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THE INDEX OF LEADING INDICATORS: "MEASUREMENT WITHOUT THEORY," TWENTY-FIVE YEARS LATER

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ABSTRACT

The index of leading economic indicators first developed by the NBER remains a popular informal forecasting tool in spite of the original criticism that its use represents "measurement without theory." This paper seeks to evaluate the performance of the index in comparison to alternative time series methods in predicting business cycle behavior.

While the actual method of choosing the weights for the twelve series included in the index is essentially unnecessary (because the resulting series is indistinguishable from another with uniform weights) the series itself helps explain business cycle behavior, and outperforms an index with econometrically chosen weights.

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I. Introduction

If the success of a specific approach to economic analysis can be measured by its longevity and continued use under a variety of environments, then the use of the index of leading economic indicators, originally developed by researchers at the National Bureau of Economic Research (see Burns and Mitchell 1946 and Moore 1961) and now published by the U.S. Bureau of Economic Analysis for prognostication about the business cycle, must stand near the top (one might say peak) of the list of such successes. This is rather remarkable in light of the criticism under which it has been since Koopmans (1947) first decried the lack of any theory behind the NBER business cycle methodology. The use of leading indicators survived through the period of advancement and demise of the structural approach to econometric forecasting and, if anything, has enjoyed a resurgence in recent years as more sophisticated time series techniques of "measurement without theory" have been developed. In fact, the relationship between the leading indicator approach and general time series methods of the type described by Box and Jenkins (1970) was formalized by Sargent and Sims (1977), who pointed out that forecasting with a composite index may be seen as the imposition of a specific set of restrictions on the vector autoregression containing the individual series included in the index.

From this standpoint, it is possible to evaluate the index of leading indicators as a tool for prediction, and such is the purpose of this paper. There are a number of questions to be answered. Among them are:

(1) Is the index of leading indicators of significant value in the prediction of cyclical variables?

(2) Is the method used currently to construct the index optimal, in a statistical sense?

(3) Would a second index composed of the same individual series help further in predicting cyclical variables?

In short, can a logical justification be found for the continued popularity of the leading indicator approach, or should its appeal, like that of astrology, be ascribed to the desire for simple answers to questions for which no answers exist.

II. Methodology

One of the problems that existed until recently was that there was no objective way to evaluate the index of leading indicators. Much time was spent "scoring" the index and its component series in terms of how well they predicted business cycle turning points, but here arose the difficulty in determining just what these series were predicting. The common approach was to say that three successive drops in the monthly index signalled a turning point, but when was the turning point so predicted supposed to occur? Indeed, as Neftci (1978) has suggested, the whole emphasis on turning points, as opposed to behavior throughout the cycle, suggests the implicit view that the "model" which underlies the economy undergoes a discrete change when turning point occur. As this assumption seems rather restrictive and because of the difficulty in even defining a turning point, our analysis will use ordinary time series estimation techniques.

In general, we will be estimating regressions of the form

$$y_t = \alpha_0 + \alpha_j y_{t-j} + \dots + \alpha_k y_{t-k} + \beta_j x_{t-j} + \dots + \beta_k x_{t-k} + \varepsilon_t \qquad (1)$$

where y is the rate of change of the cyclical variable to be predicted (either the FRB index of industrial production, or the unemployment rate). x is the rate of change of the index which is used to help predict y, and j is the number of periods (months) ahead the prediction is being made. In various situations, x will either be set equal to the BEA composite index of twelve leading indicators, or chosen simultaneously with the estimation in (1) as a way of finding the optimal composition of the index using the same twelve series. We make no attempt to identify other series not included in the twelve which might provide additional help in predicting y.

Assuming y_t and x_t to be stationary time series, we may then apply the causality test of Granger (1969) to determine whether x "causes" y or, equivalently, whether the leading indicator is significant, in a statistical sense, in forecasting cyclical behavior. By allowing the joint, maximum likelihood determination of the vector of coefficients, $\underset{\sim}{\beta}$, and the weights $\underset{\sim}{\omega}$, of the twelve series making up the index x, we may determine how good the present method for choosing weights is. We may also test whether these weights should be the same for different lags, or whether some series are good for "near" prediction and others better for "far" prediction. An important general issue is whether various versions of equation (1) are stable over different sample periods, and how out of sample prediction compares to within sample fit. The well-known "Lucas critique" of prediction using estimates of structural models applies in principle to time series prediction as well. As long as relationships between independent and dependent variables are not invariant with respect to policy, within sample fits may be misleading. One argument in favor of the use of leading indicators in this context might be that the relationships estimated are of a more fundamental nature and hence less subject to instability due to policy changes. For example, one of the twelve series included[1] in the index of leading indicators is the number of new building permits for private housing. If one used this to predict housing starts a couple of months hence, it is hard to imagine any realistic government policy that could alter the relationship. While this type of relationship is difficult to posit for many of the other twelve series, it is conceivable that a useful purpose for the composite index could be found in prediction during an unstable policy environment.

Before turning to the actual estimation results, we describe briefly in the next section the data and methodology used by the BEA in its calculation of the index of leading indicators.

III. Data: Individual Series and the Composite Index

The selection of leading indicators was begun by Wesley Mitchell and Arthur Burns at the NBER in the 1930s. Since then, periodic reviews have been made with each new business cycle of the value of various individual series as predictors of general economic performance and the composition and weights of the most frequently cited of these series, the index of leading indicators, have been adjusted. The most recent revision was done in March 1979, when, at the time of introduction of the new money stock classifications, the obsolete M1 was dropped from the index and M2 was substituted in its place, with all twelve series having their respective weights adjusted. However, for two reasons, we shall work with the index as it existed until this last revision. First, several series, including the money stock, have been revised in such a way that comparison with corresponding series from earlier periods is difficult. Second, there has not been enough time since this revision to measure fairly the new index's out of sample performance. It would not be appropriate to truncate the estimation period at, say, the end of 1973 when we know that the chief reason for the substitution of M2 for M1 in the index is the erratic performance of M1 over recent years.

We thus rely on the series and corresponding version of the index developed most recently before 1979. As described in Zarnowitz and Boschan (1975), the twelve series and their weights were determined after evaluating the performance of many series over the period 1948-1970 with respect to the following six criteria:

(1) Economic significance

(2) Statistical adequacy (in describing the economic process in question)

(3) Timing at revivals and recessions

(4) Conformity to historical business cycles

(5) Smoothness

(6) Currency or timeliness (how promptly the statistics are available)

The series were given overall scores, and twelve with high scores chosen for the index, with an intentional inclusion of some series outside the "top twelve" for the purpose of diversified economic coverage. The twelve included series were then weighted by their scores in computing the overall index. Descriptions of these series and their weights are presented in Table 1. The weights are applied to percent changes[1] of the individual series, after these changes have been "standardized" by dividing by their mean absolute values over the period 1948-1975.[2] The resulting number is the percent change in the composite leading indicator. In the final step used to calculate the indicator actually reported, these changes are themselves standardized to make them have the same volatility as changes in the composite index of coincident indicators, and then cumulated to form the leading indicator index itself. For our purposes, the unstandardized composite changes will be sufficient.

Because the series weights vary so little (from .930 to 1.079), the index is basically the unweighted sum of the standardized versions of the original series. It is a little surprising that so much effort is expended in updating

Table 1

The Index of Leading Indicators:

Component Series

BEA Series #	Description	Weight
1	Average work week of production workers, manufacturing	.984
3	Layoff rate, manufacturing*	1.025
8	New orders, consumer goods and materials, 1972 dollars	1.065
12	Index of net business formation	.984
19	Index of stock prices (Standard and Poor)	1.079
20	Contracts and orders, plant and equipment, 1972 dollars	.971
29	Building permits, private housing	1.025
32	Vendor performance	.930
36	Change in inventories on hand and on order, 1972 dollars, smoothed	.957
92	Percent change in sensitive prices, smoothed**	.971
104	Percent change in total liquid assets, smoothed**	1.011
105	Money supply (M1), 1972 dollars	1.065

* Multiplied by -1.

** Smoothed series z_t equals the moving average $v_t + 2v_{t-1} + 2v_{t-2} + v_{t-3}$ in the raw series v_t.

series scores to recalculate the weights, as is done frequently, given that the weights never vary significantly from this pattern. It is hard to imagine that the series would behave very differently if equal weights were assigned. In fact, calculating the changes in the composite index using equal weights produces a time series that, for the sample period used in this paper, has a correlation with the actual series of changes in the composite index which is indistinguishable from 1.0 to at least three decimal places. Thus, whatever merit there is in using a composite index to smooth out fluctuations in individual series, the mechanism used to choose weights is essentially unnecessary. One would do as well by abandoning the seemingly complicated procedure and just adding up the series.

The series which we will attempt to predict are the Federal Reserve Board's Index of Industrial Production (JQ) and the unemployment rate for men and women over sixteen (RU). These variables are chosen because they are available monthly, have been used in previous studies, and while they both are associated with the business cycle, their timing is not identical. Thus, it will be possible to evaluate the leading indicators in prediction of different cyclical patterns.

IV. Predicting with the Leading Indicators

The first issue we shall explore is whether the index as constructed by BEA is helpful in predicting the unemployment rate and the FRB index or, equivalently, whether the vector $\underset{\sim}{\beta}$ in equation (1) is significantly different from zero for x set equal to the changes in the composite index. Such tests have been performed for the same two dependent variables and eleven of the twelve individual components of the composite index for the period 1948:1 to 1971:12 by Neftci (1979)[3], with the finding that only six of the eleven (series 1, 3, 8, 12, 20 and 32) helped predict (at the .05 level of significance) JQ, with the same six series being the only ones helpful in predictin RU. As these variables are all highly correlated, a test which includes them all at the same time would be valuable.

Equation (1) was estimated for each dependent variable with the composite index for the sample period 1949:6 to 1977:8[4] with the first and last lags j and k set equal to one and ten respectively.[5] Corresponding equations were estimated with $\underset{\sim}{\beta}$ set equal to zero, and the F statistics constructed using the sums of squared residuals from the constrained and unconstrained regressions. These results are displayed in Table 2 and show that changes in the index are clearly helpful in predicting changes in the cyclical variables.

Given that the index as a whole is useful in forecasting changes in RU and JQ, is it possible to construct an alternative index from the same twelve series that would perform significantly better, or are the equal weights fairly appropriate? The use of positive and roughly equal weights for the various series in constructing the index has been criticized in the past by several authors. For example, Hymans (1973) argued that some of the weights should be negative. He estimated the "appropriate" weights using a regression of the BEA's coincident index on the component series of the leading index, using only one lag from each series corresponding to the number of months by which that series was supposed to lead the business cycle. Finding some of the coefficients to be negative, he took this as evidence that the weights of these series should be negative. As the twelve series are highly correlated, it is not surprising that at least some would have negative coefficients in such a regression. However, it is unclear why one would use such an arbitray procedure to choose the weights of the index.

Table 2

Causality Tests of the Leading Indicator

Sample Period: 1949:6 - 1977:8

	RU	JQ
$SSR_{BEA\ index}$	.5811	.03427
$SSR_{No\ index}$	.6903	.04156
F(10,329)	5.21*	5.77*

* Significant at the .01 level
  (critical value = 2.32)

Following the terminology of Sargent and Sims, if we posit that there is some index composed of the twelve leading series which is useful in predicting the cyclical variables, then equation (1) in conjunction with the equation

$$x_t = \omega_1 s_{1t} + \omega_3 s_{3t} + \omega_8 s_{8t} + \ldots + \omega_{105} s_{105t} \tag{2}$$

(where s_{it} corresponds to the rate of change of series i as defined in Table 1) is an "observable index" model, and it is a straightforward procedure to jointly estimate the vectors $\underset{\sim}{\alpha}$, $\underset{\sim}{\beta}$ and $\underset{\sim}{\omega}$ in a constrained non-linear regression of y on the lagged values of itself and the twelve individual leading indicator series s_i. That is, we choose the weights in the index to maximize the predictive power of equation (1). This seems like a natural way of deriving the weights of the leading indicator, and will allow us to determine how much better we can do with the same data, and restriction to the use of a single index, than is accomplished using the BEA index.

Since one of the parameters in either $\underset{\sim}{\beta}$ or $\underset{\sim}{\omega}$ must be normalized, we set $\sum_i \omega_i = 12$ to keep the same order of magnitude for the weights in the indicator published by BEA and the one to be estimated. Table 3 presents the weights calculated from the joint estimation of equations (1) and (2) for the sample period 1949:6 - 1977:8 and (j,k) = (1, 10) for each of the dependent variables, RU and JQ. Using the sums of squared residuals from these regressions and those from the regressions using the BEA index, we may construct test statistics, which asymptotically approach a chi-squared distribution with eleven degrees of freedom, corresponding to the hypothesis that the BEA index weights are optimal.

These results are interesting for a number of reasons. First of all, they suggest that the equal weight index used by BEA can be significantly improved upon in predicting the unemployment rate (RU), while the same cannot

Table 3

Index Weights: Joint Estimation

Sample Period: 1949:6 - 1977:8

Independent Variable	Dependent Variable RU	Dependent Variable JQ
1	0.476	0.659
3	6.320	2.013
8	2.275	-2.568
12	1.924	1.352
19	0.721	1.205
20	0.766	1.854
29	-1.272	1.361
32	-1.839	-0.947
36	0.907	3.305
92	0.818	2.541
104	0.899	-0.003
105	0.005	1.226
$SSR_{1\text{-index}}$	.4939	.03242
$SSR_{\text{BEA index}}$ (from Table 2)	.5811	.03427
χ^2_{11}	55.12*	18.81

*Significant at the .01 level (critical value = 24.7) be said in the prediction of the FRB index. Second, there is no evidence the the weights optimal in predicting the two cyclical series are the same. Third, some of the weights derived from the regressions are negative, although only one series has a negative weight in both regressions.

Given this methodology for choosing the weights of the index, one might ask whether a significant gain in predictive power is to be gained by allowing there to be two indices, one used for predicting the near future and a second for more distant events. That is, if we rewrite equation (1) as

$$y_t = \alpha_0 + \alpha_j y_{t-j} + \ldots + \alpha_k y_{t-k} + \beta_j x^1_{t-j} + \ldots + \beta_\ell x^1_{t-\ell} + \beta_{\ell+1} x^2_{t-\ell-1} + \ldots + \beta_k x^2_{t-k} \tag{1'}$$

and estimate the weights $\underset{\sim}{\omega}^1$ and $\underset{\sim}{\omega}^2$ of two indices x^1 and x^2 jointly with $\underset{\sim}{\alpha}$ and $\underset{\sim}{\beta}$, will these two indices differ significantly? If they do, this will compromise one argument for using a single index, that it captures a single underlying factor driving the business cycle. The results of such "split-lag" estimation are reported in Table 4, with ℓ set equal to 5; series x^1 is used for lags 1 through 5, and series x^2 is used for lags 6 through 10. The test statistic using sums of squared residuals is asymptotically distributed as χ^2_{12}. Here, the constraints are rejected for prediction of the FRB index, but not for prediction of the unemployment rate. Thus, there is at best mixed evidence favoring the use of a single index.

One final question concerns the stability of the relationships estimated in this section. We have found that for at least one of the two cyclical variables being predicted, the sample fit can be significantly improved by using weights other than those used by the BEA. But how stable is this result? Table 5 reports the sums of squared residuals obtained by joint estimation of equations (1) and (2) separately for the two values of the sample period, and

Table 4

Split Lag Estimation

Sample Period: 1949:6 - 1977:8

Independent Variable	RU Index 1	RU Index 2	JQ Index 1	JQ Index 2
1	0.187	1.942	0.396	3.645
3	6.284	6.441	-1.102	0.649
8	2.072	1.701	1.356	-2.141
12	3.099	0.259	4.401	0.280
19	0.690	-1.870	2.214	-0.676
20	0.100	3.084	-1.419	4.767
29	-0.699	-2.751	1.325	0.886
32	-2.469	-3.298	2.099	-1.120
36	1.741	2.647	2.409	1.882
92	0.774	-1.331	-0.696	1.840
104	1.498	-1.200	0.858	-1.248
105	-1.278	6.380	0.158	3.237
$SSR_{2\text{-index}}$	.4688		.02995	
$SSR_{1\text{-index}}$ (from Table 3)	.4937		.03242	
χ^2_{12}	17.68		26.86*	

*Significant at the .01 level (critical value = 26.2)

Table 5

Stability Tests

Sum of Squared Residuals	Dependent Variable	
	RU	JQ
$\underset{\sim}{\omega}$ free		
49:6 - 63:7	.3276	.02210
63:8 - 77:8	.0899	.00593
Sum	.4175	.02803
49:6 - 77:8 (from Table 3)	.4939	.03242
χ^2_{32}	56.97*	49.32**
$\underset{\sim}{\omega}$ fixed		
49:6 - 63:7	.4168	.02620
63:8 - 77:8	.1133	.00709
Sum	.5301	.03329
49:6 - 77:8 (from Table 3)	.5811	.03427
χ^2_{21}	31.14	9.84

* Significant at the .01 level (critical values are 53.5 and 38.9, respectively)

**Significant at the .05 level (cricial values are 46.2 and 32.7, respectively) those corresponding to separate estimation of (1) using the BEA index. Again using the appropriate asymptotic χ^2 text, we reject the stability of both models in which $\underset{\sim}{\omega}$ is estimated, but accept stability in both cases for models using $\underset{\sim}{\omega}$ set at the BEA values. These results suggest that the goodness of fit of our estimates within the sample period may give misleading answers concerning the predictive power of the estimated index versus the BEA index. We therefore turn to evaluation of these measures in out-of-sample prediction.

V. Forecasting in a Recession

The 1974-75 recession was the worst during the postwar period, and few predictions were very accurate in forecasting its severity. Thus, shortening our estimation period to end before it and predicting out of sample should be instructive.

For each dependent variable, RU and JQ, we estimated equation (1) for the three assumptions about the composite index (no index, BEA index, estimated index) and for two sample periods, 1949:6 - 1973:10 and 1963:8 - 1973:10. The initial lag, j, is set equal to three, rather than one, since information lags must be recognized in evaluating out-of-sample performance. That is, it would be inappropriate to assess the predictive power of one step ahead forecasts when the explanatory variables are available after a one or two month lag.[6] (To maintain the same number of estimated lag coefficients, we set the final lag k equal to twelve). In Table 6 we present the root-mean-squared-error of prediction for each of these equations over the period 1973:11 - 1977:10 and various subsamples. For comparison, we also present the standard error of estimate for each of the equations.

For the entire four year prediction period, the equations estimated over the full sample all perform better than their counterparts estimated beginning

Table 6

Out of Sample Fit

Dependent Variable:	RU		JQ	
Estimation Period:	63:8-73:10	49:6-73:10	63:8-73:10	49:6-73:10
Model:				
No Leading Indicator				
SEE	.02807	.04761	.00680	.01189
RMSE:				
73:11-74:10	.03564	.03529	.00816	.00867
74:11-75:10	.06329	.06052	.02786	.02461
75:11-76:10	.01474	.01630	.00545	.00578
76:11-77:10	.02366	.02453	.00363	.00437
73:11-77:10	.03890	.03800	.01431	.01364
BEA Leading Indicator				
SEE	.02795	.04503	.00639	.01093
RMSE:				
73:11-74:10	.03690	.03043	.00634	.00639
74:11-75:10	.05514	.04542	.02200	.01758
75:11-76:10	.01907	.02212	.00874	.00683
76:11-77:10	.02259	.03107	.00307	.00324
73:11-77:10	.03632	.03317	.01235	.01009
Estimated Leading Indicator				
SEE	.02674	.04469	.00582	.01044
RMSE:				
73:11-74:10	.02985	.03471	.00865	.00699
74:11-75:10	.05715	.04552	.02396	.01878
75:11-76:10	.03138	.02727	.00917	.00643
76:11-77:10	.02998	.03273	.00352	.00599
73:11-77:10	.03886	.03568	.01365	.01094

in 1963:8, although the latter do better for certain subsamples, particularly the last year of prediction, 1976:11-1977:10. For the full sample estimates, an interesting result may be noted: use of the BEA index results in better prediction than a simple regression on own lagged values; moreover, it is also superior to the index chosen with "optimal" weights. (This outcome is even clearer when the half-sample estimates are used in prediction.) For the unemployment rate, the root mean squared error is smaller using the BEA index rather than the estimated index for each after the four twelve-month subperiods, despite the fact that a test of within sample fits (in Table 3) found the estimated index to be superior. For the FRB index, it is smaller for three of the four periods and only slightly larger for the fourth.

A second finding which is consonant with the notion that leading indicators should be most valuable in predicting turning points is that the prediction error in using the BEA index versus a simple autoregression is lower largely because of improved results during the first two years of the prediction period, 1973:11 - 1975:10, when the recession was unfolding.

While choosing the index weights statiscally does not appear to help in predicting future business cycle behavior, one still might suppose that a better leading indicator could be formed by simply dropping certain series that do not seem to be very helpful individually in predicting the unemployment rate or the FRB index. However, at least one simple test indicates that this is not so. An index was formed from the unweighted sum of the six series found by Neftci to help in explaining JQ and RU. This index proved inferior to the BEA index in out-of-sample prediction of both dependent variables. To summarize the results, the root mean squared error in predicting RU for the period 1973:11 - 1977:10 was .03647 and .03862 using late sample (63;8 - 73;10) and full sample (49:6 - 73:10) estimates, respectively, compared to .03632 and .03317 for the BEA index. In predicting JQ, the RMSEs were .01325 and .01189 using late and full sample estimates, compared to .01235 and .01009 for the BEA index.

VI. Conclusions

The aim of this paper has been to evaluate the BEA index of leading economic indicators. Our results may be summarized as follows:

(1) The method of choosing series for inclusion in the index has not been directly evaluated. However, the extensive effort devoted to assigning and updating weights for the series included in the index has no apparent purpose. The weights are always so close to being equal that simply assigning the series equal weights would have no distinguishable effect on the resulting index.

(2) Though previous work has found that only about half of the individual series were of significant help in predicting cyclical variables, the composite index itself is strongly significant.

(3) There is some evidence that a better within-sample fit can be obtained by allowing the index weights to be estimated jointly with the other coefficients in the constrained autoregression. The weights so obtained do not resemble closely those of the BEA index, and some are negative.

(4) The stability of equations using the estimated index is rejected, while

(5) Out-of-sample prediction suggests that the BEA index performs better than the estimated index, despite poorer within-sample fits.

(6) Simply excluding from the index those series which do not individually help explain business cycle variables worsens the performance of the BEA indicator in out-of-sample predictions.

These findings suggest that if there really is a single index underlying cyclical fluctuations, its identity in relation to the twelve component series of the BEA index is unstable over time. Thus, the equal-weight procedure serves to smooth out such shifts. Though this does not mean that better time series predictors cannot be found, it does suggest that, whatever the motivation of its creators, the index does serve a useful function.

Footnotes

1. For series 3, 32, 36, 92 and 104, first differences are used, as these series are already expressed as percentages.

2. The index weights and standardization factors are updated more frequently than the twelve series are determined. The weights and standardization factors reported here are from the Handbook of Cyclical Indicators.

3. All but series 104, the percent change in total liquid assets, smoothed, were studied. Also examined were several other individual series not included in the twelve making up the composite index.

4. This period was the longest one for which comparable data was available for all series.

5. The ten period lag was found after some experimentation to be sufficient in that coefficients for lags eleven and beyond were rarely significant.

6. An alternative method of allowing for this information lag would be to use the one-step-ahead forecasts based on estimated values of the yet unobserved explanatory variables with lags less than three. The two methods should yield approximately the same results.

References

Box, G. and G. Jenkins, 1970, Time Series Analysis, Forecasting and Control. (San Francisco: Holden Day).

Burns, A.F. and W.C. Mitchell, 1946, Measuring Business Cycles, (New York: NBER).

Granger, C., 1969, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," Econometrica, July, pp. 424-428.

Hymans, S., 1973, "On the Use of Leading Indicators to Predict Cyclical Turning Points," Brookings Papers on Economic Activity, 1973:2.

Koopmans, T., 1947, "Measurement Without Theory," Review of Economics and Statistics, August, pp. 161-172.

Moore, G.H., editor, 1961, Business Cycle Indicators (Princeton: Princeton University Press).

Neftci, S., 1978, "Optimal Prediction of Cyclical Downturns," mimeo.

Neftci, S., 1979, "Lead Lag Relations, Exogeneity and Prediction of Economic Time Series," Econometrica, January, pp. 104-113.

Sargent, T. and C. Sims, 1977, "Business Cycle Modeling Without Pretending to Have Too Much A Priori Economic Theory," in C. Sims et al., New Methods in Business Cycle Research: Proceedings from a Conference. (Minneapolis: Federal Reserve Bank of Minneapolis).

U.S. Department of Commerce, Bureau of Economic Analysis, 1977, Handbook of Cyclical Indicators, May.

Zarnowitz, V. and C. Boschen, 1975, "Cyclical Indicators: An Evaluation and New Leading Indexes," in U.S. Department of Commerce, Bureau of Economic Analysis, Business Conditions Digest, May. Reprinted in Handbook of Cyclical Indicators.