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12 Major Macroeconomic Variables and Leading Indexes

12.1 Background and Objectives

How the economy moves over time depends on its structure, institutions, and policies, all of which are subject to large historical changes. It would be surprising if the character of the business cycle did *not* change in response to such far-reaching developments as the Great Contraction of the 1930s and the post-Depression reforms, the expansion of government and private service industries, the development of fiscal and other built-in stabilizers, and the increased use and role of discretionary macroeconomic policies. It is consistent with our priors that the data for the United States and other developed market-oriented countries generally support the hypothesis that business contractions were less frequent, shorter, and milder after World War II than before (R. J. Gordon 1986; see chapter 3).

Although business cycles have moderated, they retain a high degree of continuity, which shows up most clearly in the comovements and timing sequences among the main cyclical processes.[1] An important aspect of this continuity is the role of the variables that tend to move ahead of aggregate output and employment in the course of the business cycle. The composite index of leading indicators combines the main series representing these variables. Several studies point to the existence of a relatively close and stable relationship between prior changes in this index and changes in macroeconomic activity (Vaccara and Zarnowitz 1977; Auerbach 1982; Zarnowitz and Moore 1982; Diebold and Rudebusch 1989). Yet, the currently popular, small reduced-form

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1. For assessments and references concerning the U.S. record, see Moore 1983, chs. 10 and 24; and Zarnowitz and Moore 1986.

macro models make little or no use of the leading indicators.[2] We suspect that the reason is lack of familiarity. The role of the indicators is probably often misperceived as being purely symptomatic. Heterogeneous combinations of such series resist easy theoretical applications. On a deeper level, the notion that the private market economy is inherently stable led to an emphasis on the role of the monetary and fiscal disturbances. Interest in the potential of stabilization policies had a similar effect in that it stimulated work on models dominated by factors considered to be amenable to government control.

This orientation is understandably appealing but can easily become one-sided and error-prone, both theoretically and statistically. For example, a simple vector autoregressive (VAR) model in log differences of real GNP, money, and government expenditures suggests the presence of strong lagged monetary and fiscal effects on output.[3] However, it is easy to show that these relationships are definitely misspecified. One way to demonstrate this is by adding changes in a leading index that excludes monetary and financial components so as not to overlap any of the other variables. In this expanded model, the dominant effects on output come from the past movements of the leading index, while the roles of the other variables (including the lagged values of output growth itself) are greatly reduced (see sec. 12.4). In general, omitting relevant variables in a VAR will cause the standard exogeneity tests, impulse responses, and variance decompositions to be biased, as shown in Lütkepohl 1982 and Braun and Mittnik 1985.

The first objective of this chapter is to examine the lead-lag interactions within larger sets of important macroeconomic variables, including interest and inflation rates along with output, monetary, and fiscal variables, and a nonduplicative leading index. The rationale for including this index is two-fold: (1) The changes in the leading index can be interpreted broadly as representing the early collective outcomes of investment and production (also, less directly, consumption) decisions. As such, they presumably reflect the dynamic forces that shape the basic processes within the private economy and account for the continuity of business cycles. Both aggregate demand and aggregate supply shifts are involved, but the demand effects may be stronger in the short run. (2) The addition of the leading index helps us overcome the bias due to the omitted variables. The index stands for a number of important factors that would otherwise be omitted. It would not be practical to include the several individual series to represent these variables.

We work with equations that include up to six variables plus constant terms and time trends. They are estimated on quarterly series, each taken with four lags, which means using up large numbers of degrees of freedom. Given the size of the available data samples, it is not possible for such models to accommodate more variables and still retain a chance to produce estimates of param-

2. Large econometric models incorporate some individual indicators but probably suboptimally and not in a comprehensive and systematic way.

3. This recalls the old St. Louis Fed model with its reliance on "policy variables" only.

eters in which one could have some confidence. It is, of course, easy to think of additional, possibly important variables whose omission might cause some serious misspecifications. All VAR models face this dilemma, but the only way to avoid it is by assuming a full structural model, which could be still more deficient. We seek some partial remedies in alternative specifications guided by economic theory and history as well as comparisons with related results in the literature.

Although the format adopted is that of a VAR model, the implied system-wide dynamics (i.e., impulse response functions and variance decompositions) are beyond the scope of this study. These statistics seek to describe behavior in reaction to innovations, require longer series of consistent data than are actually available,[4] and are probably often very imprecise even for smaller systems (see Zellner 1985 and Runkle 1987 with discussion). In contrast, there is sufficient information to estimate the individual equations well, even with more lagged terms. We find that much can be learned from attention to the quality and implications of these estimates, which are logically prior to inferences on overall dynamics but carry no commitment to the particular interpretations of a VAR model.

The second and related objective is to extend the analysis to the periods between the two world wars and earlier in another effort to study the continuity and change in U.S. business cycles. To evaluate any persistent shifts or the secular evolution in the patterns of macroeconomic fluctuation, it is of course necessary to cover long stretches of varied historical experience. Estimates of the interrelations among the selected variables are calculated from quarterly seasonally adjusted data for three periods: 1886–1914, 1919–40, and 1949–82. Generally, we look for the similarities and differences within the three periods that are suggested by this exercise.

Historical data are scanty and deficient, which inevitably creates some difficult choices and problems. The next part of this chapter discusses this and lists the variables and series used. The following section discusses the applied methods and presents tests that determine what transformations must be used on any of the series to validate our statistical procedures. Then the results are examined, focusing on simple exogeneity and neutrality tests for a succession of models as well as on interperiod comparisons. The final section sums up our conclusions and views on the need for further work.

12.2 Data

12.2.1 The Selected Variables and Their Representations

Table 12.1 serves as a summary of the information on the data used in this study. It defines the variables and identifies the time series by title, period,

4. With $m = 6$ variables and $k = 4$ lags, $km^2 = 144$. For the sample period 1949:2–1982:4 covered by our postwar series, the number of degrees of freedom is 109.

Table 12.1 List of Variables, Symbols, and Sources of Data

Number (1)	Variable[a] (2)	Periods[b] (3)	Form[c] (4)	Symbol[d] (5)	Source[e] (6)	Notes on Derivation[f] (7)
1	Real GNP (1972 dollars)	1,2,3	Δln	q	B&G	Annual data from F&S 1982 and Kuznets 1961 and Commerce NIPA (1981ff. since 1889), interpolated quarterly by Chow-Lin (1971) method using the Persons (1931) index of industrial production and trade
2	Implicit price deflator	1,2,3	Δln	p	B&G	(nominal GNP/real GNP) × 100
3	Monetary base	1,2,3	Δln	b	B&G	Based on data in F&S 1970 and 1963a through 1914 and R. J. Gordon and Veitch 1986 for 1949–82
4	Money supply, M1	2,3	Δln	m_1	B&G	1919–46: R. J. Gordon and Veitch 1986; 1947–58: old M1, *FRB*: 1958–82: new M1, *FRB*
5	Money supply, M2	1,2,3	Δln	m_2	B&G	1886–1907: F&S 1970; 1907–14 and 1919–80; R. J. Gordon 1982a; 1980–82: *FRB*
6	Commercial paper rate	1,3	ln level	I	B&G	1886–89: in New York City, from Macaulay 1938; 1890–1914, 1919–80: 4–6 month prime, from R. J. Gordon 1982a; 1981–82: 6 month, from *FRB*
7	Commercial paper rate	2	Δ	i	B&G	do.

8	Federal expenditures	1	ln level	*GX*	Firestone	Based on *Daily Treasury Statements of the United States* (sec Firestone 1960, app. pp. 76–86, and data, seasonally adjusted, pp. 97–111)
9	Federal expenditures	2	Δln	*gx*	Firestone	do.
10	Fiscal index	3	ln level	*G*	Blanchard	From Blanchard 1985 and Blanchard and Watson 1986, app. 2.2; based on data for government spending, debt, and taxes
11	Diffusion index, 75 leading series	1	Δln	ℓdc	Moore	Analyzed in Moore 1961, vol. 1, ch. 7; based on specific-cycle phases; data from Moore 1961, vol. 2, p. 172
12	Amplitude-adjusted (composite) index, six leading series	2	Δln	ℓd	Shiskin	Analyzed in Shiskin 1961a, pp. 43–55; Data from NBER files
13	Composite index of leading indicators	3	Δln	ℓ	Commerce	The composite index of 12 leading indicators minus three components: M2 in constant dollars, change in business and consumer credit outstanding, and the index of stock prices, from *BCD*

[a]All variables are used as quarterly series.

[b]Period 1: 1886–1914; period 2: 1919–40; period 3: 1949–82.

[c]Δln: first difference in natural logarithm; Δ: first difference.

[d]Small letters are used for rates of change or absolute changes; capital letters are used for levels of the series.

[e]B&G: Balke and Gordon 1986, app. B. Firestone: Firestone, 1960, app. tables, Blanchard: Blanchard and Watson 1986, app. 2.2. Moore: Moore 1961. Shiskin: Shiskin 1961a. Commerce: U.S. Department of Commerce, Bureau of Economic Analysis.

[f]F&S: M. Friedman and Schwartz. NIPA: national income and product accounts. *FRB: Federal Reserve Bulletin.* NBER: National Bureau of Economic Research. *BCD: Business Conditions Digest* (U.S. Department of Commerce).

symbol, and source. Some notes on the derivation of the underlying data are included as well.

The table includes 11 different variables and 23 segments of the corresponding series, counting one per time period (cols. 2 and 3). No equation contains more than six variables. Some variables have different representations across the three periods covered because consistent data are not available for them. Further, unit root tests indicate that in some cases, levels of a series ought to be used in one period and differences in another. (These tests and the required transformations are discussed in sec. 12.3, which covers the statistical framework.) As shown in column 4, natural logarithms are taken of all series except the commercial paper rate. Federal expenditures in 1886–1914, the fiscal index in 1949–82, and the interest rate in both of these periods are level series; in all other cases first difference series are used.

Lowercase letters serve as symbols for variables cast in the form of first differences; capital letters for those cast in levels (table 12.1, col. 5). The series relating to output (q), prices (p), the alternative monetary aggregates (b, m_1, m_2), and interest (I or i) are staple ingredients of small reduced-form, or VAR, models. They appear in the table on lines 1–7. Of the additional series, three represent fiscal variables (8–10). For the postwar period, there is an index combining federal spending, debt, and taxes (G). For the interwar and prewar periods, there are two segments of the federal expenditures series (gx and GX, respectively).

Finally, there are three different indexes of leading indicators (11–13). The only such series presently available for 1886–1914 is a diffusion index based on specific cycles in individual indicators (ldc). The composite indexes for 1919–40 and, particularly, for 1949–82 (ld and l, respectively) are much more satisfactory.

12.2.2 Data Sources and Problems

The "standard" historical estimates of GNP before World War II, based mainly on the work of Kuznets, Kendrick, and Gallman, are annual at most. We use the new quarterly series for real GNP and the implicit price deflator from Balke and Gordon (1986b).[5] These data are constructed from the standard series by means of quarterly interpolators which include the Persons 1931 index of industrial production and trade before 1930, the Federal Reserve Board (FRB) industrial production index for 1930–40, constant terms, and linear time trends. The use of interpolations based on series with narrower coverage than GNP is a source of unavoidable error if the unit period is to be shorter than a year.[6]

5. New annual estimates of nominal GNP, the implicit price deflator (1982 = 100), and real GNP for 1869–1929 are presented in Balke and Gordon (1989). This study develops some additional sources for direct measurement of nonmanufacturing output and the deflator. It concludes that real GNP was on the average about as volatile as the traditional Kuznets-Kendrick series indicate, but that the GNP deflator was significantly less volatile.

6. The Persons index consists of a varying assortment of weighted and spliced series on bank clearings outside New York City, production of pig iron and electric power, construction contracts,

The historical annual estimates of U.S. income and output leave much to be desired, but it is difficult to improve on them because the required information simply does not exist. The series have been recently reevaluated, leading to new estimates by Romer (1986 and 1987) and Balke and Gordon (1988). Romer's method imposes certain structural characteristics of the U.S. economy in the post–World War II period on the pre–World War I data. This produces results that contradict the evidence of postwar moderation of the business cycle by prejudging the issue (Lebergott 1986; Weir 1986; Balke and Gordon 1988). It is mainly for this reason that we do not use Romer's data. The basic source of historical monetary statistics (monthly since May 1907, biennial earlier) is Friedman and Schwartz 1970. Here, too, interpolations based on related series are applied in early years. The data for money (like those for income, output, and prices) improve over time but are never without serious problems. The interwar and postwar series are produced by the FRB.

Market interest rates are more easily and much better measured than the macroeconomic aggregates and indexes on our list. The commercial paper rate series (Macaulay 1938 and FRB) is of good quality, at least in a comparative sense.

The Blanchard fiscal index is designed to measure "the effect of fiscal policy on aggregate demand at given interest rates" (Blanchard and Watson 1986, p. 149). This series moves countercyclically most of the time, hence presumably retains in large measure elements of built-in tax-and-transfer stabilizers. For the earlier periods, no comparable comprehensive index is available, and we use the series on federal expenditures from Firestone (1960).

From the Commerce Department's leading index for 1949–82, we exclude real money balances (M2 deflated by the consumer price index) and change in business and consumer credit outstanding. This is done to avoid overlaps or conflicts with the monetary variables covered in our equations. The stock price component (Standard & Poor's index of 500 common stocks) may be strongly affected by monetary and fiscal developments, and adopting a conservative bias, we remove it as well. This newly adjusted composite index consists of nine series representing primarily the early stages of fixed capital investment, inventory investment, and marginal adjustments of employment and production.[7]

The only composite index of leading indicators available in the literature for the interwar period covers six series: average workweek, new orders for

railroad car loadings and net ton-miles of freight, indexes of volume of manufacturing and mining, etc. The compilation is spotty and uneven, particularly before 1903. A few other historical indexes of business activity are available but they have similar limitations (see chapter 7).

7. These indicators are average workweek, manufacturing; average weekly initial claims for unemployment insurance; vendor performance (percentage of companies receiving slower deliveries); change in sensitive materials prices; manufacturers' orders in constant dollars, consumer goods and materials industries; contracts and orders for plant and equipment in constant dollars; index of net business formation; building permits for new private housing units; change in manufacturing and trade inventories on hand and on order in constant dollars.

durable-goods manufacturers, nonfarm housing starts, commercial and industrial construction contracts, new business incorporations, and Standard & Poor's index of stock prices. The index is presented and discussed in Shiskin 1961a. Its method of construction is very similar to that presently used for the Commerce index.[8] The coverage of the Shiskin index, though narrower, also resembles that of the postwar index, particularly when the money and credit components are deleted from the latter. The one major difference is that the interwar index is based on changes in the component series over 5-month spans, whereas the postwar index is based on month-to-month changes.[9]

Unfortunately, no composite index of leading indicators exists for the pre–World War I period. To compute such an index from historical data would certainly be worthwhile but also laborious; the project must be reserved for the future. In the meantime, we report on some experimental work with the only available series that summarizes the early cyclical behavior of a set of individual leading indicators. The set consists of 75 individual indicators whose turning points have usually led at business cycle peaks and troughs. It covers such diverse areas as business profits and failures, financial market transactions and asset prices, bank clearings, loans and deposits, sensitive materials prices, inventory investment, new orders for capital goods, construction contracts, and the average workweek. Moore (1961) presents a diffusion index showing the percentage of these series expanding in each month from 1885 to 1940. The index is based on cyclical turns in each of its components: a series is simply counted as rising during each month of a specific-cycle expansion (and declining otherwise). Clearly, the type of smoothing implicit in this index construction is ill-suited for our purposes as it was designed for a very different task of historical timing analysis. Nevertheless, for lack of any other measure, we use this diffusion index by cumulating its deviations from 50 and taking log differences of the results.

12.3 The Statistical Framework

12.3.1 Method of Estimation

Conflicting macromodels draw support not only from different theoretical rationalizations of economic behavior but also, when implemented econo-

8. Percentage changes in each component series (computed so as to ensure symmetrical treatment of rises and declines) are standardized, that is, expressed as ratios to their own long-run mean, without regard to sign. The resulting changes are averaged across the series for each month and then cumulated into an index. Simple averages are used by Shiskin, and weighted averages by Commerce, but this makes little difference since the Commerce weights, based on performance scores of the selected indicators, are nearly equal. Also, the Commerce index has a trend adjusted to equal the trend in the index of coincident indicators (which is close to the trend in real GNP), whereas the Shiskin index has no such adjustment (Shiskin 1961a, pp. 43–47 and 123–25; U.S. Department of Commerce 1984, pp. 65–70).

9. Except for the inventory and price components, which are weighted 4-month moving averages, trailing.

metrically, from different empirical priors imposed on the data. Dissatisfaction with the "incredible identification" of existing large-scale simultaneous equation systems led to the recent popularity of vector autoregressions, which treat all variables as endogenous and shun unfounded *a priori* restrictions. The method has been used in attempts to discriminate among alternative explanations of money-income causality (Sims 1980a).

This chapter examines the interactions within a larger set of macroeconomic variables than that considered in the money-income causality studies. The particular statistics that interest us in this context are exogeneity and neutrality tests for the selected macrovariables within the different time periods.

Define $x^i_{s,t}$ as a generic variable with s denoting the time series (q, p, b,. . .) and i denoting the time frame (prewar, interwar, postwar). For each series and time frame, we estimate ordinary least squares regressions of the form (the superscript i is henceforth omitted for simplicity)

$$x_{s,t} = \alpha_s + \beta_s t + \sum_{r=1}^{R} \sum_{j=1}^{J} \gamma_{r,j} x_{r,t-j} + e_t, \tag{1}$$

where $R = 3$, . . . up to 6 series and $J = 4$ quarterly lags. The neutrality test is a t-statistic which tests the null hypothesis

$$H_0: \sum_{j=1}^{J} \gamma_{s,j} = 0 \tag{2}$$

against the alternative that the sum is not equal to 0. The exogeneity test is an F-statistic which tests

$$H_0: \gamma_{s,1} = \ . \ . \ . = \gamma_{s,k} = 0 \tag{3}$$

against the alternative that not all γ are equal to 0.

12.3.2 Unit Roots and Transformations

Since the work of Nelson and Plosser (1982), much interest has been paid to the existence of unit roots in macroeconomic time series. The magnitudes of the secular and cyclical components of these series receive primary attention in the work of Cochrane (1988) and Campbell and Mankiw (1987). Sims, Stock, and Watson (1986) also consider the role unit roots play in hypothesis testing with VARs. They show that to interpret correctly exogeneity and neutrality tests using standard asymptotic theory, it is necessary to transform the data to zero-mean stationary series. Moreover, Stock and Watson (1987) shed new light on the long-debated problem of money-income causality by taking nonstationarities into account. Therefore, because of both an explicit interest in the results and also the necessity of having stationary series to employ standard asymptotic theory, we calculate a set of unit root tests.

We test the null hypothesis

(4) $$x_{s,t} = \sum_{j=1}^{J} p_{s,j} x_{s,t} + e_t$$

against the general alternative

(5) $$x_{s,t} = \mu_s + \psi_s t \sum_{j=1}^{J} p_{s,j} x_{s,t} + e_t$$

with $\Sigma\, p_{s,i} < 1$ and, depending on the test, with and without ψ_s restricted to be 0. Rejection of the null hypothesis implies that the series does not contain a unit root and is stationary either around its mean, when ψ_s is restricted to be 0, or around a time trend, when ψ_s is not so restricted.

The unit root tests are presented in Tables 12.2, 12.3, and 12.4 for the postwar, interwar, and prewar sample periods, respectively. Part A of each table includes the tests for a single unit root for each series, calculated using levels. Part B contains tests for a second unit root calculated using first differences.

Because there is no uniformly most powerful test for unit roots, we use two different sets of test statistics. To test the hypothesis that a series is stationary around its mean, we estimate the Dickey-Fuller $\hat{\tau}_\mu$ statistic and the Stock-Watson q_f^μ statistic. These statistics restrict ψ_s in the alternative hypothesis (eq. [5]) to be 0. To test the hypothesis that a series is stationary around a linear time trend, we estimate the Dickey-Fuller $\hat{\tau}_\tau$ statistic and the Stock-Watson $q\tau_f$ statistic.

The Dickey-Fuller statistics are calculated by estimating via ordinary least squares (OLS) the following transformation of equation (5):

(6) $$x_{s,t} = \mu_s + \psi_s t + \phi_{s,1} x_{s,t} + \sum_{j=2}^{J} \phi_{s,j}(x_{s,j+1} - x_{s,t-j});$$

and calculating the adjusted t-statistic for $\phi_{s,t}$ as

(7) $$\hat{\tau}_\mu = \frac{\phi_{s,1} - 1.00}{\mathrm{SE}(\phi_{s,1})}$$

with and without ψ_s restricted to be 0. $\mathrm{SE}(\phi_{s,1})$ is the typically reported standard error of ϕ_s. The critical values for these statistics are tabulated in Fuller 1976.

The Stock-Watson test statistics we use are based on the more general Stock-Watson $q_f(k, m)$ test for common trends in a vector of time-series variables. The statistic is simply

(8) $$q_f(k, m) = T[\mathrm{Re}(\hat{\lambda}) - 1],$$

where $\hat{\lambda}$ is the largest real (Re) root of the sample autocorrelation matrix and T is the number of observations. The $q_f(k, m)$ statistic tests the hypothesis of k versus m unit roots for an n-vector time series ($m < k \leq n$). For the univar-

Table 12.2 Univariate Tests for Unit Roots and Time Trends for the Postwar Sample: Quarterly Data, 1949:1–1982:4

	Unit Root Test Statistics[b]				*t*-Statistics[c]	
Series[a]	$\hat{\tau}_\mu$	q_f^μ	$\hat{\tau}_\tau$	q_f^τ	Time	Constant
			A. Tests on Levels[d]			
Q	−1.92	−0.61	−1.90	−7.82	2.17	2.04+
M_1	4.21	1.39	0.53	0.44	0.71	−3.23*
M_2	2.22	0.41	−1.56	−2.92	2.09+	−1.74°
B	3.12	0.58	−1.45	−0.74	2.81*	−2.64*
G	−2.90+	−15.56+	−4.76*	−36.21**	−3.34**	−2.81*
L	−1.54	−1.48	−3.38°	−17.83°	4.51**	1.72
I	−1.78	−7.00	−3.73+	−24.96+	3.17*	1.89°
P	3.16	−0.13	0.68	−0.08	0.89	−1.89°
			B. Tests on Differences[d]			
q	−5.09*	−85.86**	−5.41*	−88.41**	−1.72°	4.52**
m_1	−2.67°	−54.56**	−4.21*	−89.71**	4.20**	3.51**
m_2	−2.84°	−24.10**	−4.07*	−48.73**	3.21*	3.24*
b	−3.29+	−37.60**	−4.73*	−65.18**	4.37**	3.08*
g	−6.28*	−114.65**	−6.24*	−114.63**	0.50	−0.33
ℓ	−7.26*	−87.91**	−7.39*	−88.68**	−1.19	3.79**
i	−3.42+	−115.49**	−3.30°	−115.48**	−0.06	0.64
p	−3.30+	−39.14**	−4.20*	−67.00**	2.94*	3.05*

[a]On the definitions of the variables, see table 12.1. Capital letters denote levels (in logs, except for I) Lowercase letters denote first differences (in logs, except for i).

[b]$\hat{\tau}_\mu$ denotes the Dickey-Fuller (1979) statistic computed using a regression with four lags. q_f^μ is the Stock-Watson (1986) statistic, also from a regression with four lags. $\hat{\tau}_\tau$ and q_f^τ are again, respectively, the Dickey-Fuller and Stock-Watson statistics calculated using a time trend.

[c]*t*-statistics for the time and constant coefficient estimated from a regression of the variable on four own lags with time trend and without.

[d]Significance level at the 1/10 of 1% level is denoted by ** (except for the Dickey-Fuller tests, for which 0.001 significance levels are not tabulated); at the 1% level by *; 5% level by +; and 10% level by °.

iate tests used here, the null hypothesis (eq. [4]) is one unit root, $k = 1$, against the alternative (eq. [5]) of no unit root, $m = 0$. The critical values for the q_f^μ and q_f^τ statistics are tabulated in Stock and Watson 1986.

We also test for the order of any deterministic components in these series. We regressed the level and first difference of each series against a constant, time, and four of its own lags. Likewise we tested for significant drift terms by replicating this estimation without a time trend. The last column reports the *t*-ratio on the constant term.

Looking at the results for the postwar sample (table 12.2), only the fiscal index is stationary in levels around its mean as well as around a time trend. The leading index and the commercial paper rate are stationary in levels around a time trend only. All postwar series are stationary in first differences, with significant time trends occurring for all three money series and prices.

Table 12.3 **Univariate Tests for Unit Roots and Time Trends for the Interwar Sample: Quarterly Data, 1919:1–1940:1**

	Unit Root Test Statistics[b]				t-Statistics[c]	
Series[a]	$\hat{\tau}_\mu$	q_f^μ	$\hat{\tau}_\tau$	q_f^τ	Time	Constant
			A. Tests on Levels[d]			
Q	−1.21	−8.74	−1.90	−11.33	1.71°	1.60
M_1	0.29	1.05	−0.87	−3.15	2.17⁺	0.05
M_2	−0.94	−2.55	−1.63	−5.71	1.78°	1.18
B	3.06	3.14	0.48	−1.49	2.17⁺	−2.28⁺
GX	0.06	−1.36	−3.07*	−13.65	3.33*	0.04
LD	−1.53	−4.99	−1.78	−7.04	−1.23	2.33⁺
I	−1.42	−4.26	−3.38*	−16.68	−2.93*	0.66
P	−3.38*	−8.74	−3.11	−11.33	−1.26	3.28**
			B. Tests on Differences[d]			
q	−3.33*	−35.18**	−3.22⁺	−35.64	0.59	0.96
m_1	−2.67°	−21.32**	−3.05	−23.96**	1.80°	1.08
m_2	−3.33*	−21.02**	−2.58	−20.41**	0.89	0.89
b	−2.25	−58.90**	−4.30*	−76.41**	3.76**	1.79°
gx	−5.85*	−90.52**	−6.72*	−99.09**	2.20⁺	0.90
ℓd	−4.80*	−57.41**	−4.77*	−54.29**	0.16	0.00
i	−5.43*	−49.00**	−5.38*	−48.95**	0.33	−1.21
p	−5.64*	−35.18**	−6.10*	−35.65**	−2.07	−1.26

[a]On the definitions of the variables, see table 12.1. Capital letters denote levels (in logs, except for I) Lowercase letters denote first differences (in logs, except for i).

[b]$\hat{\tau}_\mu$ denotes the Dickey-Fuller (1979) statistic computed using a regression with four lags. q_f^μ is the Stock-Watson (1986) statistic, also from a regression with four lags. $\hat{\tau}_\tau$ and Q_f^τ are again, respectively, the Dickey-Fuller and Stock-Watson statistics calculated using a time trend.

[c]t-statistics for the time and constant coefficient estimated from a regression of the variable on four own lags with time trend and without.

[d]Significance level at the 1/10 of 1% level is denoted by ** (except for the Dickey-Fuller tests, for which 0.001 significance levels are not tabulated); at the 1% level by *; 5% level by ⁺ ; and 10% level by °.

We infer from this that it is necessary to take first differences of real GNP, money, and prices.

Although the tests indicate the leading index is stationary in levels around a time trend, we decided to perform our subsequent analysis using first differences. This is because the leading index has a built-in nonstationary component constructed from the trend of the coincident index (see U.S. Department of Commerce 1984, pp. 65–69). Because this nonstationary component is implicitly related to the trend rate of growth of GNP and we take first differences of GNP, we also take first differences of the leading index. According to Sims, Stock, and Watson (1986), the presence of significant trends in the series of money and price changes makes it necessary to include a time trend in our equations to permit us to use standard asymptotic theory to interpret the exogeneity and neutrality tests.

For the interwar period (table 12.3), the unit root tests are more difficult to

Table 12.4 Univariate Tests for Unit Roots and Time Trends for the Prewar Sample: Quarterly Data, 1886:1–1914:4

	Unit Root Test Statistics[b]				t-Statistics[c]	
Series[a]	$\hat{\tau}_\mu$	q_f^μ	$\hat{\tau}_\tau$	q_f^τ	Time	Constant
			A. Tests on Levels[d]			
Q	−0.93	−0.93	−2.24	−15.22	3.11*	1.20
M_2	0.00	−0.45	−2.04	−6.50	1.85°	1.31
B	0.17	−0.10	−1.94	−19.77	2.11⁺	2.28⁺
GX	−1.17	−2.23	−3.64*	−43.42**	4.04**	1.52
LDC	−2.84°	−5.66	−4.24*	−21.90⁻	2.66*	2.15⁺
I	−5.10*	−49.94*	−6.30*	−56.93**	−2.68*	4.59**
P	0.45	0.91	−1.35	−2.74	2.35⁺	−0.15
			B. Tests on Differences[d]			
q	−5.18*	−70.48**	−5.18*	−70.77**	−0.68	3.19*
m_2	−4.09*	−161.64**	−8.04*	−39.39**	0.38	3.17*
b	−5.88*	−161.65**	−5.88*	−161.86**	0.60	3.87**
gx	−6.60*	−150.58**	−6.58*	−150.58**	−0.40	−1.80°
$ℓdc$	−7.45*	−68.23**	−7.71*	−63.13**	−1.40	2.02⁺
i	−6.98*	−123.60**	−6.95*	−123.59**	−0.18	0.09
p	−5.72*	−113.51**	−6.15*	−117.50**	2.11⁺	1.30

[a]On the definitions of the variables, see table 12.1. Capital letters denote levels (in logs, except for I) Lowercase letters denote first differences (in logs, except for i).

[b]$\hat{\tau}_\mu$ denotes the Dickey-Fuller (1979) statistic computed using a regression with four lags. q_f^μ is the Stock-Watson (1986) statistic, also from a regression with four lags. $\hat{\tau}_\tau$ and Q_f^τ are again, respectively, the Dickey-Fuller and Stock-Watson statistics calculated using a time trend.

[c]t-statistics for the time and constant coefficient estimated from a regression of the variable on four own lags with time trend and without.

[d]Significance level at the 1/10 of 1% level is denoted by ** (except for the Dickey-Fuller tests, for which 0.001 significance levels are not tabulated); at the 1% level by *; 5% level by ⁺; and 10% level by °.

interpret because of the small sample size (87 observations). For levels (pt. A), the Dickey-Fuller tests indicate that the interest rate is stationary around a time trend and the price level is stationary around its mean. The Stock-Watson tests contradict these particular results, however, bringing into question the power of these tests (see Dickey and Fuller 1979 for power calculations of $\hat{\tau}_\mu$). Looking at the tests on differences (pt. B), the tests indicate that all of the interwar series are stationary, except for the Dickey-Fuller tests for m_1 and m_2 around a trend and the monetary base around its mean. However, these particular tests again contradict the Stock-Watson tests. Because of these results, we act conservatively and use first differences of all of the interwar series. Moreover, following the arguments for the postwar sample, a time trend is also necessitated by the significant t-ratios for m_1, b, and g on the trend coefficients.

Finally, for the prewar sample (table 12.4) it is sufficient to take first differences only of real GNP, the monetary base, M_2, and the implicit price deflator, whereas the series on government expenditures and the interest rate can be left in levels. Again, although the tests indicate the leading diffusion index is stationary in levels around a trend, we instead use first differences of this series in our subsequent analysis. This is because the trend is artificially induced via the accumulation of the original series. A time trend is also included because of the significant trend coefficient for inflation.

12.4 The Results

12.4.1 Factors Influencing Changes in Real GNP: A Stepwise Approach

1949–1982

Table 12.5 is based on regressions of real GNP growth on its own lagged values (q_{t-i}, i = 1, . . . ,4) and the lagged values of from two to five other selected series, plus a constant term and time. Each variable has the form shown in table 12.1, col. 4, as indicated by the tests discussed previously. The calculations proceed by successively expanding the set of explanatory variables, in four steps. First, only the lagged terms of q are used along with the corresponding values of a fiscal and a monetary variable. The inflation group is added next, and then the interest-rate group. The last step includes the leading-index terms as well.

This table and those that follow are standardized to show the F-statistics for conventional tests of exogeneity and, underneath these entries, the t-statistics for the neutrality tests, that is, for the *sums* of the regression coefficients of the same groups of lagged terms for each variable. The estimated individual coefficients are too numerous to report and their behavior is difficult to describe in the frequent cases where their successive values oscillate with mixed signs. It seems advisable, however, to show at least the summary t-ratios in each equation. When sufficiently large, these statistics suggest that the individual terms in each group are not all weak or not all transitory, that is, that they do not offset each other across the different lags.

In the 1949–82 equations with three variables only, the lagged q terms are always significant at least at the 5% level; each of the monetary alternatives makes a contribution (m_2 is particularly strong); and the fiscal index G is relatively weak, except when used along with the monetary base b (table 12.5, pt. A, eqs. [1]–[3]). Adding inflation (p) is of little help in explaining q, but on balance the coefficients of p are negative and some may matter (eqs. [4]–[6]). When the commercial paper rate (I) is entered, it acquires a dominant role at the expense of the other (especially the monetary) variables (eqs. [7]–[9]).[10] Finally, equations (10)–(12) show that of all the variables considered,

10. The addition of I reduces further the statistics for p. The simple correlation between I and p in 1949–82 is about 0.7. During the latter part of the postwar era, inflation spread and accelerated and financial markets became increasingly sensitive to it. Since I depends on the real interest rate (R) and expected inflation (i.e., forecasts of p, probably based in part on p_{t-i}), our results suggest an independent role for R in codetermining q.

Table 12.5 **Rate of Change in Real GNP (q) Regressed on Its Own Lagged Values and Those of Other Selected Variables: Tests of Exogeneity and Significance, Quarterly Data for Three Periods between 1886 and 1982**

			Test Statistics[c] for							
Equation No.	df[a]	Lagged Explanatory Variables[b]	q (1)	b, m_1, m_2 (2)	G (3)	p (4)	I, i (5)	$\ell, \ell d, \ell dc$ (6)	t (7)	$\bar{R}_2$ (8)
			A. Sample Period 1949:2–1982:4							
1	121	q, b, G	4.2*	3.4*	3.1⁺					0.26
			1.6	−0.7	2.7*				1.3	
2	121	q, m_1, G	2.9⁺	3.1⁺	1.6					0.26
			1.1	1.1	1.6°				−0.3	
3	121	q, m_2, G	3.1⁺	5.3**	1.3					0.30
			0.8	2.7*	0.9				−1.5	
4	117	q, b, G, p	3.5*	3.2⁺	2.1°	0.8				0.26
			1.2	0.1	2.2⁺	−1.6			1.4	
5	117	g, m_1, G, p	2.1°	3.5⁺	1.1	1.3				0.27
			0.6	1.7°	0.9	−1.8°			−0.3	
6	117	q, m_2, G, p	2.3°	5.2**	1.0	0.9				0.30
			0.8	2.4⁺	0.8	−0.8			−1.0	
7	113	q, b, G, p, I	2.0°	2.4⁺	0.9	0.3	4.7**			0.34
			0.4	−1.2	0.7	0.4	−3.2*		3.0*	
8	113	q, m_1, G, p, I	2.3°	2.0°	0.7	0.4	4.0*			0.34
			−0.7	2.3⁺	−0.8	−0.6	−3.2**		0.5	
9	113	q, m_2, G, p, I	2.0	2.3°	1.0	0.8	2.8⁺			0.34
			0.2	1.0	0.7	0.1	−2.4⁺		0.5	
10	109	q, b, G, p, I, ℓ	1.3	1.3	1.7	0.7	3.7*	4.4*		0.41
			−1.9	−0.1	−0.6	1.3	−3.3**	3.7**	1.1	
11	109	q, m_1, G, p, I, ℓ	2.7⁺	2.4°	2.5⁺	0.4	4.6*	6.0**		0.44
			−3.1*	2.2*	−1.8°	0.9	−3.8**	4.7**	−0.5	

(*continued*)

Table 12.5 Continued

Equation No.	df[a]	Lagged Explanatory Variables[b]	Test Statistics[c] for q (1)	b, m_1, m_2 (2)	G (3)	p (4)	I, i (5)	$\ell, \ell d, \ell dc$ (6)	t (7)	$\bar{R}_2$ (8)
12	109	q, m_2, G, p, I, ℓ	1.7	2.1°	2.4+	0.9	3.2+	5.3**		0.43
			−2.3	0.6	−1.0	1.5	−3.1*	4.4**	0.2	
				B. 1920:4–1940:4						
13	67	q, b, gx	7.0**	5.2**	6.7**					0.44
			3.0*	1.4	−1.4				−0.7	
14	67	q, m_1, gx	2.6	3.9*	5.3***					0.40
			0.7+	2.0+	−1.3				−0.5	
15	67	q, m_2, gx	4.6*	4.0*	5.2*					0.41
			1.7°	0.9	−1.5				0.4	
16	63	q, b, gx, p	5.2**	5.3**	5.6**	0.9				0.43
			3.0*	1.4	−1.5	−0.8			−0.4	
17	63	q, m_1, gx, p	1.1	5.0*	3.9*	1.7				0.43
			0.8	2.7*	−0.8	−2.0+			−0.4	
18	63	q, m_2, gx, p	2.4°	4.6*	3.6*	1.2				0.42
			1.6	1.6	−1.0	−1.7°			0.8	
19	59	q, b, gx, p, i	4.8*	4.4*	5.3**	0.8	0.2			0.41
			2.9*	1.5	−1.4	−0.6	−0.5		−0.5	
20	59	q, m_1, gx, p, i	0.8	4.2*	3.6*	1.8	0.3			0.40
			0.6	2.7*	−0.8	−2.1+	0.5		−0.5	
21	59	q, m_2, gx, p, i	2.1°	3.9*	3.6*	1.4	0.3			0.39
			1.2	1.7°	−1.0	−1.7°	0.3		0.8	
22	55	$q, b, gx, p, i, \ell d$	1.4	4.1*	3.0+	1.3	0.2	3.9*		0.50
			−0.6	1.3	−1.0	−0.1	−0.2	2.6*	−0.7	

23	55	$q, m_1, gx, p, i, \ell d$	2.0	3.5*	1.9	1.9	0.2	3.5*		0.49
			−1.4	2.4⁺	−0.7	−1.4	0.7	2.3⁺	−0.7	
24	55	$q, m_2, gx, p, i, \ell d$	1.9	3.7*	1.7	1.2	0.6	4.0*		0.49
			−0.8	1.5	−0.5	−1.2	0.4	2.2⁺	0.4	
				C. 1886:2–1914:4						
25	101	q, b, G, x	8.9**	0.2	0.7					0.21
			0.9	0.3	1.1				−1.2	
26	101	q, m_2, GX	3.0⁺	5.3**	0.2					0.34
			−0.5	2.2⁺	0.3				−0.6	
27	97	q, b, GX, p	7.2**	0.2	0.8	1.7				0.23
			1.3	0.4	1.4	−1.7*			−1.4	
28	97	q, m_2, GX, p	3.0*	5.0**	0.2	1.6				0.36
			−0.6	2.6*	0.3	−1.8°			−0.4	
29	93	q, b, GX, p, I	4.0*	0.3	0.3	1.7	3.3*			0.30
			0.0	0.7	0.6	−1.7°	−2.4⁺		−1.0	
30	93	q, m_2, GX, p, I	2.4⁺	3.0⁺	0.2	1.6	1.6			0.37
			−0.8	2.2⁺	0.1	−1.7°	−1.4		−0.4	
31	89	$q, b, GX, p, I, \ell dc$	4.0*	0.3	0.1	1.5	3.7*	0.7		0.29
			−0.3	0.7	0.5	−1.4	−2.4⁺	−0.7	−1.1	
32	89	$q, m_2, GX, p, I, \ell dc$	2.6⁺	3.5*	0.1	1.6	2.3°	1.2		0.38
			−1.1	2.2°	−0.4	−1.5	−1.8°	−1.2	−0.4	

[a]Degrees of freedom.

[b]See table 12.1 for definitions of the variables and sources of the data.

[c]The first line for each equation lists the F-statistics for groups of lagged values of each variable covered (cols. 1–6) and squared correlation coefficients adjusted for the degrees of freedom (col. 8). The second line lists the t-statistics for the sums of regression coefficients of the same groups (cols. 1–6) and for the time trend (col. 7). Significance at the ⅒ of 1% level is denoted by **; at the 1% level by *; at the 5% level by ⁺; and at the 10% level by °.

the rate of change in the leading index exerts the statistically most significant influence on q. Five of the test statistics for l are significant at the 0.1% level; one at the 1% level. The level of interest rates represented by I retains its strong net inverse effect on q. The direct contributions of m_1, m_2, and G to the determination of real GNP growth are much fewer and weaker; those of b and p are altogether difficult to detect.[11]

Alternative calculations show that when l is added to the equations with the monetary and fiscal variables only, the effects of these variables on q are again drastically reduced. Had we retained the money, credit, and stock price components in the leading index, the role of the index in these equations would have been even stronger and that of the other regressors generally weaker.[12] In any event, the evidence indicates that the quarterly movements of the economy's output in 1949–82 depended much more on recent changes in leading indicators and interest rates than on recent changes in output itself, money, the fiscal factor, or inflation.

Conceivably, longer lags could produce different results, so we checked to see what happens when eight instead of four lags are used. These tests suggest some gains in power for the lagged q and G terms, but the leading index and the interest rate still have consistently strong effects. However, we do not report these statistics because the restriction to lags of one–four quarters is dictated by the limitations of the available data. With eight lags, for example, the number of degrees of freedom is reduced from 109 to 81 for the six-variable equations.

1919–1940

In the equations for the interwar period, all variables appear in the form of first differences. In the first subset (table 12.5, pt. B, eqs. [13]–[15]), q depends positively on its own lagged values and those of the monetary variables and inversely on the recent values of federal expenditures gx. All the F-statistics are significant, most highly so. On the other hand, inflation contributes but little to these regressions, as shown by the results for equations (16)–(18) (only two t-tests indicate significance and none of the F-tests). Further, no gains at all result from the inclusion of the change in the commercial paper rate (eqs. [19]–[21]).

11. These results are not inconsistent with b influencing q with longer lags via changes in m_1 or m_2 or I, or with a negative effect of inflation uncertainty on output, which is found in some studies that work with higher moments or forecasts of inflation (see Makin 1982; Litterman and Weiss 1985; chapter 17).

12. It should be noted that the index is robust in the sense of not being critically dependent on any of its individual components or their weights. Thus, any large subset of these indicators can produce a fair approximation to the total index under the adopted construction and standardization procedures. Some of the components are known to have good predictive records of their own (e.g., stock prices, as shown in Fischer and Merton 1984), but the leading index outperforms any of them on the average over time. The reductions in coverage and diversity detract from the forecasting potential of the index but, up to a point, only moderately. And, as in the present case, they may often be advisable for analytical purposes.

In contrast, there is strong evidence in our estimates for 1919–40 that the lagged rates of change in the index of six leading indicators (*ld*) had a large net positive influence on *q*. Four of the corresponding test statistics are significant at the 1% level and two at the 5% level (pt. B, col. 6). In equations (22)–(24), *ld* shows the strongest effects, followed by the monetary variables; *gx* is significant only in one case; and the tests for lagged *q*, *p*, and *i* terms are all negative.

On the whole, the monetary series appear to play a somewhat stronger role in the interwar than in the postwar equations, whereas the leading series appear to play a somewhat weaker role. It should be recalled, however, that *l* is a more comprehensive index than *ld* and is based on better data. Even for the series that are more comparable across the two periods, the quality of the postwar data is probably significantly higher. Further, the reliability of the results for 1919–40 suffers from the small-sample problem: the number of observations per parameter to be estimated here is little more than half the number available for 1949–82.

In light of these considerations, it seems important to note that the interwar results resemble broadly the postwar results in most respects and look rather reasonable, at least in the overall qualitative sense. The leading indexes are highly effective in the regressions for both periods. The main difference between the two sets of estimates is that the commercial paper rate contributes strongly to the statistical explanation of *q* in 1949–82, but the change in that rate does not help in the 1919–40 regressions (cf. col. 5 in pts. A and B of table 12.5). We checked whether interest levels (*I*) would have performed significantly better than interest changes (*i*) in the interwar equations, and the answer is no.

1886–1914

For the pre–World War I period, the equations with three variables indicate strong effects on *q* of its own lagged values and those of m_2, but no significant contributions of either the monetary base or government expenditures (table 12.5, pt. C, eqs. [25]–[26]). The inflation terms add only a weak negative influence, as shown in the summary *t*-statistics for equations (27)–(28).

The recent values of the commercial paper rate have substantial inverse effects on the current rate of change in real GNP, particularly in the equations with the base and after the change in the diffusion index of leading indicators (*ldc*) is added (eqs. [29]–[32]). The *ldc* index itself appears to be ineffective. In light of the major importance of the leading indexes in the postwar and interwar equations, this negative result is probably attributable mainly to the way *ldc* is constructed. (Recall from a previous discussion that this index uses only the historical information on specific-cycle turning points in a set of 75 individual indicators.)

12.4.2 Test Statistics for Six-Variable Equations

1949–1982

Each of the monetary variables (b, m_1, m_2) depends strongly on its own lagged values and those of the interest rate (I), as shown by the corresponding F-values in table 12.6, equations (1)–(3). The I terms have coefficients whose signs vary, and their t-statistics are on balance small, though mostly negative. The fiscal index (G) appears to have a strong positive effect on m_1, and the time trends in column 7 are important. The effects of the other variables are sporadic and weak.

G is more strongly autoregressive yet. It also depends positively on b and m_2 and inversely on I, the change in the leading index l, and time (eqs. [4]–[6]).

Inflation (p) also depends mainly on its own lagged values, according to equations (7)–(9). A few relatively weak signs of influence appear for b, I, and G. The time trends are significant. These results are consistent with a view of the price level as a predetermined variable adjusting slowly with considerable inertia. Monetary influences on p involve much longer lags than are allowed here.

The interest rate depends most heavily on its own recent levels, as is immediately evident from equations (10)–(12). Still, some significant inputs into the determination of I (which yields R^2 as high as 0.95) are also made by other factors, notably m_1 and l.

As for l, it is not strongly influenced by either its own recent past or that of the other variables. The largest F-values here are associated with the interest rate in equations (13) and (14) and with inflation in equation (15).

The corresponding tests for real GNP (q) equations have already been discussed in the previous section (relating to the estimates in the last six lines of table 12.5, pt. A). It is interesting to note that very few significant F- or t-statistics are associated with the lagged q terms according to our tests (table 12.6, col. 1).

1919–1940

Tests based on the interwar monetary regressions indicate high serial dependence for m_1 and m_2 but not b (table 12.7, eqs. [1]–[3]). The base is influenced strongly by recent changes in output (q), moderately by those in the leading index (ld). There are signs of some effects on m_2 of ld and p, but no measurable outside influences on m_1.

Equations (4)–(6) for the rate of change in government expenditures (gx) produce F-statistics that are generally low and significant only for the lagged values of the dependent variable. The same applies to equations (10)–(12) for the change in the interest rate (i).

The rate of inflation (p) depends heavily on its own lagged values, too (eqs.

Table 12.6 Tests of Exogeneity and Significance, Six-Variable Equations: Quarterly, 1949–82

		Test Statistics[c] for							
Equation No.[a]	Dependent Variable[b]	q (1)	b, m_1, m_2 (2)	G (3)	p (4)	I (5)	ℓ (6)	t (7)	$\bar{R}_2$ (8)
1	b	1.7	10.5**	1.2	1.5	3.4*	2.9+		0.71
		1.8°	3.2**	−0.2	0.1	−0.9	1.7°	2.6*	
2	m_1	1.1	3.3*	3.3*	1.3	8.0**	0.4		0.54
		0.6	1.5	2.0+	0.7	−0.4	1.2	3.3*	
3	m_2	0.7	7.3**	0.8	0.4	10.6**	0.4		0.76
		0.4	3.7**	0.3	−0.2	−1.6°	0.3	2.9*	
4	G	1.1	2.4+	36.0**	0.7	3.5*	0.1		0.87
		−0.8	2.4+	9.7**	−0.7	−0.1	−0.2	−2.9*	
5	G	0.7	1.3	28.3**	1.0	3.6*	0.1		0.86
		−0.6	1.6	8.6**	−1.7°	−0.9	0.1	−2.3+	
6	G	0.7	2.4+	34.8**	1.1	2.6+	0.4		0.87
		−0.4	1.8°	9.6**	−1.9°	0.1	1.2	−2.7*	
7	p	1.1	2.5+	2.3°	0.5	2.8+	9.1**		0.63
		0.7	−1.8°	2.6*	−1.1	0.7	4.6**	3.0*	
8	p	1.0	0.8	1.1	0.3	1.7	8.7**		0.61
		−0.4	0.9	1.5	−0.3	1.0	4.0**	1.2	
9	p	1.0	1.6	2.1°	0.2	1.6	8.4**		0.62
		0.5	−1.9+	2.5*	−0.8	0.2	4.1**	3.0*	
10	I	1.8	1.3	0.2	4.1*	81.0**	3.0+		0.94
		1.1	−0.4	−0.5	0.5	13.1**	1.7°	0.9	
11	I	2.8+	6.6**	0.2	1.6	98.1**	1.9		0.95
		0.7	0.2	−0.1	0.5	14.8**	1.6	0.9	
12	I	1.8	2.1°	0.2	3.4*	68.0**	2.4+		0.95
		1.5	−0.8	−0.0	0.3	12.5**	1.2	1.5	
13	ℓ	1.2	1.1	1.9	1.8	3.8*	1.3		0.45
		0.1	−1.8°	2.2+	0.2	−1.4	−1.3	3.6**	
14	ℓ	1.2	1.6	1.6	2.2°	4.0*	2.5+		0.46
		−1.0	0.6	1.6°	1.0	−1.1	−2.4+	2.3+	
15	ℓ	1.0	1.2	1.7	2.1°	1.2	2.5+		0.45
		−0.4	−0.5	2.1+	0.9	−1.1	−2.5*	2.3+	

[a]Sample period: 1949:2–1982:4. Degrees of freedom: 109.

[b]See table 12.1 for definitions of the variables and sources of the data.

[c]F-statistics on the first line and t-statistics on the second line for each equation. Significance at the 1/10 of 1% level is denoted by **; at the 1% level by *; at the 5% level by + ; and at the 10% level by °.

[7]–[9]). Some of the test statistics suggest that m_1, *ld*, and perhaps *i* may influence *p* slightly over the course of a year.

Interestingly, according to equations (13)–(15), *ld* is affected much more strongly by the recent monetary changes than by its own lagged values. There are also some signs of influence of *gx* on *ld*. This raises the possibility that monetary and fiscal changes, including those due to policy actions, may affect real GNP with long lags through the mediating role of the leading indicators

Table 12.7 **Tests of Exogeneity and Significance, Six-Variable Equations: Quarterly, 1919–40**

		Test Statistics[c] for							
Equation No.[a]	Dependent Variable[b]	*q* (1)	*b*, m_1, m_2 (2)	*g* (3)	*l* (4)	*i* (5)	*p* (6)	*t* (7)	$\bar{R}_2$ (8)
1	*b*	3.5	0.1	1.4	2.6+	0.7	0.7		0.40
		2.8**	−0.3	1.3	−1.7°	−1.4	−0.7	3.7**	
2	m_1	0.3	8.2**	1.4	0.9	0.1	1.3		0.55
		−0.1	3.3*	−1.7°	−0.3	−0.2	0.7	1.5	
3	m_2	0.6	4.6*	1.7	2.1°	0.7	2.2°		0.60
		0.3	2.8*	−2.4+	0.7	−0.3	1.6	1.1	
4	*gx*	1.9	1.1	2.7+	1.4	1.5	0.8		0.36
		−1.8	−1.2	−2.0+	1.4	0.4	1.5	2.1+	
5	*gx*	1.6	1.2	2.2+	1.5	1.0	0.7		0.36
		−1.9	−0.4	−1.8°	1.7	0.4	1.5	1.5	
6	*gx*	1.3	1.2	3.3+	1.2	0.9	0.9		0.36
		−1.5	−1.4	−2.3+	1.5	0.3	1.9°	1.7	
7	*p*	0.7	0.2	1.0	1.7	1.7	5.1*		0.54
		0.5	−0.2	1.4	1.4	−2.1+	1.9°	1.1	
8	*p*	1.2	2.2°	1.5	2.1°	1.4	6.2**		0.60
		0.2	−0.5	1.2	2.0+	−1.4	2.0+	1.4	
9	*p*	1.4	1.4	1.2	2.3+	2.0	5.7**		0.58
		0.7	−1.3	0.7	1.6	−1.6	2.2+	1.6	
10	*i*	0.6	0.7	0.5	1.3	2.7+	0.3		0.14
		−0.6	0.9	0.9	1.1	0.9	0.8	−0.7	
11	*i*	0.5	0.1	0.4	1.0	2.7+	0.3		0.10
		−0.1	0.1	1.0	0.7	0.7	0.6	−0.0	
12	*i*	0.6	0.9	0.7	1.3	2.6+	0.3		0.15
		−0.4	0.8	1.5	0.9	0.7	0.2	−0.1	
13	*ℓd*	1.1	4.7*	2.2°	3.0+	0.8	1.4		0.39
		−1.1	2.4+	−1.4	2.2+	−0.6	−0.1	−1.4	
14	*ℓd*	1.3	4.6*	1.5	2.0°	0.5	1.8+		0.39
		−1.8°	3.0*	−1.1	1.7°	0.6	−1.7	−0.7	
15	*ℓd*	1.3	7.4**	2.0°	2.7+	1.5	1.5		0.47
		−1.2	2.1+	−1.0	1.9°	0.5	1.6°	0.7	

[a]Sample period: 1920:4–1940:4. Degrees of freedom: 55.

[b]See table 12.1 for definitions of the variables and sources of the data.

[c]*F*-statistics on the first line and *t*-statistics on the second line for each equation. Significance at the 1/10 of 1% level is denoted by **; at the 1% level by *; at the 5% level by +; and at the 10% level by °.

(*ld*). But note that this is suggested only by the estimates for the interwar period, not by those for the postwar era.[13]

Comparing Tables 12.6 and 12.7 and drawing also on Table 12.5 (pts. A and B, eqs. [10]–[12] and [22]–[24]), we observe that *q* depends strongly on

13. The difference could be related to the fact that the interwar index includes, while the postwar index excludes, the stock price series. Financial asset prices and returns are probably subject to stronger monetary and fiscal influences than other leading indicators are.

the leading indexes (*l*, *ld*) in both periods and on the monetary factors in the interwar period. The autoregressive elements are weak in *q*, *l*, and *ld* and strong (as a rule dominant) in the other variables according to the interwar as well as the postwar estimates. The effects of *q* on the other factors are generally weak or nonexistent.

1886–1914

The *F*-statistics for the own-lag terms are significant in all the pre–World War I equations, highly so (at the 0.1% level) for the monetary, fiscal, leading, and interest series, less so for *q* and *p* (see table 12.8 and table 12.5, pt. C, eqs. [30]–[32]). The leading index *ldc* for 1886–1914 is very strongly autocorrelated, in contrast to the indexes *ld* for 1919–40 and *l* for 1949–82. This reflects the construction of the prewar index, which assumes smooth cyclical movements in the index components (see section on data sources and problems).

Prewar changes in the monetary base are poorly "explained," mainly by own lags and those of government expenditures (*GX*) and the commercial paper rate (*I*). The corresponding changes in the stock of money (m_2) are fitted much better by lagged values of m_2 itself, *I*, and *p*. And as much as 94% of the variance of *GX* is explained statistically, mainly by lagged *GX* terms and the time trend. (See table 12.8, eqs. [1]–[4]).

The estimates for inflation (*p*) are problematic. They suggest that *p* was influenced positively by lagged money changes but also inversely by its own lagged values and those of *I* and *ldc*. The R^2 coefficients are of the order of 0.2–0.3 (eqs. [5]–[6]).

The equations for the interest rate (eqs. [7]–[8]), besides being dominated by autoregressive elements, indicate some short-term effects of *q* (with plus signs) and m_2 (minus). These results seem generally reasonable.

The leading diffusion index *ldc* (eqs. [9]–[10]) depends primarily on own lags, with traces of positive effects of *q* and *p* and negative effects of *I*. In view of the probable measurement errors involved (mainly in the *ldc* series), the serviceability of these estimates is uncertain.

12.5 Conclusions and Further Steps

The following list of our principal findings begins with a point of particular importance, which receives clear support from the better quality of the data available for the postwar and interwar periods.

1. Output depends strongly on leading indexes in equations which also include the monetary, fiscal, inflation, and interest variables (all taken in stationary form, with four quarterly lags in each variable). Hence, models that omit the principal leading indicators are probably seriously misspecified.

2. Short-term nominal interest rates had a strong inverse influence on output (specifically, the rate of change in real GNP) during the 1949–82 period.

Table 12.8 **Tests of Exogeneity and Significance, Six-Variable Equations: Quarterly, 1886–1914**

		Test Statistics[c] for							
Equation No.[a]	Dependent Variable[b]	*q* (1)	*b*, m_2 (2)	*GX* (3)	*p* (4)	*I* (5)	*ℓdc* (6)	*t* (7)	$\bar{R}_2$ (8)
1	*b*	0.7	7.3**	2.0°	0.3	2.8+	0.9		0.14
		1.4	−3.7**	1.7°	0.1	2.8*	0.6	−1.1	
2	m_2	1.1	20.8**	0.5	1.7	2.8+	4.2*		0.59
		−1.8	5.2**	−0.2	−1.4	−2.0+	0.6	−0.2	
3	*GX*	0.9	0.4	10.8**	0.2	0.9	0.3		0.94
		−0.4	0.9	5.1**	−0.4	−1.4	0.5	3.7**	
4	*GX*	1.6	0.9	9.2**	0.3	0.4	0.1		0.94
		−1.0	1.1	4.6**	0.2	−0.9	0.4	3.7**	
5	*p*	1.4	1.2°	1.5	3.3*	3.7*	1.8		0.23
		−0.3	2.0+	−0.3	−2.7*	−2.6+	−1.6°	0.1	
6	*p*	2.3°	2.8+	2.1°	3.3*	2.7+	2.5+		0.28
		−1.8°	3.2*	−1.0	−3.1*	1.4	−2.3*	1.1	
7	*I*	2.6+	1.9	0.7	2.3°	11.4**	1.5+		0.49
		2.8*	−2.5*	0.1	1.2	4.6**	2.3+	−0.4	
8	*I*	1.9	2.3°	0.7	1.7	8.1**	0.8		0.51
		2.3+	−1.2	−0.5	1.2	3.5**	1.3	0.1	
9	*ℓdc*	1.8	0.3	1.9	55.6**	2.2°	2.0°		0.72
		2.3+	0.4	−0.5	6.6**	−1.7°	0.4	−0.2	
10	*ℓdc*	1.3	0.3	1.9	56.3**	2.2°	2.1°		0.72
		−1.8°	0.3	−0.5	6.7**	−1.5	0.1	−0.1	

[a]Sample period: 1886:2–1914:4. Degrees of freedom: 89.

[b]See table 12.1 for definitions of the variables and sources of the data.

[c]*F*-statistics on the first line and *t*-statistics on the second line for each equation. Significance at the 1/10 of 1% level is denoted by **; at the 1% level by *; at the 5% level by +; and at the 10% level by °.

When interest is included, the effects of the monetary and fiscal series are reduced (this resembles the results of some earlier studies; cf. Sims 1980a). When the leading index is also included, most of the monetary effects are further diminished.

3. In the interwar period, the role of money appears greater, and the fiscal and interest effects tend to wane. In the prewar (1886–1914) equations, output is influenced mainly by its own lagged values and those of the money stock and the interest rate. The other factors, including a diffusion index based on specific cycles in a large set of individual leading series, have no significant effects. However, this probably reflects errors in the data, especially the weakness of the available leading index.

4. The monetary, fiscal, and interest variables depend more on their own lagged values than on any of the other factors, and the same is true of inflation, except in 1886–1914. The opposite applies to the rates of change in output and (again, except in 1886–1914) the leading indexes. None of the variables in question can be considered exogenous.

5. The reported unit root tests are consistent with earlier findings that most macroeconomic time series are difference-stationary (see Nelson and Plosser 1982 on annual interwar and postwar data, and Stock and Watson 1987 on monthly postwar data). The major exceptions to this are the prewar and postwar fiscal and interest series.

Our work offers some suggestions for further research. The following steps at least should be considered:

(*a*) Construct a satisfactory composite index of leading indicators for the periods before World War II from the best available historical data.

(*b*) Compute variance decompositions and impulse response functions for alternative subsets of up to four variables represented by the quarterly series used in this paper.

(*c*) Do the same computations for larger sets of six variables by using monthly data. This would complement the results obtained here for individual equations in the same sets; further, it would permit comparisons with some recent smaller VAR models estimated on monthly data. The main problem with this approach is that no suitable monthly proxies for GNP may be found.

(*d*) Update the postwar series and check on predictions beyond the sample period, for example, for 1983–88.

(*e*) Try to find out where the explanatory or predictive power of the leading index is coming from by testing important subindexes relating to investment commitments, profitability, etc.

(*f*) Compare the implications of this paper with those of the most recent and ongoing studies of leading indicators (de Leeuw 1988, 1989; Stock and Watson 1988a, 1988b).