An Index of Leading Indicators for Inflation

Roy H. Webb and Tazewell S. Rowe

Macroeconomic forecasts attempt to provide useful information on aggregate economic conditions. A good forecast provides a user with specific information that allows him or her to make better decisions. A forecast, whether explicit or implicit, underlies a wide range of choices, such as consumer decisions on whether to spend or save, business decisions on investments in plant and equipment, and central bank actions affecting reserve supply.

No single approach to macroeconomic forecasting has dominated the others. Different users may require different types of information, leading to different forecasting methods. For example, researchers have proposed substantially different strategies for predicting the timing of an event, such as a recession, versus predicting the magnitude of a related statistic, such as the rate of real GDP growth. Probably most important, even the best forecasts lack precision. Macroeconomic forecasts usually have high average errors, but even the average size of errors can change substantially over time. It can therefore be difficult to distinguish a good forecasting method from a mediocre one.

One approach to forecasting is to construct a theoretical model, use it to identify the shocks affecting economic activity, and then use it for forecasting. But forecasters of inflation must confront the difficulty in modeling the interaction of real and nominal variables. No consensus has emerged among economists on the best way to model that interaction. The large macroeconomic models designed specifically for forecasting typically incorporate such ingredients as a Phillips Curve relationship between wage inflation and unemployment, and a backward-looking method for modeling how individuals form expectations. Many macroeconomists, however, do not believe that such relationships

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accurately reflect actual behavior. In the 1970s those models had large errors when predicting inflation, which is consistent with the critics' concerns.[1]

Another approach to forecasting involves using an explicit statistical model that requires little economic theory. A prime example of this "atheoretical" approach is the vector autoregressive (VAR) model. While that strategy has produced relatively accurate forecasts of real variables, it has also produced inflation forecasts that not only failed to be more accurate than the large models, but also were worse than a naive no-change forecasting method.[2]

This article takes a different approach to forecasting inflation. Like VAR models, it uses little explicit theory. Unlike the standard theoretical and atheoretical models, however, its primary contribution is not to predict the magnitude of future inflation, but rather to help recognize and predict major swings in inflation, based on an index of leading indicators for inflation (ILII). The article first presents background information on leading indicators, followed by a detailed account of the ILII's construction. The index's performance is then evaluated. Finally, that performance is related to the business cycle and the strategy of monetary policy.

1. WORK BY OTHER AUTHORS ON LEADING INDICATORS

The study of leading indicators of cyclical change was an important part of the pathbreaking studies of business cycles conducted by scholars associated with the National Bureau of Economic Research (NBER). This classic NBER approach is well represented by Burns and Mitchell (1946) and Moore (1961). That work has inspired more recent work such as that by Stock and Watson (1989).

The performance of traditional leading indicators has been mixed. The same, of course, can be said about every macroeconomic forecasting method. One problem is that the best-known index, the Commerce Department's Composite Index of Leading Indicators (CLI), does not have a precise meaning defined by economic or statistical theory. Any evaluation of that index must therefore begin with two key considerations: the objective of the CLI and a method for defining signals. The objective of predicting cyclical turning points is usually taken for granted, and perhaps the most common definition is that two or three successive declines signal an imminent recession.

Diebold and Rudebusch (1991) evaluated the three-decline rule and also a newer technique proposed by Neftci (1982) for using the index of leading

[1] Lucas and Sargent (1979) give a forceful statement of that view.

[2] McNees (1986) documents the poor performance of Robert Litterman's VAR inflation forecasts versus other forecasters. Webb (1995) documents the poor performance of many VAR forecasts of inflation in comparison to the naive no-change forecast.

indicators to predict cyclical changes. When using originally released data and the Neftci approach, they found at best a slight improvement over a simple rule of always predicting a constant probability of a turning point. They found no improvement for the three-decline rule when compared to the simple prediction. Their negative judgment was seconded by Koenig and Emery (1991). Niemira and Fredman (1991) found a more positive value for the index, possibly because they used revised values of the CLI instead of originally released data. Zarnowitz (1992a) presented another positive view of the leading index. Instead of using the usual three-decline rule, he used a multi-step rule that yielded a more complicated signal[3] of an approaching cyclical turning point. Despite their advocacy, this rule has not been widely used, although it continued to work well after they proposed it.

Responding to the lack of specific meaning of the Commerce Department's leading index, Stock and Watson (1989) proposed an index of leading indicators that has a well-defined meaning in a particular statistical model. First, they defined a coincident index as an estimate of the unobserved state of the economy, that is, as a measure that summarizes the economy's position in relation to the business cycle. They then constructed a leading index by predicting the value of the coincident index six months ahead. They were then able to calculate a recession index as the probability that the coincident index would decline over the next six months. In its first post-sample test, their index failed to predict or recognize the 1990 recession (Stock and Watson 1993).

A few authors have constructed leading indicators for inflation. Roth (1991) gives an initial assessment of their performance. Most prominent is a leading series constructed by Geoffrey Moore and his associates at the Center for International Business Cycle Research (CIBCR).[4] That series now includes seven constituent series, including a commodity price measure, the growth rate of total debt, and the ratio of employment to population. Roth found that the Moore index anticipated turning points in CPI inflation "quite well."

All of the leading indicator indexes mentioned above share an important characteristic: they are constructed as a weighted average of a fixed set of indicators. The weights and components, however, are subject to change at irregular intervals according to criteria that have not been specified in advance. An index can therefore be constructed to do well in a particular period under study, but when the economy changes, the index will need revision. Users are thus faced with the necessity of deciding whether a signal may have been produced by

[3] The complexity of the signal results from it having three parts at peaks and troughs. The first indication of a peak, labeled P1, is a long-leading signal that has produced several false positives. A first confirmation, labeled P2, has had only one false positive, in 1951, and has correctly anticipated or confirmed the eight peaks since then. The median P2 signal arrives two months following the peak. In addition, there is a second confirming signal labeled P3 that has had no false positives.

[4] See, for example, Klein (1986).

an out-of-date index that will be substantially revised in the near future. This is a particular problem for a leading indicator of inflation, since changes in monetary regimes may well change previous historical relationships.[5]

Sims (1989) proposed a solution for the problem of adapting an index to a changing economic environment. In his comments on the work of Stock and Watson (1989), he advocated using a model with time-varying coefficients, rather than the fixed coefficients they actually employed. In addition, he proposed performing their variable selection process annually. (Stock and Watson examined 280 series in order to select the 7 in their leading index.) Sims argued that because of abnormal events in the 1970s, Stock and Watson's index overemphasized interest rates, which affected estimates for the whole sample period. That large emphasis on interest rates did lead to the failure of their index to capture the 1990 recession, which in turn led them to propose an alternative leading index that omits the financial variables.

The index of leading indicators for inflation that we propose incorporates one of Sims's suggestions. Instead of relying on a fixed set of series that will probably be changed at an unspecified future date, we propose a strategy for each month selecting seven indicators from a much larger set of candidates. The following section explains that strategy in detail.[6]

2. CREATING AN INDEX OF LEADING INDICATORS OF INFLATION

To create an index of leading indicators of inflation (ILII), we initially specified a set of time series that might be included in the ILII. Potential indicators had to meet two criteria. First, each series had to be related to inflation in some plausible manner since we did not want to include any series that had a completely spurious correlation with inflation. Second, in order to construct an index that would be available promptly, we studied only potential indicators that would be available prior to the release of the monthly CPI figures. A notable example of a series that failed to meet the latter requirement is the capacity utilization rate.

Table A1 in the appendix lists the potential indicators used below. Series can be grouped into several broad categories, including money supply data, interest rates (studied as a leading indicator of inflation, for example, by Dasgupta and Lahiri [1991]), commodity prices (for example, see Boughton and

[5] For example, Webb (1995) found that two changes in the monetary regime account for the poor forecasting record for inflation rates of VAR models using postwar U.S. data.

[6] Another strategy for handling a changing relationship between indicators and inflation is sketched by Niemira and Klein (1994, pp. 383–88). Their prediction of inflation from seven leading indicator series is based on a neural network method, which was designed to be able to adapt over time to certain economic changes.

Branson [1991]), and labor market measures. Note that in some cases, one series is simply a transformation of another series, such as an interest rate and its difference over six months. Those cases resulted if we were unsure as to whether to remove a trend or how best to transform a nonstationary variable to a stationary one. There are 30 potential indicators, including different transformations of the same variable.

The second step was to create a strategy to select seven series for the index.[7] Rather than following the traditional approach and using a single set of inflation indicators for the entire sample, we developed a method for creating an index for which components could change frequently. The strategy was designed to use only information that would have been available to a "real time" user; that is, the index for January 1966 would be based only on data released by the middle of that month.

For each month from January 1958 to December 1994, the strategy was to select the seven candidate series that had the largest correlation coefficients with inflation. We measured inflation by the percentage change in the monthly level of the core CPI—that is, the CPI excluding food and energy prices—from its value 12 months earlier. We used the core CPI in order to focus on sustained inflation trends; the core CPI removes transitory changes in the CPI caused by movements in volatile food and energy prices.[8] In order to reflect current economic conditions, each correlation coefficient was calculated over the most recent 48-month period rather than using a longer sample. And to examine correlations with *future* inflation, we lagged each candidate series 12 months. For example, in January 1995 the latest inflation reading would be calculated from December 1993 to December 1994, and the latest observation of a candidate series *before* that inflation occurred would be December 1993. A correlation coefficient dated January 1995 would thus be computed between (1) inflation rates calculated using price levels from December 1989 to December 1994 and (2) a candidate series from December 1989 to December 1993.

At each date the seven selected series were then combined into a leading indicator index. First, each series was adjusted for differences in levels and volatility by subtracting the mean (computed over the previous 48 months) and dividing by its standard deviation (also calculated over the previous 48 months). To avoid undue influences from highly unusual events, such as the government's freeing the price of gold, each observation had a maximum absolute value of three (larger values were accordingly reduced). Unlike the procedure for

[7] Why seven? That seems to be a popular number that works reasonably well. Stock and Watson (1989) include seven series in their index of leading indicators for predicting the real economy. The CICBR index of leading indicators for predicting inflation has seven components, as does the index for predicting inflation described in Niemira and Klein (1994).

[8] Official data on the CPI excluding food and energy prices only extend back to 1959. For earlier data, we used the nonfood CPI.

producing the CLI for most of its history, the strategy employed here was to use equal weights for the series. Our index was simply the average of the seven transformed series.[9]

The graph of the resulting series, along with the 12-month change in the core CPI, is presented in Figure 1. The inflation series is dated so that an entry at date t is the percentage change in the core CPI from t to $t + 12$. Table A2 in the appendix shows how often the various series enter the index, and Table A3 contains the composition of the index at turning points of the inflation cycle.

3. PERFORMANCE OF THE INDEX OF LEADING INDICATORS OF INFLATION

Ex Post Qualitative Evaluation

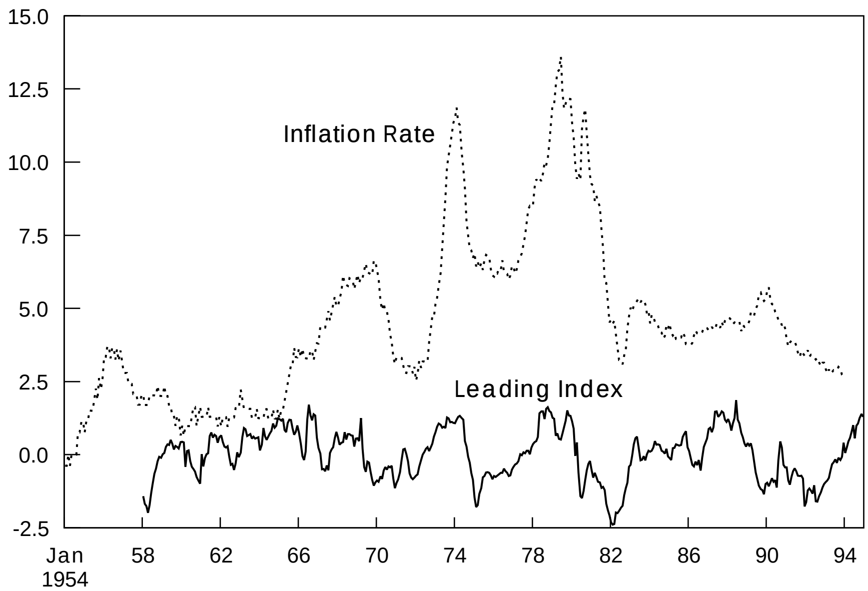
We experimented with the possibility of following Stock and Watson (1989) and constructing an index with an explicit statistical meaning, namely, the forecast of the core CPI from a bivariate VAR of the core CPI and the ILII. When such models are estimated for U.S. data over the last 30 years, however, the estimated coefficient on the first lagged value of the inflation rate in the price equation is always relatively large and tends to overshadow other terms. If one then uses that estimated equation for forecasting, it therefore tends to place such a large weight on recent inflation that the resulting forecasts are lagging indicators around turning points. Since the goal of the ILII is to promptly recognize or predict sustained and substantial changes in the inflation rate, the additional lag introduced by stating the index as a VAR forecast is unacceptable.

The ILII therefore needs a well-defined signal before its performance can be assessed. Figure 1 indicates that the ILII tends to promptly recognize substantial changes in inflation, although inevitably there are a lot of small fluctuations in the graph. In order to filter out small changes, we reduced to zero those values that had absolute values of less than one, thereby producing the series shown in Figure 2. A signal of rising inflation is thus a value greater than or equal to one, and a signal of declining inflation is a value less than or equal to minus one. An observation of at least one in absolute value will be referred to as a main signal.

The interpretation of observations with absolute values less than one is less obvious. We adopt the rule that a main signal is valid for up to 11 months if followed by absolute values less than one. Twelve months of such small readings, however, can be an early signal of a turning point. We define it as a signal if the ILII in the twelfth month is positive for a signal of rising inflation

[9] Although the weights on individual series are equal, it is possible for several closely related series to be included. The effective weight on commodity prices, for example, could be quite high. In Table A3, note that the index in November 1983 contained six commodity price series.

Figure 1 Core CPI and Leading Indicator Index

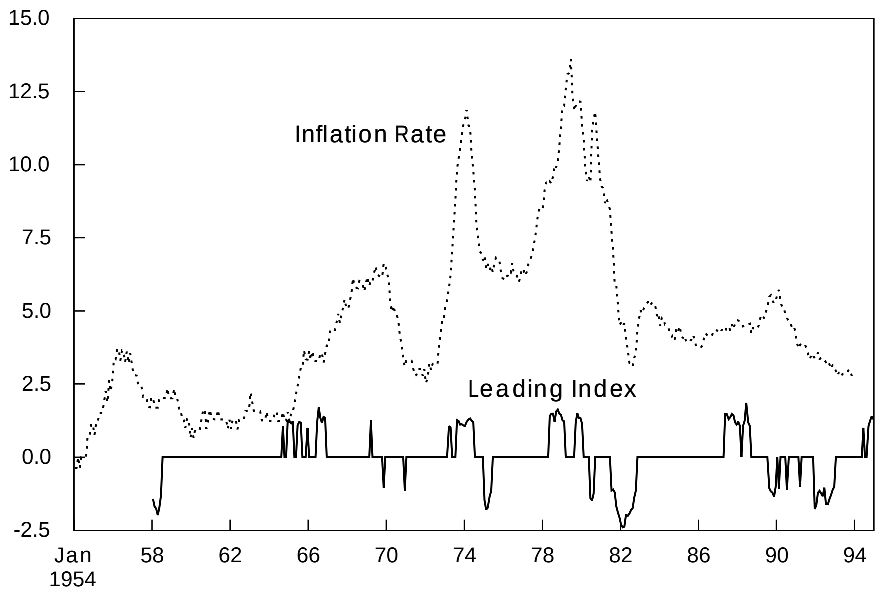


Note: The inflation rate is from t to $t + 12$.

(that is, in the neighborhood of a trough) or if the ILII is negative for a signal of falling inflation. An early signal remains valid until a main signal is received. As can be seen in Figure 2 or Table 1, in several instances there is no early signal of a turning point.

There is also no official dating of periods of substantial and sustained changes in the rate of inflation. Inspecting Figure 1 yields the following dates: peaks in March 1956, November 1969, February 1974, June 1979, and February 1990, and troughs in January 1962, January 1972, October 1976, August 1982, and possibly in December 1993. There is, of course, room for disagreement about particular dates. The hardest call was whether to define another peak and trough in the mid-1980s. Other authors, looking at slightly different data, have taken opposing sides. Roth (1989) argued that "[t]he eleven-month upturn in inflation beginning in March 1983 is most likely a statistical artifact" (p. 283). Moore (1991), however, found a peak in early 1984 and a trough in 1986. By looking at the 12-month forward rate of change of the core CPI, one can see that inflation reached a local minimum in August 1982 at 3.1 percent. It then rose to 5.3 percent in July 1983, which is a substantial change. However, it then fell to 4.2 percent by July 1984 and to 3.8 percent in November 1985. Thus the bulk of the increase was not sustained but rather was fairly quickly

Figure 2 Core CPI and Filtered Leading Indicator Index



Note: The inflation rate is from t to $t + 12$.

reversed. Accordingly, the 11-month upswing is not counted as a substantial and sustained increase in the rate of inflation.

Table 1 contains the resulting inflation signals from the ILII and compares them with peaks and troughs. The index is helpful in recognizing major changes in inflation rates, but often does not anticipate turning points; the median time for receiving the first signal is five months after the turning point. The 1990 peak is the only one that is clearly predicted, although the turn is recognized immediately at the November 1969 peak. If December 1993 or a nearby date turns out to be a trough, the ILII will have given a prompt signal; it is possible, however, that it will turn out to be a false signal. The worst performance is the 1982 trough, which is only recognized after 15 months. Other turning points are recognized within a year. Importantly, *no* false signals are generated[10] and no turning points are missed. In addition, although the ILII appears to recognize, not anticipate, the dates of major changes in the rate of inflation, Table 2 presents evidence that it does anticipate the bulk of the change in the inflation rate. The change in the inflation rate before a signal is no greater than 0.5

[10] A false signal would be one that is later reversed before a predicted peak or trough occurs.

Table 1 Turning-Point Signals from the Index of Leading Indicators of Inflation

Date of Turning Point	Early Signal	Main Signal	Lead (+) or Lag (−) from First Signal	Recognition Rule
Peak, March 1956 (April 1957)		Down, January 1958	na	November 1958
Trough, January 1962 (January 1963)	Up, June 1959	Up, September 1964	+31	January 1964
Peak, November 1969 (April 1970)		Down, November 1969	0	August 1971
Trough, January 1972 (January 1973)	Up, June 1972	Up, March 1973	−5	November 1973
Peak, February 1974 (October 1974)		Down, January 1975	−11	June 1975
Trough, October 1976 (December 1976)	Up, May 1977	Up, May 1978	−7	October 1978
Peak, June 1979 (April 1980)		Down, June 1980	−12	January 1981
Trough, August 1982 (March 1983)	Up, November 1983	Up, May 1987	−15	March 1984
Peak, February 1990 (August 1990)		Down, August 1989	6	February 1992
Trough? December 1993	Up, December 1993	Up, June 1994	0?	

Notes: The leading indicator series begins in January 1958 and ends in December 1994. Peaks and troughs correspond to the 12-month percentage change in the CPI excluding food and energy, as shown in Figures 1 and 2. (The dates in parentheses are peaks and troughs in the "6-month smoothed inflation rate" discussed in the text and footnote 11.) The inflation series begins in January 1954 and ends in December 1993 and represents the inflation rate from each date to 12 months ahead. The last trough, identified by the question mark, is tentative. The rightmost column presents the first date that a two percentage point change in the inflation rate from a previous turning point could have been observed.

Table 2 Inflation Rates Before and After Lagging Signals of Turning Points

Turning-Point Date	Inflation Rate, Previous Turning Point to First Signal	Inflation Rate at Next Turning Point	Anticipated Change	Unanticipated Change
January 1972	2.8	11.9	9.1	0.3
February 1974	11.8	6.0	5.8	0.1
October 1976	6.2	13.6	7.4	0.2
June 1979	13.6	3.1	10.5	0.0
August 1982	3.6	5.7	2.1	0.5

Notes: The table presents turning-point dates for which the first signal from the leading index occurred after a turning point. The first column lists turning-point dates at which a lagging signal of a turning point was given. The second column gives the annualized rate of change in the core CPI from the turning-point date to the date of the first signal given by the ILII. The third column gives the rate of inflation at the next turning point. The fourth column represents the change in inflation after a signal is received, calculated as the difference between column three and column two. The last column represents the change in inflation before a signal is received and is calculated as the difference between the inflation rate at the previous turning point and the value listed in column two.

percent, whereas the change after the signal is received ranges from 2.1 to 10.5 percent.

Although the format of Table 1 and Figure 2 may at first glance resemble those used by others who have evaluated leading indicators, such as Klein (1986), Moore (1991), and Roth (1991), there is a key difference. The other authors compare the value of a leading indicator with inflation calculated as the contemporaneous value's change from *lagged* values. Thus they are comparing an indicator with lagging inflation, a comparison that may not be relevant for actual use of a leading index. Our analysis compares the leading indicator with future inflation. The difference can be seen in Table 1, in which inflation is also calculated in the manner used by the other authors, and the resulting dates of turning points are displayed in parentheses. From those dates it would appear that the index has more predictive power than originally indicated, even though the ILII is unchanged. What has changed is the method of calculating inflation, which shifts the dates of turning points forward by a little over eight months, on average.[11]

Recognizing major swings in inflation is not always a simple exercise, as Cullison (1988) demonstrates. An example is 1972: inflation's low point was

[11] The alternative method of calculating inflation is referred to as the "6-month smoothed annual rate." It is calculated as the ratio of the current month's price index to the average index of the preceding 12 months and is converted to an annual rate by raising the ratio to the 12/6.5 power.

in January, and the ILII gives an early signal in June, lagging the change by five months. The following commentary on a well-regarded model's forecasts is recorded by Cullison:

> April, 1972: "The rate of price increase is expected to slow. . . . The anticipated slowing . . . reflects the large projected rise in real product and associated productivity gains."
>
> June, 1972: "The rise in the [GNP implicit price] deflator is expected to . . . moderate. . . . The expected moderation reflects a moderation in the rise in unit labor costs."
>
> May, 1973: "The projected slowdown in the rise in the private GNP fixed weight price index reflects primarily the anticipation that food price increases will slow sharply."[12]

As this example illustrates, having leading indicators that began to signal rising inflation in June 1972 could have been valuable to forecasters. Another comparison can be seen by using the rightmost column of Table 1, in which each entry denotes the first date at which one could observe a 200 basis point change in the inflation rate after a turning point. The ILII signals turning points much sooner than that simple rule.

While the index appears to perform well, that judgment is based on the same data that were used to construct the index; its actual performance will be revealed by new data. The apparent performance of the index undoubtedly could have been improved by a systematic search over parameters such as the number of series, the weights on each series, the magnitude of the main signal, or the number of months required for either a main signal or an early signal. The future performance of an index so constructed undoubtedly would deteriorate, however. We therefore picked obvious values that seemed to work well, but a caveat remains. Any choice that we made would have been rejected if it conflicted with the data. The proof of how well the index works must await new data that were not used to construct it. An additional caveat is that we used the latest revisions of data, not data as originally released. That fact should be less important for this index than for the Commerce Department's CLI, however, since most of the individual series employed in this paper are not revised by substantial amounts.

Simulated Forecasts

Another check on whether the ILII contains useful information is to test whether it adds predictive power to lagged values of inflation. To test for additional

[12] Cullison's quotations are from the Greenbook, prepared by the staff of the Board of Governors of the Federal Reserve System prior to meetings of the Federal Open Market Committee. Karamouzis and Lombra (1989) have conducted a thorough examination of the quality of these forecasts and have concluded that the forecasts were "state of the art" in comparison with other macroeconomic forecasts.

predictive power, we constructed a bivariate VAR for monthly percentage changes in the core CPI and the level of the ILII. We first set lag lengths in the VAR by minimizing the Akaike Information Criterion over each lag length in each equation, resulting in the following equations:

$$P_t = \beta_{10} + \sum_{i=1}^{9} \beta_{11,i} P_{t-i} + \beta_{12} \mathrm{ILII}_t + e_{1,t}, \tag{1}$$

$$\mathrm{ILII}_t = \beta_{20} + \sum_{i=1}^{2} \beta_{21,i} P_{t-i} + \sum_{i=1}^{3} \beta_{22,i} \mathrm{ILII}_{t-i} + e_{2,t}, \tag{2}$$

where P is the percentage change in the core CPI from the previous month, ILII is the index of leading indicators of inflation, β is the model's coefficients, and e is the error term. For comparison we also estimated a univariate autoregression for the core CPI, using nine lagged values. The equations were estimated starting in 1958:1 and ending in 1969:12, and out-of-sample forecasts were made up to 12 months ahead. One month was then added to the period, the equations were reestimated, and new forecasts were made. We repeated this process to create series of 12-month inflation forecasts for the period 1970:12 to 1994:12.

Forecast errors were calculated as the difference between actual inflation and forecasted values, and summary statistics were calculated. The root mean squared error for the univariate forecasts was 2.19; it fell to 1.96 for the bivariate forecasts. Comparing the two series of squared errors, we found the difference to be significant at the 1 percent level according to a test proposed by Diebold and Mariano (1991). We conclude that the index does contain information with significant predictive value beyond that contained in the inflation series itself. The size of the forecast error, however, is a reminder of substantial remaining uncertainty in forecasts from this method. For perspective, consider that in the post-1983 period the average 12-month change in the core CPI was 4.2 percent. Taking the root mean squared error as an approximation of the anticipated standard error of current forecasts, even a 70 percent confidence interval, ± 2 percent, includes a wide range of outcomes.

We also estimated equation (1) over the entire sample period. The average error was again significantly lower when the ILII was included, indicating that it significantly improved one-month forecasts of inflation.

4. WHY THE INDEX APPEARS TO WORK, AND WHAT COULD CHANGE

On the basis of experience in the United States and other industrial countries before 1913, Wesley Mitchell (1941) presented an account that describes a stylized business cycle. The behavior of prices played a key role in that account, as the following passages illustrate.

> A revival of activity, then, starts with this legacy from depression: a level of prices low in comparison with the prices of prosperity, drastic reductions in the cost of doing business [p. 150]. While the price level is often sagging slowly when a revival begins, the cumulative expansion in the physical volume of trade presently stops the fall and starts a rise [p. 151]. Like the increase in the physical volume of business, the rise in prices spreads rapidly; for every advance of quotations puts pressure upon someone to recoup himself by making a compensatory advance in the prices of what he has to sell. . . . Retail prices lag behind wholesale . . . and the prices of finished products [lag] behind the prices of their raw materials [p. 152]. [O]ptimism and rising prices both support each other and stimulate the growth of trade [p. 153]. Among the threatening stresses that gradually accumulate within the system of business during seasons of high prosperity is the slow but sure increase in the costs of doing business [p. 29]. The price of labor rises. . . . The prices of raw materials continue to rise faster on the average than the selling prices of products [p. 154]. [T]he advance of selling prices cannot be continued indefinitely . . . [because] the advance in the price level would ultimately be checked by the inadequacy of the quantity of money [p. 54]. [Once a downturn begins] with the contraction in trade goes a fall in prices [p. 160]. [T]he trend of fluctuations [in prices] continues downward for a considerable period. . . . [T]he lowest level of commodity prices is reached, not during the crisis, but toward the close of the subsequent depression, or even early in the final revival of business activity. The chief cause of this fall is the shrinkage in the demand for consumers' goods, raw materials, producers' supplies, and construction work [p. 134]. [E]very reduction in price facilitates, if it does not force, reductions in other prices [p. 160]. Once these various forces have set trade to expanding again, the increase proves cumulative, though for a time the pace of growth is kept slow by the continued sagging of prices [p. 162].

Zarnowitz (1992b) reviewed the literature and found that much of Mitchell's account has been consistent with cyclical data generated after he wrote it. There has been an important change, however. Under the gold standard there was little, if any, trend to the price level, and prices could fall in one phase of the business cycle and rise in another. In contrast, American monetary policy in the last 50 years has put in place an upward trend in prices. Thus, where Mitchell observed prices declining when cyclical contractions ended and expansions began, one now observes inflation being relatively low. Similarly, toward the end of expansions Mitchell saw price increases, but one now would see relatively high inflation.

Table 3 presents some evidence on this last point by looking at the behavior of inflation and other statistics over the business cycle. Expansions are divided into four segments of equal length, and contractions are divided into two equal segments. The inflation rate is calculated for each cycle, measured on a trough-to-trough basis. For each segment of the cycle, the average inflation rate for the cycle is subtracted from the inflation rate for that segment; the result is a relative inflation rate for each cyclical segment. The relative rates can then be averaged over the last seven business cycles in order to depict the average cyclical behavior of inflation. The picture is clear: inflation is low early in a cyclical expansion, is relatively high in the last quarter of expansion, and peaks in the first half of recessions. Inflation is therefore procyclical in the sense that its rate increases during expansions and declines during contractions. It is also a lagging indicator in the sense that its highest rate usually occurs after the cyclical peak and its lowest rate usually occurs after the cyclical trough.[13] The leading indicator series anticipates that behavior by peaking in the third quarter of a typical expansion and hitting its low point in the last half of recessions.

It therefore appears that the leading indicator index is capturing a regular feature of the business cycle. High-frequency changes in inflation, which are clearly not sustained, are ignored by design. Changes in inflation rates between business cycles are also excluded from the picture. What is left are cyclical movements that have been reliable and predictable. An individual indicator can be a useful predictor if it has a definite place in the sequence of events of a typical business cycle.

Consequently, this index has a reason for working and does not simply reflect a spurious correlation. It is designed to continue to work under certain changing conditions. If any particular indicator were to change its cyclical behavior, its correlation with inflation would diminish and it would not be included in the index. Similarly, adding new indicators would be straightforward. The one event that could drastically change the role of the index would be a substantial change in the strategy of monetary policy. After all, the shift from the gold standard to a fiat money system that involved a particular central bank strategy changed the cyclical behavior of prices to the cyclical behavior of inflation. A different monetary strategy might cause another dramatic change that could change the role of this index.

For example, imagine a monetary strategy that eliminated the trend in prices by keeping inflation rates small in magnitude and centered on zero. Without sustained and substantial changes in inflation, would the index have any purpose? Certainly the strategy of choosing indicators by past correlations with inflation would need replacing. For a closely related example, imagine a monetary strategy that eliminated large fluctuations in inflation by keeping it relatively low but positive. In that case, the index would be much more

[13] Some authors, such as Cooley and Ohanian (1991), have asserted that prices are countercyclical. By their definition, prices are countercyclical if there is a negative correlation between the level of prices and the level of output when the same statistical transformation is applied to both series. For example, in Table 3 there is a negative comovement between real GDP growth and inflation: during the segment of the business cycle where one series peaks, the other series reaches its lowest value. Their finding does not contradict the statement that inflation is procyclical, using the usual NBER definition for procyclical.

Table 3 Cyclical Behavior of Inflation and Other Series

Statistic	Expansion First Quarter	Expansion Second Quarter	Expansion Third Quarter	Expansion Fourth Quarter	Recession First Half	Recession Second Half
Core CPI	−0.40	−0.45	−0.53	1.66	2.09	0.90
CPI	−1.28	−0.90	0.15	2.14	2.21	0.91
PPI, Finished Goods	−1.57	−1.44	0.95	1.75	3.22	0.34
ILII	−0.21	0.02	0.51	0.28	−0.11	−0.85
Real GDP	3.55	2.42	0.43	−0.61	−6.10	−3.52

Notes: Entries for all statistics except the ILII are relative rates of change. Each is calculated by subtracting the average rate of change over each business cycle from the rate of change during each segment of the business cycle, and then averaging over all post-Korean War cycles (the core CPI begins with the business cycle trough of 1958). The ILII is the relative value, calculated by subtracting the average value over each business cycle from the average value in each segment and then averaging over the post-1960 business cycles.

valuable if it could give a third signal, stable inflation, in addition to signals of inflationary increases and decreases.

This latter possibility can be illustrated with the ILII. The following rule for a stable price signal is added in order to identify periods in which the index is low and stable. If the level of the index, the 12-month change in the index, and the 12-month average value of the index are all less than 0.3, then a stable inflation period is signaled. This signal overrides the early signal of a turning point and, in turn, is overridden by a main signal.

That rule gave two signals that identify the two major periods of stable inflation in the sample period. The first signal was in May 1960; the inflation rate was within a two percentage point range from April 1957 until June 1965, with the low point in February 1960 and the first main signal of an upswing occurring in September 1964. The second was in March, 1984; the inflation rate was within a two percentage point range from September 1982 until July 1989, with the first main signal of an upswing occurring in May 1987. Based on those two observations, it appears that the index can be adapted to recognizing periods of stable inflation as well as signaling major changes in the inflation rate.

5. CONCLUSION

We have proposed a strategy for constructing an index of leading indicators for inflation. The goal is to recognize or predict sustained and substantial changes in the rate of inflation. A notable feature of our strategy is that it allows the composition of the index to change over time in response to changing economic conditions.

Our evaluation of the index emphasized its link to future inflation rates. In contrast, other evaluations of inflation indicators have often looked at less relevant lagging inflation rates. Our index appears to have value recognizing, and sometimes predicting, major swings in inflation. Important to its possible use is the fact that no false signals were generated and no turning points were missed. In each case, the index allowed the bulk of the change in inflation rates to be anticipated. And although the index was not designed to forecast the magnitude of inflation, it did help lower the forecast error for inflation rates in a simple model.

The performance of the index was related to typical movements of inflation over the business cycle. Whereas inflation is a procyclical but lagging indicator, the leading index typically peaks in the middle of expansions and has its lowest value in the first half of recessions. While this cyclical behavior should be robust in many environments, a major change in the strategy of monetary policy could substantially change the value of such an index. We illustrated the possibility of using the index to recognize periods of stable inflation.

It should be emphasized that the same data were used to construct the index and evaluate its performance. Since out-of-sample data will give the best test of the index's usefulness, the performance of the index outside the sample period will be studied in future research.

APPENDIX: SERIES USED IN THE INDEX OF LEADING INDICATORS FOR INFLATION

The appendix lists the series used to create the index of leading indicators for inflation. Table A1 contains series originally provided by the following sources: the Bureau of Labor Statistics (BLS), the Board of Governors of the Federal Reserve System (FRB), the Federal Reserve Bank of St. Louis (FSL), the National Association of Purchasing Management (NAPM), *The Wall Street Journal* (WSJ), the *Journal of Commerce* (JOC), the Commodity Research Bureau (CRB), and the *Treasury Bulletin* (TB). Data used in this article were obtained from secondary sources. The starting date, either January 1954 or the first month for which the transformed series is available, is affected by data availability and the particular method used for detrending data. Detrending methods are denoted by superscripts.

Table A2 provides further information on the series, as well as how often the individual series are included in the seven-series index. All three labor utilization measures are included more frequently than any other series. The NAPM price index is the only other series included more than half the time. Table A3 gives the composition of the leading index at times of inflation turning-point signals. Again, the three labor utilization measures and the NAPM price index are included more frequently than other series.

Table A1 Candidates for the Index of Leading Indicators for Inflation

Mnemonic	Definition	Source	Series Start
Labor Utilization			
U[a]	Civilian unemployment rate	BLS	1954:1
EP[a]	Employment to population ratio	BLS	1954:1
HR[a]	Index of aggregate weekly hours	BLS	1954:1
Money and Interest Rates			
M1[b]	M1 money supply	FRB	1954:1
M2[b]	M2 money supply	FRB	1954:1
MB[b]	Monetary base	FSL	1954:1
RFF[c]	Federal funds rate	FRB	1954:8
RT10[c]	Ten-year Treasury bond rate	FRB	1954:1
RSP	RT10−RFF		1954:8
Commodity Prices			
PN	Commodity price diffusion index	NAPM	1954:1
PAU[d]	Price of gold, London fix	WSJ	1967:12
PO[d]	Producer price index, crude oil	BLS	1960:1
PJC[d]	Price index of industrial commodities	JOC	1954:1
PCS[e]	Spot price index	CRB	1981:12
PCF[d]	Futures price index	CRB	1970:7
PPIF[b]	Producer price index—finished goods	BLS	1974:7
PPII[b]	Producer price index—intermediate goods	BLS	1974:7
PPIC[b]	Producer price index—crude goods	BLS	1974:7
Other Indicators			
SUP	Supplier deliveries diffusion index	NAPM	1960:1
LD	Lead time for orders and materials	NAPM	1977:1
XD	Trade-weighted value of the dollar	FRB	1960:1
W[b]	Average hourly earnings	BLS	1968:7
FD[b]	Federal government debt	TB	1958:7

[a] Each value is the ratio of the current month to the five-year average ending in the previous month.

[b] Each value is the six-month difference of logarithms of the variable.

[c] The series is used both in level form and in the difference over six months.

[d] The series is used in two forms; one is detrended by the method described in footnote a, and the other is detrended by the method described in footnote b.

[e] Each value is the ratio of the current month to the one-year average ending in the previous month.

Table A2 Candidate Series Selected for Leading Indicator Index

Candidate Series	Number of Months Available	Number of Months Included	Percent
U	444	275	62
EP	444	307	69
HR	444	247	56
M1	444	86	19
M2	444	118	27
MB	444	93	21
RFF, level	437	191	44
RFF, difference	431	64	15
RT10, level	444	64	14
RT10, difference	444	103	23
RSP	437	60	14
PN	444	226	51
PAU*	318	87	27
PAU, difference	372	55	15
PO*	372	55	15
PO, difference	372	91	24
PJC*	444	193	43
PJC, difference	444	132	30
PCS*	104	45	43
PCS, difference	109	34	31
PCF*	193	58	30
PCF, difference	246	51	21
PPIF	198	11	6
PPII	198	82	42
PPIC	198	39	20
SUP	372	120	32
LD	168	47	28
XD	372	67	18
W	337	50	15
FD	390	57	15

* Ratio of the value of the variable divided by a trailing five-year average (one-year average for PCS).

Notes: The first column lists each candidate series (see Table A1 for more complete descriptions). The second column lists the maximum number of months each series could enter the ILII. The third column lists the number of months the mechanical method outlined in the text selected each series to enter the index. The fourth column shows the ratio of column 3 to column 2.

Table A3 Composition of Index of Leading Indicators of Inflation at Dates of Turning-Point Signals

Series	Jan 58	June 59	Nov 69	June 72	Jan 75	May 77	June 80	Nov 83	Aug 89	Dec 93	Total
U	+	+		+	+	+	+	+	+	+	9
EP	+	+		+	+	+	+			+	7
HR	+	+		+	+	+	+			+	7
M1			+								1
M2			+							+	2
MB											0
RFF		+			+						2
ΔRFF				+							1
RT10	+										1
ΔRT10	+	+		+							3
RSP			+								1
PN	+	+			+	+	+	+	+		7
PAU			+					+	+	+	4
ΔPAU			+								1
PO											0
ΔPO						+					1
PJC	+	+				+		+		+	5
ΔPJC				+			+				2
PCS									+		1
ΔPCS											0
PCF								+		+	2
ΔPCF					+			+			2
PPIF											0
PPII								+	+		2
PPIC							+		+		2
SUP				+	+	+	+		+		5
LD											0
XD											0
W			+								1
FD			+								1

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