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Business Cycles: Real Facts and a Monetary Myth[*]

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Ever since Koopmans (1947) criticized Burns and Mitchell's (1946) book on *Measuring Business Cycles* as being "measurement without theory," the reporting of business cycle facts has been taboo in economics. In his essay, Koopmans presents two basic criticisms of Burns and Mitchell's study. The first is that it provides no systematic discussion of the theoretical reasons for including particular variables over others in their empirical investigation. Before variables can be selected, Koopmans argues, some notion is needed of the theory that generates the economic fluctuations. With this first criticism we completely agree: Theory is crucial in selecting which facts to report.

Koopmans' second criticism is that Burns and Mitchell's study lacks explicit assumptions about the probability distribution of the variables. That is, their study lacks "assumptions expressing and specifying how random disturbances operate on the economy through the economic relationships between the variables" (Koopmans 1947, p. 172). What Koopmans has in mind as such relationships is clear when he concludes an overview of Burns and Mitchell's so-called measures with this sentence: "Not a single demand or supply schedule or other equation expressing the behavior of men [i.e., people] or the technical laws of production is employed explicitly in the book, and the cases of implicit use are few and far between" (p. 163). Koopmans repeatedly stresses this need for using a structural system of equations as an organizing principle (pp. 169–70). Economists, he argues, should first hypothe-

size that the aggregate time series under consideration are generated by some probability model, which the economists must then estimate and test. Koopmans convinced the economics profession that to do otherwise is unscientific. On this point we strongly disagree with Koopmans: We think he did economics a grave disservice, because the reporting of facts—without assuming the data are generated by some probability model—is an important scientific activity. We see no reason for economics to be an exception.

As a spectacular example of facts influencing the development of economic theory, we refer to the growth facts that came out of the empirical work of Kuznets and others. According to Solow (1970, p. 2), these facts were instrumental in the development of his own neoclassical growth model, which has since become the most important organizing structure in macroeconomics, whether the issue is one of growth or fluctuations or public finance. Loosely paraphrased, the key growth facts that Solow lists (on pp. 2–3) are

- Real output per worker (or per worker-hour) grows at a roughly constant rate over extended time periods.
- The stock of real capital, crudely measured, grows at a roughly constant rate which exceeds the growth rate of labor input.

- The growth rates of real output and the stock of capital goods tend to be similar, so the capital-to-output ratio shows no systematic trend.
- The rate of profit on capital has a horizontal trend.

These facts are neither estimates nor measures of anything; they are obtained without first hypothesizing that the time series are generated by a probability model belonging to some class. From this example, no one can deny that the reporting of growth facts has scientific value: Why else would Kuznets have received a Nobel Prize for this work? Or Solow, as well, for developing a parsimonious theory that rationalizes these facts—namely, his neoclassical growth model?

The growth facts are not the only interesting features of these aggregate time series. Also of interest are the more volatile changes that occur in these and other aggregates—that is, the cyclical behavior of the time series. These observations are interesting because they apparently conflict with basic competitive theory, in which outcomes reflect people's ability and willingness to substitute between consumption and leisure at a given point in time and between consumption at different points in time.

The purpose of this article is to present the business cycle facts in light of established neoclassical growth theory, which we use as the organizing framework for our presentation of business cycle facts. We emphasize that the statistics reported here are not measures of anything; rather, they are statistics that display interesting patterns, given the established neoclassical growth theory. In discussions of business cycle models, a natural question is, Do the corresponding statistics for the model economy display these patterns? We find these features interesting because the patterns they seem to display are inconsistent with the theory.

The study of business cycles flourished from the 1920s through the 1940s. But in the 1950s and 1960s, with the development of the structural system-of-equations approach that Koopmans advocated, business cycles ceased to be an active area of economic research. Now, once again, the study of business cycles, in the form of recurrent fluctuations, is alive. At the leading research centers, economists are again concerned with the question of why, in market economies, aggregate output and employment undergo repeated fluctuations about trend.[1]

Instrumental in bringing business cycles back into the mainstream of economic research is the important paper by Lucas (1977), "Understanding Business Cycles." We follow Lucas in defining *business cycles* as the deviations of aggregate real output from trend. We complete his definition by providing an explicit procedure for calculating a time series trend that successfully mimics the smooth curves most business cycle researchers would draw through plots of the data. We also follow Lucas in viewing the business cycle facts as the statistical properties of the comovements of deviations from trend of various economic aggregates with those of real output.

Lucas' definition differs importantly from that of Mitchell (1913, 1927), whose definition had guided students of business cycles up until World War II. Mitchell represents business cycles as sequences of expansions and contractions, particularly emphasizing turning points and phases of the cycle. We think the developments in economic theory that followed Mitchell's work dictate Lucas' representation of cycles.

Equipped with our operational definition of cyclical deviations, we present what we see as the key business cycle facts for the United States economy in the post–Korean War period (1954–1989). Some of these facts are fairly well known; others, however, are likely to come as a surprise because they are counter to beliefs often stated in the literature.

An important example of one of these commonly held beliefs is that the price level always has been procyclical and that, in this regard, the postwar period is no exception. Even Lucas (1977, p. 9) lists procyclical price levels among business cycle regularities. This perceived fact strongly influenced business cycle research in the 1970s. A more recent example of this misbelief is when Bernanke (1986, p. 76) discusses a study by King and Plosser (1984): "Although some points of their analysis could be criticized (for example, there is no tight explanation of the relation between transaction services and the level of demand deposits, and the model does not yield a strong prediction of price procyclicality), the overall framework is not implausible." Even more recently, Mankiw (1989, p. 88), in discussing the same paper, points out that "while the story of King and Plosser can explain the procyclical behavior of money, it cannot explain the procyclical behavior of prices." We shall see that, in fact, these criticisms are based on what is a myth. We show that during the 35 years since the Korean War, the price level has displayed a clear *countercyclical* pattern.

Other misperceptions we expose are the beliefs that

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[1] The view of Hayek (1933, p. 33) in the 1930s and Lucas (1977, p. 7) in the 1970s is that answering this question is one of the outstanding challenges to economic research.

the real wage is either countercyclical or essentially uncorrelated with the cycle and that the money stock, whether measured by the monetary base or by M1, leads the cycle.

The real facts documented in this paper are that major output components tend to move together over the cycle, with investment in consumer and producer durables having several times larger percentage deviations than does spending on nondurable consumption.

Alternative Views of Business Cycles

To many, when we talk about cycles, the picture that comes to mind is a sine wave with its regular and recurrent pattern. In economics and other sciences, however, the term *cycle* refers to a more general concept. One of the best-known examples of cycles is the sunspot cycle, which varies in length from under 10 years to nearly 20 years. The significant fact about cycles is the recurrent nature of the events.

In 1922, at a Conference on Cycles, representatives from several sciences discussed the cyclical phenomena in their fields. The participants agreed on the following definition (quoted in Mitchell 1927, p. 377) as being reasonable for all the sciences: "In general scientific use . . . the word (cycle) denotes a recurrence of different phases of plus and minus departures, which are often susceptible of exact measurement." Our definition of business cycles is consistent with this general definition, but we refer to departures as *deviations*.

Mitchell's Four Phases

In 1913, Wesley C. Mitchell published a major work on business cycles, in it reviewing the research that had preceded his own. The book presents his largely descriptive approach, which consists of decomposing a large number of time series into sequences of cycles and then dividing each cycle into four distinct phases. This work was continued by Mitchell (1927) and by Burns and Mitchell (1946), who defined business cycles as

> . . . a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own (p. 3).

From the discussion in their books, it is clear the authors view business cycles as consisting of four phases that

inevitably evolve from one into another: prosperity, crisis, depression, and revival. This view is expressed perhaps most clearly by Mitchell ([1923] 1951, p. 46), who writes: "Then in order will come a discussion of how prosperity produces conditions which lead to crises, how crises run into depressions, and finally how depressions after a time produce conditions which lead to new revivals." Mitchell clearly had in mind a theoretical framework consistent with that view. In defending the use of the framework of four distinct cyclical phases, Mitchell later wrote that "most current theories explain crises by what happens in prosperity and revivals by what happens in depression" (Mitchell 1927, p. 472). (For an extensive overview of these theories and their relationship to Mitchell's descriptive work, see Haberler 1937.)

We now know how to construct model economies whose equilibria display business cycles like those envisioned by Mitchell. For example, a line of research that gained attention in the 1980s demonstrates that cyclical patterns of this form result as equilibrium behavior for economic environments with appropriate preferences and technologies. (See, for example, Benhabib and Nishimura 1985 and Boldrin 1989.) Burns and Mitchell would have been much more influential if business cycle theory had evolved in this way. Koopmans (1957, pp. 215–16) makes this point in his largely unnoticed "second thought" on Burns and Mitchell's work on business cycles.

In retrospect, it is now clear that the field of business cycles has moved in a completely different direction from the one Mitchell envisioned. Theories with deterministic cyclical laws of motion may a priori have had considerable potential for accounting for business cycles; but in fact, they have failed to do so. They have failed because cyclical laws of motion do not arise as equilibrium behavior for economies with empirically reasonable preferences and technologies—that is, for economies with reasonable statements of people's ability and willingness to substitute.

Frisch's Pendulum

As early as the 1930s, some economists were developing business cycle models that gave rise to difference equations with random shocks. An important example appears in a paper by Ragnar Frisch ([1933] 1965). Frisch was careful to distinguish between impulses in the form of random shocks, on the one hand, and their propagation over time, on the other. In contrast with proponents of modern business cycle theory, he emphasized damped oscillatory behavior. The concept of

equilibrium was interpreted as a system at rest (as it is, for instance, in the science of mechanics).

The analogy of a pendulum is sometimes used to describe this view of cycles. Shocks are needed to provide "energy in maintaining oscillations" in damped cyclical systems. Frisch reports that he was influenced by Knut Wicksell, to whom he attributes the following: "If you hit a wooden rocking horse with a club, the movement of the horse will be very different to that of the club" (quoted in Frisch [1933] 1965, p. 178). The use of the rocking horse and pendulum analogies underscores their emphasis on cycles in the form of damped oscillations.

The research of Frisch and Wicksell received considerable attention in the 1930s, but no one built on their work. Construction stopped primarily because the neoclassical growth model and the necessary conceptual tools (particularly the Arrow–Debreu general equilibrium theory) had not yet been developed. Since the tools to do quantitative dynamic general equilibrium analysis weren't available, whereas statistical time series techniques were advancing rapidly, it's not surprising that quantitative system-of-equation models—especially the Keynesian income-expenditure models—received virtually all the attention.

Slutzky's Random Shocks
An entirely different way of generating cycles is suggested by the statistical work of Eugen Slutzky (1937). Slutzky shows that cycles resembling business fluctuations can be generated as the sum of random causes—that is, by a stable, low-order, stochastic difference equation with large positive real roots.

The following exercise illustrates how Slutzky's method can generate cycles. Let the random variable e_t take the value 0.5 if a coin flip shows heads and −0.5 if tails. Assume that

$$(1) \quad y_{t+1} = 0.95y_t + e_{t+1}.$$

By repeated substitution, y_t is related to current and past shocks in the following way:

$$(2) \quad y_t = e_t + 0.95e_{t-1} + 0.95^2 e_{t-2} + \cdots$$
$$+ 0.95^{t-1}e_1 + 0.95^t y_0.$$

The y_t are geometrically declining sums of past shocks. Given an initial value y_0 and a fair coin, this stochastic difference equation can be used to generate a random path for the variable y.

Chart 1

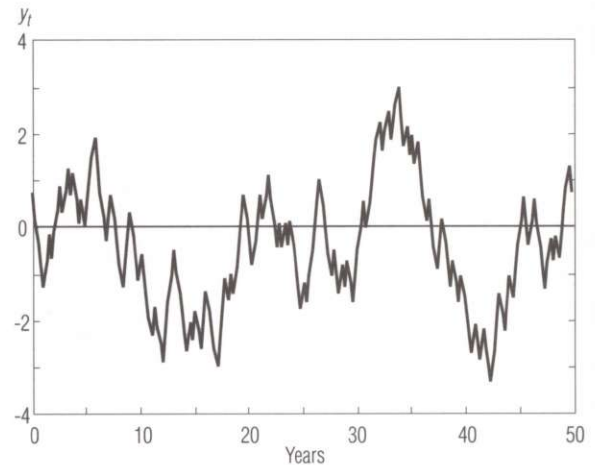Cycles Generated by Slutzky's Mechanism

Chart 1 plots a time series generated in this way. The time series displays patterns that Burns and Mitchell (1946) would characterize as business cycles.[2] The amplitudes and duration of cycles are variable, with the duration varying from 1 to 12 years and averaging about 3½ years. The time series seems to display cycles in Mitchell's sense of expansions containing the seed for recessions and vice versa. But, by construction, recessions do not contain the seed of subsequent expansions. At each point in time, the expected future path is monotonic and converges to the zero mean, with 5 percent of the distance being closed in each quarterly time period.

Another demonstration of the role that random shocks can play appears in a paper by Adelman and Adelman (1959). Using the Klein–Goldberger model, they show that by adding random shocks to the model, it produces aggregate time series that look remarkably like those of the post–World War II economy of the United States. The deterministic version of this model converges almost monotonically to a point. This exercise forcefully demonstrates that a stochastic process can generate recurrent cycles while its deterministic version can converge monotonically.

Advancing to Lucas' Deviations
In the 1940s and the 1950s, while macroeconometric

[2]King and Plosser (1989) describe a well-defined, judgment-free scheme that successfully mimics the Burns and Mitchell procedure. The description of the cycles in the time series plotted in Chart 1 is based on this procedure.

system-of-equations models were being developed, important theoretical advances were being made along entirely different fronts. By the early 1960s, economists' understanding of the way economic environments work in general equilibrium had advanced by leaps and bounds. The application of general equilibrium theory in dynamic environments led to theoretical insights on the growth of economies; it also led to important measurements of the parameters of the aggregate production function that formed the foundation for neoclassical growth theory. Thus, by the late 1960s, there were two established theories competing for dominance in aggregate economics. One was the behavioral-empirical approach reflected in the Keynesian system-of-equations models. The other was the neoclassical approach, which modeled environments with rational, maximizing individuals and firms. The neoclassical approach dominated public finance, growth theory, and international trade. As neoclassical theory progressed, an unresolvable conflict developed between the two approaches. The impasse developed because dynamic maximizing behavior is inconsistent with the assumption of invariant behavioral equations, an assumption that underlies the system-of-equations approach.

Not until the 1970s did business cycles again receive attention, spurred on by Lucas' (1977) article, "Understanding Business Cycles." There, Lucas viewed business cycle regularities as "comovements of the deviations from trend in different aggregative time series." He defined the business cycle itself as the "movements about trend in gross national product." Two types of considerations led Lucas to this definition: the previously discussed findings of Slutzky and the Adelmans, and the important advances in economic theory, especially neoclassical growth theory. We interpret Lucas as viewing business cycle fluctuations as being of interest because they are at variance with established neoclassical growth theory.

Another important theoretical advance of the 1960s and 1970s was the development of recursive competitive equilibrium theory. This theory made it possible to study abstractions of the aggregate economy in which optimizing economic behavior produces behavioral relations in the form of low-order stochastic difference equations. The role these advances played for Lucas' thinking is clear, as evident from one of his later articles discussing methods and problems in business cycle theory (see Lucas 1980).

In contrast with Mitchell's view of business cycles, Lucas does not think in terms of sequences of cycles as inevitable waves in economic activity, nor does he see a need to distinguish among different phases of the cycle. To Lucas, the comovements over time of the cyclical components of economic aggregates are of primary interest, and he gives several examples of what he views as the business cycle regularities. We make explicit and operational what we mean by these terms and present a systematic account of the regularities. When that step is implemented quantitatively, some regularities emerge that, in the 1970s, would have come as a surprise—even to Lucas.

Modern Business Cycle Theory

In the 1980s and now in the early 1990s, business cycles (in the sense of recurrent fluctuations) increasingly have become a focus of study in aggregate economics. Such studies are generally guided by perceived business cycle regularities. But if these perceptions are not in fact the regularities, then certain lines of research are misguided.

For example, the myth that the price level is procyclical largely accounts for the prevalence in the 1970s of studies that use equilibrium models with monetary policy or price surprises as the main source of fluctuations. At the time, monetary disturbances appeared to be the only plausible source of fluctuations that could not be ruled out as being too small, so they were the leading candidate. The work of Friedman and Schwartz (1963) also contributed to the view that monetary disturbances are the main source of business cycle fluctuations. Their work marshaled extensive empirical evidence to support the position that monetary policy is an important factor in determining aggregate output, employment, and other key aggregates.

Since the early studies of Burns and Mitchell, the emphasis in business cycle theory has shifted from essentially pure theoretical work to quantitative theoretical analysis. This quantitative research has had difficulty finding an important role for monetary changes as a source of fluctuations in real aggregates. As a result, attention has shifted to the role of other factors—technological changes, tax changes, and terms-of-trade shocks. This research has been strongly guided by business cycle facts and regularities such as those to be presented here.

Along with the shift in focus to investigating the sources and nature of business cycles, aggregate analysis underwent a methodological revolution. Previously, empirical knowledge had been organized in the form of equations, as was also the case for the early rational expectations models. Muth (1960), in his pioneering work on rational expectations, did not break with this

system-of-equations tradition. For that reason, his econometric program did not come to dominate. Instead, the program which has prevailed is the one that organizes empirical knowledge around preferences, technology, information structure, and policy rules or arrangements. Sargent (1981) has led the development of tools for inferring values of parameters characterizing these elements, given the behavior of the aggregate time series. As a result, aggregate economics is no longer a separate and entirely different field from the rest of economics; it now uses the same tools and empirical knowledge as other branches of economics, such as finance, growth theory, public finance, and international economics. With this development, measurements and quantitative findings in those other fields can be used to restrict models of business cycles and make our knowledge about the quantitative importance of cyclical disturbances more precise.

Business Cycle Deviations Redefined

Because economic activity in industrial market economies is characterized by sustained growth, Lucas defines business cycles as deviations of real gross national product (GNP) from trend rather than from some constant or average value. But Lucas does not define *trend,* so his definition of business cycle deviations is incomplete. What guides our, and we think his, concept of trend is steady state growth theory. With this theory there is exogenous labor-augmenting technological change that occurs at a constant rate; that is, the effectiveness of labor grows at some constant rate. Steady state growth is characterized by per capita output, consumption, investment, capital stock, and the real wage all growing at the same rate as does technology. The part of productive time allocated to market activity and the real return on capital remain constant.

If the rate of technological change were constant, then the trend of the logarithm of real GNP would be a linear function of time. But the rate of technological change varies both over time and across countries. (*Why* it varies is the central problem in economic development or maybe in all of economics.) The rate of change clearly is related to the arrangements and institutions that a society uses and, more important, to the arrangements and institutions that people expect will be used in the future. Even in a relatively stable society like the United States since the Second World War, there have been significant changes in institutions. And when a society's institutions change, there are changes in the productivity growth of that society's labor and capital. In the United States, the rate of

technological change in the 1950s and 1960s was significantly above the U.S. historical average rate over the past 100 years. In the 1970s, the rate was significantly below average. In the 1980s, the rate was near the historical average. Because the underlying rate of technological change has not been constant in the period we examine (1954–1989), detrending using a linear function of time is inappropriate. The scheme used must let the average rate of technological change vary over time, but not too rapidly.

Any definition of the trend and cycle components, and for that matter the seasonal component, is necessarily statistical. A *decomposition* is a representation of the data. A representation is useful if, in light of theory, it reveals some interesting patterns in the data. We think our representation is successful in this regard. Our selection of a trend definition was guided by the following criteria:

- The trend component for real GNP should be approximately the curve that students of business cycles and growth would draw through a time plot of this time series.
- The trend of a given time series should be a linear transformation of that time series, and this transformation should be the same for all series.[3]
- Lengthening the sample period should not significantly alter the value of the deviations at a given date, except possibly near the end of the original sample.
- The scheme should be well defined, judgment free, and cheaply reproducible.

These criteria led us to the following scheme. Let y_t, for $t = 1, 2, \ldots, T$, denote a time series. We deal with logarithms of a variable, unless the variable is a share, because the percentage deviations are what display the interesting patterns. Moreover, when an exponentially growing time series is so transformed, it becomes linear in time. Our trend component, denoted τ_t, for $t = 1, 2, \ldots, T$, is the one that minimizes

$$(3) \quad \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

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[3] The reason for linearity is that the first two moments of the transformed data are functions of the first two moments, and not the higher moments, of the original data. The principal rationale for the same transformation being applied to all time series is that it makes little sense to carry out the analogue of growth accounting with the inputs to the production function subject to one transformation and the outputs subject to another.

for an appropriately chosen positive λ. (The value of λ will be specified momentarily.) The first term is the sum of the squared deviations $d_t = y_t - \tau_t$. The second term is multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component, with the penalty being correspondingly larger if λ is larger.

The first-order conditions for this convex minimization problem are linear and can be solved for the τ_t.[4] We found that if the time series are quarterly, a value of $\lambda = 1600$ is reasonable. With this value, the implied trend path for the logarithm of real GNP is close to the one that students of business cycles and growth would draw through a time plot of this series, as shown in Chart 2. The remaining criteria guiding our selection of a detrending procedure are satisfied as well.

We have learned that this procedure for constructing a smooth curve through the data has a long history in both the actuarial and the natural sciences. Stigler (1978) reports that actuarial scientists used this method in the 1920s. He also notes that John von Neumann, who undoubtedly reinvented it, used it in the ballistics literature in the early 1940s. That others facing similar problems developed this simple scheme attests to its reasonableness. What is surprising is that economists took so long to exploit this scheme and that so many of them were so hostile to the idea when it was finally introduced into economics.[5]

## Business Cycle Facts and Regularities

We emphasize that our selection of the facts to report is guided by neoclassical growth theory. This theory, currently the established one in aggregate economics, is being used not only to study growth and development but also to address public finance issues and, more recently, to study business cycles. The facts we present here are the values of well-defined statistics for the U.S. economy since the Korean War (1954–1989). We refer to consistent patterns in these numbers as business cycle *regularities*.

The statistics presented in Tables 1–4 provide information on three basic aspects of the cyclical behavior of aggregates:

- The amplitude of fluctuations
- The degree of comovement with real GNP (our measure of pro- or countercyclicality)
- The phase shift of a variable relative to the overall business cycle, as defined by the behavior of cyclical real GNP.

Chart 2

Actual and Trend of U.S. Real Gross National Product

Quarterly, 1954–1989
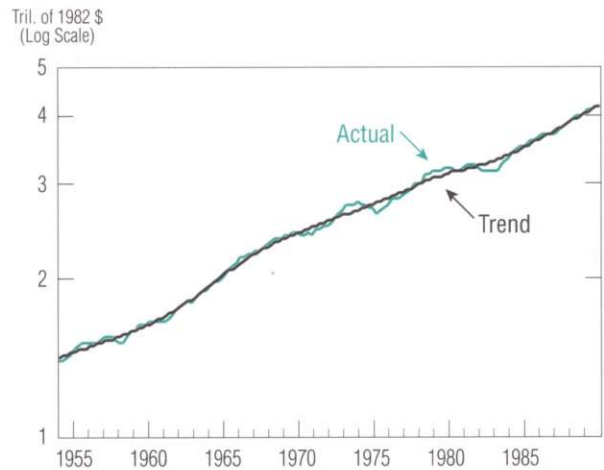
Source of basic data: Citicorp's Citibase data bank

We emphasize that, except for the share variables shown in Table 2, these statistics are percentage, not absolute, deviations. For instance, the percentage deviation of investment expenditures is more than three times that of total real GNP. Since this component averages less than one-fifth of real GNP, its absolute volatility is somewhat less than that of total output.

In the tables, the degree of contemporaneous comovement with real GNP is indicated in the $x(t)$ column. The statistics in that column are the correlation coefficients of the cyclical deviations of each series with the cyclical deviations of real GNP. A number close to one indicates that a series is highly *procyclical*; a number close to one but of the opposite sign indicates that a series is *countercyclical*. A number close to zero means that a series does not vary contemporaneously with the cycle in any systematic way, in which case we say the series is *uncorrelated* with the cycle.

The remaining columns of the tables also display

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[4] A short FORTRAN subroutine that efficiently computes the trend and deviations components is available on request to the Research Department, Federal Reserve Bank of Minneapolis. The computation time required by this algorithm increases linearly with the length of the sample period, as do storage requirements.

[5] This approach was introduced in an unpublished paper by Hodrick and Prescott (1980).

correlation coefficients, except the series have been shifted forward or backward, relative to real GNP, by from one to five quarters. To some extent these numbers indicate the degree of comovement with GNP. Their main purpose, however, is to indicate whether, typically, there is a phase shift in the movement of a time series relative to real GNP. For example, if for some series the numbers in the middle of each table are positive but largest in column $x(t-i)$, where $i > 0$, then the numbers indicate that the series is procyclical but tends to peak about i quarters before real GNP. In this case we say the series *leads* the cycle. Correspondingly, a series that *lags* the cycle by $j > 0$ quarters would have the largest correlation coefficient in the column headed by $x(t+j)$. For example, productivity is a series that leads the cycle, whereas the stock of inventories is one that lags the cycle.

We let the neoclassical growth model dictate which facts to examine and how to organize them. The aggregate economy can be divided broadly into three sectors: businesses, households, and government. In the business sector, the model emphasizes production inputs as well as output components. Households allocate income earned in the business sector to consumption and saving. In the aggregate, there is an accounting relation between household saving and business investment. Households allocate a fraction of their discretionary time to income-earning activities in the business sector. The remaining fraction goes to nonmarket activities, usually referred to as leisure but sometimes (perhaps more appropriately) as input to household production. This time-allocation decision has received little attention in growth theory, but it is crucial to business cycle theory. The government sector, which is at the heart of public finance theory, also could play a significant role for business cycles.

Table 1

Cyclical Behavior of U.S. Production Inputs

Deviations From Trend of Input Variables
Quarterly, 1954–1989

Variable x	Volatility (% Std. Dev.)	Cross Correlation of Real GNP With										
		$x(t-5)$	$x(t-4)$	$x(t-3)$	$x(t-2)$	$x(t-1)$	$x(t)$	$x(t+1)$	$x(t+2)$	$x(t+3)$	$x(t+4)$	$x(t+5)$
Real Gross National Product	1.71	−0.03	0.15	0.38	0.63	0.85	1.00	0.85	0.63	0.38	0.15	−0.03
Labor Input												
Hours (Household Survey)	1.47	−0.10	0.05	0.23	0.44	0.69	0.86	0.86	0.75	0.59	0.38	0.18
Employment	1.06	−0.18	−0.04	0.14	0.36	0.61	0.82	0.89	0.82	0.67	0.47	0.25
Hours per Worker	0.54	0.08	0.21	0.35	0.49	0.66	0.71	0.59	0.43	0.29	0.11	−0.02
Hours (Establishment Survey)	1.65	−0.23	−0.07	0.14	0.39	0.66	0.88	0.92	0.81	0.64	0.42	0.21
GNP/Hours (Household Survey)	0.88	0.11	0.21	0.34	0.48	0.50	0.51	0.21	−0.02	−0.25	−0.34	−0.36
GNP/Hours (Establishment Survey)	0.83	0.40	0.46	0.49	0.53	0.43	0.31	−0.07	−0.31	−0.49	−0.52	−0.50
Average Hourly Real Compensation (Business Sector)	0.91	0.30	0.37	0.40	0.42	0.40	0.35	0.26	0.17	0.05	−0.08	−0.20
Capital Input												
Nonresidental Capital Stock*	0.62	−0.58	−0.61	−0.51	−0.48	−0.31	−0.08	0.16	0.39	0.56	0.66	0.70
Structures	0.37	−0.45	−0.51	−0.55	−0.53	−0.44	−0.29	−0.10	0.09	0.25	0.38	0.45
Producers' Durable Equipment	0.99	−0.57	−0.58	−0.53	−0.41	−0.22	0.02	0.26	0.47	0.62	0.70	0.71
Inventory Stock (Nonfarm)	1.65	−0.37	−0.33	−0.23	−0.05	0.19	0.50	0.72	0.83	0.81	0.71	0.53

*Based on quarterly data, 1954:1–1984:2.
Source of basic data: Citicorp's Citibase data bank

The standard version of the neoclassical growth model abstracts from money and therefore provides little guidance about which of the nominal variables to examine. Given the prominence that monetary shocks have held for many years as the main candidate for the impulse to business cycles, it seems appropriate that we also examine the cyclical behavior of monetary aggre-

gates and nominal prices.

Real Facts

□ Production Inputs

We first examine real (nonmonetary) series related to the inputs in aggregate production. The cyclical facts

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Table 2

Cyclical Behavior of U.S. Output and Income Components

Deviations From Trend of Product and Income Variables
Quarterly, 1954–1989

| Variable x | Volatility (% Std. Dev.) | Cross Correlation of Real GNP With | | | | | | | | | | |
		x(t−5)	x(t−4)	x(t−3)	x(t−2)	x(t−1)	x(t)	x(t+1)	x(t+2)	x(t+3)	x(t+4)	x(t+5)
Real Gross National Product	1.71	−0.03	0.15	0.38	0.63	0.85	1.00	0.85	0.63	0.38	0.15	−0.03
Consumption Expenditures	1.25	0.25	0.41	0.56	0.71	0.81	0.82	0.66	0.45	0.21	−0.02	−0.21
Nondurables & Services	0.84	0.20	0.38	0.53	0.67	0.77	0.76	0.63	0.46	0.27	0.06	−0.12
Nondurables	1.23	0.29	0.42	0.52	0.62	0.69	0.69	0.57	0.38	0.16	−0.05	−0.22
Services	0.63	0.03	0.25	0.46	0.63	0.73	0.71	0.60	0.49	0.39	0.23	0.07
Durables	4.99	0.25	0.38	0.50	0.64	0.74	0.77	0.60	0.37	0.10	−0.14	−0.32
Investment Expenditures	8.30	0.04	0.19	0.39	0.60	0.79	0.91	0.75	0.50	0.21	−0.05	−0.26
Fixed Investment	5.38	0.09	0.25	0.44	0.64	0.83	0.90	0.81	0.60	0.35	0.08	−0.14
Nonresidential	5.18	−0.26	−0.13	0.05	0.31	0.57	0.80	0.88	0.83	0.68	0.46	0.23
Structures	4.75	−0.40	−0.31	−0.17	0.03	0.29	0.52	0.65	0.69	0.63	0.50	0.34
Equipment	6.21	−0.18	−0.04	0.14	0.39	0.65	0.85	0.90	0.81	0.62	0.38	0.15
Residential	10.89	0.42	0.56	0.66	0.73	0.73	0.62	0.37	0.10	−0.15	−0.34	−0.45
Government Purchases	2.07	0.00	−0.03	−0.03	−0.01	−0.01	0.05	0.09	0.12	0.17	0.27	0.34
Federal	3.68	0.00	−0.05	−0.08	−0.09	−0.09	−0.02	0.03	0.06	0.10	0.19	0.24
State & Local	1.19	0.06	0.10	0.17	0.25	0.26	0.25	0.20	0.16	0.19	0.27	0.36
Exports	5.53	−0.50	−0.46	−0.34	−0.14	0.11	0.34	0.48	0.53	0.53	0.53	0.45
Imports	4.92	0.11	0.18	0.30	0.45	0.61	0.71	0.71	0.51	0.28	0.03	−0.19
Real Net National Income												
Labor Income*	1.58	−0.18	−0.02	0.18	0.42	0.68	0.88	0.90	0.80	0.62	0.40	0.19
Capital Income**	2.93	0.10	0.24	0.44	0.63	0.79	0.84	0.60	0.30	0.02	−0.19	−0.29
Proprietors' Income & Misc.†	2.70	0.11	0.24	0.38	0.55	0.62	0.68	0.46	0.29	0.11	0.02	−0.10

*Employee compensation is deflated by the implicit GNP price deflator.

**This variable includes corporate profits with inventory valuation and capital consumption adjustments, plus rental income of persons with capital consumption adjustment, plus net interest, plus capital consumption allowances with capital consumption adjustment, all deflated by the implicit GNP price deflator.

†Proprietors' income with inventory valuation and capital consumption adjustments, plus indirect business tax and nontax liability, plus business transfer payments, plus current surplus of government enterprises, less subsidies, plus statistical discrepancy.

Source of basic data: Citicorp's Citibase data bank

are summarized in Table 1. Since it is not unreasonable to think of the inventory stock as providing productive services, we include this series with the labor and capital inputs.

The two most common measures of the labor input are aggregate hours-worked according to the household survey and, alternatively, the payroll or establishment survey. We see in Table 1 that total hours with either measure is strongly procyclical and has cyclical variation which, in percentage terms, is almost as large as that of real GNP. (For a visual representation of this behavior, see Chart 3.) The capital stock, in contrast, varies smoothly over the cycle and is essentially uncorrelated with contemporaneous real GNP. The correlation is large, however, if the capital stock is shifted back by about a year. In other words, business capital lags the cycle by at least a year. The inventory stock also lags the cycle, but only by about half a year. In percentage terms, the inventory stock is nearly as volatile as quarterly real GNP.

The hours-worked series from the household survey can be decomposed into employment fluctuations on the one hand and variations in hours per worker on the other. Employment lags the cycle, while hours per worker is nearly contemporaneous with it, with only a slight lead. Much more of the volatility in total hours worked is caused by employment volatility than by changes in hours per worker. If these two subseries were perfectly correlated, their standard deviations would add up to the standard deviation of total hours. Although not perfectly correlated, their correlation is quite high, at 0.86. Therefore, employment accounts for roughly two-thirds of the standard deviation in total hours while hours per worker accounts for about one-third.

As a measure of the aggregate labor input, aggregate hours has a problem: it does not account for differences across workers in their relative contributions to aggregate output. That is, the hours of a brain surgeon are given the same weight as those of an orderly. This

Table 3

Cyclical Behavior of U.S. Output and Income Component Shares

Deviations From Trend of Product and Income Variables
Quarterly, 1954–1989

Variable x	Mean % of GNP	Volatility (% Std. Dev.)	Cross Correlation of Real GNP With										
			x(t−5)	x(t−4)	x(t−3)	x(t−2)	x(t−1)	x(t)	x(t+1)	x(t+2)	x(t+3)	x(t+4)	x(t+5)
Gross National Product													
Consumption Expenditures	63.55	0.58	0.29	0.15	−0.06	−0.32	−0.56	−0.78	−0.68	−0.52	−0.33	−0.17	−0.03
Nondurables & Services	54.79	0.70	0.06	−0.08	−0.27	−0.51	−0.72	−0.89	−0.73	−0.50	−0.23	0.01	0.18
Durables	8.76	0.33	0.36	0.43	0.48	0.54	0.56	0.53	0.36	0.15	−0.10	−0.31	−0.44
Investment Expenditures	15.85	1.07	0.03	0.18	0.36	0.56	0.75	0.87	0.71	0.47	0.18	−0.09	−0.30
Fixed Investment	15.16	0.56	0.11	0.25	0.40	0.57	0.74	0.81	0.77	0.61	0.40	0.14	−0.08
Change in Business Inventories	0.69	0.69	0.04	0.07	0.24	0.40	0.56	0.69	0.48	0.22	−0.05	−0.25	−0.40
Government Purchases	20.13	0.57	0.04	−0.09	−0.25	−0.40	−0.55	−0.61	−0.52	−0.36	−0.15	0.09	0.28
Net Exports	0.47	0.45	−0.51	−0.51	−0.48	−0.43	−0.37	−0.28	−0.17	0.00	0.17	0.30	0.38
Net National Income*													
Labor Income	58.57	0.47	−0.29	−0.36	−0.45	−0.52	−0.47	−0.39	−0.03	0.23	0.42	0.48	0.46
Capital Income	24.38	0.42	0.19	0.25	0.36	0.43	0.48	0.43	0.17	−0.13	−0.35	−0.48	−0.46
Proprietors' Income & Misc.	17.04	0.34	0.18	0.19	0.17	0.17	0.06	0.00	−0.16	−0.19	−0.20	−0.11	−0.11

*For explanations of the national income components, see notes to Table 2.
Source of basic data: Citicorp's Citibase data bank

Chart 3

Deviations From Trend of U.S. Real Gross National Product and Hours Worked*

Quarterly, 1954–1989
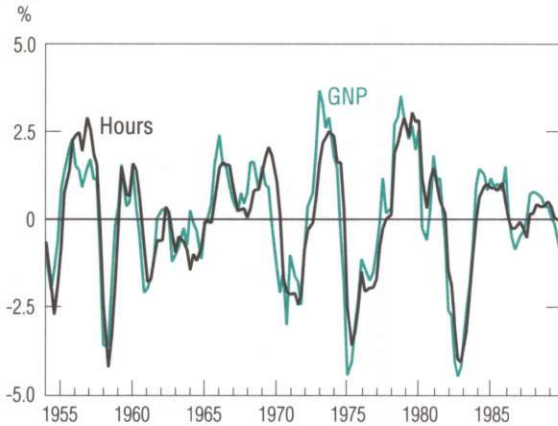
*The estimate of hours worked uses the establishment survey.
Source of basic data: Citicorp's Citibase data bank

disparity would not be problematic if the cyclical volatility of highly skilled workers resembled that of the workers who are less skilled. But it doesn't. The hours of the less-skilled group are much more variable, as established in one of our recent studies (Kydland and Prescott 1989). Using data for nearly 5,000 people from all major demographic groups over the period 1969–82, we found that, cyclically, aggregate hours is a poor measure of the labor input. When people were weighted by their relative human capital, the labor input for this sample and period varied only about two-thirds as much as did aggregate hours. We therefore recommend that the cyclical behavior of labor productivity (as reported by GNP/hours in Table 1) be interpreted with caution.

Since the human-capital-weighted cyclical measure of labor input fluctuates less than does aggregate hours, the implicit real wage (the ratio of total real labor compensation to labor input) is even more procyclical than average hourly real compensation. (For the latter series, see Table 1.) This finding that the real wage behaves in a reasonably strong procyclical manner is

Table 4

Cyclical Behavior of U.S. Monetary Aggregates and the Price Level

Deviations From Trend of Money Stock, Velocity, and Price Level
Quarterly, 1954–1989

Variable x	Volatility (% Std. Dev.)	Cross Correlation of Real GNP With										
		$x(t-5)$	$x(t-4)$	$x(t-3)$	$x(t-2)$	$x(t-1)$	$x(t)$	$x(t+1)$	$x(t+2)$	$x(t+3)$	$x(t+4)$	$x(t+5)$
Nominal Money Stock*												
Monetary Base	0.88	−0.12	0.02	0.14	0.25	0.36	0.41	0.40	0.37	0.32	0.28	0.26
M1	1.68	0.01	0.12	0.23	0.33	0.35	0.31	0.22	0.15	0.09	0.07	0.07
M2	1.51	0.48	0.60	0.67	0.68	0.61	0.46	0.26	0.05	−0.15	−0.33	−0.46
M2 − M1	1.91	0.53	0.63	0.67	0.65	0.56	0.40	0.20	−0.01	−0.21	−0.39	−0.53
Velocity*												
Monetary Base	1.33	−0.26	−0.15	0.00	0.22	0.40	0.59	0.50	0.37	0.22	0.08	−0.08
M1	2.02	−0.24	−0.19	−0.12	−0.01	0.14	0.31	0.32	0.27	0.20	0.10	0.00
M2	1.84	−0.63	−0.59	−0.48	−0.29	−0.05	0.24	0.34	0.40	0.43	0.44	0.43
Price Level												
Implicit GNP Deflator	0.89	−0.50	−0.61	−0.68	−0.69	−0.64	−0.55	−0.43	−0.31	−0.17	−0.04	0.09
Consumer Price Index	1.41	−0.52	−0.63	−0.70	−0.72	−0.68	−0.57	−0.41	−0.24	−0.05	0.14	0.30

*Based on quarterly data, 1959:1–1989:4.
Source of basic data: Citicorp's Citibase data bank

counter to a widely held belief in the literature. [For a fairly recent expression of this belief, see the article by Lawrence Summers (1986, p. 25), which states that there is "no apparent procyclicality of real wages."]

□ *Output Components*

Real GNP is displayed in Chart 4, along with its three major components: consumption, investment, and government purchases. These three components do not quite add up to real GNP, the difference being accounted for by net exports and change in business inventories. Because household investment in consumer durables behaves similarly to fixed investment in the business sector, we have added those two series. By far the largest component (nearly two-thirds) of total output is consumption of nondurable goods and services. This component, moreover, has relatively little volatility. The chart shows that the bulk of the volatility in aggregate output is due to investment expenditures.

The cyclical components (relative to cyclical real GNP) of consumer nondurables and services, consumer durable investment, fixed investment, and government purchases are reported in Table 2 and plotted in Charts 5–8. From the table and charts, we can see that all but government purchases are highly procyclical. Household and business investment in durables have similar

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Chart 4

U.S. Real Gross National Product and Its Components*

Quarterly, 1954–1989

*Consumption includes nondurable goods and services. Investment is the sum of consumer durable investment and business fixed investment. Components do not add to total because net exports and the change in business inventories are excluded.

Source of basic data: Citicorp's Citibase data bank

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amplitudes of percentage fluctuations. Expenditures for consumer durables leads slightly while nonresidential fixed investment lags the cycle, especially investment in structures. Consumer nondurables and services is a relatively smooth series.

Some of the interesting features of the other components are that government purchases has no consistent pro- or countercyclical pattern, that imports is procyclical with no phase shift, and that exports is procyclical but lags the cycle by from six months to a year.

The cyclical behavior of the major output components, measured as shares of real GNP, is reported in Table 3. Using fractions rather than the logarithms of the series permits us to include some series that could not be used in Table 2 because they are negative during some quarters. We see that the change in business inventories is procyclical. Net exports is a countercyclical variable, with the association being strongest for exports shifted back by about a year.

□ *Factor Incomes*

Tables 2 and 3 also provide information about factor incomes, which are the components of national income. The cyclical behavior of factor incomes is described in terms of their levels (Table 2) and their shares of GNP (Table 3). Since proprietors' income includes labor and capital income, we treat this component (plus some small miscellaneous components) separately. We find that proprietors' income, as a share of national income, is uncorrelated with the cycle.

Table 2 shows that both labor income and capital income are strongly procyclical and that capital income is highly volatile. Table 3 shows that, measured as shares of total income, labor income is countercyclical while capital income is procyclical.
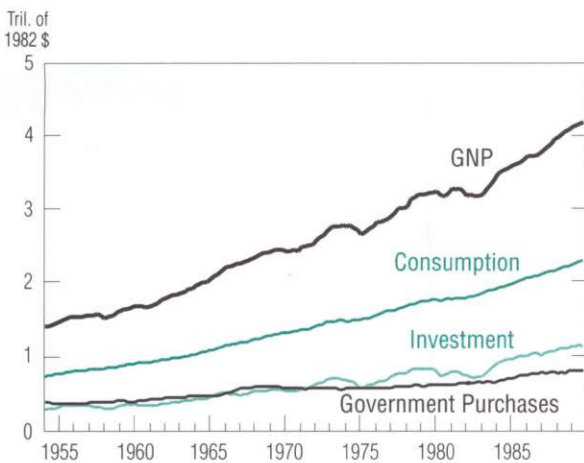
Nominal Facts

The statistical properties of the cyclical components of various nominal aggregates are summarized in Table 4, and four of these series along with cyclical real GNP are plotted on Charts 9–12.

□ *Monetary Aggregates*

There is no evidence that either the monetary base or M1 leads the cycle, although some economists still believe this monetary myth. Both the monetary base and M1 series are generally procyclical and, if anything, the monetary base lags the cycle slightly.

An exception to this rule occurred during the expansion of the 1980s. This expansion, so long and steady, has even led some economists and journalists to

Charts 5–8

Deviations From Trend of U.S. Real Gross National Product and Its Components

Quarterly, 1954–1989

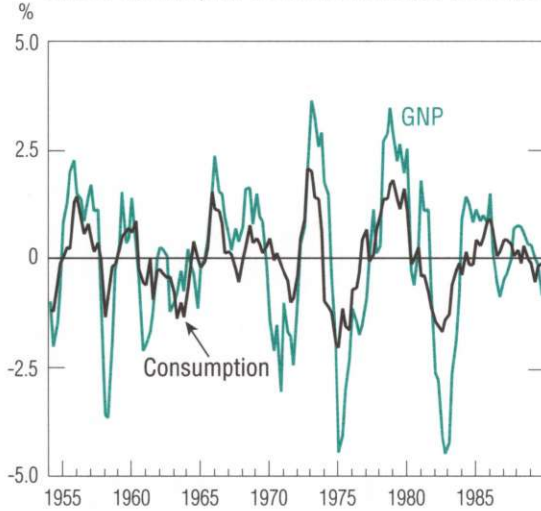### Chart 5 Consumption of Nondurable Goods & Services
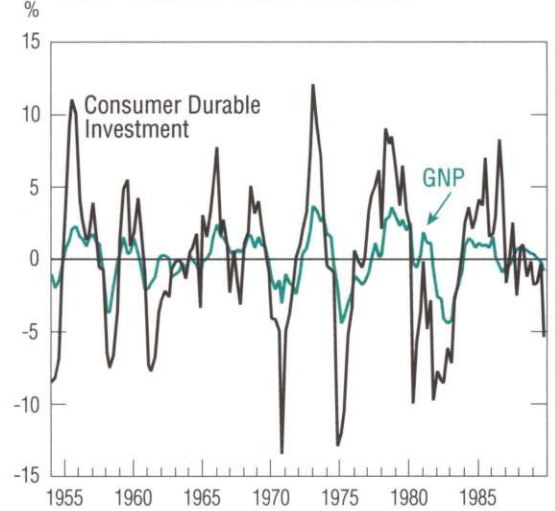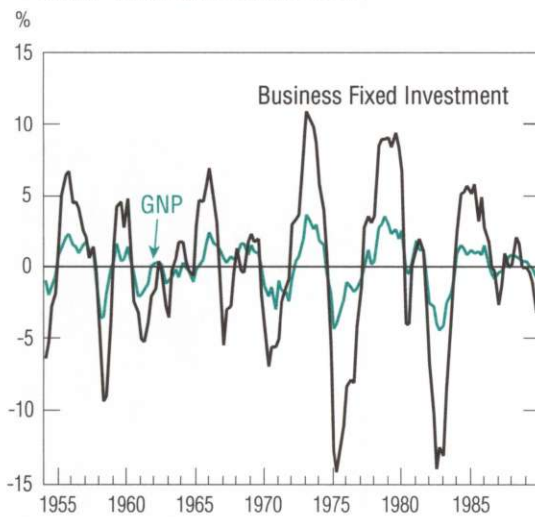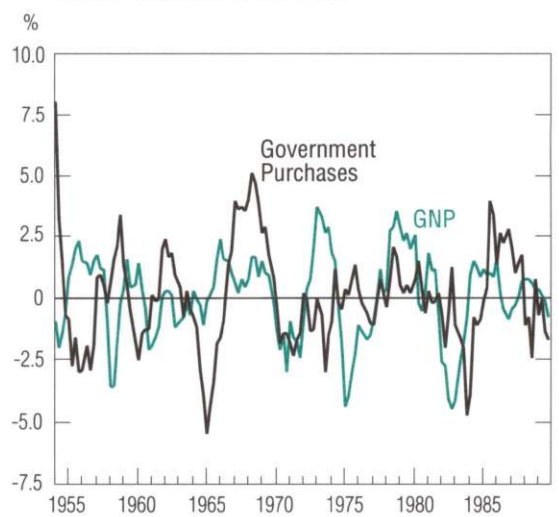
Chart 6 Consumer Durable Investment

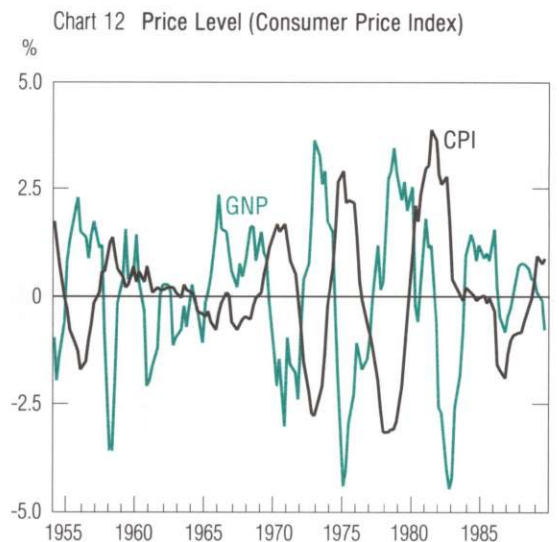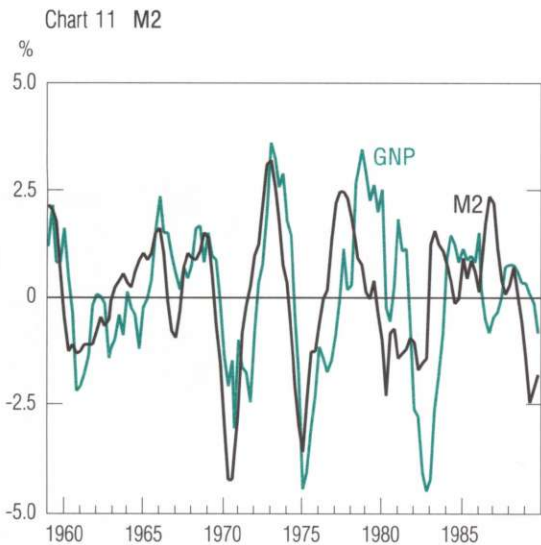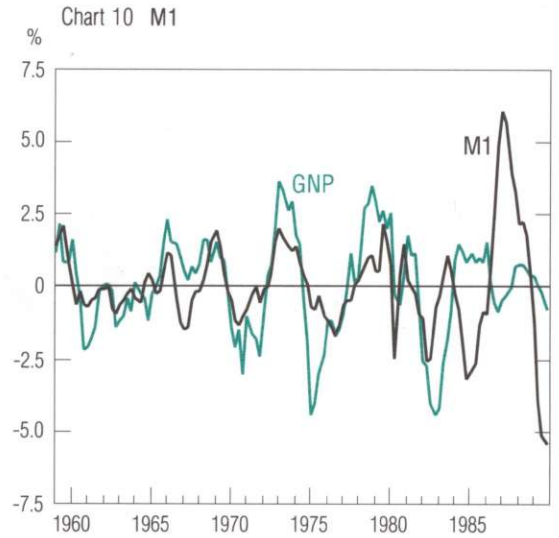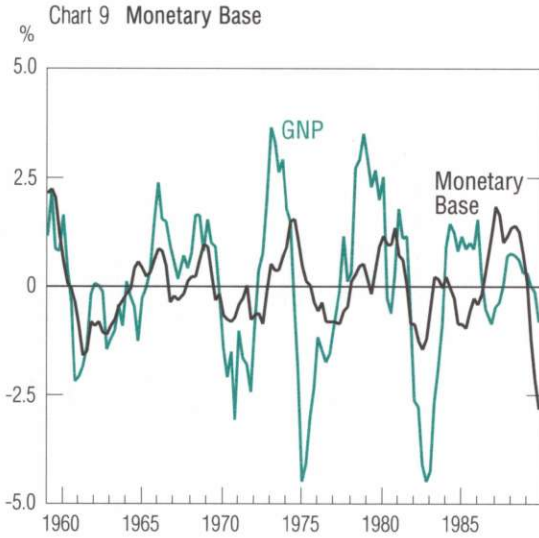### Chart 7 Business Fixed Investment

Chart 8 Government Purchases

Source of basic data: Citicorp's Citibase data bank

Charts 9–12

Deviations From Trend of U.S. Real Gross National Product and Selected Nominal Aggregates

Quarterly, 1959–1989*

Chart 9 Monetary Base

Chart 10 M1

Chart 11 M2

Chart 12 Price Level (Consumer Price Index)

*For the price level, 1954–1989.
Source of basic data: Citicorp's Citibase data bank

speculate that the business cycle is dead (Zarnowitz 1989 and *The Economist* 1989). During the expansion, M1 was uncommonly volatile, and M2, the more comprehensive measure of the money stock, showed some evidence that it leads the cycle by a couple quarters.

The difference in the behavior of M1 and M2 suggests that the difference of these aggregates (M2 minus M1) should be considered. This component mainly consists of interest-bearing time deposits, including certificates of deposit under $100,000. It is approximately one-half of annual GNP, whereas M1 is about one-sixth. The difference of M2 − M1 leads the cycle by even more than M2, with the lead being about three quarters.

From Table 4 it is also apparent that money velocities are procyclical and quite volatile.

□ *Price Level*
Earlier in this paper, we documented the view that the price level is always procyclical. This myth originated from the fact that, during the period between the world wars, the price level *was* procyclical. But because of the Koopmans taboo against reporting business cycle facts, no one bothered to ascertain the cyclical behavior of the price level since World War II. Instead, economists just carried on, trying to develop business cycle theories in which the price level plays a central role and behaves procyclically. The fact is, however, that whether measured by the implicit GNP deflator or by the consumer price index, the U.S. price level clearly has been countercyclical in the post–Korean War period.

Concluding Remarks
Let us reemphasize that, unlike Burns and Mitchell, we are not claiming to measure business cycles. We also think it inadvisable to start our economics from some statistical definition of trend and deviation from trend, with growth theory being concerned with trend and business cycle theory with deviations. Growth theory deals with both trend and deviations.

The statistics we report are of interest, given neoclassical growth theory, because they are—or maybe were—in apparent conflict with that theory. Documenting real or apparent systematic deviations from theory is a legitimate activity in the natural sciences and should be so in economics as well.

We hope that the facts reported here will help guide the selection of model economies to study. We caution that any theory in which procyclical prices figure crucially in accounting for postwar business cycle fluctuations is doomed to failure. The facts we report indicate that the price level since the Korean War

moves countercyclically.

The fact that the transaction component of real cash balances (M1) moves contemporaneously with the cycle while the much larger nontransaction component (M2) leads the cycle suggests that credit arrangements could play a significant role in future business cycle theory. Introducing money and credit into growth theory in a way that accounts for the cyclical behavior of monetary as well as real aggregates is an important open problem in economics.[6]

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[6]Two interesting attempts to introduce money into growth theory are the work of Cooley and Hansen (1989) and Hodrick, Kocherlakota, and D. Lucas (1988). Their approach focuses on the transaction role of money.

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