BRUCE C. GREENWALD
Bell Communications Research
JOSEPH E. STIGLITZ
Princeton University

Examining Alternative Macroeconomic Theories

THE PAST TWO DECADES have witnessed intense competition among theories attempting to explain macroeconomic behavior. Alternative theories have made claims with respect both to the purity of their methodology and to their ability to explain the "facts." This paper reviews the ability of three of the major competitors—new classical, traditional Keynesian, and what we call new Keynesian theories—to explain what we take to be the most important stylized facts. Our perspective is unabashedly biased: we believe that new Keynesian theories—particularly those focusing on the consequences of imperfections in the capital, goods, and labor markets arising from imperfect and costly information—provide the best available explanation.[1]

Some Words on Methodology

Because our objective is to persuade the reader why these new Keynesian theories should be taken seriously, and because methodological issues have been frequently raised in discussions of theory assessment in recent years, we comment briefly on these issues.

We do *not* provide here an econometric test of a well-articulated

Thanks are due for helpful comments to members of the Brookings Panel.

1. By "imperfections," we mean deviations in these markets from that characteristic standard, neoclassical markets with perfect competition and perfect information.

version of our model and contrast it with a version of the alternative theories. Eventually, we hope, such a test will be conducted. But tests of relativity theory were not based on a statistical comparison of goodness of fit between the Newtonian and relativity views of the world. A far more powerful test—and one that was actually used—was to find circumstances in which the two theories yielded markedly different predictions and to see which did better on these crucial tests. That is the approach we take here.[2] We look for certain crucial facts and ask whether they are in accord with the theory.

Economic theory is, from some perspectives, too rich. Essentially any function that is homogeneous of degree one in the full set of prices could be a demand function: economic theory places no further restrictions on the form of such a function. Rationality simply does not buy us enough. Conventionally, what macroeconomists mean by a theoretically derived model is one that is consistent not just with rational behavior, but with some strong restrictions, such as that all individuals are identical. We know that all individuals are not identical, and it is here that the "as if" story begins. We also know that a model with identical individuals cannot explain some important aspects of macroeconomic behavior—that some individuals lend others money or that some individuals are unemployed while others are not.

Nevertheless, we can still ask whether such a model can explain aggregates such as wages, prices, employment, and output. Again, to get any meaningful results, we must further restrict the model. If we allow preferences and technology to shift in an arbitrary way from period to period, it is not difficult to write down functions for which the number of parameters is equal to the number of data points. We have an identification problem of immense proportions. Innumerable models could fit the data perfectly.

Studies of each of the principal markets of the economy provide natural restrictions. We do not want a separate microeconomic theory and macroeconomic theory—that is a point upon which by now most participants in the debate agree—or a separate microeconometrics and macroeconometrics. And we know more than just the results of cross-section econometric studies: we know, for instance, that most economies

2. We suspect that there is some loss function for which our crucial-tests approach represents a good approximation to a properly specified Bayesian approach.

have not experienced technological regress, even if the rate of technological progress may have varied from time to time. Thus, in looking for crucial tests we will examine a wide range of stylized facts, both macroeconomic and microeconomic, that characterize business-cycle–related behavior.

To narrow the range of potential stylized facts about business cycles to a manageable number that might usefully distinguish, or perhaps more properly, begin to distinguish, the validities of various business-cycle theories, we applied two significant criteria. First, we required a clear indication that the facts in question are true. For example, evidence concerning the relationship between output and monetary aggregates is often contradictory. In simple terms, some monetary aggregates may vary procyclically, some countercyclically. However, attempts to move beyond this insight to define more usefully the temporal relationships involved have produced few confident conclusions.[3] Second, we required a clear connection between the facts at issue and the different broad theoretical approaches to explaining business cycles. For example, much information has been collected about the sequence in which shifts in orders, shipments, and output occur in cyclical fluctuations. However, while the data suggest the existence of recurrent patterns in this sequence, it is not clear how realistically formulated traditional Keynesian, new classical, and new Keynesian models would differ in this regard.[4]

3. An example is the large and growing literature on the causal relationship between various kinds of initiating "shocks," both nominal and real, and fluctuations in output. See, for example, Christopher A. Sims, "Money, Income, and Causality," *American Economic Review*, vol. 62 (September 1972), pp. 540–52; Christopher A. Sims, "Comparisons of Interwar and Postwar Business Cycles: Monetarism Reconsidered," *American Economic Review*, vol. 70 (May 1980, *Papers and Proceedings, 1979*), pp. 250–57; Robert B. Litterman and Laurence Weiss, "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data," *Econometrica*, vol. 53 (January 1985), pp. 129–56; Olivier J. Blanchard and Mark W. Watson, "Are Business Cycles All Alike," in Robert Gordon, ed., *The American Business Cycle: Continuity and Change* (University of Chicago Press, 1986), pp. 123–56; and Ben S. Bernanke, "Alternative Explanations of the Money Income Correlation," in Karl Brunner and Allan H. Meltzer, *Real Business Cycles, Real Exchange Rates, and Actual Policies* (Amsterdam: North-Holland, 1986), pp. 49–99.

4. Arthur Okun examines the predictions of new classical models against such cyclical variables and finds the models wanting. See his "Rational-Expectations-with-Misperceptions as a Theory of the Business Cycle," *Journal of Money, Credit and Banking*, vol. 12 (November 1980, part 2), pp. 817–25 (Brookings Reprint 376). For a discussion of such cyclical variables, see Victor Zarnowitz, *Orders, Production, and Investment—A Cyclical and Structural Analysis* (New York: National Bureau of Economic Research, 1973).

While attempts to describe business cycles empirically have a long tradition, recent work has tended to concentrate on postwar business cycles in the United States, and many stylized facts are based primarily on that experience.[5] However, the major theoretical explanations of business cycles apply generally to developed industrial economies. For this reason, the information presented below will focus not just on the postwar United States but on other developed economies and on prewar history of both the United States and other developed economies. Data are presented primarily for the United States, West Germany, Great Britain, Japan, and Australia (as a southern hemisphere economy with relatively mild seasonal weather changes), but also selectively for the Netherlands (as a small open economy). For the prewar period, particular attention is paid to the Great Depression as an extreme and, therefore, potentially highly revealing experience. The data presented are quarterly, where available, and annual otherwise.[6] The stylized facts that emerge from both these data and a collateral examination of the large related literature have been organized according to the three major markets for labor, capital, and goods upon which traditional macroeconomic analyses have been based. We suspect that experts in the data may quarrel with the detail of some of these facts. But we suspect that unless some agreement can be reached about what macroeconomic observations a theory is supposed to explain, there is little hope of reaching agreement about what is a good theory.

After presenting the stylized facts, we present three alternative

5. For a recent survey, see Victor Zarnowitz, "Recent Work on Business Cycles in Historical Perspective: A Review of Theories and Evidence," *Journal of Economic Literature*, vol. 23 (June 1985), pp. 523–80. International data on business-cycle characteristics were analyzed recently in Edward C. Prescott, "Can the Cycle Be Reconciled with a Consistent Theory of Expectations" (Federal Reserve Bank of Minneapolis, May 1983); John B. Taylor, "Differences in Economic Fluctuations in Japan, the United States, and Europe" (Stanford University, April 1987); Lawrence H. Summers and Sushil Wadhwani, "Some International Evidence on Labor Cost Flexibility and Output Variability," Discussion Paper 1353 (Harvard Institute of Economic Research, November 1987); and John Pencavel, "The Classical Unemployment Hypothesis and International Comparisons of Labor Market Behavior," CEPR Publication 110 (Stanford University, July 1987).

6. Quarterly data are used because annual data tend to obscure the impact of cycles by averaging over periods that typically include parts of several phases of the traditional business cycle (for example, the year 1981 includes part of the recovery from the 1980 recession and part of the descent into the trough of the 1981–82 recession), and monthly data raise serious difficulties of seasonal adjustment and high-frequency noise.

theories—traditional Keynesian models, the real business-cycle variant of new classical theory, and new Keynesian theory—and ask to what extent they address, or are consistent with, these observations. Our purpose is not to present a complete articulation of these alternative theories. We confront stylized versions of theories with stylized facts. We have every confidence that versions of each of the theories with sufficient epicycles could be constructed with sufficient degrees of freedom to be consistent with most if not all of the facts, but that is hardly a test of a theory.

Characteristics of Business Cycles

We now present stylized facts that any viable model of the business cycle should be able to explain. The variables are organized around the markets for goods, capital, and labor.

GOODS MARKETS

The traditional way of characterizing business cycles is as contemporaneous deviations from an appropriate trend growth in the level of activity in many, if not all, industries—deviations that are reflected in deviations in the overall level of seasonally adjusted GNP and that persist for several quarters. Table 1, which presents the variances and lagged correlations of differences between actual and trend levels in the log of real GNP, illustrates the cyclical deviation of output from trend. We calculated trend GNP by fitting a piecewise linear function, linear over four-year periods, to logged actual GNP. We did so for the complete available quarterly data for the United States, Japan, West Germany, Great Britain, and Australia; for the period 1967–86 for the United States, Japan, West Germany, and Great Britain; and for the earlier interval 1947–66 for the United States. In every case, serial correlation of the trend deviations is positive, confirming widely reported results in a similar vein, by Edward Prescott among others, although the method of trend-fitting used here differs from many of those used elsewhere.[7]

An issue has, however, arisen over the interpretation of the data

7. See Prescott, "Can the Cycle Be Reconciled with a Consistent Theory of Expectations," and Zarnowitz, "Recent Work on Business Cycles in Historical Perspective."

Table 1. Variation of Output from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	*Output level*					*Output change (first-difference form)*				
	Standard deviations of variations from trend (percent)	*Serial correlations of variations from trend*				*Standard deviations of variations from trend (percent change per quarter)*	*Serial correlations of variations from trend*			
		1 lag	*2 lags*	*3 lags*	*4 lags*		*1 lag*	*2 lags*	*3 lags*	*4 lags*
Full period										
United States (1947–86)	2.04	0.852	0.618	0.340	0.083	1.08	0.311	0.180	−0.090	−0.198
Japan (1965–86)	1.48	0.705	0.518	0.341	0.165	1.13	−0.111	−0.029	−0.020	0.019
West Germany (1960–86)	1.58	0.620	0.352	0.203	0.003	1.32	−0.182	−0.079	0.085	0.170
Great Britain (1960–86)	1.75	0.633	0.415	0.233	0.107	1.47	−0.232	−0.040	−0.119	0.008
Australia (1969–86)	1.52	0.566	0.292	0.085	−0.121	1.32	−0.233	−0.034	0.033	−0.312
1967–86										
United States	1.88	0.849	0.652	0.417	0.193	1.10	0.242	0.201	0.013	−0.012
Japan	1.82	0.802	0.626	0.392	0.141	1.08	−0.128	0.102	−0.004	−0.020
West Germany	1.64	0.676	0.489	0.379	0.186	1.38	−0.078	−0.104	0.086	0.112
Great Britain	1.70	0.567	0.307	0.126	0.006	1.58	−0.203	−0.052	−0.076	−0.048
1947–66										
United States	2.27	0.853	0.595	0.290	0.017	1.10	0.363	0.142	−0.212	−0.411

Source: Authors' calculations with data from Citibank Citisource Database.

a. Quarterly data. Trend GNP was calculated by fitting a piecewise linear function (over four years) to the log of actual real GNP.

presented in table 1. The traditional reading of such data is that actual output tracks a steadily growing level of trend, or full-employment, output and, thus, that business cycles are temporary, if persistent, deviations from the path of full-employment output. An alternative view, first put forward by Charles Nelson and Charles Plosser, would produce observed patterns of output variations similar to those in table 1.[8] That view is that trend output itself is simply the sum of permanent, or near-permanent, single-period shocks to output—in other words, that there is a unit root, or near–unit root, in the stochastic process governing levels of output. Under these conditions, output changes continue to be persistent, but such a characterization of macroeconomic reality appears to require a reinterpretation of theoretical macroeconomic models. In fact, as described below, models in which there is either learning by doing or fluctuating investment in productivity-improving innovations yield such random walk behavior in a context much like traditional macroeconomic models.[9] Estimation techniques must, however, be adjusted to accommodate the nonstationarity associated with the possible existence of unit roots.

The simplest way to do so is to examine output fluctuations in terms of first differences in the log of GNP. We fitted a piecewise linear function to changes in the log of real GNP and examined the standard error and serial correlation of the residuals—that is, the difference between actual and trend growth rates in real GNP. The piecewise linear function, again with four-year periods, was fitted to growth rates to eliminate long-term changes in growth that might otherwise be interpreted as positive serial correlation of successive changes in real GNP. The results are also reported in table 1.

Here no clear pattern emerges. For the United States in 1947–66, 1967–86, and in the postwar period as a whole, successive deviations in

8. Charles R. Nelson and Charles I. Plosser, "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications," *Journal of Monetary Economics*, vol. 10 (September 1982), pp. 139–62. See Francis X. Diebold and Glenn D. Rudebusch, "Long Memory and Persistence in Aggregate Output" (Washington, D.C.: Board of Governors of the Federal Reserve System, January 1988); and J. Bradford Delong and Lawrence H. Summers, "Assessing Macroeconomic Performance: An Output Gap Approach" (Harvard University, March 1988), for recent contributions to and summaries of this literature.

9. See Bruce C. Greenwald, Meir Kohn, and Joseph E. Stiglitz, "Financial Market Imperfections and Productivity Growth" (Princeton University, May 1988), for an example of such a model.

changes in output are positively serially correlated, suggesting that there is no immediate reversion to trend and a very strong form of persistence. However, successive changes are negatively correlated in Great Britain, Australia, Japan, and West Germany, suggesting some slight reversion to trend.[10]

The important result to note is that, on average, fluctuations in output in the postwar period appear to be ubiquitous and closely similar in size across national economies. This point, emphasized by Robert Lucas, emerges from the surprising similarity across major industrial countries in the standard deviations of output fluctuations, whether measured in terms of levels or changes.[11]

In terms of levels, standard deviations during 1967–86 differ across Japan, West Germany, Great Britain, and the United States by only 14 percent. Even during significantly different periods the range of standard deviations among these four countries and Australia runs from 1.48 percent per quarter for Japan to 2.04 percent per quarter for the United States. Data for the United States cover 1947 to 1986; for the other countries, they cover periods beginning in the 1960s and going through 1986. Excluding the United States, the greatest quarterly variation is 1.75 percent for Great Britain.

Moreover, the ordering among countries is sensitive both to the period of estimation and to the method of calculating deviations. For example, Japanese output appears to be slightly more volatile than U.S. output during 1967–86 but, as estimated by John Taylor, substantially less so during 1976–86.[12] In terms of changes, Japanese volatility between 1967 and 1986 appears to be slightly lower than U.S. volatility (see table 1). However, using annual data and polynomials to establish trend growth, Lawrence Summers and Sushil Wadhwani find Japanese volatility significantly greater than that in the United States.[13] Prescott finds approximately equal volatilities among all five countries covered here, with

10. None of this is evidence either way for a unit root, because reversion to trend may occur only with a long lag. In fact the debate on this point is inconclusive since the relevant tests have low power. See Diebold and Rudebusch, "Long Memory and Persistence in Aggregate Output."

11. Robert E. Lucas, Jr., *Studies in Business Cycle Theory* (MIT Press, 1981).

12. Taylor, "Differences in Economic Fluctuations in Japan, the United States, and Europe."

13. Detailed analysis in both Taylor, "Differences in Economic Fluctuations in Japan, the United States, and Europe," and Summers and Wadhwani, "Some International Evidence on Labor Cost Flexibility and Output Variability," indicates at least partially the extent to which their United States–Japan differences depend on the particular approach

Japan having slightly greater volatility than the United States.[14] John Pencavel, examining annual data for France, Germany, Italy, Sweden, Great Britain, Japan, the United States, and Canada from 1957 through 1984, found standard deviations of changes in the detrended log of real output running from 3 percent (Japan) to 1.8 percent (Sweden), with only these two outside of a range from 2.2 percent to 2.5 percent.[15] Thus, despite widely different institutional structures, such as those in labor markets and financial markets, there appear to be only minor differences in output volatilities.[16]

Examining differences in volatility over time leads to a broadly similar conclusion. The standard deviation of differences between actual and trend output in the United States fell only slightly, from 2.27 for 1947–66 to 1.88 for 1967–86. Measured using first differences, the volatilities are almost identical for the two periods. In historical comparisons over a longer period, the traditional view was that pre-Depression volatilities were substantially higher than post–World War II volatilities.[17] More recently, it has become clear that a significant part of the discrepancy has been due to the statistical methods used to construct historical series on output and employment.[18]

An analysis of the extent to which fluctuations in the outputs of individual industries have historically been due to aggregate national economic conditions as opposed to industry-specific conditions that

used. When Taylor examines Japanese and U.S. volatilities for 1972–86, he finds that the ratio falls to 1.5 (in favor of Japan) from 2.3, while the ratio of European-Japanese deviations falls from 1.5 for 1976–86 to 1.1 for 1972–86. For Summers and Wadhwani, the United States–Japan volatility ratio rises from 0.32, when the log of GNP is fitted with a linear trend, to 0.99 when a quintic trend is used.

14. Prescott, "Can the Cycle Be Reconciled with a Consistent Theory of Expectations."

15. Pencavel, "The Classical Unemployment Hypothesis and International Comparisons of Labor Market Behavior."

16. Summers and Wadhwani, "Some International Evidence on Labor Cost Flexibility and Output Variability," reach a similar conclusion regarding labor market institutions. Although they find marked international differences in volatility, these appear to be unrelated to any other differences in the economies involved (for example, wage flexibility, size, and the importance of international trade).

17. See Zarnowitz, "Recent Work on Business Cycles in Historical Perspective."

18. See Christina Romer, "Spurious Volatility in Historical Unemployment Data," *Journal of Political Economy*, vol. 94 (February 1986), pp. 1–37; Christina D. Romer, "The Pre-War Business Cycle Reconsidered: New Estimates of Gross National Product, 1869–1980" (Princeton University, February 1987); and Robert J. Gordon and John Veitch, "Fixed Investment in the American Business Cycle," in Gordon, ed., *The American Business Cycle*, pp.267–335, for alternative views.

apply to particular industries across national boundaries was carried out by Alan Stockman.[19] By decomposing the variances in industry outputs into a national component (common across industries within a national economy), an international industry component (common within the same industry across countries), and a random disturbance, Stockman found that the national variance components were larger than the industry components.

By the same token, it should be noted that the impact of individual events like the Depression may vary widely across economies, as we will show later.

Data on price changes comparable to the output change data in table 1 are given in table 2 for the period 1967 through 1986. The data are calculated as deviations of inflation rates from trend. Aggregate producers' price inflation tends to be characterized by more persistence than changes in output. Serial correlations in deviations of price changes (that is, inflation rates) from trend are uniformly positive at one- and two-quarter lags compared with serial correlations of deviations of output changes from trend that are as often negative as positive at these lags (see table 1). The magnitudes of the positive serial correlations in deviations of price change are uniformly larger than the corresponding correlations of deviations of output changes from trend.

One obvious interpretation of the greater persistence of nominal price changes is that they merely track persistent changes in money supply levels that are generated, in turn, by a money supply rule that accommodates past changes in price levels. An alternative explanation is that the persistence of price changes is due to rigidities in the price-setting process (due, for example, to menu costs associated with price changes). Evidence distinguishing between these possibilities is provided by Robert Barro and by Robert Gordon.[20] They estimate the impact of unexpected money supply changes on both output and prices. Barro, examining postwar U.S. data, found that while the response of output

19. Alan C. Stockman, "Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries," Working Paper 2313 (NBER, July 1987).

20. See Robert J. Barro, "Unanticipated Money, Output, and the Price Level in the United States," *Journal of Political Economy*, vol. 86 (August 1978), pp. 549–80; and Robert J. Gordon, "A Century of Evidence on Wage and Price Stickiness in the United States, the United Kingdom, and Japan," in James Tobin, ed., *Macroeconomics, Prices, and Quantities: Essays in Memory of Arthur M. Okun* (Brookings, 1983), pp. 85–121. Julio J. Rotemberg, "Sticky Prices in the United States," *Journal of Political Economy*, vol. 90 (December 1982), pp. 1187–1211, reaches a similar conclusion from a rational expectations model of price and output changes.

Table 2. Variation of Inflation Rates from Fitted Trends, Selected Countries, 1967–86[a]

Inflation measure	*Standard deviations of variations from trend (percent change)*	*Correlations of inflation variations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
		United States				
Producers' prices	1.87	0.562	0.365	0.294	0.152	0.279
Intermediate goods prices	1.49	0.534	0.683	0.302	0.038	−0.039
Raw materials prices	3.49	0.377	0.068	0.114	0.118	−0.011
		Japan				
Producers' prices	2.37	0.431	0.605	0.386	0.160	−0.014
Intermediate goods prices	3.03	0.506	0.713	0.396	0.157	−0.013
Raw materials prices	5.56	0.392	0.595	0.336	0.051	−0.095
		West Germany				
Producers' prices	1.37	0.638	0.395	0.082	0.005	0.024
Intermediate goods prices	2.32	0.619	0.567	0.197	0.094	−0.055
Raw materials prices	2.22	0.640	0.607	0.260	0.126	−0.065
		Great Britain				
Producers' prices	1.31	−0.059	0.467	0.233	−0.008	−0.223
Raw materials prices	5.04	0.232	0.209	0.152	−0.063	−0.150
		Australia[b]				
Producers' prices	2.79	0.158	0.159	0.244	0.121	−0.146

Source: Same as table 1.
a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.
b. 1968–86.

to unanticipated money supply changes is essentially complete in three years, the price level response continues to be significant at a lag of five years. In the absence of price rigidities, the response profiles should be of similar durations. Gordon performed similar tests over an extended period for the United States, Great Britain, and Japan, reaching the same conclusion.

Further aggregate evidence on price stickiness is provided by James Poterba, Julio Rotemberg, and Lawrence Summers, who found that changes in the composition of the tax burden between income and indirect business taxes such as the value added tax significantly affected the aggregate level of real economic activity, even when there was no shift in aggregate tax rates.[21] That finding suggests that the associated

21. James M. Poterba, Julio J. Rotemberg, and Lawrence H. Summers, "A Tax-Based Test for Nominal Rigidities," *American Economic Review*, vol. 76 (September 1986), pp. 659–75.

shifts in the legal incidence of taxes were not fully reflected in subsequent price adjustment and hence that there was nominal price inertia. William Nordhaus has also described the stability of prices in the face of changing demand conditions over the business cycle.[22] Finally, Olivier Blanchard notes the existence of significant lags in passing on price increases through the chain of production from materials to intermediate to final goods.[23]

Because these aggregate data are supported by microeconomic investigations that tend to find relatively long intervals between price changes,[24] the available evidence indicates that price inertia plays a significant role in product markets.[25]

Thus, taken as a whole, goods markets are characterized by persistent, ubiquitous fluctuations in aggregate output, similar average magnitude of output fluctuations across economies, and nominal price inertia.

CAPITAL MARKETS

Because information on real interest rates and actual employment of capital goods is scarce,[26] this section focuses on the cyclical behavior of

22. William D. Nordhaus, "Recent Developments in Price Dynamics," in Otto Eckstein, ed., *The Econometrics of Price Determination* (Washington, D.C.: Board of Governors of the Federal Reserve System, 1972), pp. 16–49.

23. Olivier J. Blanchard, "Aggregate and Individual Price Adjustment," *BPEA, 1:1987*, pp. 57–109. For a survey of the price rigidity evidence, see Julio J. Rotemberg and Garth Saloner, "The Relative Rigidity of Monopoly Pricing," Working Paper 1943 (National Bureau of Economic Research, May 1986).

24. See, for example, George J. Stigler and John Kindahl, *The Behavior of Industrial Prices* (Columbia University Press, 1970); Dennis W. Carleton, "The Rigidity of Prices," *American Economic Review*, vol. 76 (September 1986), pp. 637–58; and Stephen G. Cecchetti, "The Frequency of Price Adjustment: A Study of the Newsstand Prices of Magazines," *Journal of Econometrics*, vol. 31 (August 1986), pp. 255–74.

25. Evidence on at least relative price inertia is also provided directly in table 2. If changes in relative raw materials prices are independent of changes in overall rates of inflation, the first-order serial correlation in raw materials price inflation should be approximately $\rho[\text{var}(s)/\text{var}(s_j)] + (0.25)\{1 - [\text{var}(s)/\text{var}(s_j)]\}$, where ρ is the first-order serial correlation in aggregate price inflation, $\text{var}(s)$ is the variance in aggregate price inflation, $\text{var}(s_j)$ is the variance in raw material price inflation, and 0.25 is a factor to account for the bias introduced by using quarterly averages of monthly prices. The figures in table 2 yield the implied serial correlations in relative raw materials price inflation for Japan and West Germany of, respectively, 0.306 and 0.294. The actual serial correlations are 0.595 and 0.607, respectively, which suggests that some degree of relative materials price rigidity exists—at least in those countries.

26. See Frederic S. Mishkin, "The Real Interest Rate: A Multi-Country Empirical Study," *Canadian Journal of Economics*, vol. 17 (May 1984), pp. 283–311, for an attempt to estimate ex ante real rates of interest.

investment, or additions to the capital stock. As tables 3 and 4 show, for all countries in all time periods, investment fluctuations are at least three times as large as fluctuations in output, both when measured in terms of first differences and when measured in levels. Many studies confirm this insight.[27] Again, as in the case of output, the United States is something of an anomaly in the extent to which fluctuations in first differences of investment are positively correlated over time, as they are both in 1947–66 and in 1967–86 (see table 3).

The relative amplitudes of investment and output fluctuations, however, do appear to differ among economies. Whether measured in terms of levels or first differences, investment fluctuations appear to be greater relative to output fluctuations in the United States and Australia than in Great Britain and West Germany; in turn, relative British and German investment fluctuations appear to be greater than relative investment fluctuations in Japan. From 1967 through 1986, the ratio of the standard deviation of investment fluctuations to output fluctuations is about 60 percent greater for the United States than for Japan. Over a similar period Australia's ratio is more than twice that for Japan. Thus, although the Japanese economy does not appear to experience smaller output fluctuations than others, the associated fluctuations in investment do seem to be less severe.

In terms of categories of investment, producers' durable equipment investment fluctuates less by all measures than investment as a whole (see table 5). Business construction in the United States, the only country in the sample for which separate data were available, appears to fluctuate less than investment in producers' durable equipment. For 1947–66, the standard deviations of the gaps between investment and trend investment were 6.2 percent for producers' durable equipment and 3.8 percent for business construction. For 1967–86, the durable equipment and business construction figures were 6.5 percent and 6.1 percent, respectively.[28]

27. See Zarnowitz, "Recent Work on Business Cycles in Historical Perspective," or Prescott, "Can the Cycle Be Reconciled with a Consistent Theory of Expectations." Prescott found a ratio of investment to output fluctuations of about 4.7.

28. These figures are for trends fitted to levels of investment, but similar results hold for trends fitted to first differences. R. J. Hodrick and Edward C. Prescott, "Post-War U.S. Business Cycles: An Empirical Investigation" (Carnegie-Mellon University, 1980), find similar relative magnitudes for the United States. Also, a similar situation appears to exist in the United Kingdom and West Germany, where total construction fluctuations are comparable in size to producers' durable equipment fluctuations and residential construction appears to be more cyclically sensitive than business construction.

Table 3. Variation of Total Investment from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	*Standard deviations of variations from trend (percent)*	*Ratio of investment standard deviations to output standard deviations*	*Correlations of investment variations with output variations*	*Serial correlations of variations from trend*			
				1 lag	*2 lags*	*3 lags*	*4 lags*
Full period							
United States (1947–86)	9.10	4.46	0.686	0.789	0.493	0.172	−0.122
Japan (1965–86)	5.25	3.55	0.642	0.624	0.332	0.121	−0.167
West Germany (1960–86)	6.02	3.81	0.837	0.665	0.428	0.286	−0.001
Great Britain (1960–86)	7.61	4.34	0.705	0.718	0.479	0.265	0.063
Australia (1969–86)	11.50	7.57	0.625	0.552	0.256	−0.037	−0.422
1967–86							
United States	9.15	4.87	0.898	0.810	0.546	0.287	0.031
Japan	5.63	3.09	0.739	0.824	0.623	0.396	0.098
West Germany	5.99	3.65	0.825	0.690	0.487	0.352	0.085
Great Britain	6.97	4.10	0.728	0.674	0.389	0.163	−0.040
1947–66							
United States	8.85	3.89	0.524	0.750	0.400	−0.009	−0.359

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

Table 4. Variation of Changes in Total Investment from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	*Standard deviations of variations from trend (percent)*	*Ratio of investment standard deviations to output standard deviations*	*Correlations of investment variations with output variations*	*Serial correlations of variations from trend*			
				1 lag	*2 lags*	*3 lags*	*4 lags*
Full period							
United States (1947–86)	6.129	5.675	0.852	0.238	0.088	−0.030	−0.317
Japan (1965-86)	4.433	3.933	0.403	0.010	−0.112	0.068	−0.064
West Germany (1960–86)	4.694	3.571	0.740	−0.101	−0.089	0.237	−0.064
Great Britain (1960–86)	5.628	3.810	0.510	−0.104	−0.072	−0.040	−0.124
Australia (1969–86)	10.654	7.902	0.492	−0.165	0.025	0.125	−0.389
1967–86							
United States	5.995	5.424	0.852	0.260	0.055	0.048	−0.151
Japan	3.308	3.022	0.333	0.018	0.044	0.169	−0.262
West Germany	4.894	3.543	0.673	−0.055	−0.128	0.285	−0.038
Great Britain	5.746	3.591	0.498	−0.054	−0.089	−0.029	−0.141
1947–66							
United States	6.428	5.744	0.768	0.224	0.124	−0.099	−0.465

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

Table 5. Variation in Levels of Investment in Producers' Durable Equipment from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	*Standard deviations of variations from trend (percent)*	*Ratio of investment standard deviations to output standard deviations*	*Correlations of investment variations with output variations*	*Serial correlations of variations from trend*			
				1 lag	*2 lags*	*3 lags*	*4 lags*
Full period							
United States (1947–86)	6.38	3.13	0.733	0.806	0.520	0.242	−0.002
Japan (1965–86)	4.86[b]	3.28	0.532	0.787	0.483	0.171	−0.084
West Germany (1960–86)	4.75	3.01	0.568	0.493	0.368	0.187	0.048
Great Britain (1960–86)	5.21	2.90	0.504	0.541	0.430	0.303	0.174
Australia (1969–86)	6.75	4.44	0.309	0.354	0.249	0.015	−0.254
1967–86							
United States	6.49	3.45	0.854	0.883	0.721	0.487	0.252
Japan	5.05[b]	2.77	0.650	0.886	0.690	0.444	0.199
West Germany	4.67	2.85	0.740	0.410	0.359	0.335	0.204
Great Britain	5.08	2.89	0.551	0.426	0.315	0.166	0.073
1947–66							
United States	6.22	2.74	0.650	0.712	0.300	−0.023	−0.269

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

b. Includes all business investment.

Fluctuations in consumer investment in durables, for which again only U.S. data were available, appear to track those of producers' durable equipment investment.

Residential construction (see table 6) and inventory accumulation are the two most volatile categories of investment, with amplitudes of fluctuation generally greater than that of investment as a whole.

Measures of inventory investment fluctuations, like those calculated for other categories of investment, could not be obtained because episodes of negative inventory investment made it impossible to calculate complete series on proportional changes in inventory investment. The greater volatility of inventories than investment as a whole can be inferred from the fact that noninventory investment fluctuates less than total investment. Also, Alan Blinder has demonstrated the significant role that inventories play in business cycles, at least in the United States.[29]

THE LABOR MARKET

As has been widely noted, variations in wages are at best weakly procyclical, while hours and employment variations are strongly procyclical.[30] If real wages are defined relative to producers' prices, then

29. See, for example, Alan S. Blinder, "Can the Production Smoothing Model of Inventory Behavior Be Saved?" *Quarterly Journal of Economics*, vol. 101 (August 1986), pp. 431–54. Data on other aspects of capital markets over the business cycle, notably relating to financial structure, show systematic patterns within the United States. Space limitations preclude our exploring these issues, other than to note that, of the three approaches, only the new Keynesian speaks to these issues.

30. A large literature investigating the relationship of hours, employment, and real wage changes has developed since Keynes made nominal wage rigidities central to his theory of business cycles. Early contributors to this literature were John T. Dunlop, "The Movement of Real and Money Wages," *Economic Journal*, vol. 48 (September 1938), pp. 413–34; and Lorie Tarshis, "Changes in Real and Money Wages," *Economic Journal*, vol. 49 (March 1939), pp. 150–54. More recent contributions include Patrick T. Geary and John Kennan, "The Employment-Real Wage Relationship: An International Study," *Journal of Political Economy*, vol. 90 (August 1982), pp. 854–71; Thomas J. Sargent, "Estimation of Dynamic Labor Demand Schedules under Rational Expectations," *Journal of Political Economy*, vol. 86 (December 1978), pp. 1009–44; Joseph Altonji and Orley Ashenfelter, "Wage Movements and the Labor Market Equilibrium Hypothesis," *Economica*, vol. 47 (August 1980), pp. 217–45; Salih N. Neftci, "A Time-Series Analysis of the Real Wages-Employment Relationship," *Journal of Political Economy*, vol. 86 (April 1978), pp. 281–91; Robert E. Hall, "Labor Supply and Aggregate Fluctuations," in Karl Brunner and Allan H. Meltzer, *On the State of Macro-Economics* (Amsterdam: North-Holland, 1980), pp. 7–33; and Mark J. Bils, "Real Wages over the Business Cycle: Evidence from Panel

Table 6. Variation in Levels of Investment in Residential Structures from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	Standard deviations of variations from trend (percent)	Ratio of investment standard deviations to output standard deviations	Correlations of investment variations with output variations	Serial correlations of variations from trend			
				1 lag	2 lags	3 lags	4 lags
Full period							
United States (1947–86)	11.11	5.45	0.279	0.860	0.608	0.330	0.070
Japan (1965–86)	6.45	4.36	0.665	0.373	0.142	0.043	−0.098
Australia (1969–86)	7.39	4.86	0.589	0.800	0.532	0.206	−0.104
1967–86							
United States	12.71	6.76	0.597	0.870	0.664	0.422	0.173
Japan	5.86	3.22	0.680	0.626	0.328	0.186	−0.120
1947–66							
United States	9.33	4.11	−0.066	0.791	0.437	0.063	−0.225

Source: Same as table 1.
a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

there is some slight indication that real wages are weakly countercyclical in the United States and Australia. Otherwise, correlations between deviations of real wages from trend and deviations of output from trend (see tables 7 and 8) are either positive or effectively zero, as they are in Australia when real wages are measured in terms of consumer prices. Also, except for Australia, for which only a limited sample period of complete data was available, hours and employment respond positively to changes in output. Similar results obtain if trends are defined in terms of levels rather than first differences.

The relative magnitudes of the labor quantity and price effects in the postwar data are described in table 9. If output changes are generated entirely by exogenous shocks to either demand or labor productivity that affect only the labor demand curve, the relative sizes of the hours and real wage effects of output changes represent an estimate of labor supply elasticity.[31] For the United States, the implied supply elasticities for all periods are far greater than those obtainable from other sources. For example, over long periods, as wage levels have risen, average hours worked per week have either declined or remained roughly constant, suggesting an inelastic or backward-bending labor supply curve. The temporary nature of cyclical wage fluctuations might account for the greater elasticities implicit in the response of cyclical hours variations (see table 9) as workers substitute leisure in low-wage periods for leisure in temporarily high-wage periods. However, microeconomic cross-sectional estimates of intertemporal elasticities of substitution from life-cycle models range for primary workers from 0.1 to 0.45 in the United States to roughly 0.15 for the United Kingdom.[32] For other countries,

Data," *Journal of Political Economy*, vol. 93 (August 1985), pp. 666–89. For a valuable survey and contribution, see John Kennan, "Equilibrium Interpretations of Employment and Real Wage Fluctuations," in Stanley Fischer, ed., *NBER Macroeconomics Annual, 1988* (MIT Press, forthcoming).

31. Strictly speaking, this will not usually be true because the labor supply elasticity would have to be estimated either using appropriate instrumental variables (for example, defense spending) or on the basis of other identifying assumptions. For estimates of this kind see Kennan, "Equilibrium Interpretations of Employment and Real Wage Fluctuations." The results are comparable to those presented in table 9.

32. See Thomas E. MaCurdy, "An Empirical Model of Labor Supply in a Life-Cycle Setting," *Journal of Political Economy*, vol. 89 (December 1981), pp. 1059–85; and Martin Browning, Angus Deaton, and Margaret Irish, "A Profitable Approach to Labor Supply and Commodity Demands Over the Life-Cycle," *Econometrica*, vol. 53 (May 1985), pp. 503–43. Other estimates of the microelasticity of supply are sometimes negative (see Orley

Table 7. Variation in Real Wage Changes from Fitted Trends: Consumer Price Based, Selected Countries and Periods, 1948–86[a]

Country and period	*Standard deviations of variations from trend (percent per quarter)*	*Correlations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
Full period						
United States (1948–86)	0.64	0.134	0.098	−0.070	0.098	−0.075
Japan (1970–86)	2.48	0.222	−0.478	−0.052	0.057	−0.023
West Germany (1960–85)	1.31	0.249	0.013	−0.112	−0.161	−0.007
Great Britain (1963–86)	1.68	0.240	−0.054	−0.056	−0.294	−0.089
Australia (1976–86)	1.71	−0.023	−0.215	−0.265	−0.475	−0.105
1967–86						
United States	0.66	0.147	0.130	−0.000	0.175	0.075
West Germany	1.34	0.165	−0.165	−0.133	−0.150	0.235
Great Britain	1.80	0.247	−0.081	−0.029	−0.272	−0.082
1948–66						
United States	0.61	0.181	−0.077	−0.244	0.130	−0.174

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years. Real wages were computed using consumer prices.

Table 8. Variation in Real Wage Changes from Fitted Trends: Producer Price Based, Selected Countries and Periods, 1948–86[a]

Country and period	*Standard deviations of variations from trend (percent per quarter)*	*Correlations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
Full period						
United States (1948–86)	1.22	−0.119	0.341	0.187	0.044	−0.027
Japan (1970–86)	3.20	0.400	−0.071	0.037	0.024	0.008
West Germany (1960–85)	1.24	0.128	−0.141	−0.166	−0.112	0.133
Great Britain (1963–86)	1.82	0.197	0.029	−0.039	−0.183	−0.148
Australia (1976–86)	3.65	−0.029	0.383	0.249	0.176	−0.183
1967–86						
United States	1.31	0.030	0.239	0.224	0.141	0.149
West Germany	1.28	0.105	−0.050	−0.052	−0.143	−0.015
Great Britain	3.96	0.194	0.031	−0.039	−0.174	−0.143
1948–66						
United States	1.15	−0.241	0.412	0.144	−0.112	−0.236

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years. Real wages were computed using producer prices.

Table 9. Normalized Effect of Aggregate Output Changes on Hours and Wages, Selected Countries and Periods, 1948–86

Country and period	*Regression coefficient of percent hours on percent output changes*	*Regression coefficient of percent wage on percent output changes*[a]	*Ratio of hours coefficient to wage coefficient*
Full period			
United States (1948–86)	0.224	0.086	2.60
Japan (1970–86)	0.424	0.551	0.77
West Germany (1960–85)	0.207	0.326	0.63
Great Britain (1963–86)	0.345	0.405	0.85
1967–86			
United States	0.251	0.097	2.59
West Germany	0.193	0.221	0.87
Great Britain	0.383	0.445	0.86
1947–66			
United States	0.221	0.110	2.00

Source: Same as table 1.

a. Coefficients are for normalized regressions in which the variation of percent output changes has been set to one. See text.

the implied supply elasticities in table 9 are less extreme (another respect in which the U.S. economy appears to be an anomaly). However, they remain above estimates from microeconomic data sets. A large literature confirms this general point.[33]

Tables 7, 8, 10, and 11 show that in terms of the patterns of serial correlation in trend deviations of changes in real wages, hours, and employment, different national economies appear to react very differently. As table 10 shows, Japan is a clear exception in employment, perhaps because of difficulties associated with imperfect seasonal adjustment. Even the U.S. data have exhibited apparently significant changes over time.

Ashenfelter, "Macroeconomic Analyses and Microeconomic Analyses of Labor Supply," in Karl Brunner and Allan H. Meltzer, *Essays on Macroeconomic Implications of Financial and Labor Markets and Political Processes* [Amsterdam: North-Holland, 1984], pp. 117–56), and confirm these generally low elasticities (Joseph G. Altonji, "Intertemporal Substitution in Labor Supply: Evidence from Micro Data," *Journal of Political Economy*, vol. 94 [June 1986], pp. S176–S215). Also MaCurdy's elasticity of 0.45 was not significantly different from zero.

33. See Kennan, "Equilibrium Interpretations of Employment and Real Wage Fluctuations"; Hall, "Labor Supply and Aggregate Fluctuations"; and Ashenfelter, "Macroeconomic Analysis and Microeconomic Analysis of Labor Supply."

Table 10. Variation in Employment Changes from Fitted Trends, Selected Countries and Periods, 1948–86[a]

Country and period	*Standard deviations of variations from trend (percent per quarter)*	*Correlations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
Full period						
United States (1948–86)	0.61	0.604	0.459	0.164	−0.005	−0.125
Japan (1965–86)	0.51	0.428	−0.375	−0.073	−0.353	0.723
West Germany (1960–85)	0.45	0.293	0.319	0.114	0.080	0.390
Great Britain (1963–86)	0.44	0.239	0.342	0.299	0.099	0.144
Australia (1976–86)	0.63	0.288	0.010	0.079	−0.307	0.213
1967–86						
United States	0.57	0.653	0.509	0.234	0.120	−0.080
Japan	0.76	0.131	−0.208	−0.228	−0.216	0.422
West Germany	0.27	0.219	0.418	0.050	0.032	0.143
Great Britain	0.44	0.271	0.445	0.364	0.207	0.114
1948–66						
United States	0.65	0.567	0.419	0.098	−0.134	−0.224

Source: Same as table 1.
a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

Table 11. Variation in Weekly Hours Worked Changes from Fitted Trends, Selected Countries and Periods, 1948–86[a]

Country and period	*Standard deviations of variations from trend (percent per quarter)*	*Correlations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
Full period						
United States (1948–86)	0.55	0.407	−0.317	−0.025	−0.050	0.084
Japan (1970–86)	0.82	0.517	−0.031	0.172	0.023	−0.100
West Germany (1960–85)	0.93	0.223	−0.047	−0.088	0.088	0.024
Great Britain (1963–86)	1.25	0.276	−0.252	−0.020	−0.294	−0.089
Australia (1976–86)	3.33	−0.173	−0.427	−0.087	0.008	0.147
1967–86						
United States	0.51	0.493	−0.148	−0.327	0.074	0.264
West Germany	0.80	0.242	0.002	−0.057	0.058	−0.062
Great Britain	1.37	0.280	−0.272	−0.028	−0.015	−0.240
1948–66						
United States	0.58	0.382	−0.418	0.201	−0.119	−0.111

Source: Same as table 1.
a. Quarterly data. The trend was calculated using a piecewise linear trend over four years.

Table 12. Output, Employment, Hours, and Wages in the Trough Years of the Depression, Selected Countries

Index, 1929 = 100

Country	*Year*	*Industrial production*	*Nonfarm employment*	*Nominal wage*	*Real wage*[a] *(CPI based)*	*Weekly hours*
United States	1932	52.7	78.4	84.4	107.5	72.0
Japan	1931	92.1	96.9[b]	92.0	n.a.	98.0
Germany	1932	53.3	71.1[c]	81.7[d]	104.0	90.1
Great Britain	1932	83.5	91.4	95.9	109.1	n.a.
Netherlands	1933	84.0	85.0	89.0	111.0	n.a.
Australia	1932	70.0	87.7	84.0	104.0	n.a.

Sources: U.S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970* (Government Printing Office, 1975); International Labor Office, *Yearbook of Labor Statistics*, various years; and John T. Dunlop, "The Movement of Real and Money Wages," *Economic Journal*, vol. 49 (March 1939), pp. 150–54.

n.a. Not available.

a. Nominal wages deflated by the consumer price index.

b. Does not include commercial employment.

c. Includes agriculture employment.

d. This is the "official" series. An alternative series yields a nominal wage index of 75.4.

Hours, employment, and wage behavior in the extreme conditions of the Depression were in some ways anomalous. Table 12 describes employment, wages, and, where available, weekly hours worked in the trough years of the Depression for the United States, Japan, Germany, Great Britain, the Netherlands, and Australia. Because of the rapid decline of food prices, real wages tended to rise significantly.[34] At the same time, both employment and hours worked fell, except in Japan where the Depression was extremely mild. Thus, the usual pattern of cyclical real wage and employment movements in the same direction appears not to have been true of the decline into the trough of the Depression. However, wages in terms of producers' prices, where such data are available, often moved in more usual ways. For example, manufacturing wages deflated by output prices fell in the United States between 1929 and 1932 by 12.2 percent in motor vehicles, by 1.4 percent in household durables, and by 2.0 percent in producers' durable equipment. Wages in durable industries as a whole rose only 2.6 percent when deflated by output prices. Employment in these industries fell roughly

34. The Depression was also characterized by nominal wage changes that were unusually small by contemporary historical standards. For example, nominal wages in Great Britain fell over 25 percent between 1921 and 1922 compared with a 1929–1932 decline of only 4.1 percent (see Dunlop, "The Movement of Real and Money Wages"). See also Martin Neil Baily, "The Labor Market in the 1930s," in Tobin, ed., *Macroeconomics, Prices, and Quantities*, pp. 21–61.

50 percent over this period.[35] Thus, these industries were characterized by the usual pattern of nearly constant or slightly procyclical real wage changes (in terms of producers' prices) and strongly procyclical employment changes. Similarly, in Great Britain, John Dunlop found that after adjusting for terms-of-trade shifts, real wages (in producers' prices) rose only 2.7 percent between 1929 and 1932.[36]

Data on the relationship between deviations from trend in productivity growth and output growth confirm a widely noted positive relationship between output and productivity growth.[37] For the United States, nonfarm business productivity data, available quarterly, show that U.S. productivity changes are strongly procyclical. The correlation of productivity with output variations was 0.617 for 1947–86 as a whole, 0.604 for 1947–66, and 0.643 for 1967–86. Quarterly nonfarm business productivity data are not available except for the United States, but rates of manufacturing productivity growth show that in all countries, including the United States, productivity growth has been positively correlated with overall output growth and presumably also with manufacturing output growth. The correlation of productivity with output variations during 1967–86 is as follows.

United States	*Japan*	*West Germany*	*Great Britain*	*Australia*
0.728	0.305	0.461	0.446	0.177

For the United States from 1929 through 1932, nonfarm productivity declined with output, falling from an index level of 100 in 1929 to 95.4 in 1932.

A further labor market aspect of business cycles is illustrated by the

35. These figures were calculated from data in U.S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970* (Government Printing Office, 1975).

36. See Dunlop, "The Movement of Real and Money Wages."

37. See, for example, discussion in Arthur M. Okun, "Inflation: Its Mechanics and Welfare Costs," *BPEA, 2:1975*, pp. 351–90. Robert Hall, "The Relationship between Price and Marginal Cost in U.S. Industry," *Journal of Political Economy* (forthcoming, 1988), also notes that, in cases where an increase in output can be identified as being demand driven (for example, due to an increase in military spending), the resulting increase in productivity indicates that marginal costs must be well below average costs. This, in turn, suggests that, especially in a recession where capacity constraints are not an issue, marginal costs, as Hall points out, are below prices. The U.S. data for 1929 and 1932 are from *Historical Statistics of the United States*.

Table 13. Variation of Changes in Unemployment Rates from Fitted Trends, Selected Countries and Periods, 1947–86[a]

Country and period	*Standard deviations of variations from trend (percent change)*	*Correlations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
Full period						
United States (1947–86)	0.45	−0.744	0.610	0.207	−0.110	−0.304
Japan (1960–86)	0.12	−0.173	−0.302	0.100	−0.258	0.340
West Germany (1960–86)	0.21	−0.398	0.635	0.234	−0.065	−0.253
Great Britain (1960–86)	0.24	−0.141	0.715	0.523	0.323	0.059
Australia (1968–86)	0.35	−0.265	0.360	0.100	0.039	−0.189
Netherlands (1971–86)	0.37	n.a.	0.276	0.009	0.100	0.074
1967–86						
United States	0.42	−0.726	0.600	0.287	0.069	−0.151
Japan	0.11	−0.165	−0.174	−0.017	−0.244	0.199
West Germany	0.22	−0.406	0.629	0.352	0.106	−0.046
Great Britain	0.26	−0.173	0.716	0.542	0.333	0.050
1947–66						
United States	0.51	−0.770	0.616	0.150	−0.247	−0.423

Source: Same as table 1.
n.a. Not available.
a. Quarterly data. The trend was calculated using a piecewise linear trend over four years. Changes in unemployment rates are measured as differences in actual unemployment rates.

data in table 13. Cyclical fluctuations in output and employment are associated with persistent cyclical changes in measured unemployment rates. Table 13 describes deviations from fitted trends of actual changes in unemployment rates. Excepting Japan, all economies, now including that of the Netherlands, exhibit persistent fluctuations in unemployment rate changes that are positively correlated over time.[38] However, the international differences in unemployment are striking. The standard deviations of fluctuations in changes in Japanese unemployment rates are only about one-quarter the comparable standard deviations in the United States, despite the fact that variations in output are comparable. And the persistence of unemployment rate changes in the United States, West Germany, and Great Britain is significantly greater than the persistence of changes in Australia, Japan, and the Netherlands. Un-

38. This may be a result of improper seasonal adjustment of the Japanese data (note the strong positive four-quarter correlation). Four seasonal dummies were included in the regression.

employment, therefore, appears to be governed by factors beyond those affecting the level of activity in the overall macroeconomy. A key question, however, is whether these cyclical changes in measured unemployment constitute a phenomenon separate from fluctuations in aggregate employment that a well-specified macroeconomic theory ought to explain. There are grounds for believing so.

An important distinction has been maintained since the development of job search models between unemployment on the one hand and nonemployment (or perhaps more properly non–labor-market-related employment) on the other. Unemployment in these models is related to active job search, just as measured unemployment is usually related to willingness to work as measured by active job search. At a minimum, therefore, cyclical increases in unemployment indicate an increase in the number of workers searching for jobs, and that increase is so pervasive a business-cycle phenomenon that it ought to be explained.

The special aspect in this respect of cyclical changes in unemployment is illustrated by the marked difference in the United States between the unemployment effects of cyclical and seasonal variations in output. Work by Robert Barsky and Jeffrey Miron indicates that seasonal fluctuations in unemployment are far smaller per percent change in output than cyclical fluctuations in unemployment.[39] For example, from 1948 through 1985, in the first quarter of each year, U.S. GNP fell an average of 8.01 percent from the fourth quarter of the previous year, while unemployment increased an average of only 1.08 percent of the labor force. The ratio of this seasonal decline in GNP to the corresponding seasonal rise in unemployment is about 7.4, compared with a postwar Okun's Law figure of between 2 and 3 for cyclical fluctuations. In the final quarter of each year postwar U.S. output was on average about 4.36 percent above second-quarter output, while unemployment as a fraction of the labor force was only 0.43 percent below its second-quarter level, yielding an Okun's Law ratio of about 10.

The rise in unemployment during recessionary periods is also associated with cyclical changes in the nature of job separations. As output declines, quits fall, and layoffs and other involuntary separations rise. The distinction between these two forms of job separation is not an artificial one. Studies of individuals by Ann Bartel and George Borjas

39. See Robert B. Barsky and Jeffrey A. Miron, "The Seasonal Cycle and the Business Cycle" (NBER, July 1987).

indicate that those involuntarily separated from jobs suffer significant permanent losses in future earnings.[40] To the extent that cyclical increases in unemployment (that is, job search while not employed) are associated with increases in the incidence of involuntary job losses, the phenomenon of cyclical unemployment also raises the question of why cyclical reductions in labor inputs take this particular form and not others, such as hours reduction, shortened workweeks, and temporary furloughs of fixed duration that are rotated among workers.[41]

Thus, the cyclical behavior of labor markets is characterized not just by generally procyclical variations in real wages and productivity, the former of which are small relative to procyclical employment and hours fluctuations, but also by noticeable differences in real wage fluctuations when measured in producers' as opposed to consumers' prices and by countercyclical unemployment variations that appear to be representative of a related set of labor market phenomena, including layoff and quit behavior, that are distinct from cyclical fluctuations in the overall level of labor input.

Alternative Theories

Currently fashionable theories for explaining business-cycle behavior fall, broadly speaking, into three categories. First, there are new classical approaches that describe cycles as movements in Walrasian equilibria in response to several varieties of external shocks. The first incarnation of such a theory was the information-based business-cycle model of Robert Lucas.[42] More recently, attention within this tradition has shifted to real business-cycle models in which shocks to technology drive cyclical disturbances. Therefore, as a representative of the new classical approach we will examine a simple real business-cycle model.[43] The

40. See Ann P. Bartel, "Earnings Growth on the Job and between Jobs," *Economic Inquiry*, vol. 18 (January 1980), pp. 123–37; and Ann P. Bartel and George J. Borjas, "Wage Growth and Job Turnover: An Empirical Analysis," in Sherwin Rosen, ed., *Studies in Labor Markets* (University of Chicago Press, 1981), pp. 65–90.

41. This point is forcefully made in Robert E. Hall, "Employment Fluctuations and Wage Rigidity," *BPEA, 1:1980*, pp. 91–124.

42. See Robert E. Lucas, Jr., "Expectations and the Neutrality of Money," *Journal of Economic Theory*, vol. 4 (April 1972), pp. 103–24.

43. The model discussed is based on Edward C. Prescott, "Theory ahead of Business-Cycle Measurement," in Brunner and Meltzer, *Real Business Cycles*, pp. 11–44; and Finn E. Kydland and Edward C. Prescott, "Time to Build and Aggregate Fluctuations," *Econometrica*, vol. 50 (November 1982), pp. 1345–70.

second category of models uses the traditional Keynesian nominal wage rigidity assumption, recently updated by Stanley Fischer and John Taylor.[44] We will use a simple variate of such a model to represent a traditional Keynesian approach. Finally, a family of what we have called new Keynesian models grew out of a variety of attempts to place the assumptions underlying traditional Keynesian analysis on a more solid footing. A variant of this model that focuses primarily on imperfections in capital markets will be presented as the representative of this approach.

REAL BUSINESS-CYCLE MODELS

Real business-cycle models are built around two fundamental sets of behavioral relationships. First, a representative firm maximizes profits subject to a production function of the usual constant-returns-to-scale sort. In line with most of the real business-cycle literature, we will assume that this function is Cobb-Douglas so that

$$y_t = \epsilon_t l_t^{\theta} k_t^{1-\theta}, \tag{1}$$

where y_t is real output, l_t is labor input, k_t is the capital stock, and ϵ_t is a random technology shock. The firm rents capital from households at a rental rate, r_t, and hires labor at a real wage, w_t.

Second, a representative household maximizes expected utility over an infinite horizon, deciding in each period on a level of labor supply, a level of consumption, c_t, and, therefore, implicitly on a level of investment, i_t, that determines the evolution of the capital stock. The competitive equilibrium in this model, which is also the solution to the household's intertemporal optimization problem given the production technology, can be characterized as a set of functions relating the two state variables, technology (ϵ_t) and the capital stock (k_t), to output (y_t), the level of labor supplied (l_t), and the level of investment (i_t):

$$y_t = y(k_t, \epsilon_t), \tag{2}$$

$$l_t = l(k_t, \epsilon_t), \tag{3}$$

$$i_t = i(k_t, \epsilon_t). \tag{4}$$

44. See Stanley Fischer, "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule," *Journal of Political Economy*, vol. 85 (February 1977), pp. 191–205; and John B. Taylor, "Aggregate Dynamics and Staggered Contracts," *Journal of Political Economy*, vol. 88 (February 1980), pp. 1–23.

Once these real magnitudes have been determined, along with real wages, consumption, and interest rates, nominal levels of prices and economic activity are determined by the interaction of real activity with a monetary sector as discussed, for example, by Robert King and Charles Plosser.[45] This interaction serves only to determine the aggregate price level, since changes in monetary aggregates are neutral in most recent real business-cycle models.

The broad characteristics of real business cycles can be described in terms of this simple structure. Though the designers of these models have argued for them on the basis of their broad agreement, in simulation exercises, with macroeconomic data, attention has not been focused on how well the models explain what we have identified as the central stylized facts of the goods, capital, and labor markets.

Goods Markets. From an output market perspective, the most significant characteristic of the real business-cycle model is that, both in spirit and in structure, it is an extension of the usual competitive general equilibrium model and thus shares the basic properties of that model. The most important of these is the general tendency for competitive markets to dampen the effect of external disturbances. For example, in a simple two-good model, the price increase engendered by an increase in the demand for one good counteracts the output-increasing tendencies of the original increase in demand. Thus, the basic motive force for any business-cycle fluctuations must necessarily be an external disturbance whose impact is generally attenuated by the reaction of markets in a real business-cycle economy. By contrast, in traditional Keynesian and more recent imperfect-information-based models, market imperfections give rise to rigidities and externalities that, in turn, often amplify rather than attenuate external disturbance, as exemplified by the traditional Keynesian multiplier. In the latter models, the critical focus of attention is not so much on the external disturbances that initiate cyclical fluctuations as on the imperfections that transmit and amplify those disturbances. For real business-cycle models, however, success in explaining the nature of output and price fluctuations is inextricably tied to the plausibility and consistency of the description of the external shocks that are necessary to generate realistic cyclical fluctuations.

There are two sources of persistent economywide output fluctuations in the simple real business-cycle model described above: persistence

45. Robert G. King and Charles I. Plosser, "Money, Credit, and Prices in a Real Business Cycle," *American Economic Review*, vol. 74 (June 1984), pp. 363–80.

across time in the level of the capital stock, k_t, and the serial and cross-sectoral correlation properties of the technology parameter, ϵ_t. Of these, the latter is far more influential at the frequencies most commonly associated with business cycles. The aggregate capital stock changes only slowly and smoothly. During any particular phase of the business cycle, which might be of two years duration, the aggregate capital stock remains roughly constant. Thus, although capital stock movements may account for longer-term cycles, the cyclical persistence properties of real business-cycle models depend on the persistence properties and hence the nature of ϵ_t.

The real business-cycle interpretation of ϵ_t is as a measure of the state of development of technology. This interpretation suggests that since technological developments should not be forgotten and since negative developments in technology ought to be uncommon, an appropriate specification of the process governing the evolution of ϵ_t is

$$\epsilon_t = \epsilon_{t-1} + \mu_t, \quad \mu_t \geq 0, \tag{5}$$

where μ_t is a random term that may but need not be either stationary or serially independent.[46]

In this form, in the absence of the nonnegativity constraint on μ_t, the real business-cycle model does well in explaining the patterns of persistence in output changes in table 1. Indeed, the ability to do so is perhaps the primary recommendation in favor of the real business-cycle model. However, without any restrictions on the form or magnitude of ϵ_t, this success should not be surprising. There are enough degrees of freedom in ϵ_t to fit any observed pattern of output fluctuations. A more appropriate test, therefore, is to ask whether the patterns of ϵ_t implied by observed cyclical behavior are consistent with the technology-based interpretation of ϵ_t on which most real business-cycle models are based.

In this regard, the real business-cycle model performs less well. The natural restriction that μ_t be nonnegative makes it difficult for real business-cycle models to explain instances in which aggregate output and productivity fall. The most notable of these is the Great Depression (see table 12), when output in the United States fell 30 percent between

46. Because new technology is adopted only gradually, a more appropriate representation of equation 5 might be $\epsilon_t = \epsilon_{t-1} + \alpha(\epsilon_{t-1} - \epsilon_{t-2}) + (1 - \alpha)\mu_t$, where μ_t now represents new technology improvement and α is the fraction of firms that adopt the latest technology in each period (other diffusion-like models yield similar specifications). As noted below, this model is more difficult to accommodate to the observed data than the model of equation 5.

1929 and 1932. The factors responsible for technological regress of this magnitude are difficult to identify. In addition, recessions in which output actually falls have occurred regularly in the postwar period without any clear association with negative productivity developments.[47]

Also, because the aggregate shocks, ϵ_t, are the sum of technology shocks over many industries, it is difficult to account for their size. For the United States, the standard deviation of the underlying productivity shocks necessary to account for the observed magnitude of output fluctuations in terms of a real business-cycle model is about 0.75 percent per quarter. If aggregate output were composed of the output of 50 independent subindustries, the implied standard deviation of independent quarterly industry productivity shocks would be 5 percent, which seems to be very high relative to observed data on fluctuations in industry productivity. Consequently, aggregate shocks must come at least in part from productivity shocks that simultaneously affect many industries, and these shocks are difficult to identify.

To the extent that the composition of economic activity is similar in industrial economies, real business-cycle models with common technological disturbances and similar consumer behavior would predict similar magnitudes of output fluctuations. Again, however, the technological disturbances of the real business-cycle models do not appear to account well for the nature of these magnitudes.

First, if technology is commonly available to all industrial economies, fluctuations in output across major industrial economies should be closely correlated. Yet Prescott finds variations in output from trend in Japan, the United Kingdom, and Australia to be negatively correlated with contemporaneous variations from trend in the United States (for German-U.S. variations the correlation is positive, but small).[48] Specific incidents like the mild Japanese response to the 1980 oil shock are also difficult to explain in terms of common technology shocks.

Second, if the technology shocks that underlie cyclical movements in aggregate output are the sum of shocks to technology in individual industries, then national economic conditions should be affected by

47. Even the oil price shocks of 1973–74 and 1979–80 that have been blamed for the recessions in 1974–75 and 1981–82 do not appear clearly to have represented negative productivity shocks of significant magnitude. Also, their impact was uneven across countries. For example, Japan suffered little or not at all from the second oil shock.

48. Prescott, "Can the Cycle Be Reconciled with a Consistent Theory of Expectations."

these industry movements rather than vice versa. Thus, related movements across countries in industry productivities should account for a greater part of total output fluctuations than related movements across industries within particular national economies.[49] But the data Stockman examines suggest, as noted above, the opposite: national factors seem to be more important than industry factors.

Finally, the real business-cycle models provide no explanation for the apparent degree of actual price rigidity. On this point, the real business-cycle models are silent. However, since they are based on underlying competitive structures with perfectly flexible prices, the data in this area run strongly counter to the spirit of the real business-cycle models.

Capital Markets. Real business-cycle models exhibit striking accelerator behavior and hence disproportionate fluctuations in investment. Most real business-cycle models involve capital-output ratios that tend, temporary adjustments aside, to be constant over time. Thus, a permanent change in productivity that raises permanent output 1 percent should lead to a 1 percent change in the equilibrium capital stock. Average gross investment, assuming an average depreciation rate of 7 percent per year in the capital stock[50] and a 3 percent average annual growth rate in GNP, and hence the capital stock, should be about 10 percent of the capital stock per year, or 2.5 percent per quarter. Thus, an unusual technology-driven increase of 1 percent in the level of output in a quarter would increase investment about 40 percent (1 percent divided by 2.5 percent), if the increase in the capital stock were translated into an immediate change in investment in that quarter. Planned investment in a real business-cycle model should, therefore, be much more highly variable than output.[51] Actual investment fluctuations will be smaller than the changes in planned investment because of time-to-build and other constraints.

49. Stockman, "Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries."

50. This estimate may be high since, for the United States, the capital-output ratio is about 2.5 and depreciation is typically about 12.5 percent of output.

51. Several factors mitigate the extreme fluctuations in planned investment implied by this simple calculation. Higher planned investment should raise interest rates and the relative prices of capital goods. The extent of these effects will depend, respectively, on the degree of intertemporal substitution in consumption and the elasticity of supply of investment goods. Also, if some part of any technology shock is transitory, the desired capital stock will increase by less than the change in output. However, as noted above, the notion of transitory technology shifts is not easy to interpret.

Recessions raise difficulties for the model. If recessions are a consequence of negative productivity shocks, then the associated reduction in the capital stock should lead to negative net investment. But except in the Great Depression, no such aggregate investment levels have been observed. For example, the level of real output in the United States in the fourth quarter of 1982 was below the level of output for 1979 as a whole, yet at no time in the intervening period does net investment appear to have been negative, as a real business-cycle model would appear to imply.[52]

Real business-cycle models are successful in explaining the pattern of fluctuations across categories of investment. Extending the simple calculation above, planned gross investment of type j for any quarter should increase by an amount $[1/(d_j + g)]$ per percent change in output, where d_j is the depreciation rate for capital of type j and g is the average growth rate in the economy.[53] If this increase in planned investment is spread over k_j period for capital of type j, then the relative size of actual investment fluctuations will depend roughly on $[1/(d_j + g)k_j]$. If k_j is eight quarters for business structures, and two quarters for producers' durable equipment, if the depreciation rates for the two categories of investment are 1 percent and 4 percent per quarter, respectively, and if the average growth rate is 1 percent per quarter, fluctuations in investment in structures relative to equipment should be about 60 percent. This is approximately the actual ratio in the data available. However, a similar calculation indicates that fluctuations in residential construction should be roughly comparable to those in investment as a whole, which is certainly not consistent with the data in tables 3 and 6. And real business-cycle models do not yet provide an explanation for the particularly high sensitivity of inventory investment. Moreover, being technologically based, real business-cycle models cannot explain differences in the pattern of fluctuations in different investment categories across countries that are apparent in tables 3, 5, and 6.

The Labor Market. The assumption of real business-cycle models

52. This could be due to nonconvexities (due to nonnegativity constraints) in investment as a function of productivity growth at the industry level. However, independent individual industry productivity shocks are difficult to reconcile with the size of the aggregate shock.

53. This assumes that technology shocks affect all kinds of capital equally and that the effects of interest rates are roughly equal across types of investment.

that households maximize utility in a competitive environment means that equilibria always lie on the competitive labor supply curve of workers. The evidence of cyclical wages, hours, and employment movement argues against this. As noted above in tables 7–11, variations in observed employment levels and in hours worked per week in all countries appear to be large relative to fluctuations in real wages, and, in general, there is only a slight tendency for real consumer wages to fall in recessions. However, the relative behavior of wages and hours of work appear to vary significantly across countries, time periods, and special circumstances.

The detrended wage-hours relationships in table 9 are slightly upward sloping, but appear inconsistent with most cross-sectional studies, which find this curve to be highly inelastic. To reconcile the data with the hypothesis that firms operate along the labor supply curve, one must argue either that the cross-sectional studies are wrong or that there are important shifts in the short-run labor supply curve.

Extreme instances like the Great Depression also cast doubt on the degree to which workers are always on their labor supply curve. In the Depression, agricultural prices fell relative to manufacturing prices, as one might have expected, given the inelasticity of demand for agricultural goods, and given the relative importance of imperfect competition in manufacturing.[54] As a result, real consumer wages appear to have risen, especially in the early stages of the contraction. From 1929 through 1932, real wages in the United States in terms of consumer prices appear to have risen by about 7.5 percent (see table 12). Yet rather than rising in response to the increase in real wages, hours of work and, therefore, presumably, labor supply contracted. Nonfarm employment fell about 22 percent between 1929 and 1932.

A simple model may help to illustrate what was at issue in the Great Depression and in other contractions in which real wages in terms of food prices increased, or did not decline significantly (see table 14). We need to distinguish between the hours supplied by employed workers

54. That is, this change in relative prices is one of the aspects of macroeconomic fluctuations that a good theory ought both to explain and to take account of. The theory that we present below, as well as other theories of imperfect competition, yields predictions at least grossly consistent with these observations. See Joseph E. Stiglitz, "Price Rigidities and Market Structure," *American Economic Review*, vol. 74 (May 1984, *Papers and Proceedings, 1983*), pp. 350–55; Julio J. Rotemberg and Garth Saloner, "The Relative Rigidity of Monopoly Pricing"; and Hall, "The Relationship between Price and Marginal Cost in U.S. Industry."

Table 14. Variation in Deviations of Real Wages from Trend, United States, Selected Periods, 1947–86[a]

Period	*Standard deviations of variations from trend (percent per quarter)*	*Correlations of variations with output variations*	*Serial correlations of variations from trend*			
			1 lag	*2 lags*	*3 lags*	*4 lags*
1947–86	2.06	−0.143	0.817	0.565	0.318	0.045
1967–86	2.34	−0.090	0.878	0.684	0.475	0.225
1948–66	1.58	−0.263	0.689	0.350	0.068	−0.198

Source: Same as table 1.

a. Quarterly data. The trend was calculated using a piecewise linear trend over four years. Real wages were computed using consumer food prices.

and the number of workers employed. We first focus on the decisions of a worker who remains employed throughout the recession. Consider a representative individual, with a separable utility function between food, leisure, and other goods. (As we argued before, we need some restrictions, if utility maximization is to yield any interesting predictions.)

$$W = \Sigma[u_t^F(F) + U_t^G - \eta_t V_t(L)]\delta^t,$$

where F is food consumption, G is consumption of other goods, and L is labor supply. The parameter δ is the discount factor: future utility is discounted relative to current utility. Technological change increases an individual's productivity not only at work, but also at leisure, as reflected in the factor η_t. We postulate that η_t is of the special form $\eta_t = \eta^t$. (Without some restriction of this form, again we have too many degrees of freedom to obtain meaningful results.)

The first-order condition with respect to L_t can be written

$$U_t^{F'} w^t p_t^F = \eta^t V_t',$$

where w^t is the wage and p^F is the price of food.[55] Taking the continuous time approximation, and differentiating with respect to time, we obtain

$$-\tau(d \ln F/dt) + d \ln v^F/dt = \hat{\eta} + \Omega d \ln L/dt,$$

where we have made the further assumptions that U^F is of constant elasticity, with elasticity τ, V is of constant elasticity, with elasticity Ω, where $v \equiv w/p^F$, and where $\hat{\eta}$ is the rate of change of η.

55. The fact that he is employed throughout means that we can ignore boundary constraints.

We immediately see that if real wages, in terms of food, increase and if the consumption of food decreases, relative to trend, the supply of labor should increase.[56] Moreover, in this case, adjustment costs appear unlikely to account for any temporary deviations in behavior from the optimum since it is easy to adjust consumption of food.[57]

This is not the only first-order condition. There may be other first-order conditions that are consistent with the theory, but that hardly constitutes confirmation of the theory: all first-order conditions must be satisfied.

A similar result arises, for instance, from the intertemporal first-order conditions for labor, which we can write

$$\eta_t V_t' / \eta_{t+1} V_{t+1}' = \delta v_t (1 + r_t)/v_{t+1},$$

where v_t is the real consumption wage and r_t is a real rate of interest in period t. We now see why we have introduced the efficiency factor η. Without it, in steady state with increasing real wages, there should be constantly increasing hours of work. If productivity in leisure increases at the same rate as the real consumption wage, there will be constant hours.[58]

56. Ideally, our data should relate to consumption and employment of workers who remain employed throughout the recession. We suspect that the variability in consumption (in general, or of food in particular) of these workers may be less than that of total consumption. This general point is also made by Robert J. Barro and Robert G. King, "Time-Separable Preferences and Intertemporal-Substitution Models of Business Cycles," *Quarterly Journal of Economics*, vol. 99 (November 1984), pp. 817–39.

Note that workers who are "planning" to choose not to participate in the labor force in the future will still satisfy this first-order condition. If nonparticipation is a "forced" decision, then the uncertainty about future employment is likely to lead to reduced consumption in a recession and an increased labor supply.

57. With a broader measure of consumption in the relationship described above, we face two problems, as is well known. First, if durables are included, we need to include the services of durables, not the purchases. These are likely to be less volatile than purchases. Thus a time series of expenditure on consumption goods would suggest a larger *increase* in labor supply in a recession than a series reflecting "true consumption." On the other hand, with some goods, there are costs of adjustments, with resulting lags, that lead to less variability in the observed series. Of course, if there are costs of adjustment, they need to be incorporated formally into the analysis.

58. Note that our formulation also provides a reconciliation of the seeming inconsistency between time series and cross-sectional studies of the labor supply. The fact that hours have decreased slightly over the past 50 years suggests a backward-bending supply curve of labor, while most cross-section studies show a basically inelastic supply of labor for males and a highly elastic supply schedule for secondary workers.

Again, looking at the continuous time formulation, we have

$$\hat{\eta} + \Omega d \ln L/dt = d \ln v/dt + (\delta^* - r),$$

where δ^* is the pure rate of time preference ($\delta^* \approx 1/1 + \delta$). Labor supply will increase relative to trend if the real wage is increasing faster than trend, or if the rate of interest is below trend.

This first-order condition brings out the intertemporal substitution of labor. It emphasizes that what is relevant is the rate of change of the *real consumption wage* and the real consumption rate of interest. Again, a rise in real consumption wages, such as occurred during the Depression, should have led to an increase in hours worked.[59]

Consider next workers who cease working. Do they choose to substitute a large dose of leisure during recession? The notion of nonconvexities, associated with employment, that played a role in earlier discussions of implicit contract theory has been revived in recent years in the context of real business-cycle literature, though the objections raised in the earlier discussion remain equally valid. Even if the nonconvexities imply that it is better for individuals to work an eight-hour day than for two individuals to work four hours a day, natural restrictions on preference (diminishing marginal utility of leisure) suggest that there should be job rotation, a fact reinforced by the provisions limiting unemployment compensation to 26 or 39 weeks.[60] Moreover, with full insurance for layoffs, individuals would prefer to be laid off than to remain employed; few industries exhibit this reverse seniority.[61] Indeed, real business-cycle models do not recognize unemployment as a phe-

59. Furthermore, in recessions, there is evidence of labor hoarding, which translates into more on-the-job leisure. Thus, the effective wage is *higher* than the observed wage. This implies that the supply of labor will increase more or will decline in a recession even less than our previous analysis suggested. On the other hand, in the context of long-term employment relationships, changes in current wages need not reflect completely changes in the discounted future value of earnings that are a result of current hours of work.

60. See Hall, "Employment Fluctuations and Wage Rigidities," for a forceful discussion of this point.

61. For a more thorough analysis of these problems, in the context of implicit contract theory, see Joseph E. Stiglitz, "Theories of Wage Rigidity," in James L. Butkiewicz and others, eds., *Keynes' Economic Legacy: Contemporary European Theories* (Praeger, 1986), pp. 153–206; and Richard Arnott, Arthur Hosios, and Joseph E. Stiglitz, "Implicit Contracts, Labor Mobility, and Unemployment," Working Paper 2316 (NBER, July 1987).

There are also nonconvexities associated with search. Arnott, Hosios, and Stiglitz, "Implicit Contracts, Labor Mobility, and Unemployment," show that these nonconvexities do imply that work reductions may *partially* take the form of layoffs, even with reasonably specified preferences.

nomenon distinct from overall fluctuations in employment. Again, observed behavior does not appear to be consistent with the fact that workers are on their labor supply curves and, thus, does not appear to be consistent with the real business-cycle model.

TRADITIONAL KEYNESIAN MODELS

The simplest possible traditional Keynesian model consists of the interaction of *IS* and *LM* curves that determines an aggregate demand curve (relating output to the price level) and a labor market equilibrium generating an aggregate supply curve. These can be written, respectively, as

$$y_t = f(M_t/P_t), \tag{6}$$

$$y_t = g(W_{t-1}/P_t), \tag{7}$$

where M_t is the level of an appropriate monetary aggregate, P_t is the nominal price level, y_t is real output, and W_{t-1} is the previous period's nominal wage, which affects nominal wage levels in period t because of the existence of multiperiod overlapping nominal contracts. Equation 7 is based on the assumption that the labor demand curves of firms determine employment. The price level P_t is assumed to be fully flexible and determined so the goods market clears.[62] As before, the implications of this model can be compared with the stylized facts about cycles outlined above.

Goods Markets. Persistent deviations of actual output levels from trend in output occur in this model through the lagged impact of past nominal wage contracts on current wage levels. With overlapping contracting periods, Taylor has shown that deviations may persist over extended periods.[63] Since disequilibria are rooted in the labor market, the effects of fluctuations in the aggregate price levels are transmitted across industries, producing movements in output that are highly correlated across industries within national economies. However, the extreme form of persistence of output fluctuations evident in at least the U.S. data in table 1 is not consistent with the spirit of the traditional Keynesian model. Some permanent effects of any temporary decline in

62. Most of what we have to say in this section would apply equally to more recent Keynesian models in which neither the goods market nor the labor market clears.

63. Taylor, "Aggregate Dynamics and Staggered Contracts."

aggregate production will arise as the result of a fall in investment (and hence a reduction in the future capital stock), but any such effect will likely be small. Extending the basic model to incorporate activities that generate productivity growth and whose levels are endogenously determined might lead to long-term unit-root persistence in output changes. But it is not clear why temporarily high real wages, the basis of the reduction in output, should discourage, rather than perhaps encouraging, such activities.

Implicit in the formulation of the traditional Keynesian model, with its emphasis on stabilizing policy interventions, is the notion that the severity of business cycles can be significantly alleviated under appropriate circumstances. The current rationale for active government fiscal and monetary policies is based on their possible value in avoiding extreme fluctuations. Institutional arrangements may have similar effects. Taylor has emphasized the value of synchronized wage setting (for example in Japan) in minimizing the persistence of nominal wage rigidities.[64] Economic structure should also affect the stability of the Keynesian model. A small open economy, selling in world markets, should be less sensitive to aggregate demand shifts than a large closed economy. Consequently, the similarity of the magnitudes of output fluctuations in table 1 is not what would be expected in a traditional Keynesian world.

Persistence in rates of price change arise in traditional Keynesian models from persistence in rates of wage change that are due, in turn, to staggered wage setting and the existence of long-term wage contracts. If average wage levels affect prices and production on an economywide basis, wage rigidities may lead to the kinds of price rigidities observed in practice. However, if contracting procedures merely fix average inframarginal wages and do not fix either the opportunity cost of labor subject to these contracts or the marginal cost of incremental workers, then it is not clear that wage rigidities due to contracting procedures imply that prices will be rigid.

Capital Markets. The traditional Keynesian explanation for the disproportionate size of fluctuations in investment has been the accelerator principle, the same phenomenon that yields disproportionate shifts in investment in the real business-cycle model. A change in output leads to

64. Taylor, "Differences in Economic Fluctuations in Japan, the United States, and Europe."

a proportionate change in the desired capital stock that leads to a large change in investment when expressed as a fraction of the much smaller average level of investment. However, in a Keynesian framework, where the original changes in output are assumed to be transitory, the strength of this argument is far weaker than in the case of real business-cycle models, especially since the change in output is not due to any change in technology, but rather to temporary changes in real wages or aggregate demand. As the economy recovers, the demand for additional capital should readjust.

An alternative version of the accelerator hypothesis relates to the timing of investment. Investment is concentrated in periods of unusually high output because they are also periods of unusually high capacity utilization. Yet again it should be noted that capacity utilization is high only temporarily. With substantial delivery and construction lags before equipment is put in place, it is not at all obvious that capacity utilization will be high when the new investment becomes available for use.

For a long-lived investment project, the expected return over the life of the project in question should, given delivery and production lags, be relatively insensitive to temporary current deviations of economic activity from trend. Thus, small price adjustments should be sufficient to shift the demand for investment to periods of low output. As a result, if the marginal costs of investment are relatively low when investment goods–producing sectors are operating below capacity, small shifts in investment goods prices should substantially stabilize investment goods output. It is not clear, therefore, that investment levels should fluctuate much more than output in a Keynesian world. Indeed, they might reasonably be expected to fluctuate less, or even to be countercyclical.

This kind of argument should apply relatively strongly to residential construction. The demand for housing should depend on lifetime, not current, household income. Changes in current output should, therefore, have little impact on housing demand. Shifts in housing demand should be absorbed as changes in the prices of the large existing stock of housing and land. Fluctuations in the level of construction activity should, then, be determined by the interaction of a supply curve with changes in the prices of existing housing (partially offset by changes in land prices). Since many resources involved in residential construction appear to be relatively highly specialized, marginal costs in construction should decline significantly with the level of activity. Thus, small cyclical

changes in housing prices (net of land prices) should lead to either countercyclical, or at most small procyclical output fluctuations along a relatively inelastic supply curve. Yet residential construction is, in the United States at least, one of the most volatile investment sectors.

The problems posed by investment in inventories are by now well known.[65] With concave production functions, inventories serve a buffer stock role. With labor underemployed in a recession, it should be used to add to inventories, given that shadow real product wages are, if anything, slightly lower than normal.

In the absence of adjustment costs for production,[66] and ignoring storage costs, production should be such that the real marginal costs of production are the same each period, that is,

$$v_t^P/F_t' = v_{t+1}^P/F_{t+1}'(1 + r^P),$$

where v^P is the real product wage, r^P is the real product interest rate, and F' is the marginal product of labor.[67] (When there are changes in relative prices, the real product interest rate may differ from the real consumer interest rate.) Expressing this in continuous time, we have, in the obvious notation,

$$d \ln v^P/dt - r^P = -(1/\alpha)d \ln L/dt,$$

where α is the elasticity of demand for labor with respect to the wage. (With a Cobb-Douglas production function, it is the reciprocal of one minus the share of labor.) Given observed small variations in real wages and interest rates, employment should vary little, with the difference between output and sales going into or out of inventories. But not only is production not smoothed, as the theory of intertemporal substitution suggests it ought to be, but inventories are reduced in recessions.[68]

The Labor Market. As tables 7 and 8 show, movements in real wages are generally procyclical. In the postwar period, only in the United States for the period 1948–66 and in terms of producers' prices do real wages appear to have varied countercyclically. Before that, only in the

65. Blinder, "Can the Production Smoothing Model of Inventory Behavior Be Saved?"

66. Adjustment costs simply strengthen the presumption for production smoothing.

67. We assume intertemporal separability in production and that we are in an interior solution with positive inventory stocks.

68. Inventories of inputs can be thought of as part of the production process, and, as such, when production decreases, the demand for these inventories will decrease. The paradox arises in the context of inventories of finished goods.

Great Depression do real wages appear to have varied countercyclically, and those were consumer price wages, not, in many industries, the critical producers' price wage. Higher levels of output are generally associated with higher levels of real wages and are almost invariably associated with higher, not lower, levels of productivity per man-hour. The latter was true even during the Depression. The existence of fixed costs could account for the productivity variations since these are given in average, not marginal, terms. However, the wage data run directly counter to the predictions of the traditional Keynesian model.

One of the earliest objections to traditional Keynesian theory was that the evidence suggested that the firm was not on its labor demand curve. If, for instance, we postulate a Cobb-Douglas production function, with a coefficient on labor of 0.75, and a 25 percent decline in labor input, as in the Great Depression, then the real product wage should have *risen* by 6 percent. And the real product interest rate (marginal return on capital) should have fallen 30 percent. If, as much of the econometric evidence suggests, the elasticity of substitution is less than unity, then real wages should have risen even more. If the elasticity of substitution was 0.6, and real interest rates remained the same, then if the only disturbance to the economy was a productivity shock, real wages should have risen more than 40 percent. (If the real marginal return to capital decreased, then the increase in real product wages should have been even greater.)

Dunlop and Tarshis pointed out that there was no evidence of this kind in the Depression, and the evidence presented above suggests that real product wages fall when output and hours fall.[69] There are three possible approaches to take at this point in adapting the traditional Keynesian model. One is to assume that the firms are not on their labor demand curve.[70] The main objection to this has not been empirical, but theoretical: no convincing explanation for why firms do not lower their prices (within a competitive framework) to increase sales has been provided.

69. See Dunlop, "The Movement of Real and Money Wages"; and Tarshis, "Changes in Real and Money Wages."

70. This is the approach taken by Alvin M. Hansen, *Business Cycles and National Income*, expanded edition (Norton, 1951); Robert M. Solow and Joseph E. Stiglitz, "Output, Employment, and Wages in the Short Run," *Quarterly Journal of Economics*, vol 82 (November 1968), pp. 537–60; Robert J. Barro and Herschel I. Grossman, *Money, Employment, and Inflation* (Cambridge University Press, 1976); and the subsequent fix-price literature.

The second is to attack the data: the wage series do not reflect the marginal wage paid. But upon closer examination, this approach exacerbates the problem, for two reasons. In implicit contract theory, the wage received can be thought of as containing a payment to or from an "insurance" fund. In a recession, the wage received is *greater* than the marginal product, because of a payment to the individual. Moreover, in booms, firms pay overtime, and thus the *marginal* wage is considerably in excess of the average wage.

The third is to assume that the demand curve for labor is *not* derived from the aggregation of simple competitive market demand curves of the conventional kind. Two approaches have been taken here. One approach is based on capital market imperfections and is discussed in the next section. Alternatively, we can assume imperfect competition. Assume the i^{th} firm's production function (with fixed capital) is $F(L_i)$, so that with competition, $v^P = F'$, where v^P is the real product wage. Then under imperfect competition, firms will set[71]

$$v^P = F'/m. \tag{8}$$

If the markup were constant, there would be little difference between the competitive analysis and the analysis with imperfect competition. Equation 8 allows us to define an aggregate demand for labor relationship. As usual, with imperfect competition, we should not think of this as just a demand curve, but as the aggregation of the equilibrium employment conditions of the firms in the economy.

It is *possible* that m changes over the business cycle in a way that can account for the observations. For a simple monopolistic competition model in which m is just $1/[1 - (1/\textit{elasticity of demand})]$, there are demand structures for which the elasticity varies with consumption levels in a way that is consistent with the aggregate observations. Robert Hall, while arguing convincingly that the data simply cannot be accounted for by a competitive supply model, has put forward a more sophisticated version of this hypothesis, though there is little cross-sectional econometric evidence to support the view that preferences have the required shapes.[72] Stiglitz has considered alternative versions of the imperfect competition model that might give rise to the kinds of movements in the perceived elasticity of demand facing firms that would

71. This is just another way of writing the familiar markup equation. The marginal labor cost of producing an extra unit is w/F'. Hence $p = mw/F'$.

72. Hall, "The Relationship between Price and Marginal Cost in U.S. Industry."

be consistent with the aggregate data.[73] It should be noted that *some* versions of the imperfect competition model predict just the opposite movements in the elasticities of demand—that competition breaks out more fiercely as demand falls (witness OPEC)—and that markups thus decrease in recessions.

The data presented in the first part of this paper raise doubts about the validity of at least the simpler versions of the imperfect competition theories. Presumably the importance of these effects should differ markedly across countries, and, in particular, small open economies should face fairly elastic demands for at least many of their commodities. Yet the puzzle we have identified is ubiquitous: all of the countries exhibit large changes in labor inputs (employment plus hours) relative to variations in real product wages and, more strikingly, variations in output of similar magnitudes.

NEW KEYNESIAN THEORY

New Keynesian theories have modified traditional Keynesian assumptions in a number of ways. The different modifications can be grouped by the market on which they have focused. Three broad theoretical approaches have focused on labor markets, concentrating separately on implicit contracts, search, and efficiency wages. Another set of approaches has focused on product markets, seeking to explain price rigidities in terms of menu (adjustment) costs or imperfect competition.[74] Still another set of theories has focused on capital markets and has stressed the roles of credit rationing and equity rationing.[75] In terms of these theories, the different markets are not completely sepa-

73. Stiglitz, "Price Rigidity and Market Structure."

74. For menu costs, see George A. Akerlof and Janet Y. Yellen, "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia," *Quarterly Journal of Economics*, vol. 100 (Supplement 1985), pp. 823–38; N. Gregory Mankiw, "Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly," *Quarterly Journal of Economics*, vol. 100 (May 1985), pp. 529–37; and Lawrence J. Ball and David Romer, "Sticky Prices as Co-ordination Failures" (Princeton University, July 1987). For imperfect competition, see Hall, "The Relationship between Price and Marginal Cost in U.S. Industry"; Stiglitz, "Price Rigidity and Market Structure"; Rotemberg and Saloner, "The Relative Rigidity of Monopoly Pricing"; Martin L. Weitzman, "Increasing Returns and the Foundations of Unemployment Theory," *Economic Journal*, vol. 92 (December 1982), pp. 787–804; and Oliver Hart, "A Model of Imperfect Competition with Keynesian Features," *Quarterly Journal of Economics*, vol. 97 (February 1982), pp. 109–38.

75. See, for example, Bruce C. Greenwald and Joseph E. Stiglitz, "Financial Market Imperfections and Business Cycles," Working Paper 2494 (NBER, January 1988).

rate. Versions of the equity rationing theories have, accordingly, been used to explain both labor market behavior (wage rigidities and persistent unemployment) and pricing behavior. Nor are the different theories mutually exclusive. Models incorporating search, implicit contracts, and efficiency wage considerations have been constructed.[76]

However, to develop as simple a variant of this model as possible, we focus on one built around equity rationing constraints and efficiency wages. Equity rationing—the fact that firms have only limited recourse to sales of new equity as a means of raising external capital—arises in a world of imperfect information because of both adverse selection and moral hazard. Adverse selection occurs when the decisionmakers of a firm have information about its future prospects that is superior to that of potential equity buyers. A decision to sell new equity under those conditions suggests that, on average, the views of the firm's managers are less optimistic than the views of the market at large (otherwise the firm's market value would be less than that indicated by the managers' superior information, and selling new equity would be inadvisable). The announcement of a new equity issue should thus lead to a downward revaluation of the firm by the market. The potential for such a downward revaluation should act as a cost, inhibiting new equity sales.[77]

The consequences of equity rationing depend upon the assumption that the decisionmakers of a firm are averse to the risks of bankruptcy or more generally that they are averse to the risks of deterioration in their equity positions.[78] Then, in the absence of a full set of futures markets, production lags mean that every production decision is a risk decision. Firms pay factors of production at fixed rates and obtain an output whose value is uncertain, being determined only when it is sold in the future. The stronger a firm's equity base, the smaller the incremental risk associated with any such increase in output will be. Thus, the marginal cost of additional output, including the marginal increase in risk borne by the firm's decisionmakers, falls when a firm's equity

76. See Arnott, Hosios, and Stiglitz. "Implicit Contracts, Labor Mobility, and Unemployment."

77. For the moral hazard argument against equity finance, see William H. Meckling and Michael C. Jensen, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," *Journal of Financial Economics*, vol. 3 (June 1976), pp. 305–60; Joseph E. Stiglitz, "Incentives and Risk Sharing in Sharecropping," *Review of Economic Studies*, vol. 41 (April 1974), pp. 219–55.

78. With the risk behavior being characterized by declining absolute risk aversion.

position improves and rises when it deteriorates. In labor demand terms, the marginal product of labor, net of the cost of additional risk that employment of the workers entails, rises when the equity position of the firm improves and falls when it deteriorates.

Investment in this context can be thought of as current payment for inputs in return for a stream of benefits of uncertain value that may stretch far into the future. The marginal product of capital, again net of the cost of incremental risk associated with investment, will, like the marginal product of labor, rise as the equity position of the firm improves and fall as the equity position of the firm deteriorates.

Thus, the impact of imperfect information–related equity constraints can be summarized by writing aggregate real supply and investment functions of the form

$$y_t = y(a_t), \quad y' > 0$$

$$i_t = i(a_t), \quad i' > 0,$$

where y_t is real output, i_t is real investment, and a_t is the real level of firm equity holdings.

The aggregate demand for labor, like the aggregate production function, depends on the level of aggregate equity. Equilibrium in the labor market is then determined by the intersection of this demand function with an efficiency wage condition. Efficiency wage conditions arise when the level of labor productivity depends positively on the wage level, as it may because wage levels affect turnover costs, because higher wage levels elicit more effort from workers, or because higher wages attract a higher-quality applicant pool.[79] The important consequence of the de-

79. For turnover costs, see J. E. Stiglitz, "Alternative Theories of Wage Determination and Unemployment in LDCs: The Labor Turnover Model," *Quarterly Journal of Economics*, vol. 88 (May 1974), pp. 194–227; and Steven C. Salop, "A Model of the Natural Rate of Unemployment," *American Economic Review*, vol. 69 (March 1979), pp. 117–25.

For worker effort, see Carl Shapiro and Joseph E. Stiglitz, "Equilibrium Unemployment as a Worker Discipline Device," *American Economic Review*, vol. 74 (June 1984), pp. 433–44; and Jeremy I. Bulow and Lawrence H. Summers, "A Theory of Dual Labor Markets with Applications to Industrial Policy, Discrimination, and Keynesian Unemployment," *Journal of Labor Economics*, vol. 4 (July 1986), pp. 376–414.

For the quality of the applicant pool, see Andrew Weiss, "Job Queues and Lay-offs in Labor Markets with Flexible Wages," *Journal of Political Economy*, vol. 88 (June 1980), pp. 526–38; and J. E. Stiglitz, "Prices and Queues as Screening Devices in Competitive Markets," Technical Report 212 (Stanford University, August 1976).

pendence of productivity on wages is that optimal wage levels may occur at a point where there is an excess supply of labor. Lowering wages below this level is unprofitable because any gains from lower wages are offset by lower productivities. In the efficiency wage condition, therefore, unemployment levels, rather than labor supply levels, are related to the level of wages. This schedule interacts with the marginal product of labor schedule, which depends on the financial positions of firms, to yield a labor market equilibrium condition of the form

$$u_t = u(a_t), \quad u' < 0,$$

where u is the unemployment rate. Together with the output and investment functions described above, this function embodies one simple variant of the new Keynesian model whose implications can be measured against the broad business-cycle facts outlined in the first part of this paper.

Goods Markets. The behavior of output in the system described above depends on the dynamic properties and interrelationships of the financial conditions of firms, described by their equity levels, a_t. Because these firms have only limited recourse to public equity markets, the primary means for changing a firm's equity position is continuing cash flows from the firm's operations. Because cash flow accumulates only slowly, there will be substantial persistence in the response of output to either aggregate supply or aggregate demand disturbances.[80] Since demand disturbances will be transmitted from firm to firm as each reduces output in response to unexpected equity losses, firm outputs will tend to move together. A shock that reduces the value of a firm's product, for example, will lead to an immediate deterioration of the firm's balance sheet position, since the values of all assets related to production of the goods in question will fall, while the commitments incurred in acquiring these assets will not fall commensurately.[81] This, in turn, will lead, as described above, to reductions in output and investment. Because the firm's balance sheet position can be restored only slowly through retained earnings, these reductions in output and investment may be significantly long-lived. At the same time, the

80. The disturbances may also merely redistribute equity among firms since, as noted in Greenwald and Stiglitz, "Financial Market Imperfections and Business Cycles," this too may reduce overall output.

81. If the firm's debts tend to be denominated in nominal terms, while their assets have real values (that is, price-level–dependent nominal values), then nominal monetary disturbances will have real effects.

reduction in demand and output by one firm will reduce the demands and outputs of other firms. Thus, all firms will tend to have common movements in output.

Furthermore, if changes in investment resulting from changes in firms' financial positions also include investments in activities that affect future productivity, then any temporary deterioration in the financial position of firms associated with a reduction in output may have long-lived effects similar to those suggested by table 1.

The tendency for fluctuations in output to have similar magnitudes is a natural consequence of the equity-constrained models. The response of a firm to an unexpected change in market conditions depends on how vulnerable it is to such a change. For example, the equity positions of more highly leveraged firms will be more sensitive to demand and price shocks than the equity positions of less highly leveraged firms. As a result, a more highly leveraged firm should reduce its output and investment (given the assumed nature of risk aversion) in response to a given demand shock more than a less highly leveraged firm. However, if uncertainty in the external environment were to decline, both types of firms would presumably be willing to make themselves more vulnerable to shocks in return for other operating efficiencies. Thus the magnitude of the response of firms to shocks of a particular size should rise as the likely magnitude of shocks falls. For example, if a successful fiscal policy program were to soften external demand shocks, firms might respond by increasing their debt-equity ratios, by increasing their commitments to stabilize worker earnings and employment, or by operating with greater fixed-to-variable costs.[82] The measure of the success of fiscal policy will then not be a reduction in the amplitude of cycles, but rather the efficiency gains from changes in firm operating methods. Hence, the long-run tendency in capital-constrained models is for output fluctuations to converge to a common level.

As described so far, the new Keynesian model is specified entirely in real terms, although the existence of nominal contracts means, as in the traditional Keynesian model, that changes in money supply may have real effects. Inflation rates would, therefore, depend largely on the dynamics of monetary policy. However, rigidities in relative, and sometimes nominal, prices do arise in the model.

If firms are imperfect competitors facing downward-sloping demand

82. See, for example, Greenwald and Stiglitz, "Financial Market Imperfections and Business Cycles."

curves of unknown slope, then the uncertainty over the effect of a change in price (arising, for example, from uncertainties over competitor or consumer reactions) may be greater than uncertainties over the effect of a reduction in output (related solely to the effect on inventories and changes in stock-out probabilities). If firms are risk averse, the mix of price and quantity changes chosen in response to a shift in demand will be weighted in favor of the instrument whose effect is less uncertain.[83] Under the circumstances just described, this means a bias toward adjustments in quantities rather than prices and a degree of short-term-price rigidity. Indeed, an extensive literature within the new Keynesian tradition has focused directly on price rigidities due either to menu costs or to interfirm interactions. In these models imperfect competition reinforces the effect of uncertainties associated with changing prices by imposing further fixed costs on price change decisions. In the menu cost literature, these are the costs of disseminating new price information.[84] In the literature on interfirm interactions, the costs are implicitly associated with the possibility that competing firms may react to price changes in an undesirable way.[85] Still other sources of price rigidity under imperfect competition are cyclical variations in the elasticity of demand[86] and dynamic trade-offs between present and future profits.[87] Though there are important differences among the theories—some of them providing a more persuasive theory of the observed patterns than others—for our purposes, what is more important is the distinction between these theories and those that assume perfect price flexibility.

83. This is the firm level analog of an argument made by William Brainard, "Uncertainty and the Effectiveness of Policy," *American Economic Review*, vol. 57 (May 1967, *Papers and Proceedings, 1966*), pp. 411–25, in connection with macroeconomic policy instruments.

84. See, for example, Akerlof and Yellen, "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia"; Mankiw, "Small Menu Costs and Large Business Cycles"; and Ball and Romer, "Sticky Prices as Co-ordination Failures."

85. See, for example, Stiglitz, "Price Rigidity and Market Structure."

86. See Hall, "The Relationship between Price and Marginal Cost in U.S. Industry."

87. This arises when the equity-constrained model of the firm is applied to a situation in which a firm's future and current demands are positively related, as in Edmund S. Phelps and Sidney G. Winter, "Optimal Price Policy under Atomistic Competition," in Edmund S. Phelps and others, *Microeconomic Foundations of Employment and Inflation Theory* (W. W. Norton, 1970), pp. 309–37. Higher current prices may improve current profits, but they reduce future sales by driving away customers, and hence lower future profits. When such a firm's financial position deteriorates, the value of uncertain future profits falls relative to the value of current profits. As the value of future sales falls, current markups should tend to rise despite falling demand.

Capital Markets. Investment fluctuations are disproportionately large in the equity-constrained models primarily because deferring investment is one of the least costly ways to reduce the potential risk a firm bears as its financial position deteriorates. When, as the result of a negative demand shock, a firm's equity position has deteriorated, the part of the marginal cost of new investment associated with the added risk of that new investment may increase significantly. The ability of the firm to accumulate equity over time means that, on average, this risk component of cost will decline over time. Deferring investment to such a later time may, therefore, be substantially beneficial to the firm.

Adjustments in the prices of investment goods, in the face of shifts in investment goods demand, that might mitigate fluctuations in actual investment are also limited in the equity-constrained models. The demand shock to the investment goods–producing sectors will worsen the financial positions of firms producing investment goods. Thus, their marginal costs of output will rise, limiting the extent of any demand-induced reduction in price. The extent to which this occurs will depend on both the initial financial positions of the investment goods–producing firms and the contract terms under which investment goods are purchased. For business construction, where output is purchased on an "orders basis" with extensive arrangements for passing on supplier costs, the risks of additional supply to the producing firms should be relatively low. Consequently, the impact of a deterioration in their financial positions on marginal costs should be relatively limited. In residential construction, where firms often produce without prior sales and where many firms are small and highly leveraged, the impact on marginal costs of a demand shock may be substantial. Thus, the equity-constrained model is able to account, at least in principle, for the relatively high volatility of residential construction.

A second factor in the disproportionate volatility of investment in the equity-constrained model arises from any permanent effect of a temporary disturbance on productivity, due, for example, to a decline in technology spillovers as firms reduce effective research and development activity. However, the response of investment to any such fluctuations, both in terms of planned and actual investment, will be gradual as firms accumulate the equity necessary to absorb the risks of the new investment. Thus, investment responses from this cause should be less extreme than those associated with real business-cycle models without any capital market imperfections.

The Labor Market. In the new Keynesian model outlined above, wages should vary procyclically, as they appear to do, since deterioration in a firm's net asset position reduces the marginal product of labor (taking account of the risk associated with increasing output). Efficiency wage considerations move workers off their supply curves in response to these shifts in demand, inducing more variation in employment and less variation in wage levels than microeconomic labor supply considerations suggest. This is especially true of short-term adjustments. If firms are more certain of the effects of labor force adjustments than of wage adjustments (because of efficiency wage considerations), then temporary cyclical adjustments will fall more heavily on employment than wages. This too is consistent with the data. Measured productivity changes should, in the absence of fixed costs, vary countercyclically in the new Keynesian model as they do in the traditional Keynesian model and as they do not in the data. However, the existence of significant fixed costs would eliminate this discrepancy.

The rigidities introduced in the process of wage determination by efficiency wage considerations create unemployment fluctuations and involuntary separations in response to shifts in the labor demand curve just as nominal rigidities do in the traditional Keynesian models. Since persistent fluctuations in the net marginal product of labor arise from persistent shifts in the balance sheet positions of firms, the new Keynesian model yields persistent unemployment. Efficiency wage theories, unlike conventional implicit contract theories, explain why the reductions in demand for labor should take, at least in part, the form of layoffs rather than just a reduction in hours worked.

A further source of persistence in unemployment arises if firms bear fixed costs of training workers for jobs. Under these conditions a hiring decision has the characteristics of an investment decision and, as is the case in other investment decisions, deterioration in a firm's equity position will make the hiring decision attractive only at a low wage level (corresponding to a low price level for other investment goods). Thus the wages for employed workers and the wages that firms would be willing to offer for new workers are markedly different. This "marginal" wage may be so low that it lies below the reservation wage of workers; that is, workers are better off waiting a period, when the capital constraint is likely to be less binding. Just as firms postpone investment in machines during recessions, workers postpone investment in new jobs. Note that the marginal wage for new employees may decline, though the average

may increase.[88] Of course, efficiency wage considerations explain why firms may not lower the marginal wage. To put it another way, given the capital constraints and the dependence of productivity on wages, there is no wage that firms can offer for which it is desirable to hire new workers.[89]

The preceding discussion of the new Keynesian model does not, it should be stressed again, do full justice to the range of work being done under this rubric. Perhaps most important, no attempt has been made to incorporate directly the assumptions of the several menu cost and imperfect competition approaches. We exclude these approaches not because they have not identified significant aspects of macroeconomic behavior. Rather, it is sufficient to use only a single variant of the new Keynesian approach for comparison with the simple real business-cycle model and the simple traditional Keynesian model used above. In addition, the policy implications of the new Keynesian models are broadly similar. Like the traditional Keynesian model, they provide for a positive role for active aggregate demand management policies.[90]

Concluding Remarks

We have argued here that assessing the validity of different macroeconomic theories requires the identification of a set of critical tests that a good theory must pass. A good, complete theory must provide insights into *all* of these phenomena and, more importantly, should not be inconsistent with any. Of course, some theories are building blocks, to be incorporated into a more complete theory. Efficiency wage theory is one such: it does not purport to explain the fluctuations in aggregate demand.

88. This theory addresses itself to the participation decision, not to the hours puzzle.

89. The capital-constrained theories also explain why workers will not accept contingency pay, that is, why a promise to pay higher wages in the future will be unacceptable. Such promises are equivalent to a form of equity.

We should note that insider-outsider theory also is partially addressed to these issues. See, for example, Assar Lindbeck and Dennis J. Snower, "Cooperation, Harassment, and Involuntary Unemployment: An Insider-Outsider Approach," *American Economic Review*, vol. 78 (March 1988), pp. 167–88.

90. Although the prescriptions are broadly similar, they differ in detail and in measures of policy success. For example, for the model described here even a successful stabilizing policy will not eliminate fluctuations.

Table 15. Success of Alternative Theories in Explaining Basic Characteristics of Business Cycles

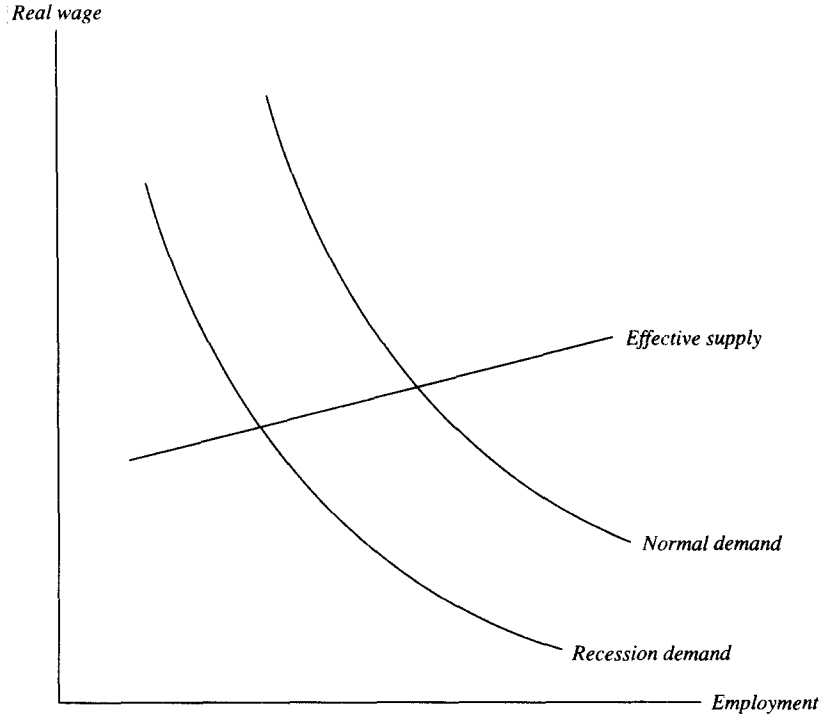
Characteristic	*Real business-cycle*	*Traditional Keynesian*	*New Keynesian*
Goods market			
Nature of output fluctuations	Partial	Partial	Yes
Common magnitude of output fluctuations	Yes	No	Yes
Price rigidities	No	Partial	Partial
Capital market			
Investment fluctuations	Partial	Partial	Yes
Labor market			
Cyclical movements in wages, hours, employment	No	No	Partial
Unemployment and layoffs	No	Yes	Yes

There are simply too many degrees of freedom, relative to the available data, to discriminate among alternative macroeconomic theories by looking at one, or a few, macroeconomic phenomena. Indeed, discriminating among theories will probably require incorporating microeconometric observations: just as macroeconomic theory and microeconomic theory should rest on similar assumptions and foundations, macroeconometric evidence should not be evaluated independently of the microeconometric evidence.

We have proposed a possible set of such tests and attempted to compare these stylized facts with stylized versions of traditional Keynesian theories, new Keynesian theories, and real business-cycle theories. Table 15 describes in broad terms how successful each of the three theoretical approaches is in explaining the general characteristics of business cycles identified in the first part of this paper in each of the three markets—goods, capital, and labor—that make up the macroeconomy. The real business-cycle approach is fully successful in explaining the stylized facts in none of the markets, especially that for labor. Traditional Keynesian approaches appear not to do significantly better. A new Keynesian approach is better. However, no model—at least in the simple variants presented here—successfully explains all the data. Whether there are additional crucial tests that these theories will fail or that will necessitate major modifications of the theory remain questions for future research.

Comments and Discussion

Robert E. Hall: The most basic issues raised by Bruce Greenwald and Joseph Stiglitz appear in the following simple labor market diagram:



Shifts in labor demand are the driving force of employment fluctuations. Effective labor supply is highly elastic, and the effective labor supply schedule is stable. The real wage is only slightly procyclical. The diagram accounts for the two most important empirical regularities cited by

Greenwald and Stiglitz: significant output and employment fluctuations and small real wage fluctuations.

An interesting feature of the current state of macroeconomic thinking is the importance of this diagram. In the fixed-price analysis that dominated mainstream macroeconomics until recently, the diagram is irrelevant. One of the most important lessons of Robert Barro and Herschel Grossman is that the labor market is not generally on either of the curves in the figure.[1] Mainstream macroeconomic textbooks develop an elaborate body of analysis before they ever get to labor market equilibrium, which is presented as relevant only to long-run analysis or to a fictitious flexible-price economy. In the new macroeconomics, the basic diagram of labor market equilibrium is the starting point.

The task of the macroeconomist within the general framework of Greenwald and Stiglitz is twofold: explain why the demand curve for labor shifts and why the effective labor supply curve is so elastic. Their paper criticizes the real business-cycle answers to these questions and advocates what they call new Keynesian answers. Briefly, the real business-cycle school says that the labor demand curve shifts because of vibrations in the production function, which cause shifts of the marginal product of labor. Effective labor supply is highly elastic because workers store up memories of past time off or because of nonconvexities in the technology.[2] The new Keynesian answers are that the labor demand curve shifts because of random variations in equity, and the effective labor supply schedule is highly elastic because of efficiency wage considerations.

I find the Greenwald-Stiglitz paper refreshing because it avoids the single-minded attention of mainstream macroeconomic theory to monetary driving forces and nominal rigidities. Although monetary shocks could be one of the sources of shifts in labor demand, the model contemplates many others that are real. Because the evidence on the importance of monetary driving forces is ambiguous, this broadening is desirable.

1. Robert J. Barro and Herschel I. Grossman, *Money, Employment and Inflation* (Cambridge University Press, 1976).

2. See Finn E. Kydland and Edward C. Prescott, "Time to Build and Aggregate Fluctuations," *Econometrica*, vol. 50 (November 1982), pp. 1345–70; Richard Rogerson, "Indivisible Labor, Lotteries and Equilibrium," *Journal of Monetary Economics*, vol. 21 (January 1988), pp. 3–16.

Greenwald and Stiglitz write as if there were a huge gulf between their own model and the real business-cycle model, a gulf as great as the one between Keynes and the classics. They could equally well have portrayed themselves as members of the real business-cycle school. They contribute new theories within the general framework that applies standard tools of equilibrium analysis to macroeconomic questions. A model with financial rather than technological shifts as the source of movements in the demand for labor would be taken seriously by real business-cycle theorists. Efficiency wages are a more significant deviation from the competitive analysis that pervades the real business-cycle school, but it may not be essential to Greenwald and Stiglitz's message. A much more significant watershed in macroeconomics, in my opinion, is between the real school, which includes Prescott and Greenwald-Stiglitz, and the nominal school, represented by Ball, Mankiw, and Romer.[3]

Greenwald and Stiglitz repeat the standard criticism of the Kydland-Prescott real business-cycle model: the model relies on vibrations of the production function as its driving force, which means that it explains major cyclical contractions as times of technical regress. If the accumulation of knowledge is monotonic, regress cannot occur. I find this criticism convincing, if not at all novel, so I am receptive to the paper's mission of finding other driving forces.

Greenwald and Stiglitz's other criticisms of the real business-cycle model fall short of the mark. First, they claim as a general matter that competition tends to dampen fluctuations. One of the main points of the real business-cycle authors is that elastic supply is what it takes to get realistic volatility in employment and output. Interestingly, Greenwald and Stiglitz do not dispute the basic high elasticity of labor supply that makes the real business-cycle model work.

Second, Greenwald and Stiglitz repeat a criticism that has been made many times before and taken seriously by Barro and others sympathetic to real business-cycle thinking: consumption of goods and consumption of leisure ought to move in parallel over the cycle. That is, when some force makes consumption fall, hours of work should rise. In fact, consumption and hours of work are somewhat positively correlated in

3. See Edward C. Prescott, "Theory ahead of Business-Cycle Measurement," in Karl Brunner and Allan H. Meltzer, eds., *Real Business Cycles, Real Exchange Rates and Actual Policies* (Amsterdam: North-Holland, 1986), pp. 11–44; and Laurence Ball, N. Gregory Mankiw, and David Romer, "The New Keynesian Economics and the Output-Inflation Trade-off," pp. 1–65, in this issue.

most economies. A simple explanation, harmonious with the real business-cycle model, is that shifts in preferences are an important driving force. If consumers postpone consumption because of a decline in time preference, then both consumption and work effort should fall in an equilibrium model. This view gets some support from the fact that when output and employment rise in response to an exogenous increase in demand (say, military spending), consumption does not rise.

Greenwald and Stiglitz mark down the real business-cycle model because of its inability to explain something they call price rigidity. The persistence of inflation is not in dispute, but the real business-cycle model has no problem explaining the persistence. The monetary authority freely chooses the price level in the real business-cycle model, with no need to worry about real effects of monetary policy. In that situation, highly persistent inflation (ideally at a zero rate) would be the norm. Barro's evidence on the correlation of real activity with surprises in money growth presents no problems to a real business-cycle interpretation.[4]

With respect to the model that Greenwald and Stiglitz would like to erect in place of the real business-cycle model, in my opinion the most successful element is the suggestion that equity rationing and other financial considerations can shift the demand curve for labor. Although financial mechanisms may ultimately prove to account for only a fraction of cyclical shifts in labor demand, I would guess that they are at least as important as shifts in the production function. The explanation of highly elastic labor supply in the paper is sketchy and unsatisfying. Firms prefer employment adjustments to wage adjustments because they are more certain of the effects. Much work needs to be done to convince me that the theory is sound and the phenomenon is quantitatively important.

To my mind, Greenwald and Stiglitz are moving in the right direction. By applying standard tools of analysis in an equilibrium framework to questions of macroeconomic fluctuations, they are creating a body of macroeconomic theory that will make sense to economists generally. I see Greenwald and Stiglitz as highly complementary to the important activities of the real business-cycle school. In particular, they are replacing unrealistic assumptions of that school with assumptions that are closer to reality for modern economies.

4. Robert J. Barro, "Unanticipated Money, Output, and the Price Level in the United States," *Journal of Political Economy*, vol. 86 (August 1978), pp. 549–80.

Stanley Fischer: The last decade has seen an explosion of analytic models that aim to lay microeconomic foundations for Keynesian macroeconomics—the macroeconomics in which aggregate demand affects output, in which high unemployment is inefficient, and in which stabilization policy can be Pareto-improving. In some combinations, or even taken together, these models begin to constitute the new Keynesianism: microeconomic-based realistic macroeconomics, realistic in the sense of the non-Friedman methodology of positive economics that sees virtue in some correspondence between the assumptions of models and the real world.

One particular combination of models that has been called new Keynesian is associated with George Akerlof and Janet Yellen, Gregory Mankiw, Olivier Blanchard, and Nobuhiro Kiyotaki, and others.[1] It consists of imperfect competition plus small menu costs of changing prices in the goods markets and of efficiency wage assumptions on the labor market side. The goods markets assumptions produce some nominal price inertia; the labor markets assumptions produce real wage inertia; and the model may accordingly generate real effects of changes in nominal demand. Promising as this model is, there are some questions about its ability to produce real effects of changes in nominal demand: Andrew Caplin and Daniel Spulber have shown that nominal price inertia at the microeconomic level does not necessarily add up to aggregate price level inertia, and efficiency wage theory in an economy where the efficiency wage is motivated by morale does not lead to real wage inertia without supplementary assumptions about conventional attitudes to real wage changes.[2] Despite these difficulties, the model does quite well overall.

Prominent among the new Keynesian contributions is a series of analytic papers by Greenwald and Stiglitz, and by Stiglitz and Andrew Weiss that have focused on apparently nonneoclassical features of goods,

1. George A. Akerlof and Janet L. Yellen, "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia," *Quarterly Journal of Economics*, vol. 100 (1985, Supplement), pp. 823–38; N. Gregory Mankiw, "Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly," *Quarterly Journal of Economics*, vol. 100 (May 1985), pp. 529–37; Olivier Jean Blanchard and Nobuhiro Kiyotaki, "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review*, vol. 77 (September 1987), pp. 647–66.

2. Andrew S. Caplin and Daniel F. Spulber, "Menu Costs and the Neutrality of Money," *Quarterly Journal of Economics*, vol. 102 (November 1987), pp. 703–25.

labor, and financial markets: notably credit rationing, equity rationing, efficiency wages, and search in the goods markets producing kinked demand curves.[3] The careful readers of these papers—and because of their volume no single person can absorb them all—must have been impressed by their creativity and the sense that the papers were about real phenomena. But it was difficult to know how and whether the contributions added up and how much they individually contributed to explaining the broad features of the business cycle.

The present paper by Greenwald and Stiglitz is an attempt to demonstrate the ability of their particular version of the new Keynesianism to explain the broad features of the business cycle. The model combines efficiency wages in the labor market with equity rationing in the assets markets—with the equity rationing feeding back into the goods and labor markets. The methodology is to compare three oversimplified models of the business cycle to see which best captures some of the stylized facts. There is a great danger in this game that the authors do not bend over backward to be favorable to the competing approaches and hard on their own contribution, and it is easy to detect some forward-leaning in this paper.

One puzzling set of facts that should be taken into account in discussing real business-cycle or more generally equilibrium theories is the seasonal business cycle. Jeffrey Miron has shown that many of the phenomena seen in the business cycle—for instance, significant movements in output and inputs without large changes in prices—are also part of the seasonal cycle.[4] Yet we do not usually regard the seasonal cycle as anything other than an equilibrium phenomenon, which raises questions about some of the evidence on the nature of the business cycle.

One of the important benefits of this paper is that Greenwald and Stiglitz have reduced the equity rationing model to two equations. The description is simple. The quantity of goods supplied at a given real wage is a function of the amount of equity the firm has. So is the rate of investment. In Greenwald and Stiglitz's equations summarizing the model, a_t is described as real holdings of equity. Is this really what the theory requires? It would seem that some measure of the firm's liquidity or cash holdings should belong in that equation. One of the areas in

3. See Stiglitz and Andrew Weiss, "Macroeconomic Equilibrium and Credit Rationing," Working Paper 2164 (National Bureau of Economic Research, February 1987).

4. Unpublished Ph.D. dissertation (MIT, 1984).

which one would like to see the Greenwald-Stiglitz paper developed is to explain more clearly what determines the shadow price of capital or liquidity. Isn't that the variable that would affect the firm's supply curve? And if so, shouldn't it also be related to the interest rate at which the firm can borrow?

It is also true that theirs is an entirely real model. It is accordingly very difficult to see what it can say about nominal inertia.

Now, what does one make of this model? The basic argument is that finance matters, not only for investment and therefore aggregate demand, but also for aggregate supply. It is thus part of a long tradition going back to Congressman Wright Patman, Leon Keyserling, and Domingo Cavallo. There have been many attempts to estimate aggregate models with interest rate effects on aggregate supply, without great success. Almost certainly those models have misspecified the cost of capital. One would like to see this model developed in that direction.

In addition, the model has strong cross-sectional implications. Some of those—relating to investment—appear to have been tested by Steven Fazzari, Glenn Hubbard, and Bruce Petersen, with reasonably favorable results.[5] Others imply that fluctuations in output should be greater for firms that have less access to the capital markets. If we interpret those as small firms, that proposition too should be testable.

Whether this particular model does better than the competitive new Keynesian model cannot really be judged from the evidence here. I would doubt it. I also doubt that the authors are right to argue that adding their imperfection to that of the Akerlof-Yellen model would be a mistake. They argue against epicycles, or putting too much in a model, but the point at which one begins to hit epicycles in this computer age may be further down the complexity tree than it used to be.

General Discussion

David Romer suggested that business-cycle models were usefully distinguished by whether they exhibited monetary neutrality and whether

5. Steven Fazzari, R. Glenn Hubbard, and Bruce C. Petersen," Financing Constraints and Corporate Investment," Working Paper 2387 (NBER, September 1987). See also Fazzari, Hubbard, and Petersen, "Financing Constraints and Corporate Investment," pp. 141–95, in this issue.

they assumed perfectly competitive markets. He noted that real business-cycle models did both. The authors' model was realistic in not treating all markets as competitive. But unlike some other recent business-cycle models, such as the Ball, Mankiw, Romer model presented in this volume, it took no stand on monetary neutrality. Romer regarded this as an important drawback because such a model could not explain why Paul Volcker's monetary policy had been so important. Alan Blinder felt that the nonneutrality of central bank policy, which may not be the same as the nonneutrality of money, should be regarded as a central fact of the economy, disagreeing with Robert Hall's view that nonneutrality of money should be regarded as a sideshow in new Keynesian models. James Tobin agreed, asserting that it was important for theoretical models to explain why U.S. monetary policy seems far from neutral. He observed that at least six of the nine postwar U.S. recessions were the result of anti-inflationary monetary policy. He regarded the negative reaction of the stock market to news of inflation as further evidence of the potency of monetary policy. The financial markets believe that the Federal Reserve will reduce the present value of earnings while attempting to reduce inflation. Greenwald reasoned that this nonneutrality of central bank policy reflects the uncertainty generated by inflation, exacerbated by uncertainty about the reaction of monetary policy. He agreed that nonneutrality of central bank policy could be regarded as a central fact about the economy, but explained that it was beyond the scope of the present paper to evaluate models by that criterion.

Several participants suggested that it made little difference whether the source of nonneutrality was modeled to arise from nominal debt contracts rather than nominal wage contracts or other sources of sticky prices. Robert Hall noted that there is a fundamental difference between the standard treatment of wage rigidity and the way debt is modeled. He disagreed with the standard view, embodied in the Fischer-Taylor contracting model, that a nominal wage contract is a call option on workers' time with a nominal striking price. He did not believe that firms take advantage of unexpected inflation by employing more labor at the lower real wage. Hence, he suggested that nominal wage contracts could be analyzed the way nominal debt is. Because both constitute a large fixed nominal burden for firms, inflationary monetary policy can have large distributional effects favoring firms. Tobin wondered why, if this view is correct, inflation news is not good for the stock market. Stanley

Fischer noted that there are two quite separate issues. One is whether the labor contract is in nominal terms. The other is whether the firm has the right to set the employment level at whatever nominal wage has been set in advance. There is nothing that applies to explaining why the labor contract is set in nominal terms that does not also apply to explaining why debts are denominated in nominal terms.

An extensive discussion centered on the driving forces of the models. One potential driving force for the authors' model is the nonneutrality of money. However, Greenwald reasoned that the model was correct in deemphasizing the source of shocks, stressing instead how shocks are amplified due to imperfect competition. He argued that the market's failure to stabilize shocks was at the heart of Keynes's thinking. By contrast, real business-cycle models are set in a perfectly competitive world so there is no way for shocks to be amplified. Therefore it is incumbent on those models to suggest a plausible source of large shocks.

Discussion turned to whether technology shocks could be accepted as the primary driving force in real business-cycle models. Martin Baily did not think the explanation could be ruled out simply because it required negative productivity shocks. Such measured productivity changes could reflect factors other than technology, such as changes in the cost of imported materials or new regulations. George von Furstenberg agreed, pointing out that Prescott and other proponents of real business-cycle models associate productivity shocks with the Solow residual of growth accounting, which does sometimes take on negative values. Hall countered that the Solow residual mismeasures shifts in the production function in the presence of imperfect competition. The problem arises because the Solow calculation assumes that the elasticity of output with respect to labor is equal to labor's share of output. Under imperfect competition, the real wage is less than the marginal product of labor, so labor's share underestimates the elasticity of output with respect to labor. Hence reductions in labor input are mistakenly associated with downward shifts of the production function. When imperfect competition is allowed for, negative shocks disappear. Thus we are still unable to explain reductions in output by productivity shocks.

Edmund Phelps wondered why positive productivity shocks would not quickly dwarf any recession caused by the process outlined in the authors' model. Greenwald explained that productivity is endogenous in the model and would be least likely to improve during a recession.

Fischer argued that a major point of the model is the importance of imperfections in the capital market; he felt there was little in the empirical evidence of the paper to back up that theoretical point. Blinder wondered why, if the capital market were so important, the October 1987 stock market crash had so little effect on the economy. Baily was not convinced that the authors' model would generate the flat supply locus that Hall described. Baily asked why high unemployment would not allow firms to lower the real wage while retaining worker efficiency. In this situation, the unemployment rate itself should motivate workers who retain their jobs. Greenwald maintained that unemployment tends to lag the business cycle so that the incentive effect of high unemployment may come too late. Furthermore he felt that cutting workers was a much easier short-run solution for managers than cutting wages.

Greg Mankiw and Hall disagreed about the cyclical behavior of real wages in a real business-cycle model. Mankiw argued that such models would predict strongly procyclical real wages and were therefore subject to the original Dunlop-Tarshis criticism of Keynes, that real wages are not very cyclical. Hall observed that special features of these models, such as lags of leisure in utility, could make the labor supply schedule flat in the short run. Greenwald agreed with Hall, adding that the extremely procyclical behavior of real interest rates is a more serious shortcoming of real business-cycle models.

Robert Gordon wondered why the fix price equilibrium version of the old Keynesian models had been ignored. Those models explain everything that the new Keynesian models do and withstand the Dunlop-Tarshis criticism. They are old Keynesian because they do not provide a microeconomic basis for the fixity of wages and prices. Furthermore, he noted that Hall's flat supply locus does not apply to the fix price models.

Sims objected to the methodological fad of looking at a few stylized facts. He was disappointed that predictions of the stochastic behavior of certain variables were not presented for each of the models. He found the usual evaluation of real business-cycle models to be more satisfactory in that respect.