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Forecasting Irish Inflation:

A Composite Leading Indicator

by

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1. Introduction

This paper presents the results of research into the construction of a composite leading indicator of the Irish rate of inflation, as measured by the annual percentage change in the Consumer Price Index (CPI). It follows the work of Fagan and Fell (1994) who applied the business cycle leading indicator methodology, initially established by Mitchell and Burns (1938,1946), to construct a composite leading indicator of the Irish business cycle.

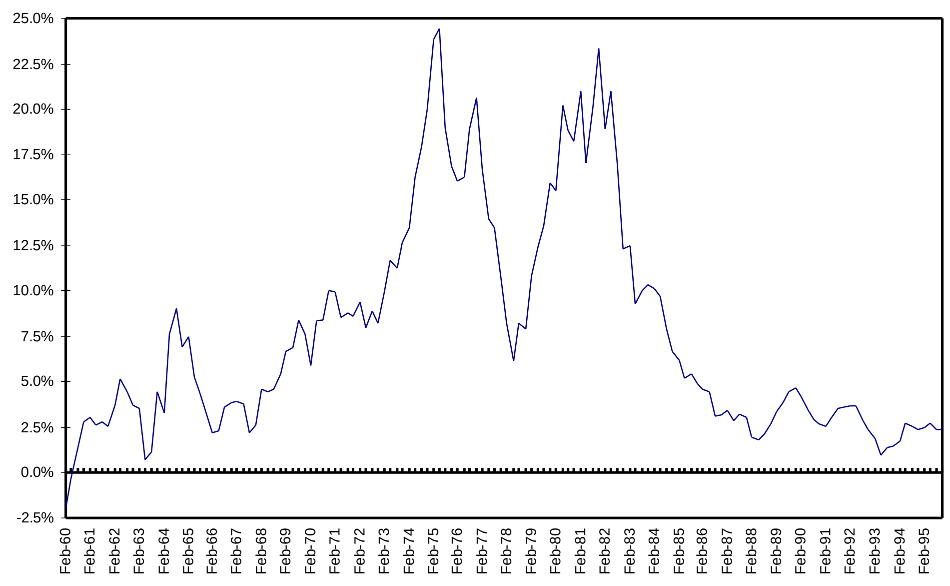
In contrast to business cycle leading indicators, there has been relatively little interest in the construction of inflation leading indicators and most that do exist relate to the US. Two exceptions are the Bikker (1993) indicator for Dutch inflation and the Artis et al (1995) inflation turning point indicator for the UK. The indicator described in this paper is, we believe, the first example of a composite leading indicator of the Irish inflation rate.

The remainder of the paper is organised as follows. Section 2 gives a brief chronology of Irish inflation cycles since 1960. Section 3 outlines the methodology used and describes the criteria for choosing the components of the composite indicator. Section 4 examines the performance of the indicator on the basis of criteria derived by Roth (1991). Finally, in section 5 we present our conclusions.

2. Irish Inflation Chronology

The Irish inflation experience from 1960 to 1995 is summarised in figure 1 and table 1 below. Over the period covered, a number of different inflation experiences for various sub-periods are apparent. The first, from 1960 to the 1973, was characterised by a gradual acceleration in the rate of inflation from a relatively low rate. The period from 1973 to 1983 was one of high and volatile inflation, partly reflecting the effect of the two oil crises. There were, however a number of other contributory factors. One of these was the significant loosening of fiscal policy in the late 1970s and another was the weakness of Sterling to which the Pound was linked.

Figure 1: IRISH CONSUMER PRICE INFLATION 1960-1995



The exchange rate is an important determinant of inflation in Ireland because of the small size and openness of the Irish economy. During the period of the Sterling link the rate of inflation in Ireland tended to remain close to the rate in the UK. After the entry of the Pound into the Exchange Rate Mechanism of the European Monetary

System, however, this relationship was gradually eroded and Irish inflation began to converge towards the average rate among the other member states of the ERM. Reflecting weak external inflationary pressure and a relatively strong exchange rate, Irish inflation has been quite stable at a low rate since the late 1980s

TABLE. 1: IRISH INFLATION CYCLES 1960- 1995

Turning Points		**Duration in Quarters**	
Trough	**Peak**	**Deceleration**	**Acceleration**
1960 Q1	**1962 Q2**	**-**	**5**
1963 Q2	**1964 Q3**	**4**	**5**
1966 Q1	**1967 Q1**	**6**	**4**
1967 Q3	**1969 Q3**	**2**	**8**
1970 Q1	**1971 Q1**	**2**	**4**
1972 Q4	**1975 Q2**	**7**	**10**
1976 Q1	**1976 Q4**	**3**	**3**
1978 Q2	**1981 Q4**	**6**	**14**
1988 Q2	**1989 Q4**	**26**	**6**
1991 Q1	**1992 Q1**	**5**	**4**
1993 Q2	**1994 Q2**	**5**	**4**
1994 Q4	**-**	**2**	**-**
Average		**6.2**	**6.1**

3. Methodology

The method used in the construction of the composite leading indicator of inflation is similar to that used by Bikker (op.cit) for his leading indicator of inflation in the Netherlands. The basic idea is to find a set of time series variables (basic series) which have cycles which resemble the inflation cycle but whose turning points occur before the turning points in inflation. These series are then weighted together into a composite indicator of inflation.

Four criteria were applied to potential component series in constructing the composite leading indicator. The first and most important criterion is that there should be some economic justification for the inclusion of the series. Secondly, it should have a cycle which is closely related to the inflation cycle with turning points that lead the turning points in the inflation cycle on a consistent basis. Thirdly, the series should be available on a timely basis. Finally, the series should be available over a long period, on a quarterly basis, so that the consistency of the cycles in the CPI and the basic series can be assessed over several cycles.

3i. Choosing Candidate Basic Series

In choosing candidate series that would meet the criterion of economic relevance, the openness of the Irish economy and the well documented influence of external factors in determining the rate of inflation suggested the inclusion of foreign and domestic variables and, of course, the exchange rate. The domestic variables considered included wage inflation and unemployment, reflecting labour market conditions, monetary aggregates, manufacturing output prices, agricultural prices, and capacity utilisation. The foreign variables considered included oil prices, non-oil commodity prices, import prices and a weighted average of consumer and export price inflation in Ireland's main trading partners. Potential financial market indicators of inflationary expectations such as bond yields interest rates and share prices were also examined.

Reflecting the high level of integration of the Netherlands and Germany, Bikker (op.cit), examined a number of German series as potential components in his leading indicator. In the Irish case, the change in currency regime in 1979 from the Sterling link to the EMS is a complicating factor, as the relative importance of UK and German influences changed after 1979. In order to take account of these changing external influences, both German and UK series were considered.

3ii. Testing the consistency of the Basic Series

The CPI and the candidate series were subjected to Augmented Dicky Fuller tests to determine the order of integration and were found to be integrated of order 1, i.e. stationary in first differences. Accordingly, following good econometric practice (Perman (1991)), each series was logged and seasonally differenced (expressed as rates of change, year on year) to remove both the long run trend and deterministic additive seasonality.

From the large number of economically relevant series which were initially considered, the choice was narrowed on the basis of the remaining criteria, listed above.

The degree to which turning points in the candidate series lead turning points in the CPI was assessed with the aid of the following correlation function:

$$r(\tau) = S_t(y_t - \overline{y})(x_{t-\tau} - \overline{x}_\tau) \,/\, (S_t(y_t - \overline{y})^2 S_t(x_{t-\tau} - \overline{x}_\tau)^2)^{1/2}$$

where y_t = inflation, $\bar{y}$ = the average of y_t, xt = the candidate series ,and τ = the degree of lead in the candidate series over y_t.

The correlation between inflation (y_t) and the candidate series ($x_{t-\tau}$) for various degrees of lead(τ) is shown by $r(\tau)$. A search is then carried out, over various t values , for the highest correlation for each series. This allows the candidate series to be judged, both on the basis of the extent to which they lead the CPI and on the strength of the relationship between the cyclical patterns of the candidate series and the CPI. Series may be excluded either on the basis of having too short a lead over CPI or if they are weakly correlated with the CPI, or on both of these counts. Using these criteria, the number of candidate series was narrowed substantially. Table 2 below lists the series considered for inclusion and the degree of lead in these series over the CPI based on the correlation function. The correlation function was calculated over the sample period, 1973Q4- 1994Q2 and over the sub-period 1980Q1- 1994Q2. The purpose of the second correlation search is to test for a post EMS entry effect.

Series which were rejected on the basis of weak correlation, or insufficient lead or lack of timeliness included wholesale prices, agricultural output prices, Irish government bond yield, Irish one month interest rate, German call money rate, German government bond yield, UK interbank overnight interest rate, UK treasury bill rate , UK long bond yield, UkM0, various commodity price indices including oil, the price of gold, Irish share prices, import prices, the Live Register of unemployment. Capacity utilisation data were rejected because the series only ran from 1984.

Table 2 Lead Times and Correlation Functions for Candidate Series

	Peak Correlation (No of Qtrs Lead)	
Series	**1973:1-1994:2**	**1980:1-1994:2**
Effective Exchange Rate(inverted)	0.52(4)	0.63(4)
New house prices	0.73(10)	0.65(6)
Manufacturing Output Prices	0.87(0)	0.87(2)
Agricultural Output prices	0.63(14)	0.35(11)
German CPI	0.75(3)	0.69(3)
UK Retail price index	0.8(0)	0.89(8)
M3	0.84(6)	0.7(6)
Private Sector Credit	0.87(11)	0.69(1)
world inflation[1]	0.87(0)	0.92(6)
world export prices[1]	0.78(2)	0.76(8)
UK industrial output prices	0.82(0)	0.91(6)
Weekly Manufacturing wages	0.85(1or3)	0.91(1or3)

1. These variables are weighted averages of consumer price inflation and export prices in Ireland's main trading partners with weights derived from import shares.

The most promising candidate series were also subjected to a visual inspection in order to identify excessively volatile series or those where the relationship with the CPI weakened during the 1980s. It also allowed for the resolution of any ambiguities, arising from the correlation search, about the appropriate degree of lead in each basic series over the CPI[1]. As a consequence, a lead of 2 quarters, 3 quarters and 8 quarters were applied to the EER(inverted), M3 and manufacturing output prices, respectively, rather than the leads of 4, 6 and 2 quarters, as suggested by the correlation search.

On the basis of the correlation search and the visual inspection the list of basic series was finally reduced to six series, M3 with a lead of 8 quarters, weekly manufacturing wages with a lead of 3 quarters output prices with a lead of 3 quarters. the EER with a 2 quarter lead, UK output prices with a 6 quarter lead and world consumer price inflation with a 6 quarter lead.

The degree of lead of the composite indicator is determined by the component series with the shortest lead. In this case, the two quarter lead of the EER would imply a lead of just two quarters. Since the CPI figures for any particular quarter are published at the end of the quarter the indicator is likely to be updated at the beginning of the next quarter. Given the daily availability of EER, it is reasonable in most cases to include an estimate of the level of the EER at the end of this quarter, thereby extending the lead of the EER and by extension the composite indicator by one quarter to 3 quarters. Similarly the lack of timeliness of wage data can be overcome by using the known increases agreed under national wage agreements to make assumptions about wage agreements up to the period of the latest CPI data.

[1] In some instances the correlation search did not clearly identify the peak correlation.

3iii. Constructing the Composite Indicator

The composite indicator was constructed using weights derived from the Principal Components technique. In using this method the data had to be further transformed so as to obtain consistent results.

In order to avoid the series with the greatest amplitudes in their cycles exerting too much influence on the composite indicator, the chosen component series were normalised to have a mean of 0 and a standard deviation of 1.

The series were then synchronised with the CPI by a process of lagging. For example, in the case of world CPI which leads the CPI by 6 quarters, the observation for the 1st quarter of 1994 was shifted to the 3rd quarter of 1995 while the observation for wages (lead 3 quarters) for the 1st quarter of 1994 was shifted to the 4th quarter of 1994.

The next stage in the process is the calculation and application of appropriate weights derived from the principal components method. The method of principal components involves the construction, from an original set of variables X_j (j=1,2,...k), a new set of variables P_i(i=1,2,...k) called principal components. These new variables are linear combinations of the X's:

$$P_1 = a_{11}X_{11} + a_{12}X_2 + \ldots\ldots + a_{1k}X_k$$

$$P_2 = a_{21}X_1 + a_{22}X_2 + \ldots\ldots + a2kX_k$$

$$\vdots$$

$$P_k = a_{k1}X_1 + a_{k2}X_2 + \ldots\ldots + a_{kk}X_k$$

The weights applied to the original series (a_{ij}) in the construction of the principal components are known as factor loadings. They are chosen so that the principal components satisfy the following conditions: (i) they are uncorrelated (orthogonal) and (ii) the first principal component will account for the maximum possible proportion of the variance of the set of X,s, the second principal component accounts for the maximum of the remaining variance and so on until the last the principal component absorbs all the remaining variance not accounted for by the preceding components.

The method of principal components has been used in econometrics where there is serious multicollinearity among the explanatory variables or where the number of potential explanatory variables which should, on a priori grounds, be included in an equation is very large relative to the size of the sample. In such cases, principal components can be used to combine variables into a composite variable to reflect the maximum possible proportion of the total variation in the set.

In practice, the first principal component usually captures sufficient variation to be an adequate representation of the original set. On the basis of this assumption, weights proportional to the factor loadings of the first principal component of the set of variables were used to construct the leading indicator.

Table 3 shows the factor loadings of the first principal component of the series used in the leading indicator of Irish inflation. They are derived from the cross correlation matrix of the normalised component series. Each factor loading represents the correlation between the normalised series concerned and the first principal component.

The weighted world inflation variable and weekly manufacturing wages have the highest factor loadings at 0.92. The loadings for Irish industrial output prices and UK industrial output prices are similar at 0.91 while the loadings for M3 and the EER (inverted) are somewhat lower, at 0.72 and 0.59, respectively.

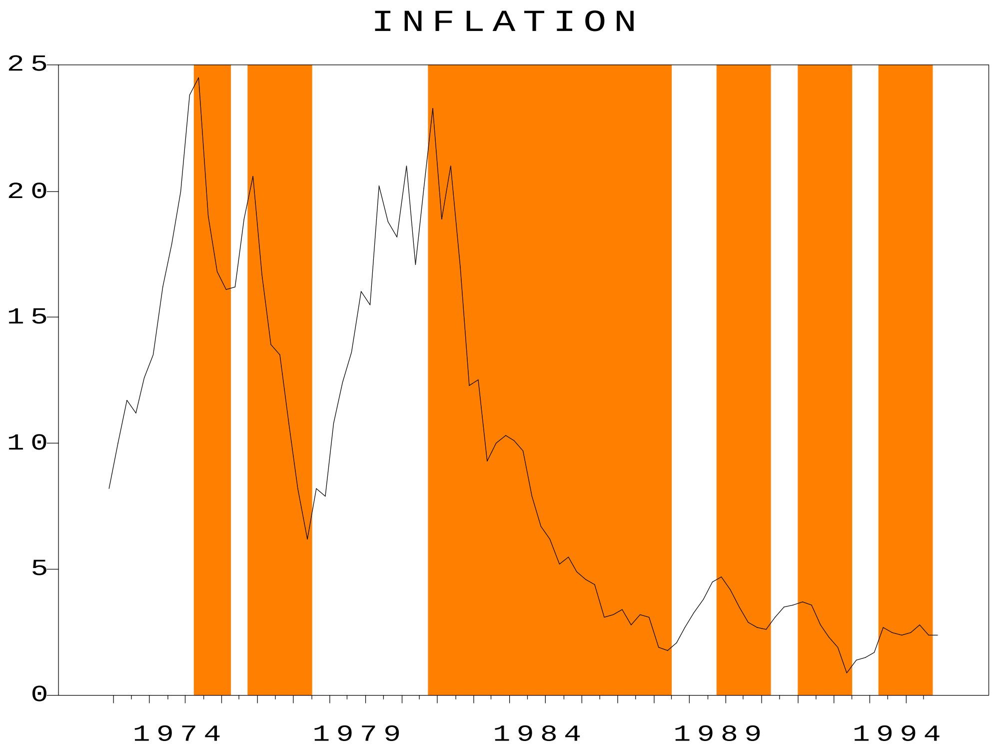
Table 3 Factor loadings of First Principal Component and Indicator Weights

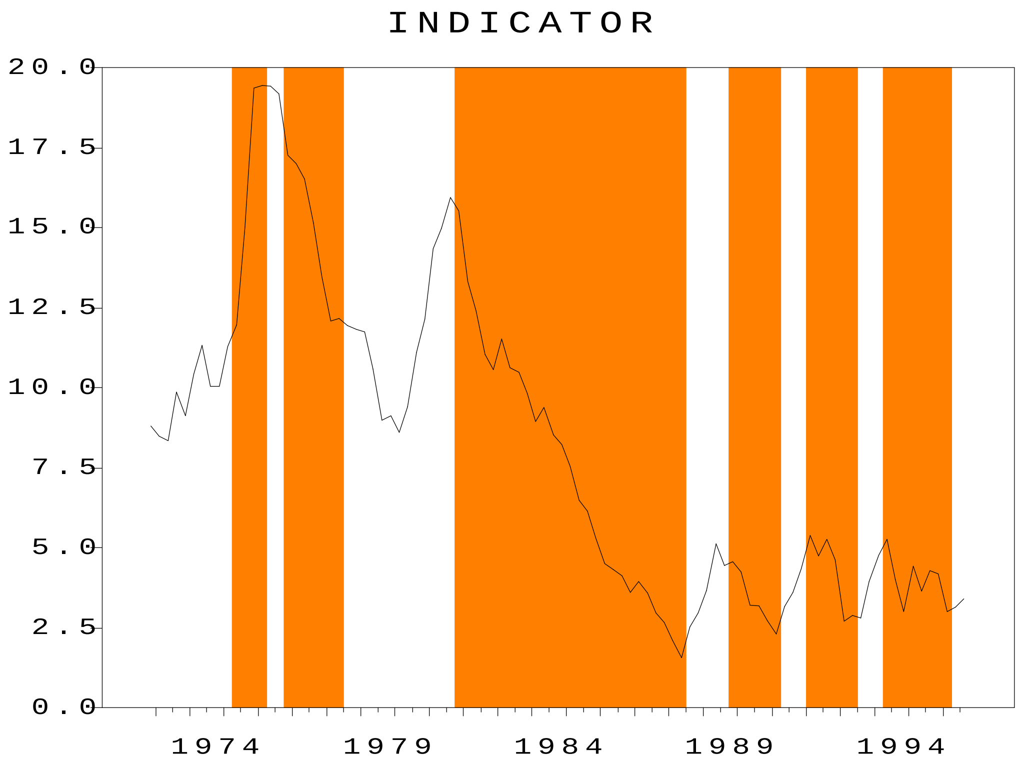
Series	**Factor loadings**	**Weight in Leading Indicator**
M3	0.72	0.15
Irish output prices	0.91	0.18
UK output prices	0.91	0.18
Manufacturing wages	0.92	0.18
World inflation	0.92	0.19
EER(inverted)	0.59	0.12

From these factor loadings it can be calculated that the first principal component explains about 70% of the total variance of the component series. This is similar to the amount of variance (64%) explained by the first principal component in Bikkers indicator. Accordingly, we have used the these factor loadings to derive the weights for the leading indicator. These weights are directly proportional to the size of the factor loadings. Given that the sum of the factor loadings is 4.96, the weight for M3 is calculated as 0.72÷4.96 or 0.15. Two of the series, M3 and the EER (inverted), have smaller weights than the other series. The size of these weights should be viewed in the context of the leading indicator approach only. This approach is not reliant on an underlying theoretical model. The weights derived here simply reflect observed correlations with the CPI. They do not necessarily contradict the implications of theoretical models such as, the small open economy model which gives a pivotal role to the exchange rate in the determination of inflation.

After applying the calculated weights to the component series, the means and standard deviations of the component series were restored. This is done to give the indicator a mean and standard deviation equal to a weighted average of the means and standard deviations of the component series.

The composite leading indicator is now complete and is illustrated in the chart below with a graph of inflation for comparison. As it has a lead of 3 quarters over the rate of inflation, the indicator, which has been synchronised with inflation, runs three quarters into the future. So, with the rate of inflation for the 4^{th} quarter 1995 available at time of writing, the indicator runs to the 3^{rd} quarter of 1996. As the graph shows, the indicator is implying no significant change in the rate of inflation up to that point.


INFLATION
25
20
15
10
5
0
1974
1979
1984
1989
1994


INDICATOR
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
1974
1979
1984
1989
1994

4. Performance

The ultimate test of the value of an indicator is its performance over time. There are a number of criteria upon which an indicator can be assessed. One possible criterion is the indicator's ability to accurately forecast the rate of inflation. The evidence from previous research suggests that composite leading indicators do not perform well on this test. Garner (1995) assessed 5 leading indicators of inflation in the US, including two composite indicators- the Centre for International Business Cycle Research (CIBCR) leading inflation index and the Paine Webber (PW) leading index. He concluded that "none of the indicators has recently been successful in predicting inflation magnitudes" but that the composite indicators in particular gave reliable signals of turning points in inflation.

Roth (1991) focuses on the success or otherwise of leading indicators in picking up turning points in the inflation cycle. He assesses five indicators; firstly on the extent to which their turning points are correlated with turning points in the inflation cycle and, secondly, on their ability to predict future turning points in inflation.

Given the poor performance of other indicators in forecasting the rate of inflation, it is perhaps unsurprising that our leading indicator does not perform particularly well in this regard. It does, however, perform quite well at tracking the turning points of inflation and as a predictor of future inflation turning points. The indicator has been subjected to the tests used by Roth (op.cit) and the results are outlined below. In order to allow for structural change, results for the sample periods 1973 Q2 to 1994 Q4 and 1980 Q1 to 1994 Q4 are reported.

Criterion 1:Correlation With Inflation Turning Points

Roth (op.cit) describes a perfect indicator with respect to this criterion as one which would "turn before each turn in inflation, lead inflation the same number of months each time, and turn only before turns in inflation". The performance of our indicator, assessed by this criterion, is summarised in Tables 4 and 5 below [2].

Table 4 reports the turning points in inflation over the sample period and the extent to which the turning points in the indicator leads (-) or lags (+) the inflation turning points It is clear that the indicator's performance in the 1970s was very poor but that there was a significant improvement during the 1980s and 1990s. This reflects the construction of the indicator as a guide for the future rather than an explanation of the past Two of the four turning points in the 1970s were missed and the other two were only picked up with a substantial lag.

By contrast, in the 1980s and 1990s the indicator turned at the same time or before all turning points in inflation. In 5 cases out of 8, the indicator and inflation turned at the same time. The improvement in the performance of the indicator during the 1980s is reflected in the standard deviation in the degree of lead(lag) of the indicator turning points over the rate of inflation. Over the entire sample period this figure was 2.59 quarters for all turning points but was much lower at 0.76 quarters in the period from 1980Q1.

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[2] When reading the results of these tables it should be borne in mind that the points in the indicator are observed three quarters before the inflation data, reflecting the degree of lead of the indicator over the CPI. This means that in those cases where the indicator turns at the same point as the rate of inflation, the turning point in the indicator is observed three quarters before the turn in the inflation rate. For example, the indicator turned in May 1988(at the same time as the rate of inflation), suggesting an acceleration in inflation and this point in the indicator could be observed in the third quarter of 1987.

Table 4. Turning Points in Inflation and The Leading Indicator

Inflation Peaks(P)and Troughs(T)	**Indicator lead(-) or Lag(+)**
1975 Q2 (P)	+3
1976 Q1 (T)	MISS
1976 Q4 (P)	MISS
1978 Q2 (T)	+7
1981 Q4 (P)	-1
1988 Q2 (T)	0
1989 Q4 (P)	-2
1991 Q1 (T)	0
1992 Q1 (P)	0
1993 Q2 (T)	-1
1994 Q2 (P)	0
1994 Q4 (T)	0

Table 5. Mean and Standard Deviation of Indicator lead or lag

	1972Q4 - 1994Q4		**1980Q1 - 1994Q4**	
	Mean (Quarters)	**Standard Deviation (Quarters)**	**Mean (Quarters)**	**Standard Deviation (Quarters)**
All Turning Points	0.6	2.59	-0.5	0.76
Peaks	0	1.87	-0.75	0.95
Troughs	1.2	3.27	-0.25	0.5

Criterion 2: Predictions of Future Turning Points in Inflation

In order to assess the reliability of a leading indicator as a predictor of turning points in inflation it is necessary to design a rule(s) which when applied to an indicator observation can determine if that point represents a turning point in the rate of inflation. The following rules have been derived for this purpose

(A) A peak in the rate of inflation is indicated if, when compared with the observation from three quarters earlier, the indicator has risen and the value of the indicator three quarters ahead represents a fall from its current position, the sum of the absolute value of these changes exceeds 2 and the previous turning point was a trough.

(B) A trough in the rate of inflation is indicated if, when compared with the observation from three quarters earlier, the indicator has fallen and the value of the indicator three quarters ahead represents a rise from its current position, the sum of the absolute value of these changes exceeds 2 and the previous turning point was a peak.

The requirement for the direction of the indicator to change from positive to negative at a peak point and from negative to positive at a trough is a logical application of the mathematical definition of a maximum or a minimum. The absolute value rule is added to avoid the tendency for noise in the indicator to cause it to give false signals. Finally the requirement that a peak signal must follow a trough and a trough signal must follow a peak is added to accommodate a tendency for flat bottomed turning points in the indicator, i.e. a tendency for turning point signals in the indicator to persist for one or two quarters after first being observed.

Applying these rules shows the leading indicator be a reasonable predictor of inflation. Its performance is summarised in tables 6 and 7.

Table 6 Inflation Turning Point Predictions

Indicator Prediction Peak(p)/Trough(T)	Actual Inflation Peak(p)/Trough(T)	Lead(-)/Lag(+)
!974 Q1 (P)	-	False signal
!974 Q4 (T)	-	False signal
1975 Q4 (P)	1975 Q2 (P)	+2
-	1976 Q1 (T)	Miss
-	1976 Q1 (P)	Miss
1979 Q3 (T)	1978 Q2 (T)	+5
1981 Q2 (P)	1981 Q4 (P)	-2
1988 Q1 (T)	1988 Q2 (T)	-1
1989 Q2 (P)	1989 Q4 (P)	-2
1990 Q4 (T)	1991 Q1 (T)	-1
1992 Q1 (P)	1992 Q1 (P)	0
1993 Q1 (T)	1993 Q2 (T)	-1
1994 Q1 (P)	1994 Q2 (P)	-1
1994 Q4 (T)	1994 Q4 (T)	0

Over the full sample period 1973.2 to 1994.4 the indicator predicted all turning points with an average lag of 0.1 quarter and a standard deviation of 2.13 quarters. Over the period 1980.1 to 1994.4, all turning points were predicted on average 1 quarter early with a standard deviation of 0.76 quarters. Over the latter period the indicator performed better at predicting troughs than peaks.

Table 7: Accuracy of Leading Indicator predictions

	1972Q4 - 1994Q4		**1980Q1 - 1994Q4**	
	Average lead(-)/lag(+) (Quarters)	**Standard Deviation (Quarters)**	**Average lead(-)/lag(+) (Quarters)**	**Standard Deviation (Quarters)**
All Turning Points	+0.1	2.13	-1.0	0.76
Peaks	-0.6	1.67	-1.25	0.96
Troughs	+0.4	2.61	-0.75	0.5

Over the full sample period the indicator gave two false signals and missed two turning points, all of these; however, occurred during the 1970s. As was the case with correlations with turning points in inflation discussed above, the indicator has performed much better as a predictor of inflation turning points since 1980.

5. Conclusions

In this paper we have reported on the results of research into the construction of a composite leading indicator of inflation in Ireland. We applied a methodology which has been widely used for predicting turning points in the business cycle but which has been applied less widely to inflation.

The degree of lead in the indicator is determined by the extent to which the component series lead inflation. In this case the component series with the shortest lead is the effective exchange rate with a lead of 2 quarters. All other component series give a 3 quarter lead at least. Since the indicator is likely to be updated in the quarter following the publication of the latest available CPI figures and, given the availability of daily EER data, we have extended the length of lead in the indicator to 3 quarters by including an estimate for the EER in the following quarter.

As is the case with other composite indicators of inflation, the indicator described here is useful primarily as a predictor of turning points in the inflation cycle. On the basis of criteria set by Roth (op.cit), the indicator performed well both in tracking and in predicting previous inflation turning points.

As regards the likely trend in inflation in 1996, the indicator suggests no significant change from current levels until the 3^{rd} quarter of 1996, at least. A low inflation performance in 1997 will, on the basis of the components of the leading indicator, require a firm exchange rate policy, low wage increases and some deceleration of the growth in the money stock.

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