	IV	.90	.90	.99	1.01	.99	1.02	.98
COAL	III	1.05	1.20	1.01	.87	.96	.68	.97
	IV	.83	.84	.91	1.09	1.02	1.02	.93
ELECT	III	.96	.98	.97	1.00	.96	.80	.94
	IV	.93	1.00	1.01	.93	1.02	1.00	1.02
CONST	III	.78	.87	.98	.92	.94	.89	.92
	IV	.99	.93	.98	1.09	1.00	1.04	.98

Note: The variables from which the ratios are formed are detrended, deseasonalized, quarterly averages of levels (not growth rates). Peak and trough quarters are from the official NBER chronology.

I: 1933:1/1929:3.
II: 1938:2/1937:2.
III: 1975:1/1973:4.
IV: 1982:4/1981:3.

the trough quarter to its average value in the preceding peak quarter. (The data are detrended and deseasonalized.) The purpose of this is to get a rough measure of the behavior of these variables in individual major recessions. (Alternatives would have been to construct multistage Burns/Mitchell "reference cycles" or to look at all quarters of the downturns. We experimented with both of these but did not find them much more informative.)

A preliminary point that should be made is that the designated peaks and troughs are based on aggregate economic variation, which may not coincide exactly with the industry-level cycles. Nevertheless, there is obviously a strong correlation between aggregate and industry output: in table 10.13 the trough-to-peak ratio for (detrended) production exceeds one only four times in thirty-eight cases.

The trough-to-peak ratios for most of the variables displayed in table 10.13 do not seem too far out of line with our findings of previous sections. Employment and hours display their strong procyclicality throughout. As in section 10.4, we see again here that postwar employers seemed to rely more on layoffs than on short workweeks as the means of reducing labor input in the trough, whereas prewar employers relied relatively more heavily on part-time work. Real wages show little systematic peak-to-trough change, which is indicative of the low coherence of real wages and output. Product wages are more variable than real wages; they also show some tendency to countercyclicality. Weekly real earnings, as would be predicted, are clearly procyclical.

A variable that is somewhat puzzling is productivity. The standard finding that productivity is procyclical implies that its trough-to-peak ratio should be less than one. This ratio is actually below one in only about half of the thirty-four cases in which output declines between peak and trough. Productivity is most procyclical in the heavy durable goods industries (iron and steel, automobiles); in the other industries productivity is more likely to rise than fall, peak to trough.

A partial explanation of these results may follow from our earlier finding that productivity, though essentially procyclical, may lead the cycle by a number of months. Thus productivity at the output peak has already fallen from its highest level, while at the output trough it has already begun to recover. (A similar observation is made by Gordon 1980.) The recovery of productivity in the trough may also be particularly strong in very deep recession, in which financial pressure on firms increases the costs of hoarding labor or permitting inefficient production. These considerations serve at least to reduce this new productivity puzzle, though they probably do not eliminate it.

Putting aside the productivity question, table 10.13 does suggest that there are qualitative similarities between major recessions and less dramatic economic fluctuations. This should be encouraging to forecasters and policymakers, whose tasks would be impossible if every severe fluctuation were essentially a unique event.

10.8 Conclusion

This exercise in "measurement without theory" has supported some existing perceptions about the cyclical behavior of labor markets and has uncovered a few additional facts. To summarize the most important findings:

1. Procyclical labor productivity (SRIRL) appears to be present in every industry, in both the prewar and postwar periods. (This paper is the first to document SRIRL for the pre-1932 period, as far as we know.) However, in confirming this standard empirical result, we have found two qualifications. First, productivity is a leading, rather than coincident, variable. Second, SRIRL may be less pronounced in major recessions.

2. Weekly hours and employment are strongly procyclical. Hours lead output, whereas employment lags. Our evidence that employment is lagging rather than coincident is somewhat novel; otherwise these observations replicate previous results.

3. A new finding is that there has been an increased reliance in the postwar period on layoffs, rather than short workweeks, as a means of reducing labor input.

4. The relationship of the real wage to other variables over the business cycle is weak, and it has been weaker in the postwar period. On the question whether any cyclical sensitivity of the real wage exists at all, the results from the frequency domain analysis are much more affirmative than those for the time domain. The difference between the two approaches probably arises because the frequency domain analysis blocks out some high-frequency interference that the time domain analysis does not; this permits the frequency domain approach to recover a relationship at business cycle frequencies that is less apparent in the time domain. The noisiness of the wage/employment relationship in the time domain may explain the inability of Geary and Kennan (1982) to reject the hypothesis that these two series are independent.

5. To the extent that the real wage is related to the cycle, there seems to be a definite difference between its prewar and its postwar behavior. The real wage was procyclical (essentially coincident) in the postwar period but "half out of phase" (usually lagging) in the prewar. This difference has not been noticed before for real wages, although Creamer (1950) found that nominal wages lagged the cycle in the early prewar period.

6. The relationship of product wages to the cycle is, if anything, weaker and more erratic than that of real wages. Real weekly earnings are strongly procyclical in both major samples.

7. Cyclical variation is a relatively small part of the total variation of the labor market variables. (A similar finding is in Bernanke 1983.) The postwar data exhibit more stability (i.e., less total variance and less business cycle variance). They also are more serially persistent than the data from the earlier period, which may be interpreted either as being consistent with Sach's (1980) finding of greater rigidity or as simply reflecting a more stable economy.

We hope that this and similar analyses will lead to a better understanding of the cyclical behavior of labor markets. However, we emphasize once again that this research is intended to be a complement to, not a substitute for, structural modeling of these phenomena.

Appendix

Sources

The sources of the *prewar* industry data used in this study are as follows:

1. Earnings, hours, and employment data are from Beney (1936) and Sayre (1940). These data are the result of an extensive monthly survey conducted by the National Industrial Conference Board (NICB) from 1920 until 1947.

All the industries in the sample paid at least part of their work force by piece rates (see *Monthly Labor Review* 41 [September 1935]:697–700). No correction was made for this.

2. Industrial production data are from the Federal Reserve Board. See "New Federal Reserve Index of Industrial Production," *Federal Reserve Bulletin* 26 (August 1940):753–69, 825–74.

3. Wholesale price indexes are from the Bureau of Labor Statistics (BLS). See the following publications of the United States Department of Labor: *Handbook of Labor Statistics* (1931 ed., bulletin 541; 1936 ed., bulletin 616; 1941 ed., bulletin 694) and *Wholesale Prices 1913 to 1927* (Washington, D.C.: Government Printing Office, 1929, bulletin 473). For the automobile industry we merged two BLS series of motor vehicle prices. Neither series covered 1935; the price series on all metal products was used to interpolate the automobiles price series for that year.

4. The consumer price series is from Sayre (1948).

All basic data were seasonally unadjusted. The span of the prewar sample is January 1923 to December 1939. Although some of the data exist before 1923, there are two major problems with extending the sample further back: some of the industrial production data are missing, and there is a six-month gap in the NICB survey in 1923. The December 1939 stop date was chosen to avoid considering the many special features of the wartime economy.

The sources of the *postwar* industry data are as follows:

1. Earnings, hours, and employment data are from *Employment and Earnings, United States* (Bureau of Labor Statistics).
2. Industrial production indexes for industries 1–10 are from the Federal Reserve Board (see Board of Governors, Federal Reserve Board, *Industrial Production,* 1976. Updates are from the *Federal Reserve Bulletin,* and some unpublished series were obtained directly from the board.) The output index for construction was obtained by dividing the value of new construction (as reported by the *Survey of Current Business* [*SCB*]) by the Department of Commerce construction cost index (also available in the *SCB*).
3. Wholesale prices are again from the Bureau of Labor Statistics. See *Wholesale Prices and Price Indexes, 1963* (BLS bulletin 1513), *Producer Price Indexes,* and the *Monthly Labor Review.*
4. The consumer price series used to calculate real wages is the Department of Labor's consumer price index (all items, wage earners and clerical workers, revised).

Again, the basic data are seasonally unadjusted. The span of the postwar sample is 1954–82, except for the wool textile industry, where the data begin in January 1958. Adequate data on output prices (and therefore on product wages) are missing for wool textiles after 1975 and for electric services before 1958.

The *total manufacturing* series were as follows:

1. For the prewar period, output was measured by the industrial production index for manufacturing. Employment, hours, and earnings data come from the National Industrial Conference Board, as reported in Beney (1936) and Sayre (1940). The NICB series are based on twenty-five major manufacturing industries; the coverage is similar but not identical to that of the industrial production index. The manufacturing output price, used only in the construction of the product wage variable, is the BLS wholesale price index for nonagricultural, nonfuel goods. Again the coverage is similar but not identical to that of the IP index.
2. For the postwar period, again the IP index for manufacturing is used to measure output. Employment, hours, and earnings data are for manufacturing production workers; the output price is the wholesale price index for total manufacturers. Those data are from *Business Sta-*

tistics and the *Survey of Current Business* and, as far as we can tell, are mutually consistent.

Stationarity

The log-differenced data series appeared in general to be stationary. We arrived at this conclusion by studying the autocorrelations and partial autocorrelations of the log-differenced data and by testing for the presence of trend shifts and higher-order trend terms in the log levels. Rejections of stationarity were sufficiently infrequent and weak that, for the sake of uniform treatment of the data, we decided to ignore them.

Reduction of High-Frequency Noise

The spectra of most of the series exhibited considerable power in the higher frequencies; high-frequency noise (primarily seasonality) may interfere with the analysis of the data at business cyle frequencies. To reduce this noise, we regressed each log-differenced series against constant, seasonal dummies and (where applicable) dummy variables for strike periods. (There was no pooling of regressions across industries or between the two major sample periods. There also appeared to be no need to allow for shifts of the regression coefficients within subsamples.) The residuals from these regressions, "cleaned" of much of the very high- and low-frequency noise of the original series, were treated as the basic data in the frequency and time domain analyses.

Details of Frequency Domain Calculations

The entries of tables 10.7 through 10.10 were constructed by simple averaging of the finite Fourier transforms, evaluated at evenly spaced intervals on $(0,\pi)$, for each data series. Since the prewar and postwar sample sizes differed, the frequencies corresponding to the "business cycle" varied as well; thus each calculation involved averages of about 7% (that is, 1/12–1/96) of the number of periodogram ordinates calculated for each variable.

Table 10.6 gives square roots of the cumulated periodogram ordinates (between twelve and ninety-six months) for each variable. These calculations (and those in the remaining tables) will not be affected by the seasonal or strike adjustments made for the log-differenced data.

Standard errors for the sample coherence $\hat{\rho}$ and phase $\hat{\theta}$ between each pair of variables were computed using the following formulas, adapted from Hannan (1970, chap. 7):

$$[\mathrm{SE}(\hat{\rho})]^2 = \nu^{-1/2}(1 - \hat{\rho}^2), \quad \text{and}$$

$$[\mathrm{SE}(\hat{\theta})]^2 = \nu^{-1/2}\left(\frac{1 - \hat{\rho}^2}{\hat{\rho}^2}\right)^{1/2},$$

where ν is twice the number of periodogram ordinates in the 12–96 month range. Since these expressions are derived from the asymptotic behavior of finite Fourier transforms, the resulting confidence intervals are only approximate and will be poorly behaved for $\hat{\rho}$ near zero or one; still, the standard errors are useful guides to the precision of the estimates.

The estimated phase leads of tables 10.8 through 10.10 were expressed in months by dividing the estimated phase angle $\hat{\theta}$ (and its standard error) by the frequency corresponding to the period in the center of the bandwidth considered. That is, the phase leads calculated for the 12–96, 2–12, 12–24, and 24–96 month bandwidths correspond to cycles with period lengths 54, 7, 18, and 60 months, respectively. These period lengths are uniformly higher than the period lengths corresponding to the average frequency in the bandwidth (which is, for example, about $2/(1/12 + 1/96) = 21.33$ months for the 12–96 month bandwidth). Since the coherences and phase angles are implicitly assumed to be constant within each frequency band, the phase lead for any frequency in the interval can be obtained by rescaling; that is, to obtain a phase lead for a "typical" 20 month cycle, the reported phase lead (and its standard error) for the 12–24 month bandwidth can simply be multiplied by 20/18. The tests of equality of phase angles in table 10.9 do not use the "scaled" phase leads above; rather, t-statistics for the difference in phase angles are constructed directly from the standard error formulas reported above (and use the large-sample independence of the phase estimates for the prewar and postwar periods).

All calculations were carried out using the RATS statistical package (see Doan and Litterman 1981). Other, more theoretical references to frequency domain methods are the texts by Hannan (1970) and Anderson (1971).

Comment Martin N. Baily

This was a very valuable paper, and I wish there were more like it. It simply presents the data, without imposing much structure or bringing in a lot of prior judgments. Of course from a discussant's point of view it is nice if authors go way out on a limb, for then you can knock them off. These authors kept fairly close to what they were observing, so that I have no major criticisms to make.

They start with a review of the literature. It would have been worthwhile in this review to distinguish overhead labor from labor hoarding.

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They mention only labor hoarding, although they do cite the article by Solow that develops the overhead labor hypothesis. The difference between the two in principle is that with labor hoarding there are workers who could be dispensed with—the same amount of output could be produced with fewer workers. With overhead labor there is a nonconvexity of the production set—in the short run the number of security guards looking after the plant cannot be reduced. The two are also different in practice. Since estimates of firm-specific human capital suggest that it is small, this means that labor hoarding is a short-run phenomenon, whereas overhead labor is likely to be longer term. The relative importance of the two can be judged from the timing of the short-run increasing returns observed in the data.

The main part of the paper is an analysis of data on output, employment, weekly hours, and wages, and the authors have done a fine job of data collection. They distinguish the real wage, defined as the money wage divided by the CPI, from the product wage, defined as the money wage divided by the wholesale price index for the particular industry they are looking at. They emphasize that there are aggregation biases and that we should look at individual industries. They have data for eight individual manufacturing industries and three nonmanufacturing industries, and they do throw in the manufacturing aggregate so that we can see what that looks like too. Since their output numbers are based on Federal Reserve Board indexes, the argument against using aggregate data is very strong, for the aggregate series is heavily contaminated with labor input data. However, there are pitfalls in avoiding the aggregate numbers that I will mention at the end. They say they cannot use high-tech industries because of the continuity problem. That seems sensible, though I think it might have introduced some bias. It is in the nature of the economy that old industries die and new ones come on line, and things that might hold true for a set of industries that have been around for a long time might not be true for new industries.

The first result they get from the raw data is that productivity growth was surprisingly strong in 1923–39 relative to 1954–82. That is consistent with my own view that the Great Depression did not push down the underlying productivity trend. It argues against a view that I encounter quite often, that slack demand since 1973 has been a major influence on the recent productivity slowdown. This first result contrasts with their second finding, that there is a very high correlation between labor productivity and output in the short run. As they indicate, this may be due to errors in the data. Correlating output divided by hours with output is a dangerous exercise. I would have left out some of those correlations. The output data are obtained from shipments adjusted by an estimate of the change in inventories. The inventory numbers are very suspect in the short run, so that the output numbers are somewhat suspect also.

Their next findings are that real wage growth was larger in 1923–39 than in the postwar period for all industries, but that declining hours of work in 1923–39 kept down real weekly earnings. They also find that the variances are very large in the output and employment numbers. They might have made more of this; it is a rather important fact. They observe extremely large variability of monthly employment, variability that is not related to aggregate conditions. Within each industry there is a lot of month-to-month variation. That gives an insight into the size of adjustment costs, an important issue because adjustment costs are used to explain persistence in equilibrium business cycle models. If the month-to-month variations within individual industries are large, this indicates that adjustment costs are not as large as they would have to be to make the persistence story carry through.

Bernanke and Powell's next empirical observation is that in the postwar period employers made greater use of layoffs and less use of hours variations compared with their prewar behavior. They suggest that this was because workers laid off in the postwar period are in a better position financially because of unemployment insurance and possibly other programs than workers who were laid off in the earlier period. Firms respond to the existence of unemployment insurance by putting their work forces on temporary layoff rather than by reducing hours.

Turning to the frequency analysis, they use deseasonalized log differences—that is, rates of growth. Dummies are used to get out the seasonal variation, a procedure I have used myself with monthly employment and output data. I was staggered by the size of the seasonal adjustments, and I thought the authors might tell us more about what they found. I found, for example, that the lowest-productivity month in manufacturing was December, and that April had productivity over 7% higher than that. The high productivity months exceeded December by the equivalent of between one and two working days' output. I found that rather implausible, and I am curious about what Bernanke and Powell found. Some of the seasonal variation comes about because of the way the data are collected. Employment is measured as of the twelfth of the month, so that holidays such as New Year's Day or Christmas reduce a month's apparent productivity.

After they remove the seasonal effects the authors look at the coherences, the phase relationships, among their different variables. Employment had the strongest coherence with output. Productivity and earnings were next, and wages and output are not very coherent. I was not sure how much to make of these results. They suggest that their findings indicate that the cycle is dominated by movements in demand. First, there are productivity gains as firms get people to work harder, then they add extra hours, and finally they add workers. It was not clear to me why this pattern showed that the cycle is demand driven. For wages, they found in the prewar period that real wages lagged output and in the postwar period real wages were more or less coherent; they even were leading in some industries. In other words, there was no consistent lead or lag between wages and output.

The authors turn next to what they call the time domain and use vector autoregressions. They found that output is exogenous and that its movements were more persistent in the postwar period than in the prewar. They found that hours and employment were not exogenous but respond to each other and to output. These results do indicate that output is driven by demand fluctuations, which then lead to hours and employment variations. They suggest that the persistence of hours indicates that there is an adjustment cost to hours variation. I did not see that; the persistence might result from expectations. When a firm decides whether to vary the number of people employed or to vary the number of hours of the people already employed, it looks ahead to see what future output is going to be, not just current output. So the finding of persistence in hours variation indicates persistence in the expectation of future output. Their analysis of wages in the time domain finds that the real wage varies independent of the other variables. This confirms the conventional wisdom that the real wage seems neither to drive nor to be driven by employment and hours. The forecasting decomposition says much the same as the results just described, and so I have no additional comments on those.

The authors then turn to major recessions, using NBER reference cycles, and they do not find that major recessions are very different from minor ones. These results reemphasize the idea that that employers relied more on layoffs in postwar major recessions than in prewar major recessions. They point out that productivity moves somewhat differently when they consider NBER reference cycles rather than correlating productivity with output in the same industry. Using the reference cycles, productivity rises peak to trough, whereas the relation with output is usually the other way. I think this finding is because their industries do not move exactly in phase with the NBER cycle. Manufacturing is typically out of phase with the overall cycle.

That completes my review of the paper and my detailed comments. I will finish with a few general points. First, I may be biased, but it seemed that contract theory did reasonably well out of these numbers. That there was a difference in the prewar versus postwar layoffs and hours decision is consistent with a contract framework. Employers are responding to the income workers receive when they are not at the firm. The lack of relationship between the wage variable and other variables is also consistent with the contract framework.

My second general point is that the authors should have recognized more clearly that there are micro results as opposed to macro results. The argument about aggregation bias is valid, but the problem is that there are results that hold at the aggregate level that would not necessarily hold at the industry level. For example, if there is a smoothly functioning labor market in which workers can move easily from one industry to another, then there is no reason for wages in a particular industry to be related to the productivity or the employment or any variable of that particular industry. Presumably firms pay the market wage, and in a high-productivity growth industry relative price falls. The finding of no relation between employment and the wage for a single industry means something very different from a similar finding for the whole economy. Even if there is not a perfectly mobile labor force, it may be that labor unions will lock up relative wages. This is another reason the wage in a particular industry may not be related to employment, even though these variables could be related in the aggregate.

The mention of labor unions brings me to my next point. The authors might have explored labor market institutions more fully. There were many changes in the organization of the labor market over the period they were looking at. It would have been interesting to track these to see if there was any relation between them and other variables. Labor union influence fell in the early 1920s, then grew very rapidly in the 1930s with the New Deal and was strong in the postwar period. A related institutional change was the growth of three-year wage contracts in the postwar period. Perhaps these changes would have been undetectable in the data, but that would have been worth knowing, too. Another way of checking for the importance of unions is that some of their industries were unionized and some were not. Cross-industry differences might have emerged.

My final point has to do with use of frequency analysis for studying cyclical behavior. The cycle is not regular; different cycles have different durations. Moreover, in the postwar period there have been several abrupt recessions, giving rise to spikes in the data. This means that in a spectral decomposition, it would be better to hang on to the high frequency end of the distribution to capture the spikes. And possibly the low frequency part of the distribution also carries cyclical information. I do not think there is a narrow range of frequencies that can be clearly identified as the cyclical component, such that all the other information can be thrown away. There is a danger of not picking up relationships among variables when information is thrown away. There were virtues to old-fashioned NBER cyclical analysis that recognized that the cycle is not a simple sine wave. Cycles do have different durations, and booms and slumps are not of the same length and do not have quite the same character.

I will stop here and again thank the authors for putting together a very useful set of data and doing a very systematic and helpful analysis of it. I think they themselves will use the data more in the future to set out what salient facts of the labor market are to be explained.

Comment Edward P. Lazear

Bernanke and Powell have presented us with a very fine piece of work. Their contribution meets two of the necessary conditions for an important paper. First, it is informative, providing valuable data that are summarized in an accessible form. Second, it is provocative. It stimulates others to pick up where they left off.

The major point I would like to make should be regarded as an extension rather than a criticism of what they have done. It is a point I have made in another context,[1] but it seems important to make it here as well.

Bernanke and Powell present detailed data on a few important series for the prewar and postwar periods. The series they are most concerned with are output, employment, productivity, and some measure of real wages. Of obvious importance is the relation of real wages to output. Whether real wages are rigid over the business cycle is of central concern to many macroeconomic theories. Although most of the important biases are discussed, there is one that is likely to be crucial but that has been ignored in the past.

Truncation Bias

The point I want to emphasize is that workers are not homogeneous and that the weights associated with various groups shift over the business cycle. This really can be broken up into two points.

First, workers are not homogeneous. The proportion of the average wage of black males compared with white males is approximately 0.7. Similarly, the proportion for white females compared with white males is about 0.6. Even within a demographic and/or occupational group, there is a great deal of dispersion in wage rates. Among the most important factors is experience, since wage rates tend to rise rapidly during the first few years on the job.

Second, employment decreases are not spread randomly across all worker classes. In particular, blacks, females, and less experienced

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1. See the discussion in Lazear 1983 on the widening of union/nonunion wage differentials during recessions.

workers tend to be affected by recessions to a greater extent than other groups.

What this implies is that the reported real wage in a recession refers to a different set of workers than the real wage during an expansion. Since these workers' wages differ, part of the movement in real wages over the business cycle reflects a change in the weights rather than some change in the wage itself.

This factor tends to suppress observed movements in wages over the business cycle. Even though the entire wage distribution may shift left in a downturn, there is a tendency for the lower tail of that distribution to disappear. The observed mean might actually rise if enough selective reduction in employment occurred in the slump.

To illustrate that this point is likely to be important in terms of magnitude, I have used Bernanke and Powell's numbers to examine the importance of this effect. What the next few paragraphs report is that this weight-shifting effect may, and is even likely to, swamp everything else.

Let us concentrate on only one factor. Suppose that workers are homogeneous in all respects other than work experience or, almost equivalently, age. The two facts from labor economics that are of central importance here are that experience/earnings profiles are positively sloped and that layoffs are negatively related to seniority.

Figure C10.1 depicts a typical experience/earnings profile. (There is much documentation of this, the most noted source being Mincer 1974.)

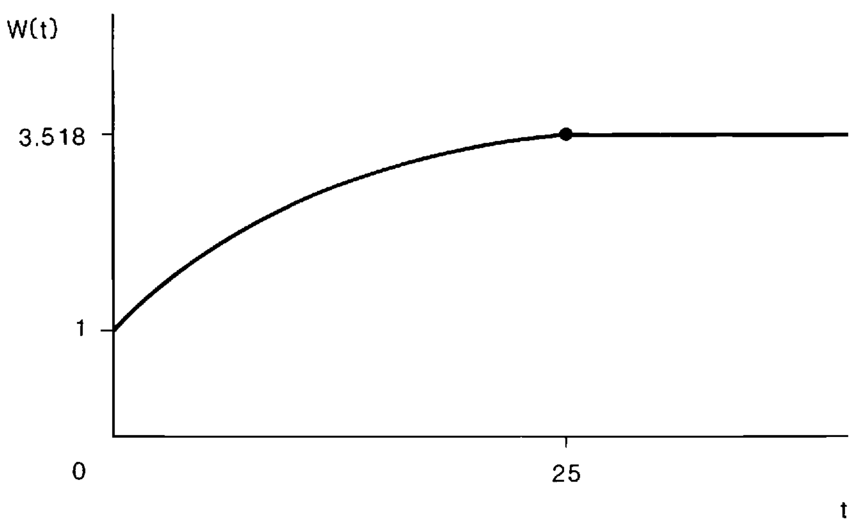

Fig. C10.1 Experience/earnings profile.

The profile is positively sloped and concave. Define $W(t)$ as the wage rate at experience level t and suppose that t goes from zero to thirty-nine years. Normalize by defining $W(0) = 1$. The function shown in figure C10.1 can be approximated by

$$W(t) = [W(t-1)]\,[1 + g(t-1)], \tag{1}$$

where

$$g(t) = .1 - .004t \qquad \text{for } t \leq 25$$
$$\quad = 0 \qquad \text{for } t > 25. \tag{2}$$

Equations (1) and (2) imply that wages grow initially at 10% per year and that the growth rate declines linearly to zero after twenty-five years, at which point it remains zero.

Suppose that workers are distributed uniformly by experience group so that initially, say at a peak, workers are found in equal numbers in each of the experience categories between zero and thirty-nine years. This distribution, coupled with the wage process described in (1) and (2), yields an average wage for all workers taken together at the peak of 2.164. Recall that $W(0) = 1$. (This is derived by computer simulation.)

Now think of moving from a peak to a trough as moving from one standard deviation above the industry employment mean to one standard deviation below it. Further, suppose that layoffs are in reverse order of seniority so that the least experienced workers are released first. If the standard deviation is expressed in percentage terms, then two times the standard deviation times thirty-nine years is removed from the bottom of the distribution. Instead of being uniform between 0 and 39, it is now uniform between, say, 0.9 and 39.

Again, a mean can be calculated for this truncated distribution, which applies during the recession. What is essential here is that the distribution is not shifted at all, but the average wage will rise because the lower tail is removed.

Table C10.1 does exactly this using the Bernanke and Powell figures from their table 10.6. That table reports the seasonally adjusted, business cycle only variation in monthly growth rates of employment and real wage by industry. The first entry for each industry is for the prewar period, and the second entry is for the postwar period. The last three entries are only for the postwar period.

Column 1 merely reproduces the employment figures from table 10.6, and column 2 reproduces the real wage series from table 10.6 of Bernanke and Powell. The most important information is contained in column 3. Recall that the average wage was 2.164 when the entire labor force was employed. What column 3 does is report the average wage corresponding to the recession work force. For example, the first row of table C10.1 reports the information for the prewar period in the steel

Table C10.1

Industry	(1)	(2)	(3)	(4)	(5)
Steel	1.590	0.590	2.230	0.030	2.572
	1.050	0.270	2.214	0.023	4.272
Autos	2.720	0.360	2.259	0.044	6.083
	1.430	0.310	2.227	0.029	4.649
Meat	1.050	0.490	2.214	0.023	2.354
	0.270	0.210	2.197	0.015	3.572
Paper	0.600	0.360	2.204	0.018	2.542
	0.300	0.140	2.197	0.015	5.463
Shoes	0.470	0.680	2.201	0.017	1.249
	0.390	0.170	2.199	0.016	4.760
Wool	0.690	0.670	2.232	0.031	2.337
	1.010	0.220	2.213	0.023	5.143
Leather	0.970	0.470	2.212	0.022	2.361
	0.490	0.140	2.201	0.017	6.138
Lumber	1.480	0.700	2.228	0.029	2.092
	0.610	0.230	2.204	0.018	4.002
Coal	0.710	0.250	2.206	0.019	3.888
Electronics	0.160	0.130	2.194	0.014	5.360
Construction	0.750	0.150	2.207	0.020	6.619

Note: $\overline{WR} = 2.164$.

$(1) = \sigma_{EMP}(\%)$

$(2) = \sigma_{WR}(\%)$

$(3) = \hat{WR}$

$$(4) = \frac{\hat{WR} - \overline{WR}}{WR}$$

$$(5) = \frac{100\left(\frac{\hat{WR} - \overline{WR}}{\overline{WR}}\right)}{2\sigma_{WR}}$$

industry. There the standard deviation of monthly growth rates was 1.59%. Under our assumptions, this implies that a recession truncates the lower 3.18% of the distribution and raises the average wage from 2.164 to 2.230.

To get a feel for the magnitude of the effect, columns 4 and 5 are presented. Column 4 reports the proportionate change in the wage that results from this truncation effect. They range from 0.014 to 0.044, and the effect measured this way is invariably smaller after the war than before.

Column 5 compares this percentage change to two standard deviations of the real wage growth rate. Those figures are perhaps the most striking because they reveal that in every case the truncation effect exceeds two standard deviations of wage growth. This is true even though the truncation effect was generated by only two standard deviations of employment reduction. In fact, in some cases it goes as high as six times two real-wage standard deviations.

Additionally, the importance of this effect relative to the change in wage rates has grown over time. For the most part, the postwar numbers in column 5 exceed the prewar numbers. Of course, the standard deviation of postwar wage rates may be low precisely because of this effect.

Although this is only an example, the Bernanke and Powell data show that truncation effects may well swamp everything else that goes on in a time series of real wages. The numbers in table C10.1 imply that it is easy for any given employed worker's real wage to drop during a recession even though the average wage remains constant or even rises. In the case of, say, postwar autos, the underlying wage distribution could shift left by approximately 3%, and as a result of the truncation effect the average wage would be observed to be constant over the business cycle. That shift in wages would correspond to 2 × (1.43%) drop in employment so that the actual, but unobserved, wage movement would equal the employment movement.

This point finds potential support not only in the Bernanke and Powell data, but also in a recent paper by Raisian (1983). Using panel data (the Panel Study of Income Dynamics), he shows that the wage of a given continuously employed worker falls significantly over the business cycle. In fact, Raisian finds that a 1% increase in the unemployment rate of a given worker's industry results in a 0.65% decline in his wage. Obviously, truncation effects are absent in panel data.

There are some findings that might be explained by this. In particular, Bernanke and Powell show that employment adjustments are more important in the postwar period. To the extent that employment adjustments are more likely to involve truncation effects hours reductions (i.e., they are more closely linked to seniority and wage levels), the truncation effect would be more important in the postwar data. This would tend to counteract procyclic movements in real wages. In fact, Bernanke and Powell find that the real wage series is less variable during the postwar period. A similar argument can be made to explain the greater persistence of the real wage in the postwar data.

If the truncation effect is important, then it helps to reconcile some findings but makes others even more difficult to explain. In particular, the procyclicality of productivity, termed SRIRL by Bernanke and Powell, creates even more of a puzzle when we recognize that the workers who retain their jobs during the recession are the higher wage group. Even though there may not be a perfect correlation between wages and productivity, it seems reasonable that the relationship would be positive. This means that SRIRL is even greater than it appears.

The point is that truncation bias is likely to be an important force. It can be dealt with explicitly, and it should be when drawing inferences about the relation of real wages to the business cycle.

Other Points

A few additional points are worthy of mention. They are listed in no particular order:

1. The emphasis in this paper is on the time series within industry. Yet, given the data, there is interesting cross-sectional evidence that might be presented. For example, tables 10.5 and 10.6 report the standard deviation within an industry over time. It would also be useful to know whether industry variables like output, employment, and real wages move in parallel across industries to a greater or lesser extent in the postwar period. Are recessions more or less confined to particular industries than they were in the past? It is conceivable that changes in demand might reflect different relative shares for the various products, leaving the aggregate output unchanged. Alternatively, a fall in employment in one industry might be mirrored in the same percentage fall in another industry. These data are ripe for this type of investigation.

2. Related, an investigation of the sort conducted by Gordon (1982) is feasible, but the analysis would be across industries rather than across countries. In particular, one can imagine that there might be a negative correlation between the effect of a fall in output on employment and on wages. In industries where wages are sensitive to changes in demand for the product, is employment less sensitive?

Some minor points:

3. Since industry definitions are quite broad, it would be useful to present more detail on what four- or five-digit industries make up the aggregate and how this has changed over time. One could argue that some of the results reflect weight shifts.

4. Is the hours figure reported hours worked or hours paid? This might be important if vacation and sick time varies over the business cycle.

5. In addition to reporting the phasing of real wages, and so on, to output, it would be useful to provide some measure of the amplitudes as well. A flat in-phase series has different implications than a highly variable in-phase series.

6. Some reporting on the nominal wage and CPI separately would be useful. One wants to know which of the two variables drives the results. This is especially important when it is recognized that the CPI is an ex post measure of prices and may not be what the worker inserts into his labor supply function.

7. I have argued elsewhere (Lazear 1974) that recessions are a time for rebuilding and for investing in new technologies, including human

capital. My results suggest that this is true to some extent. If so, output is relatively understated during downturns. Again, this may vary by industry.

8. Since output is the numerator of the productivity measure, the positive rank correlation reported in section 10.4 may reflect errors in variables. Some investigation of this might be worthwhile.

The authors are to be applauded for a provocative and useful paper that has already stimulated much thought and discussion.

Discussion Summary

The tone of the discussion was generally favorable toward both the data set and the statistical methods employed in the paper. Most of the comments involved suggestions for extensions or possible explanations of puzzling results. There was general agreement that the truncation example Lazear presented overstated his case. Even during recessions a large proportion of separations come through retirements and quits. As Summers noted, this upper truncation bias offsets the lower truncation bias elaborated by Lazear. Solomon Fabricant suggested that another possible channel for the cyclical behavior of productivity might be the production function. Bottlenecks in the delivery of the amount or quality of materials and capital goods over the business cycle might produce cyclical behavior in measured labor productivity. Robert Gordon felt that Bernanke and Powell's conclusion 5 on the acyclicality of the real wage was an artifact of their technique. If one were to remove the supply shocks of the 1970s, in which the real wage was strongly procyclical, it would be found that over the remaining business cycles the real wage moved countercyclically.

Geweke noted that the presence of a linear relation between the phase length of a variable and the length of the business cycle, investigated in tables 10.9 and 10.10 did not necessarily imply that a reference cycle approach was superior to time domain methods. Christopher Sims issued a caution regarding Bernanke and Powell's results on the lack of feedback from hours and employment to output. His experience suggested that had hours times employment been used instead, more feedback would have been found. Hence the results were sensitive to the way the variables were allowed to enter. Sims also noted that sampling errors in the interwar data might be large enough to cast doubt on the reliability of the results obtained. He suggested this might be a profitable area for further investigation.

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