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Leading inflation indicators for Greece

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Abstract

This paper investigates whether leading indicators of inflation can be found for the Greek economy since this can help identify turning points in inflation. This is of great importance for Greece since the prime concern of current monetary policy is to reduce inflation and to stabilise it at low levels so as to meet the relevant Maastricht criterion. The underlying assumption is that inflation, like output, is cyclical, with peaks and troughs defining clear inflation cycles. Using the methodology initially established by Burns and Mitchell (1946, Measuring Business Cycles, Columbia University Press) for identifying peaks and troughs in the business cycle, we develop individual leading indicators as well as composite indices for inflation. We also assess their usefulness in 'predicting' downswings and upswings of inflation. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Over recent years, attention in Europe and elsewhere has focused on the process of disinflation. A number of countries in the 1990s adopted direct inflation targeting as the monetary policy framework (e.g. the United Kingdom, New Zealand, Canada, Sweden and Norway), even if this was accompanied by an exchange rate target such as the ERM commitment by EU countries. Since the mid-1990s, the prime focus of macroeconomic policy in Greece has been on

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disinflation through an exchange rate target. The policy involved announcing a rate of depreciation of the drachma against the ECU that was less than the inflation differential between Greece and the other EU countries, and that was progressively reduced each year. In March 1998, the drachma began participating in ERM-I. It has participated in ERM-II since January 1999. The final goal of policy has, however, been disinflation and, since February 2000, its reduction to a level consistent with the Maastricht criterion.

Accompanying this focus on disinflation in Greece and elsewhere, there has been an increased interest in improving the methods of forecasting inflation behaviour. These methods are divided into several broad categories. Firstly, there are forecasts that emerge from structural models of the economy. Secondly, information on inflationary expectations (derived either indirectly from asset prices or directly via surveys) can be useful, provided agents do not make systematic errors. Thirdly, a judgmental approach is possible where various macroeconomic indicators are examined and assessed on the basis of past experience (ECB, 1999). The emphasis here is very much on 'rules of thumb'. Finally, more recently there has been a revival of interest in the leading indicator approach, which draws upon the methodology established by Burns and Mitchell (1946) and the recent compilation by Lahiri and Moore (1991) for identifying turning points in economic variables and their correlation with turning points in the business cycle. Attention has also focused on defining a composite leading-index. To a great extent this last method is similar to the third, with the difference that it seeks to systematically examine the relationship between inflation and various macroeconomic series and to build composite indicators by combining more than one series. The underlying assumption of this work is that inflation, like output, is cyclical, with peaks and troughs determining inflation cycles. Various macroeconomic series are examined for the extent to which they lead these cycles and hence provide a guide to future inflation. It is important to note at the outset that, unlike the other methods which aim at forecasting the *level* of future inflation, this last method allows only for *turning points* to be identified. Thus, it should be seen as complementary to the other methods of forecasting inflation behaviour[1].

The purpose of this paper was to develop leading indicators of inflation for Greece. In particular, we examined the predictive ability of some 20 macroeconomic series over the period 1954–1998, using monthly data. We combined the more useful series into a longer and a shorter leading indicator index and the performance of these indices is assessed over the period up until the end of 1998. We found that four variables (import prices, wholesale prices, money growth and world commodity prices) have an average lead-time of approximately 3 months and a

[1]One of the pioneering papers on cycles is Moore (1983). The leading indicator approach to inflation dates back to the 1980s and the work of Klein (1986). In the 1990s, a number of applications have been made not only on the USA but also on many European countries. See, for example, Roth (1991), Lahiri and Moore (1991), Garner (1995), Webb and Rowe (1995) for the USA; Bikker (1993) for the Netherlands; Artis et al. (1995) for the UK; Cabrero and Delrieu (1996) for Spain. More recently, Bikker and Kennedy (1999) present short- and long-term composite leading inflation indicators for seven EU countries.

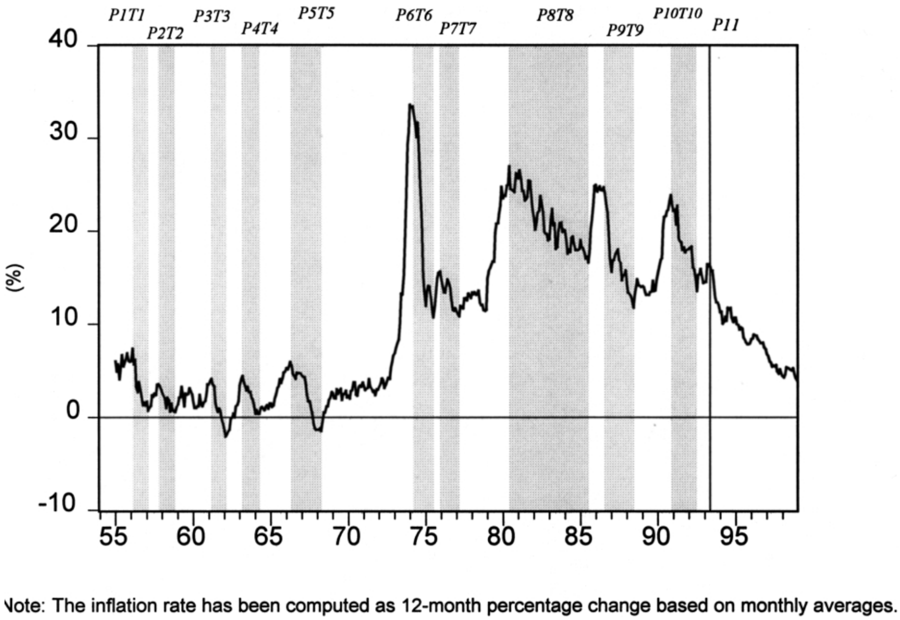

Fig. 1. The CPI inflation rate in Greece (1955–1998). *Note*: The inflation rate has been computed as 12-month percentage change based on monthly averages.

further two variables (retail sales volume and industrial production) have an average lead-time of approximately 14 months. Moreover, the indicators perform well in the sense that they miss only a few turning points and the extent to which they falsely signal is limited. We conclude that, barring structural breaks in the inflation-creating process, these series provide additional information that can assist in forecasting turning points in Greek inflation.

The remainder of the paper is organised as follows. Section 2 presents a turning point chronology for Greek inflation. Section 3 describes individual and composite leading indicators. Section 4 evaluates the performance of these indicators, namely their correlation with inflation's major swings and their ability to identify or even predict inflation turning points. Finally, Section 5 closes the paper.

2. A turning point chronology for Greek inflation

We used the 12-month rate of change of the consumer price index (CPI) as our measure of inflation and the sample period runs from January 1954 to December 1998[2]. Fig. 1 plots the series along with the cycles identified. Periods of declining

[2] Core CPI inflation, which is a smoother series and, thus, more conclusive for identifying true turning points, was not available for a long enough period to be used in this study. No smoothing was used on the reference series.

inflation are represented by the shaded areas and periods of rising inflation by the unshaded areas. Peaks and troughs are indicated by the left-hand and right-hand edge, respectively, of a particular shaded area. The identification of peaks and troughs confirms that inflation, like output[3], is cyclical. The criteria used to date the inflation cycles identified in Fig. 1 include those commonly found in the literature (see, for example, McNees, 1991; Roth, 1991; Artis et al., 1995):

- Criterion 1: peaks always follow troughs and troughs always follow peaks.
- Criterion 2: the turning point is the most extreme point between upswings and downswings.
- Criterion 3: the length of time over which the change from upswing to downswing (or vice versa) takes place is required to be at least 6 months.
- Criterion 4: the size of the change, namely the absolute difference between a trough and a peak point, cannot be smaller than 1.5 percentage points.
- Criterion 5: where there are two or more turning points with equal values, we select the most recent point.

Table 1 provides detailed information concerning the cycles identified on the basis of these criteria. The criteria are largely applied mechanically so as to avoid subjective judgements as far as possible. However, criteria 3 and 4 do provide some room for judgement to be used. With respect to criterion 3 and the minimum length required for upswings and downswings, we tested various minimum lengths, including 6, 9 and 12 months. Choosing a 9-month minimum cycle, two cycles are missed (1956–1957 and 1975–1976). Using a 12-month minimum cycle, another cycle between 1992 and 1993 is omitted. Since the amplitude of all these cycles is more than 1.5 percentage points, and therefore meet criterion 4, we would not wish to exclude them. Thus a 6-month rule was imposed in the identification procedure. Criteria 4 ensures that we did not identify as cycles essentially short-term fluctuations that would, for example, be absent from a series for core inflation. Despite the simplicity of the criteria used, Fig. 1 suggests that they capture the upswings and downswings in Greek CPI inflation very well.

Four features of the data reported in Table 1 are especially noteworthy. Firstly, over the period, 10 complete inflation cycles are identified. Secondly, there are differences in amplitude between the cycles. During downswings, inflation fell on average by 8.8 percentage points (pp), whereas, during upswings, it rose by 9.7 pp on average. Moreover, these averages hide quite a variance between different peaks and troughs. During expansions the absolute change varies from a low of 2.9 pp to a high of 35 pp; in contractions from a fall of 22.8 pp to 3 pp.

Thirdly, the duration of cycles also varies, and asymmetries between upswings and downswings are evident. Elements of asymmetry are evident in inflation cycles for other EU countries (Artis et al., 1995, on the UK; Bikker, 1993, on the Netherlands; Cabrero and Delrieu, 1996, on Spain). Downswings vary from 9 to 61

[3]On output cycles in the Greek economy using the Burns and Mitchell methodology, see Dogas (1992).

Table 1
Inflation[a] turning points, 1955–1998

Peak[b]			Trough[b]			Amplitude (% points)[c]		Duration (months)	
No.	Dating	Rate (%)	No.	Dating	Rate (%)	Contraction	Expansion	Contraction	Expansion
P1	1956/2	7.342	T1	1957/2	0.684	−6.658 (−0.555)	–	12	–
P2	1957/10	3.546	T2	1958/11	0.564	−2.982 (−0.229)	2.862 (0.358)	13	8
P3	1961/3	4.118	T3	1962/2	−2.083	−6.201 (−0.564)	3.554 (0.127)	11	28
P4	1963/3	4.415	T4	1964/4	0.367	−4.048 (−0.311)	6.498 (0.500)	13	13
P5	1966/4	5.914	T5	1968/4	−1.471	−7.385 (−0.308)	5.547 (0.231)	24	24
P6	1974/3	33.470	T6	1975/7	10.704	−22.766 (−1.423)	34.971 (0.492)	16	71
P7	1976/6	14.818	T7	1977/3	10.802	−4.016 (−0.446)	4.114 (0.374)	9	11
P8	1980/6	26.997	T8	1985/7	16.634	−10.363 (−0.135)	16.195 (0.415)	61	39
P9	1986/7	24.710	T9	1988/6	11.749	−12.961 (−0.564)	8.076 (0.673)	23	12
P10	1990/11	23.889	T10	1992/7	13.549	−10.340 (−0.517)	12.140 (0.419)	20	29
P11	1993/5	16.431					2.882 (0.288)	–	10
Average						−8.772 (−0.505)	9.684 (0.388)	20.2	24.5

[a] Inflation is expressed as 12-month percentage change in the seasonally unadjusted CPI (1994 = 100).
[b] For specifying peaks and troughs see the five criteria mentioned in the text.
[c] The average change computed as the mean absolute change over all months classified as periods of inflation contraction or expansion, appears in parentheses.

months; upswings from 8 to 71 months. Expansionary phases of inflation cycles lasted an average of 24.5 months, during which the average change in the inflation rate was 0.4 pp per month. Contractionary phases were a little shorter, lasting an average of 20 months. During these contractions, the inflation rate fell on average by 0.5 pp per month. The steepest fall in inflation (−1.4 pp per month) occurred between 1974 and 1975 when the government, in an attempt to control inflation (which had peaked at over 33% in the aftermath of the collapse of Bretton Woods, the first oil price shock and the return to democracy) imposed strict controls on wages and prices. The steepest rise (0.7 pp per month) occurred in 1986 following the devaluation of the drachma in October 1985. Finally, there is also a tendency for peaks and troughs to exhibit a seasonal pattern with the majority (6/10 troughs, 8/11 peaks) occurring in the first half of each year. This may reflect the fact that most changes in taxes and public utility prices occur at this time.

3. Leading indicators of inflation

Having presented a turning point chronology for our reference series, we were then interested in identifying leading indicators of inflation which could be used either on their own or in some combined index form to help predict turning points in inflation. Although our approach was largely statistical, economic theory did provide us with a host of candidate indicators that may, either directly or indirectly, influence the inflation process. Three broad categories of leading indicators are used in this paper. They are listed in Appendix A, Table A1. Firstly, there are those variables which reflect monetary conditions in the economy (money supplies and interest rates). Underlying the use of such variables is the view that, if inflation is essentially a monetary phenomenon, then monetary variables should be leading indicators. Thus, narrow money, broad money, credit measures and various interest rates have all been used. However, if some of these variables are used as policy variables, then their leading indicator characteristics will be greatly reduced. Assume, for example, that the central bank uses a short-term interest rate as its main tool of monetary policy. If the bank anticipates a rise in inflation, then it will tighten monetary policy now, that is, it will raise interest rates. If successful, inflation will not rise. At the limit, interest rate changes could smooth out all inflation cycles and this, of course, would imply no relationship between interest rates and inflation. Thus, it is expected that indicators which are also policy instruments, actively used to control inflation itself, will not prove to be successful predictors of inflation turning points. As Table A1 shows, we examined the leading indicator properties of the rate of growth of M0, M3 and M4, total credit expansion, along with the Bank of Greece's discount rate and the 12-month Treasury bill rate.

The second category includes price and cost variables. The argument here is that, assuming a constant mark-up, increases in input prices or the price of labour might be expected to be transmitted to output prices and hence CPI inflation (Clark, 1995). Candidate series include: rates of change of world commodity prices (Broch-Bloomberg and Harris, 1995; Garner, 1995; Webb and Rowe, 1995); energy prices; import prices (and hence the exchange rate); wholesale prices (and various components); raw material prices; wages; and unit labour costs (Bikker and Kennedy, 1999)[4]. However, it is important to remember that, theoretically, the relationship between these variables and output prices may be broken either if wage changes are offset by productivity changes or if the mark-up is not constant and firms, analogous with market conditions, use profits as a buffer against output price changes (Clark, 1995). Empirical studies using data for small open European economies indeed reveal that the mark-up is not constant (see Dombrecht and Moes, 1998, and Zonzilos, 1999, for Greece). Thus, a small increase in input prices may not lead to a one-for-one increase in output prices and hence the CPI.

[4] Unfortunately, there is no data available monthly on either wages or unit labour costs in Greece and hence we could not include those variables in our analysis.

The third main category is variables which reflect the relationship between aggregate demand and supply in the economy. To the extent that demand is approaching capacity output and still rising, so we might anticipate that this would lead to inflationary pressures in the future. In this respect, variables such as capacity utilisation and the output gap have been examined (Artis, et al., 1995; Webb and Rowe, 1995). The question of whether prices and output move counter-cyclically or procyclically is one which Bikker (1993) considers explicitly. He notes that whilst most theories would predict a positive relationship between prices and output, supply-side shocks are likely to cause countercyclical movements. An example of the latter is the oil price increase that caused both inflation and a downturn in economic activity. We have used industrial production and retail sales volume as measures of demand pressure. Additionally, conditions in the labour market, as measured by variables such as employment, vacancies and unemployment, can provide useful information not only on demand/supply conditions, but also on cost conditions (Klein, 1986). We have examined the information content of employment, anticipating that rising employment might signal increasing inflation[5].

Finally, variables reflecting inflation expectations may also provide information on future inflation. These come in the form of survey information, which provides direct measures of inflationary expectations (Roth, 1991; Bikker, 1993; Garner, 1995), or indirect measures extracted from asset price information. Since asset prices react quickly to new information and they are forward looking, it is argued that they are ideal candidates for leading indicators. Of course, one difficulty which arises is that information on inflation expectations has to be extracted from asset prices. For example, measures of the slope of the yield curve can, under certain assumptions, be interpreted as expectations of future inflation and have been used as leading indicators (Webb and Rowe, 1995; Cabrero and Delrieu, 1996; Baumgartner et al., 1997; Davis and Fagan, 1997). However, even if a satisfactory measure of inflationary expectations can be extracted, the forecast itself could be wrong, thus reducing the value of such measures as leading indicators[6].

4. How well do the indicators perform?

The first step in assessing the usefulness of a variable as a leading indicator is the identification of turning points for each candidate leading-indicator. To identify cycles for each indicator, we used precisely the same rules as employed in establishing the turning point chronology for CPI inflation. The turning points

[5] Again, productivity changes can break the relationship between employment, unit labour cost and prices.

[6] We did not test whether a measure of expectations derived from asset prices could be a useful leading indicator in the case of Greece. Brissimis and Gibson (1998), for example, find little information about future inflation in the slope of the yield curve.

were then compared with those for inflation. The ideal leading indicator would turn before inflation, it would lead inflation by the same number of months every time, and it would not generate any false signals (that is, forecast a turning point which does not then occur), nor miss any inflation turning points.

The 20 variables listed in Table A1 in Appendix A cover both real and nominal variables and hence encompass a wide range of data on the Greek economy. All series except interest rates are expressed as 12-month growth rates. Since a number of the series exhibit 'erratic' short-term fluctuations, we smoothed those affected by taking a moving average over a relatively small number of periods (less than 1 year). (See, for example, Artis et al., 1995; Webb and Rowe, 1995; Bikker and Kennedy, 1999). The 'erratic' movements, which are present in only 9 of the 20 variables, are identified by a simple inspection of the graphs of the variables. Details of the number of months used to calculate the moving averages and the series which were smoothed are noted in Table A1. The smoothed series were then graphed and their turning points identified.

4.1. Relationship between the indicators and inflation turning points

Of the 20 variables initially chosen as candidate leading indicators, only six were considered to provide some leading indicator information. The dating of the critical points could be done through a visual inspection and 'ad hoc' techniques are usually employed. However, it is preferable to impose objective criteria. Thus: (i) the potential indicator should lead inflation on average; (ii) it should also reflect minimal variance around the leading points; (iii) it should not miss inflation turning points or have extra points; and (iv) it should exhibit a high degree of accuracy in the sense of less dispersion and a large number of identified turning points. Based on these criteria, we rejected those series that had no clear turning points, or with turning points that did not generally precede inflation turning points, or that either missed too many inflation turning points or generated too many false signals.[7] Table 2 provides detailed information on the relationship between the six accepted indicators (industrial production, IP; import prices, IMP; world commodity prices, WCP; wholesale prices, WSPID; retail sales volume, RS; and M0 money supply) and the turning points in inflation. It can be noted that two of the six indicators describe the real economy, while the other four are nominal; together, they cover a range of the theoretical ideas discussed above. Figs. 2–7 illustrate movements in the six variables selected (smoothed where appropriate) and the shaded (unshaded) areas indicate inflation downswings (upswings). This allowed us to derive a picture of the extent to which each indicator leads inflation.

In general, the indicators lead inflation, as is evident from the predominance of minus signs. For example, M0 money growth rate turns one month before the inflation peak in March 1961, while industrial production has a trough 30 months

[7] By necessity, the decision about which series should be dropped is somewhat subjective, but we have no truly objective means of deciding how many missed inflation turning points or false signals are acceptable.

Table 2
Indicator correlation with inflation turning points (number of months that an indicator's turning point leads (−) or lags (+) an inflation turning point)[a]

Inflation turning points: peak (P), trough (T)	RS (1)	IP (2)	M0 (3)	WCP (4)	IMP (5)	WSPID (6)	SLI (7)	LLI (8)
P1 (1956/2)	NA	NA	+8	NA	NA	NA	+7	NA
T1 (1957/2)	NA	NA	+7	NA	NA	NA	M	NA
P2 (1957/10)	NA	NA	+11	NA	NA	NA	M	NA
T2 (1958/11)	NA	NA	+12	M	NA	NA	+12	NA
P3 (1961/3)	NA	−2	−1	−14	NA	NA	M	−2
T3 (1962/2)	NA	+4	0	−14	NA	NA	M	+4
P4 (1963/3)	NA	M	−3	M	NA	NA	−3	M
T4 (1964/4)	NA	M	−5	M	NA	NA	−8	M
P5 (1966/4)	M	−20	−17	+3	NA	NA	−17	−20
T5 (1968/4)	−9	−3	−12	−9	NA	0	+10	−5
P6 (1974/3)	−36	−4	−1	−7	−1	0	−1	−9
T6 (1975/7)	−8	−5	−11	−4	−1	+7	+6	−8
P7 (1976/6)	+10	+7	−11	+9	0	M	M	M
T7 (1977/3)	M	+11	−11	+12	+2	M	M	M
P8 (1980/6)	M	−12	−20	+11	+9	0	−4	−20
T8 (1985/7)	−34	−30	−17	−2	M	−31	−7	−33
P9 (1986/7)	−21	−6	−6	M	−7	−7	−7	−19
T9 (1988/6)	−18	−6	−3	M	−19	−16	−17	−16
P10 (1990/11)	−25	−24	−7	−29	−6	−1	−2	−26
T10 (1992/7)	−12	−15	−1	−31	M	M	−3	−14
P11 (1993/5)	M	−13	−1	+16	M	M	−5	M
No. extra turning points[b]	0	3	7	4	2	0	0	2
No. missing points	4	2	0	5	3	4	6	5
No. leading points/ turning points in inflation	8/13	12/17	17/21	8/18	6/11	7/12	11/21	11/17

Table 2 (*Continued*)

Inflation turning points: peak (P), trough (T)	RS (1)	IP (2)	M0 (3)	WCP (4)	IMP (5)	WSPID (6)	SLI (7)	LLI (8)
No. indicator's turning points	9	18	28	17	10	8	15	14
Average lead or lag (no. of months)								
All points	−17.0	−7.9	−4.2	−4.5	−2.9	−6.0	−2.6	−14.0
Peaks	−18.0	−9.2	−4.4	−1.6	−1.0	−2.0	−4.0	−16.0
Troughs	−16.2	−6.3	−4.1	−8.0	−6.0	−10.0	−1.0	−12.0
S.D. of leads and lags (no. of months)								
All points	13.5	10.9	8.8	14.4	7.6	11.3	8.3	10.1
Peaks	17.1	9.4	8.9	14.8	5.7	2.9	6.3	8.0
Troughs	9.6	12.3	8.6	13.0	9.3	14.7	9.9	11.4
Coefficient of accuracy (k)[c]	0.04	0.04	0.06	0.02	0.04	0.05	0.03	0.03

[a] M denotes that the turning point is missing, NA denotes that the turning point is not available.

[b] M0 money growth has extra points in 1969/7 (T), 1977/4 (P), 1978/3 (T), 1981/4 (T), 1982/10 (P), 1995/1 (T), 1997/9 (P); industrial production in 1966/2 (T), 1966/10 (P), 1993/9 (T); import prices in 1982/5 (T), 1997/2 (T); and world commodity prices in 1969/8 (P), 1971/11 (T), 1981/9 (T), 1983/10 (P). The LLI has two extra turning points in 1977/3 (P) and in 1978/2 (T).

[c] The coefficient of accuracy is defined as $k = (1/\sigma_i) \times (L_i^2/(T_{RF} \times T_i))$ $i = 1, \ldots, 20$ indicators, where σ_i is the standard deviation of i indicator, L_i and T_i are the number of leading points and the number of total turning points of each indicator, and T_{RF} is the number of turning points of the reference series. High values of k indicate a higher accuracy.

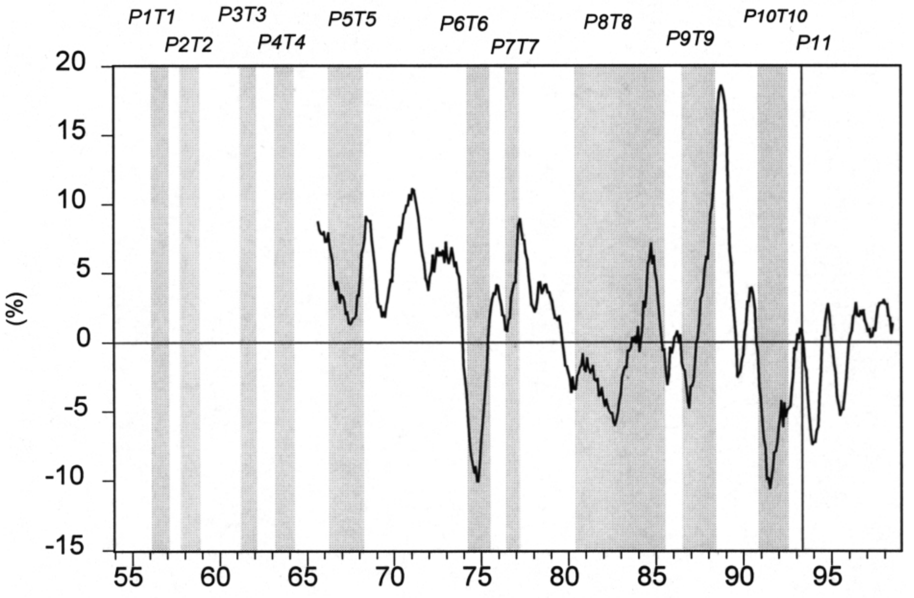

Fig. 2. Retail sales volume.

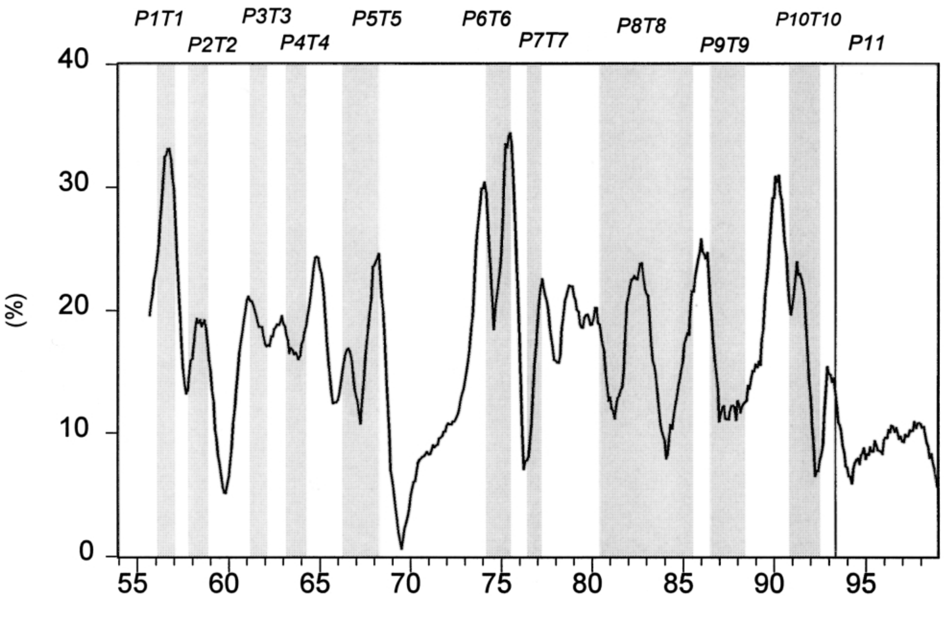

Fig. 3. Money growth.

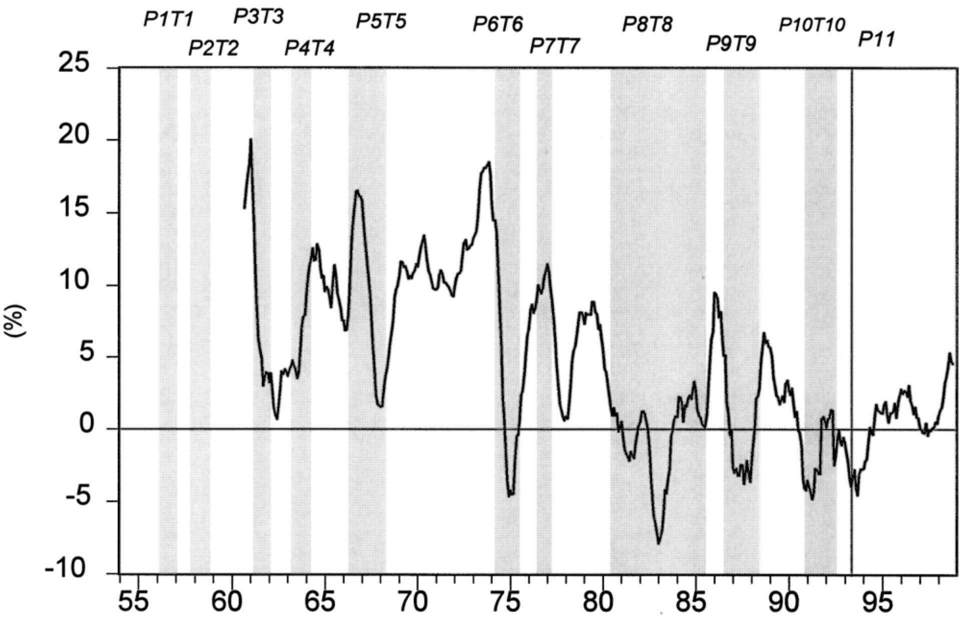

Fig. 4. Industrial production.

before the inflation trough in July 1985. All indicators, except money growth, miss two or more inflation turning points.[8] However, money growth has the highest incidence of false signals (predicting seven extra turning points which do not actually materialise). The indices of retail sales volume and wholesale prices, by contrast, have no false signals. Data in the lower half of Table 2 show the average number of months that an indicator leads (−) or lags (+) an inflation turn, as well as the standard deviation. For example, import prices lead CPI inflation by an average of 2.9 months, while the average lead of retail sales is 17 months.

The fairly high standard deviations show that these averages hide a considerable variation in the relationship between the turning points of each series and those of inflation. Import prices and money growth have the least variable lead-time, while retail sales volume and world commodity prices exhibit the highest variability. Such variability of lead-times is to be expected[9] and the implications for the usefulness of the indicator are clear: if the indicator signals a turning point, then although we may be quite sure that inflation will turn at some point in the future, we cannot be sure when.

[8] The index of wholesale prices of industrial goods misses four points, world commodity prices miss five points, the index of retail sales volume misses four points, the index of import prices misses three points and industrial production misses only two.

[9] These levels of variability in lead/lag times, along with the number of missing and false signals, compare favorably with those found for other countries (Artis et al., 1995, for the UK; Roth, 1991, for the US; Bikker, 1993, for the Netherlands; and Bikker and Kennedy, 1999, for seven EU countries).

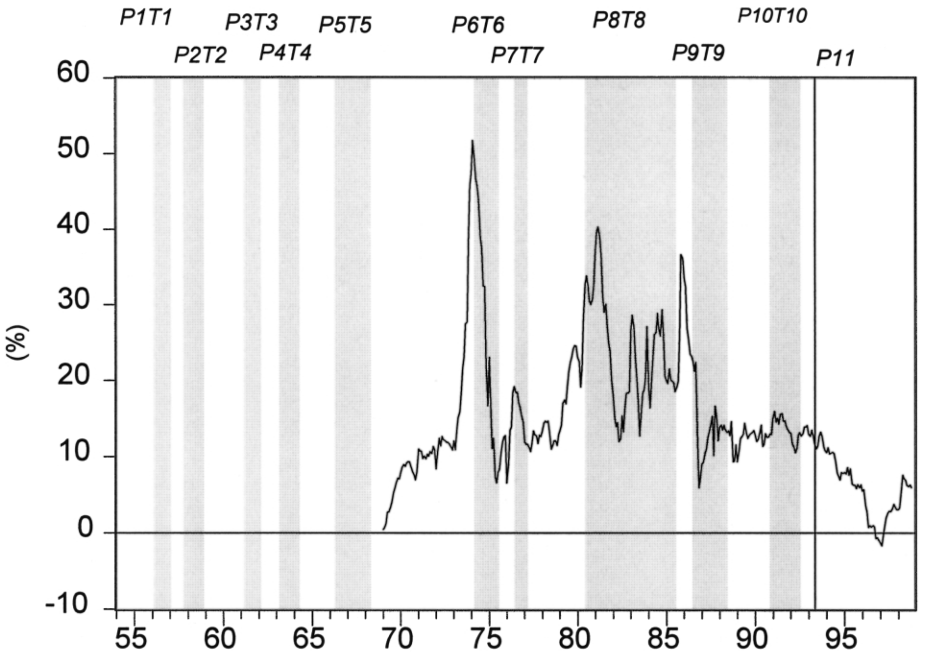

Fig. 5. Import prices.

4.2. Inflation turning points and composite indices

Based on the average duration of cycles, we could classify the individual indicators into two main groups. The first contains four variables, namely: money growth; wholesale prices; world commodity prices; and import prices, with shorter average lead-times (approx. 3–6 months). The second contains two variables with a longer average lead-time of approximately 8 and 17 months (industrial production and retail sales volume). These two groups of variables allowed us to construct two leading indices of CPI inflation: a shorter (SLI), and a longer (LLI), by combining the individual indicators.

The variables chosen for our composite indices were similar to those which have been found useful in research on other countries. In particular, Klein (1986), Bikker (1993), Artis et al. (1995) and Bikker and Kennedy (1999) find that producer prices, commodity prices and import prices are all useful additions to a composite leading indicator for a number of other EU countries. These variables are also present in composite indices for the US (Klein, 1986; Roth, 1991; Garner, 1995). Like Artis et al. (1995) for the UK, we also included M0 (in the SLI) and retail sales volume and industrial production (in the LLI). Unlike other work, however, we found no role for interest rates (Bikker and Kennedy, 1999, for 7 EU countries), the exchange rate (Roth, 1991; Garner, 1995, on the US), or employment (Klein, 1986).

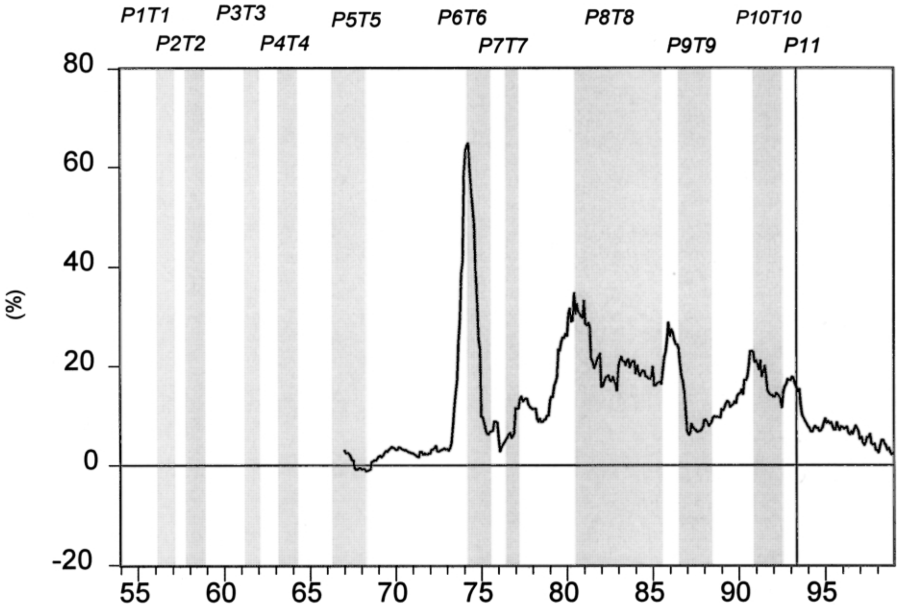

Fig. 6. Wholesale prices of industrial goods.

The first step in capturing the composite indices involved adjusting each series for differences in levels and volatility by subtracting its mean and dividing by its

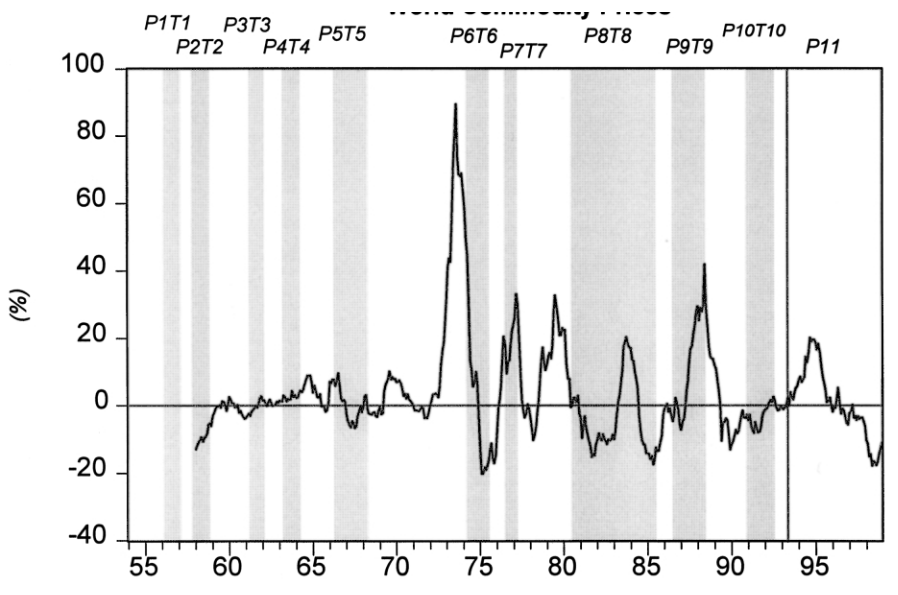

Fig. 7. World commodity prices.

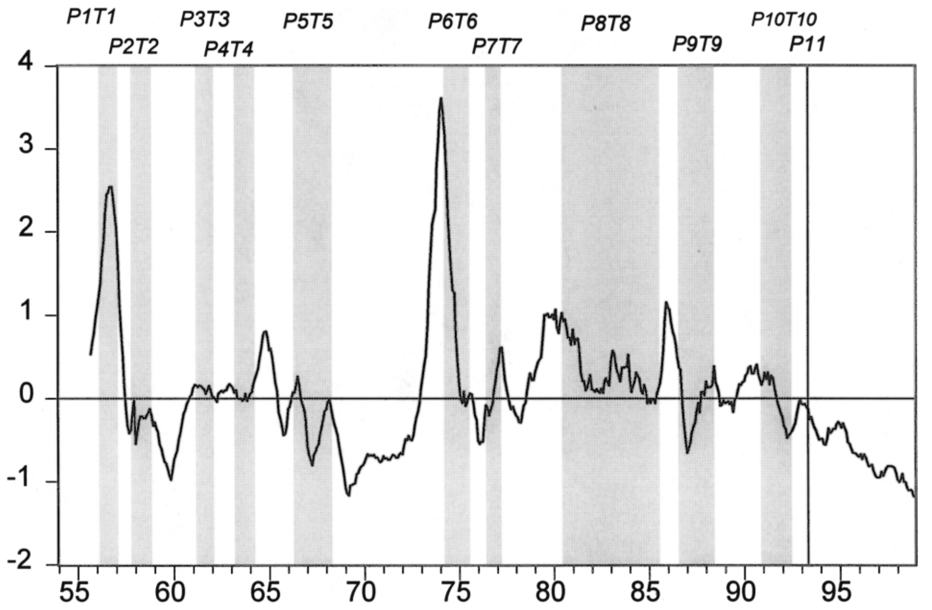

Fig. 8. The shorter leading inflation indicator.

standard deviation. The variables were then averaged using equal weights. Of course, the idea behind a composite index is that its performance may be superior to that of individual series since idiosyncratic movements are averaged out. Table 2 and Figs. 8 and 9 provide the results and a number of points can be made.

Firstly, as can be seen from Table 2 (columns 7 and 8), the high proportion of minus signs confirms that the indicators generally turn before inflation. The average lead-time of the shorter indicator index over the whole period is 3 months, while that of the longer leading indicator index is 14 months. Secondly, for both composite indices, the mean lead for inflation peaks (4 months for SLI and 16 months for LLI) is greater than for troughs (1 month for SLI and 12 months for LLI). Thirdly, the SLI is less volatile than the LLI (S.D.: 8.3 vs. 10.1), although the volatility of neither index is very different from the volatility of the individual components. Thus, the gain from constructing a composite index is reduced. Finally, the composite indices perform better than the individual series with respect to false signalling: the composite SLI does not signal falsely, while the LLI signals falsely twice. However, both composite indices miss inflation turning points; SLI misses six points and the LLI five points.

4.3. Signalling inflation turning points

Comparing turning points for the indicator series or indices with those of inflation provides some information on the performance of the indicator in the form of missing turns and false signals. However, this information is based on an ex

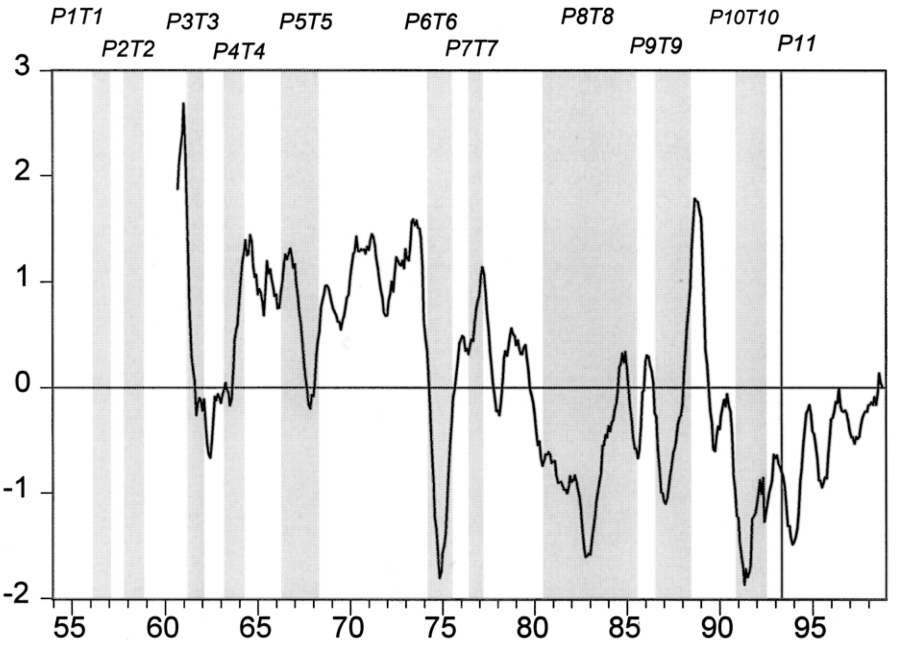

Fig. 9. The longer leading inflation indicator.

post evaluation of the turning points of the indicator series. A tougher test of the ability of an indicator to predict upturns and downturns in inflation would involve devising rules for identifying turning points in the indicator's cycle, applying those rules to the sample period, and then comparing predictions from the rules with actual turning points in inflation.

We used a simple rule that has been used with much success in the business cycle literature (Diebold and Rudebusch, 1989). The rule is defined as follows. If the indicator (I) has been increasing for three consecutive periods up to and including period t, and if the previous regime is a downswing, then a trough is signalled at time t. By contrast, if the indicator has been falling for three consecutive periods up to and including period t, and if the previous regime is an upswing, then a peak is signalled at time t. More formally, this rule (the so-called 3CD rule) can be expressed as follows[10]:

1. If $\Delta I_{t-i} > 0$, $\forall i = 0, 1, 2$ and the previous regime is a downswing, then I signals at time t that a trough occurred.

[10] Of course, there is a substantial literature on such rules. In this paper, we employed only the 3CD rule. Even though this is largely 'mechanical' and thus, it likely suffers from the problem of false signals (see Artis et al., 1995), it has the advantage of being very simple and clear-cut. We did not employ the Neftci (1984) approach because it is based on the assumption that the series are random walks. This assumption seems to be inappropriate in the case of growth rates since the variables in question are expressed in 12-month growth rates and are stationary.

Table 3
Turning points signals from the SLI and LLI of CPI inflation[a]

Inflation turning points Column (1) Peak (P); trough (T)	Signal Column (2)[b]		Lead (−), lag (+) (no. months) Column (3)[c]	
	SLI	LLI	SLI	LLI
P1: 1956/2	M	NA		
T1: 1957/2	M	NA		
P2: 1957/10	56/11, down	NA	−11	
T2: 1958/11	58/8, up	NA	−3	
P3: 1961/3		61/2, down		−1
T3: 1962/2	M	M		
P4: 1963/3	63/1, down	63/5, down	−2	+2
T4: 1964/4	63/12, up	63/8, up	−4	−8
P5: 1966/4		M		
T5: 1968/4	67/5,up	68/2, up	−11	−2
P6: 1974/3	74/3, down	73/9, down	0	−6
T6: 1975/7	75/6, up	74/12, up	−1	−7
P7: 1976/6	M	76/3, down		−3
T7: 1977/3	76/9, up	76/10, up	−6	−5
P8: 1980/6	80/9, down	79/8, down	+3	−10
T8: 1985/7	85/6, up	85/9, up	−1	+2
P9: 1986/7	86/1, down	86/3, down	−6	−4
T9: 1988/6	88/3, up	87/3, up	−3	−15
P10: 1990/11	90/10, down	90/7, down	−1	−4
T10: 1992/7	92/5, up	92/7, up	−2	0
P11:1993/5	93/1, down	93/3, down	−4	−2
No. of false signals	3	0		
	59/12, up			
	65/11, up			
	72/8, up			
Average lead time				
All points			−3.5	−4.2
Peaks			−3.0	−3.5
Troughs			−3.9	−5.0

[a]The table contains inflation signals based on the 3-month consecutive decline rule (3CD rule).
[b]Column (2) shows the dates of inflation turning points signals.
[c]Column 3 indicates the number of months by which the signal leads (−) or lags (+).

2. If $\Delta I_{t-i} < 0, \forall i = 0, 1, 2$ and the previous regime is an upswing, then I signals at time t that a peak occurred.

Table 3 presents the results of applying this rule to the shorter and longer leading indicators. The first column lists the turning points of inflation. In the second column, the dates of the turning point signals for each indicator (SLI and LLI), based on the 3CD rule, are presented, along with the direction the indicator takes: ‘down’ indicates that a peak is signalled; and ‘up’ indicates that a trough is

signalled. Finally, column 3 shows the number of months between the signal and the inflation turning point. It can be noted that both composite leading indicators not only identify, but also generally anticipate, the dates of the major turning points in inflation. The former point is supported by the relatively small number of missing signals[11]; the latter by the dominance of minus signs in column 3. The mean lead-time is 3.5 months for the SLI and 4.2 months for the LLI. The average lead for the LLI is 5.0 months at troughs and only 3.5 months at peaks, implying that inflation peaks are slightly more difficult to predict. However, the picture is reversed when we use the SLI: it predicts peaks and troughs with the same difficulty, since the average lead of downswings and upswings is almost the same (3.0 months at peaks and 3.9 months at troughs).

The LLI does not falsely signal an inflation turning point, while SLI generates three false signals. It falsely anticipates a trough in December 1959, while inflation peaks at March 1961. Similarly, it fails to signal the inflation peak in April 1966; it also falsely anticipates a trough in August 1972, while inflation peaks at March 1973.

4.4. Simulated forecasts

A more formal way of evaluating the predictive power of leading inflation indicators is to measure how well they perform in estimated inflation equations. It should be recalled in evaluating these tests that the indicator is designed to predict *turning points* and obviously this limits its role in an equation which models the *level* of inflation. Nonetheless, by using Granger causality tests, we investigated whether past values of the indicators explain inflation better than past values of inflation per se (see also Roth, 1991; Bikker and Kennedy, 1999). To do this, we estimated a bivariate vector auto-regressive model for monthly percentage changes in the CPI and the level of the SLI and LLI. Statistics that test for the lag length result in the following model specification[12]:

$$\pi_t = b_{10} + \sum_{i=1}^{12} b_{11,i}\, \pi_{t-i} + \sum_{i=1}^{12} b_{12,i}\, \mathrm{I}_{t-i} + \mathrm{u}_{1t} \tag{1}$$

$$\mathrm{I}_t = b_{20} + \sum_{i=1}^{12} b_{21,i}\, \pi_{t-i} + \sum_{i=1}^{12} b_{22,i}\, \mathrm{I}_{t-i} + \mathrm{u}_{2t} \tag{2}$$

where π is CPI inflation, I is the leading indicator (SLI or LLI), and u_1 and u_2 are serially uncorrelated random errors.

The null hypothesis to be tested was H_0: $b_{12,i} = 0$, $\forall i = 1,\ldots,12$. The test was

[11] The SLI misses four turning points (P1, T1, T3 and P7); the LLI misses only two points (T3 and P5). However, we should note that the LLI is over a shorter sample period.

[12] We used the Akaike Information Criterion, the Schwarz Criterion and the log-likelihood test. In the case of the SLI, all 3 indicate a lag of 12; for the LLI, 2 out of 3.

Table 4
Testing the indicators' ability to explain inflation

Statistics[a]	SLI	LLI
Wald test[b]	$X^2_{(12)} = 35.943$ (21.0) [0.000]	$X^2_{(12)} = 37.636$ (21.0) [0.000]
F-statistic[c]	$F_{(12,483)} = 4.723$ (1.75) [0.000]	$F_{(12, 422)} = 8.071$ (1.75) [0.000]

[a] Critical values at 5% are presented in parentheses and P-values in square brackets below the value of the tests.

[b] The Wald test measures how close the unrestricted estimates come to satisfy the restrictions under the null hypothesis.

[c] The F-statistic compares the residual sum of squares computed with and without the restrictions imposed. Small values of both tests imply that the restrictions cannot be rejected. The series are stationary at 1% and 10% Mackinnon critical values.

carried out by estimating Eq. (1) by ordinary least squares, initially unconstrained and then by imposing the constraint that all $b_{12,i}$ equal zero. The results are presented in Table 4. Looking at the SLI, both the Wald test and the F-statistic reject the null hypothesis (at the 1% and 5% level of significance, respectively), implying that the SLI does help in explaining inflation. Similar results are found for the LLI.

An alternative way of testing whether the composite indicators add predictive power to lagged values of inflation was to calculate the forecast errors from the simple bivariate model and compare them with those derived from a univariate autoregression for the CPI. More specifically, three different formulations were used. First, the regressions were estimated until end-1979[13] and out-of-sample forecasts were made up to 12 months ahead. We then added 12 months to the sample period, re-estimated the equations and made new 12-month forecasts. We continued this process until end-1998, creating a time series of monthly data for inflation forecasts starting in January 1980 and ending in December 1998[14]. Secondly, we made out-of-sample forecasts by estimating the regressions up to end-1979. Finally, we estimated regressions over the entire sample period and compared actual and forecasted values of inflation. In all three cases, the forecast errors were calculated as the difference between forecasted and actual inflation and forecast error statistics were computed.

[13] This date was chosen both here and later for the out-of-sample forecasts simply to give us enough observations on which to run an initial regression. The results are not sensitive to this choice.

[14] This forecasting procedure allowed us to take into account the effects from any policy regime switches on the structural parameters of the models. Of course, because we added observations each time, the efficiency of the estimates improved.

Table 5
Testing the indicators' predictive power

Statistics	Bivariate forecasts		Univariate forecasts	Forecast encompassing test	
	SLI	LLI		SLI	LLI
OOS[a] 12-month ahead forecasts (1980.1–1998.12)					
RMSE[b]	2.230	3.133	3.340		
Theil inequality coefficient	0.065	0.092	0.097		
Wald test $X^2_{(2)}$					
H_0: $\gamma_0 = \gamma_2 = 0$				5.175 (0.0168)	8.196 (0.0166)
H_0: $\gamma'_0 = \gamma'_2 = 0$				104.691 (0.000)	9.304 (0.0165)
OOS forecasts based on equations for period up to 1979.12					
RMSE	3.724	4.891	7.870		
Theil inequality coefficient	0.116	0.129	0.276		
Wald test $X^2_{(2)}$					
H_0: $\gamma_0 = \gamma_2 = 0$[c]				39.512 (0.000)	116.303 (0.000)
H_0: $\gamma'_0 = \gamma'_2 = 0$				259.395 (0.000)	165.811 (0.000)
In-sample forecasts (actual minus predicted)					
RMSE	3.351	4.334	4.731		
Theil inequality coefficient	0.104	0.146	0.149		
Wald test $X^2_{(2)}$					
H_0: $\gamma_0 = \gamma_2 = 0$				83.209 (0.000)	93.353 (0.000)
H_0: $\gamma'_0 = \gamma'_2 = 0$				881.730 (0.000)	179.255 (0.000)
Analysis of the RMSE					
Estimation 1996.12					
Horizon 1	0.1826	0.3382	0.3061		
3	0.4182	0.5210	0.6358		
6	0.7558	0.7425	1.1452		
9	0.9907	0.8563	1.4890		
12	1.2805	1.1259	1.8611		
16	1.4927	1.4454	2.2999		
18	1.4460	1.4675	2.3736		
20	1.3980	1.5114	2.4702		
22	1.3564	1.6001	2.5738		
24	1.3715	1.6797	2.7769		

[a] OOS, out-of-sample.
[b] The root mean square error (RMSE) is not scale-invariant; the smaller the error, the better the forecasting ability of the model. By contrast, the Theil inequality coefficient is scale-invariant and always lies between zero (perfect fit) and one.
[c] *P*-values are in parentheses.

Table 5 presents the results. As can be seen, the bivariate forecast error is always lower than that of the univariate regression. Concerning the out-of-sample 12-month ahead forecasts, including either the SLI or the LLI in the estimated equation reduces the root mean squared error (RMSE) to 67% and 94% for the SLI and the LLI respectively, compared to the RMSE for the univariate forecasts.

Based on the Diebold and Mariano (1995) test statistic, the leading-indicator rolling forecasts are more accurate than the univariate ones. The null hypothesis of equality of forecast performance is rejected at the 5% significance level (we obtained $S_1 = -1.73$ for the LLI and $S_1 = -1.87$ for the SLI; the critical value of the Z_a at the 5% level is -1.645). The RMSE for the forecasts based on estimation up to end-1979 is reduced to 47% for the SLI and 62% for the LLI, respectively. Furthermore, the Theil inequality coefficient in both cases is much lower than that produced by the univariate forecasts. Table 5 also presents the results of the forecast encompassing test (Chong and Hendry, 1986) to compare inflation forecasts generated by the bivariate and univariate autoregressive schemes[15]. Wald tests reveal that the bivariate equation's forecasts do contain additional information that help to explain the inflation forecast errors.

We also performed a post-sample prediction exercise for the years 1997 and 1998. As shown at the bottom of Table 5, analysis of the RMSE reveals that the univariate model's forecast error is considerably larger than the prediction error from the model with the composite indicators. Moreover, as the prediction horizon increases, the error grows faster in the short run and at a lower rate in the medium run. The bivariate model with the SLI reflects a progression in the prediction error in the very short run (1–3 months), while in the medium run (6–16 months) the prediction error is smaller from the model with the longer indicator. When predicting in the long run (18–24 months), the error from the model with the SLI is reduced.

5. Concluding remarks

The main purpose of this paper has been to develop and evaluate leading indicators of Greek inflation. Using the standard methodology established by Burns and Mitchell for identifying peaks and troughs in the business cycle, we proposed a turning point chronology for Greek inflation (CPI). Moreover, we constructed composite indicators and evaluated their performance in explaining inflation as well as their ability to add predictive power to regressions with only lagged values of inflation. Our findings can be summarised as follows. First, we identified 10 complete inflation cycles, indicating that inflation, like output, is cyclical, with peaks and troughs in inflation defining inflation cycles. Secondly, we

[15] The forecast encompassing regressions are: $(y_t - y^\wedge_t) = \gamma_0 + \gamma_2 y^\sim_t + \varepsilon_t$ and $(y_t - y^\wedge_t) = \gamma'_0 + \gamma'_2(y^\sim_t - y^\wedge_t) + \varepsilon_t$, which imposes an error correction restriction, where y_t is the reference series, y_t and y_t are the forecasts generated by the two different models, i.e. the univariate and bivariate inflation equations. See Chong and Hendry (1986), Ericsson and Marquez (1993) and Andrews et al. (1996). We estimate both forecast encompassing regressions by least squares using White's heteroskedastic-consistent variances and covariances, and test the null hypothesis $(y_t - y^\wedge_t) = \varepsilon_t$, that is whether the forecast error is an innovation.

investigated the leading indicator properties of some 20 macroeconomic series, six of which proved to contain useful information. From these six series, two composite indicators were constructed, and their ability to predict inflation turning points over the sample period was tested. Overall, we found that both composite indicators performed quite well as leading indicators of inflation turning points: on average they were found to lead the inflation cycle, and a simple rule, the 3CD rule, produced relatively few missing or false signals. Thirdly, even though the composite indicators were not constructed to anticipate either the level of inflation or future inflation movements, they do help in reducing the forecast error in a simple VAR model.

An interesting topic for further research would be to construct a composite leading indicator index by components from a larger set of series, which change over time in response to changing economic conditions, rather than relying on a fixed set of individual indicators for the entire sample period. The construction of the index and evaluation of its performance will be studied in future research.

Finally, three caveats are in order. First, the individual and composite indicators constructed here and elsewhere in the literature are still quite far from the ideal indicator. The extent to which each indicator leads (or lags) the inflation cycle varies significantly between cycles. Thus a leading indicator may well provide a central bank with a reliable signal that a turning point is ahead, but when exactly it will occur is not something that can be known with any great precision. Second, the leading indicator approach is largely atheoretical. Without a theoretical model of the economy for choosing the indicators, it is very difficult to predict changes in the relationship between variables. Third, the signals, on average, are rather too short, given that monetary policy acts on inflation only with a lag. These points having been said, however, it is still the case that leading indicators can provide useful additional information to a central bank seeking to control or target inflation.

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Appendix A

Table A1. Variable definitions and data sources

	Definition[a]	Sources
M0	Money supply (in 10^6 GRD)	Smoothed (8), 1954.01–1998.12 Bank of Greece, Monthly Bulletin
M3	Money supply (in 10^6 GRD)	1954.01–1998.12, Bank of Greece
M4	Money supply (in 10^6 GRD)	1954.01–1998.12, Bank of Greece
WSP	Wholesale prices (1980 = 100)	1955.06–1998.12, NSSG, Monthly Bulletin
IMP	Import prices (1990 = 100)	1968.01–1998.10, IMF, IFS
WCP	World commodity prices (1990 = 100)	1957.01–1998.12, IMF, IFS
EM	Employment (1985 = 100)	Smoothed (6), 1961.11–1998.02 NSSG, Monthly Bulletin
IP	Industrial production (1985 = 100)	Smoothed (8), 1959.01–1998.10 Bank of Greece, Monthly Bulletin
RS	Retail sales volume[b] (1994 = 100)	Smoothed (8), 1964.01–1998.07 NSSG and Bank of Greece, Monthly Bulletins
NER	Nominal exchange rate (GRD/$)	Smoothed (8), 1957.01–1998.12, IMF, IFS
NEER	Nominal effective exchange rate (1990 = 100)	Smoothed (8), 1957.01–1998.12, IMF, IFS
TB12	Treasury bill rate (up to one year)	1975.01–1998.12, Bank of Greece
UVIM	Unit value of imports (1991 = 100)	Smoothed (8), 1954.01–1996.09 NSSG, Monthly Bulletin
WSPPR	Wholesale prices of primary goods (1980 = 100)	Smoothed (8), 1966.01–1998.12 Bank of Greece, Monthly Bulletin
WSPID	Wholesale prices of industrial goods (1980 = 100)	1966.01–1998.12 Bank of Greece, Monthly Bulletin
WSPIDH	Wholesale prices of industrial and imported goods (1980 = 100)	1966.01–1998.12 Bank of Greece, Monthly Bulletin
RM	An index of raw materials prices (1978 = 100)	1955.01–1998.06 Bank of Greece, Monthly Bulletin
OILP	Oil prices (1990 = 100)	1960.01–1998.11, IMF, IFS
DSR	Discount rate[c]	1955.01–1998.03 Bank of Greece, Monthly Bulletin
CRE	Total credit expansion (in millions GRD)	Smoothed (6), 1955.01–1998.10 Bank of Greece, Monthly Bulletin
CPI	Consumer price index (1994 = 100)	1954.01–1998.12, Bank of Greece

[a]All series, except interest rates, are expressed in the form of 12-month annual growth rate. No variable is seasonally adjusted.

[b]The index of retail sales volume is deflated by the consumer price index.

[c]After March 1998 the Bank of Greece ceased to use the discount rate as an instrument of monetary policy.

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