A Composite Leading Indicator of the Inflation Cycle for the Euro Area

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Abstract

We evaluate the performances of composite leading indicators of turning points in the rate of inflation in the Euro area, constructed by combining the techniques of Fourier analysis and Kalman filters with the National Bureau of Economic Research methodology. In addition the paper compares the empirical performances of Euro Simple Sum and Divisia monetary aggregates and provides a tentative answer to the issue of whether or not the UK should join the Euro area. Our findings suggest that, firstly, the cyclical pattern of the different composite leading indicators very closely reflect that of the inflation cycle for the Euro area; secondly, the empirical performance of the Euro Divisia is better than its Simple Sum counterpart and thirdly, the UK is better out of the Euro area.

1. Introduction

Financial market participants and policymakers such as the European Central Bank (ECB) are heavily dependent on forecasts of the rate of inflation and its turning points as such information allows them to adjust their calculation of the future economic environment. In this paper we focus on inflation turning point forecast for the Euro area; inflation forecasts are looked at in a different paper co-authored by the current authors (see Binner et al., 2003). Despite advances in mathematical and statistical techniques, a reliable method to forecast inflation turning points has continued to evade forecasters. Consequently, interest in the use of composite leading indicators (CLIs) of inflation turning points has been heightened. These are constructed from a group of time series variables which have cycles which resemble the turning points in the inflation cycle but whose turning points precede the turning points in inflation cycle.

The leading indicator approach was developed by the National Bureau of Economic Research (NBER) and was popularised by the work of Burns and Mitchell (1946) in the US. This approach has since been utilised in a number of studies, but mostly applied to business cycles. Application to inflation cycle is relatively new and much of the literature is related to US (see for example Roth (1991), Boughton and Branson (1991)). A few European studies exist (see for example Artis et al., (1995) and Binner et al., (1999) for the UK and Bikker and Kennedy (1999) for seven EU countries but to the best of our knowledge no study has been carried out to develop CLIs of inflation for the Euro area. One of the main objectives of this paper, therefore, is to develop CLIs of inflation for the Euro area and to assess their forecasting performance.

Even though the leading indicator approach has been rather successful in providing early information about future turning points, it is widely believed that the way leading indicators are constructed is crude and unsatisfactory on the sort of criteria commonly applied in modern econometrics. For example in the UK, a recent research project supported jointly by the Central Statistics Office and HM treasury was designed to investigate possible alternatives to the existing methods of constructing leading indicators which form the basis of most official published leading indicators (Salazar et al., 1995). Recently, time series techniques like Fourier analysis and Kalman filters have been used in the construction of CLIs and the resulting CLIs were found to offer considerable improvement over the traditionally constructed indicators (see, Binner and Wattam, 2003). Therefore, following the seminal work of Binner and Wattam (2003), we use Fourier analysis and Kalman filters to develop more sophisticated CLIs of inflation turning points for the Euro area.

The paper has two further aims. Firstly, to evaluate the relative performances of Euro area Simple Sum and Divisia monetary aggregates, in view of the prominent role of monetary aggregates in the current monetary policy strategy of the ECB. See Appendix A for an overview of use of monetary aggregates in the Euro area and some arguments to consider a Divisia monetary aggregate as policy control tool instead of the Simple Sum aggregate. A few Euro studies exist which compare the empirical performances of the Simple Sum and Divisia aggregates, see for example Drake et *al*., (1997) and Stracca (2001), but in most cases the monetary indices are compared in a money demand framework. To the best of our knowledge, no study exists for the Euro area which compares the Simple Sum and Divisia indices in a composite leading indicator of inflation turning points framework. Hence, the motivation to perform such a comparison. The second additional aim is to provide a tentative answer to the issue of whether or not the UK should join the Euro area. This investigation is based on graphical analysis and the CLI of inflation rate framework. For the CLI framework, we first construct UK CLIs with economic series considered to have ample information for future UK inflation turning points. Then we construct Euro-based UK CLIs, constructed with Euro area inflation cycle turning point CLI as a component, in addition to component series of UK CLIs. Graphical analysis and comparison of the correlations of the aforementioned CLIS with the UK inflation cycle will be used to provide a tentative answer on the issue of whether or not the UK should join the Euro area.

The remainder of the paper is organised as follows. The next section presents the data and outlines the methodology used. Section 3 analyses the results and finally Section 4 provides a summary and the conclusions.

2. Methodology and Data

The prevailing methodology used in constructing leading indicators for economic activity is still very similar to that established by the NBER in the 1930s and 1940s. Applied to inflation cycles it consists of the following major steps:

(1) Firstly the turning points of the inflation cycle are identified.

(2) Secondly appropriate economic and financial variables which contain information about future inflation turning points are selected. This is normally done in two stages.

In the first stage, a large number of series are chosen which are thought to have a theoretical leading relationship with the inflation series[1]. In the second step, only those series are chosen whose turning points predate those of the inflation series.
(3) Thirdly composite leading indicators are constructed and their performances evaluated.

For the construction of Euro CLIs of inflation rate we are, however, unable to proceed exactly in the above described traditional manner. More specifically, instead of choosing the component series of the CLI as described in step 2, a more subjective technique is used. This is because the Euro area has come into existence only recently and therefore the set of component series from which a selection can be made is very limited. Moreover, some of the series that do exist are available for a limited historical period. Therefore, instead, the series that we use are those that are both available and that have been very successfully used in previous studies for constructing CLIs of inflation for European countries (see for example, Bikker and Kennedy (1999), Binner and Watttam (2003), Artis et al., (1995)). For the UK, we use the series used by Binner and Wattam (2003), most of which have been previously identified as leading indicators of inflation turning point by Artis et al., (1995) using the criteria described in step 2 above. Tables 1 and 2 contain the list of series used in the construction of CLIs, for the period 1980 to 1998, for the Euro area and the UK respectively. The starting and ending periods of the data sample are constrained by the availability of Euro area data taken from the Euro area studies of Stracca (2001) and Fagan et al., (2001). Monthly data are preferred in the construction of CLIs and this is often a criterion for selecting component series of CLIs. This is because the more data points are observed, the closer the cycle can be captured and better the possibilities of, for example, dating the turning points. However, some of the data are only available as quarterly series and the Euro area data made available to us were quarterly data. In these cases, we have converted the quarterly data into monthly data using linear interpolation following the Organisation for Economic Co-operation and Development (OECD) which does so while constructing leading indicators of business cycles for its member countries. For the construction of the inflation series[2], the GDP deflator is used for the Euro area while RPI is used for the UK.

In addition to our slightly different approach for constructing CLIs, we also add value to NBER methodology by using Fourier analysis and Kalman filters. Fourier analysis is used for modelling the cyclical components of the series under investigation while the Kalman filter algorithm is used to extract the inflation turning point signal from ‘crude’ forms of CLIs which are constructed by aggregating the modelled individual cyclical components. These techniques have been previously used in constructing CLIs by Binner and Wattam (2003) and the resulting CLIs were found to considerably outperform traditionally constructed CLIs.

Table 1: Data Definitions and Sources for the Euro Area

[1] Other criteria in selecting component series are that they should also be quickly and regularly available and not be subject to major revisions (Neftci, 1991)

[2] Following Artis et al. (1995) we use ‘headline inflation’ which is the annual percentage change in the seasonally unadjusted Retail Price index for the UK or GDP deflator for the Euro Area.

Variable	Original Series	Frequency	Seasonally adjusted at source	Source
DM3[3]	Real Divisia M3	Quarterly	Yes	Stracca (2001) ECB working paper no. 79
SM3	Real Simple Sum M3	Quarterly	Yes	Stracca (2001) ECB working paper no. 79
GDPDEF	GDP deflator	Quarterly	Yes	Stracca (2001) ECB Working paper no. 79
ENN	Effective Exchange Rate	Quarterly	Yes	Fagan et al. (2001) ECB Working Paper no. 42
UNN	Unemployment	Quarterly	Yes	Fagan et al. (2001) ECB Working Paper no. 42
ULC	Unit Labour Costs	Quarterly	Yes	Fagan et al. (2001) ECB Working Paper no.42
COMPR	Commodity Prices	Quarterly	Yes	Fagan et al. (2001) ECB Working Paper no.42

Table 2: Data Definitions and Sources for the UK

Variable	Original Series	Frequency	Seasonally adjusted at source	Source
DM4	Real Divisia M4	Quarterly	No	Bank of England
SM4	Real Simple Sum M4	Quarterly	No	Bank of England
RPI	Retail Price Index	Monthly	No	Datastream
IUV	Import Unit Value Index	Monthly	No	Datastream
UNE	Adult Unemployment	Monthly	No	Employment Gazette/Labour Market Trends
VAC	Vacancies at Job Centres	Monthly	Yes	Datastream
RSI	Retail Sales Index	Monthly	No	Datastream
IIP	Index of Industrial Production	Monthly	Yes	Datastream
GCP	Global Commodity Price Index	Monthly	No	Datastream

2.1 Derivation of Cycles

Cycles are an abstract concept and are not observable in reality. Therefore, to measure cycles, they must first be defined. In general, cycles are defined in two ways- classical cycles and deviation from trend cycles. Classical cycles refer to declines and rebounds in the level of economic series, whereas deviation cycles refer to deseasonalized, smoothed series expressed as the deviation from its long term trend. Most leading indicators are based on deviation cycles, as classical cycles are sometimes very difficult to identify because the fluctuations in many economic series appear to be dominated by strong trends. Therefore, in this study we chose to work with deviation cycles to construct our leading indicators.

[3] The asset components and their corresponding rates of return of the monetary aggregates SM3 and DM3 are taken from Stracca (2001) and Equations A.1 and A. 2 from Appendix A have been used for the calculation of the Divisia index. The asset components used in the construction of monetary aggregates are: currency, overnight deposits, short term deposits (other than overnight deposits) and marketable instruments.

Generally, it may be assumed that an observed univariate additive[4] time series y_t is the sum of four unobserved components, namely the cycle (C_t), seasonal (S_t), trend (T_t), and irregular components (I_t), i.e, can be represented as

$$y_t = C_t + S_t + T_t + I_t \qquad (1)$$

Adopting the deviation cycle approach the cyclical components can be obtained by subtracting the seasonal, trend and irregular components from y_t.

The seasonal and irregular components do not permit a clear vision of the cyclical behaviour and are normally filtered out first. The very commonly used Census X-12 procedure, developed by the US Bureau of Census, is used to capture these components[5]. The Census X-12 procedure is essentially a combination of moving averages. Many detrending techniques exist to remove the trend, however, it is very difficult to know which one is the most appropriate. Each one is relevant in certain circumstances and has its own implications. Canova (1999) examined the sensitivity of the turning points classification to different detrending methods and the ability of each to replicate the NBER dating of business cycles. The Hodrick-Prescott filter (HP) (Hodrick and Prescott (1980)) and the frequency domain filters (Sims(1974)) methods were found to be the most reliable methods to closely reproduce the NBER classifications. However, empirically, HP is the most extensively used technique and has the advantage of being a built-in command in Eviews. We therefore opt for the HP detrending technique in this study. The value for the smoothing parameter λ is normally chosen to be 14400 for monthly data. However, we use the value 129600 following the recommendation of Serletis and Kraus (1996).

2.2 Dating Cyclical Turning Points

The next issue is what criteria to use to date the turning points of the cyclical components. Bodies like the NBER and Central Statistics Office provide reference chronologies for business cycles but no reference chronologies exist for inflation cycles. Artis et al. (1995), however, have devised some ground rules for dating inflation turning points and despite their simplicity, they seem to capture well the turning points of inflation in studies where they have been used (see for example Binner et al. (1999). Therefore in this study also we use the rules devised by Artis et al. (1995) which are as follows. First, is the obvious requirement that peaks will always follow troughs and vice versa. Second, the duration of an upswing or downswing regime should be at least nine months in order to satisfactorily capture medium term movements in inflation. Third, a turning point is the most extreme value between two adjacent regimes and fourth, if there are two or more equal values satisfying the first three requirements, the most recent one is chosen as the turning point of the regime. The same rules are applied in dating the turning points in the cycles of the inflation series and each of the indicator series. The number of cycles identified in each case is given in Tables 3 and 4 for the Euro area and the UK respectively.

[4] A multiplicative model is essentially the same as (3) on taking logs

[5] In cases where the series have been seasonally adjusted at source only the irregular components are captured using the Census X-12 program.

Table 3: Number of cycles found in Euro Area data

Series	Number of Cycles
Real Simple Sum M3	4.5
Real Divisia M3	4.5
Inflation	4.5
Effective Exchange Rate	5
Unemployment	3.5
Unit Labour Costs	3.5
Commodity Prices	4

Table 4: Number of cycles found in UK data

Series	Number of Cycles
Real Divisia M4	2
Real Simple Sum M4	2
Inflation	3.5
Import Unit Value Index	2.5
Adult Unemployment	4
Vacancies at Job Centres	3.5
Retail Sales Index	4.5
Index of Industrial Production	3
Global Commodity Price Index	3

2.3 Fourier Analysis of Cyclical Components and Timing Classification of Indicators

In this section the cyclical components are modelled using Fourier analysis. The mathematical Fourier Theorem states that periodic data, like cyclical components of time series, can be expressed as the sum of a series of sine or cosine terms. If assumed that the periodic data consist of a single cosine wave, like in Binner and Wattam (2003), then they can be represented as

$$C_t = \mu + R\cos(\omega t + \phi) + \varepsilon_t, \qquad t = 0,1,\cdots,n-1, \qquad (2)$$

where n is the number of observation, μ is a constant, R the amplitude, $\omega = 2\pi p/n,$ is the frequency, where p is the number of cycles and ϕ is the phase of the wave and ε_t is the t^{th} residual. The unknown parameters here are μ, R, and ϕ and their estimation becomes less cumbersome if Equation 2 is reformulated as

$$C_t = \mu + A\cos\omega t + B\sin\omega t + \varepsilon_t \qquad (3)$$

where $A = R\cos\phi$ and $B = -R\cos\phi$. Estimates of μ, A, and B can be obtained from the following equations (Bloomfield, 1976).

$$\begin{aligned} \tilde{\mu} &= \tilde{C} = (1/n)\sum C_t \\ \tilde{A} &= (2/n)\sum (C_t - \tilde{C})\cos\omega t \\ \tilde{B} &= (2/n)\sum (C_t - \tilde{C})\sin\omega t \end{aligned} \qquad (4)$$

Given the estimates of A and B, we may solve for R and ϕ. The basic equation for ϕ is $\tan\phi = -B/A$. However, the solution $\phi = \tan^{-1} -B/A$ is incorrect as it gives the same values for $-A$ and $-B$ as for A and B. The full solution is obtained from the solution set (Bloomfield, 1976) given in Appendix B[6].

After the cyclical components of the different series have been modelled using Fourier analysis, the modelled cycles are normalized to make them comparable and to

[6] The estimates of μ, ϕ, A, B and R for the different series are not given here for reasons of brevity.

avoid the series with the greatest amplitudes in their cycles exerting too much influence on the composite indicator. Normalization involves setting the means of the Fourier generated cycles to zero and their standard deviations to one. The series are then expressed in the index-number form by adding 100 to them.

The modelled cycles of the indicator series are then compared to that of the inflation series. The resulting lead times in months were calculated by visual inspection and subsequently the standard deviations were also calculated. These values are given in Tables 5 and 6 for the Euro area and the UK respectively. For example, Real Simple Sum M3, in Table 5, has a 3 months warning over the next turning point (either peak or trough) in the inflation series; the standard deviation around this mean is 0.4 months. From Tables 5 and 6 it can be seen that 20 months is a natural borderline between the various lead times achieved. Hence 20 months and below were chosen to represent short leading indicators, whilst leads above 20 months were assumed to be longer leading indicators.

Table 5: Average lead times for the leading indicators versus inflation reference series for the Euro Area

Series	Lead Months	Standard Deviation	Indicator Classification
Real Simple Sum M3	3	0.387	Both
Real Divisia M3	48	0.354	Both
Effective Exchange Rate	10	0.268	Short
Unemployment	21	2.40	Long
Unit Labour Costs	24	3.51	Long
Commodity Prices	27	1.57	Long

Table 6: Average lead times for the leading indicators versus inflation reference series for the UK

Series	Lead Months	Standard Deviation	Indicator Classification
Real Simple Sum M4	31	23.5	Both
Real Divisia M4	35	23.5	Both
Import Unit Value Index	35	0.5	Long
Adult Unemployment	36	0.35	Long
Vacancies at Job Centres	20	0	Short
Retail Sales Index	17	0	Short
Index of Industrial Production	18	0	Short
Global Commodity Price Index	9	5	Short

From the tables above the average lead for composite short term and long term indicators were set at 15 and 29 months respectively, whilst Divisia and Simple Sum indices were classified as both short and long term indicators for experimental purposes. Before constructing composite leading indicators the individual leading indicators are lagged according to the average lead times.

There are various ways of combining the leading indicator series into a composite leading indicator. One of the simplest techniques, as used in, for example, Artis et al. (1995) is by simple averaging. It has been argued that such a method, however, is essentially arbitrary as it is neither data driven nor theory driven (Binner et al., 1999). For this reason, Binner et al., (1999) have derived the appropriate weight for each component using the principal components method, which assumes that the first principal component of the leading indicator series, which explains as much as possible of the variation of the leading indicator series, may be taken to represent the inflation series (see, for example, Bikker and Kennedy, 1999). In this study for every CLI, the component series are aggregated using both simple averaging (that is giving equal weights (of unity) to each of the component series) and weights derived from principal component analysis. However, we only present the CLIs resulting from whichever aggregation technique that shows in a closer relationship with the inflation cycles.

When the individual leading indicator series are combined, the CLIs do not closely resemble the inflation cycle and in some cases there are false signals of turning points. The disagreement between the CLIs and the inflation cycle is due to the undue influences of some turning points from some of the individual leading indicator series. Therefore, the true signal for inflation turning points has to be separated from unwanted information. For this purpose State Space models and Kalman filters can be used (see, for example, Harvey, (1989), Chatfield (1996)), to which we turn to in the next section. These techniques have been very successfully applied in extracting the inflation cycle turning points from the 'crude' form of CLIs by Binner and Wattam (2003).

2.4 State Space Models and Kalman Filters

Given an observed time series x_t which can be described by a possibly unobserved $(m \times 1)$ vector $\boldsymbol{\theta}_t$ known as the state vector, then a State Space model can be represented by the following equations.

$$x_t = \mathbf{h}_t^T \boldsymbol{\theta}_t + \eta_t \quad (5)$$

$$\boldsymbol{\theta}_t = \mathbf{G}_t \boldsymbol{\theta}_{t-1} + \mathbf{w}_t \quad (6)$$

where $\mathbf{h}_t$ is an $(m \times 1)$ vector and $\mathbf{G}_t$ is an $(m \times m)$ matrix, both assumed to be known. η_t and $\mathbf{w}_t$ denote the observation errors which are assumed to be independent and white noise. Equation (5) is usually referred to as the observation (measurement) equation and Equation (6) the state (or transition) equation. Though $\boldsymbol{\theta}_t$ is unobserved, it is generally assumed that $\boldsymbol{\theta}_t$ is generated by a first order autoregressive process.

The State Space form is a powerful tool that opens the way for the application of a number of important algorithms for estimating the unobserved vector $\boldsymbol{\theta}_t$. One very popular algorithm for doing this is the Kalman Filter, which is described in Appendix C.

3. Performance of Composite Leading Indicators and Discussions

The correlations of the Kalman generated Euro CLIs against the inflation reference cycle are given in Table 7. It can be seen from these results that on the whole the cyclical patterns of the different CLIs are rather similar and closely reflect the cycles in the inflation series. These findings demonstrate that CLI are a useful and powerful alternative to statistical methods for forecasting turning points of inflation. Implicit in the findings is the fact that techniques like Fourier analysis and Kalman filters can be used for constructing very sophisticated CLIs of inflation.

When the results are examined in greater detail, firstly, the longer CLIs are found to be more closely related to the inflation cycle. Secondly, CLIs that incorporate Divisia monetary indices show a stronger relationship to the inflation cycle than CLIs based on Simple Sum monetary indices. This result is suggestive that Divisia monetary indices would provide earlier warning of impending inflation their

Simple Sum counterparts. It also implies that the construction of Simple Sum aggregates is flawed and therefore the Divisia aggregates would be more appropriate than Simple Sum aggregates as a guide for the monetary policy strategy for the ECB.

Table 7: Correlations of CLIs with inflation reference cycle for the Euro Area

CLIs	Correlation with Inflation Cycle	Weight[7]
SM3 Short	0.99997636	P
DM3 Short	0.99997902	P
SM3 Long	0.99999548	P
DM3 Long	0.99999567	P

Under the heading 'Weight', P indicates the component series of the CLI were aggregated using principal components weights, while E indicates equal (unity) weights were used in the aggregation.

The difference between the Kalman generated Euro CLIs and the inflation reference cycle was compared and checked for residual autocorrelation, results are presented in Table 8. The Durbin Watson test appears to indicate that autocorrelation is present in the residuals, which suggests that observed time series have more periodic features in them than can be detected by the dating rules employed here and the equation used to model them in this paper. It might also suggest that the phase of the CLIs are out of synchronisation with the inflation reference cycle. However, graphical inspection of the CLIs plotted against the inflation reference cycle, in Appendix E suggests that the cycles are very closely synchronised. Moreover, the prediction error covariance[8], decreases asymptotically rapidly, which is indicative of the adequacy of Kalman generated CLIs.

Table 8: Residual analysis between inflation reference cycle and CLIs for the Euro Area

	SM3 Short	DM3 Short	SM3 Long	DM3 Long
Durbin Watson	0.025392	0.016368	0.000085	0.000087

There is an ongoing debate on whether or not the UK should join the Euro area. The opinions of the public, businesses and professional economists are divided on this issue. However, at present it seems that joining the Euro area does not seem to be very popular action. From an economist's perspective, one of the major concerns is membership to the Euro area would most probably deprive the UK of an independent monetary policy, that is, the Bank of England will have no say in the monetary policy, which will be carried out by policymakers at the ECB. The problem for many economists is the lack of credibility of the ECB. In contrast to the Bank of England which has become very credible because of its record on inflation, the procedures of the ECB are much less transparent and its objective less clear and the ECB is felt not to have performed so well. This results in a lack of confidence in the Euro in comparison with Sterling. Many economists also allude to the experience of Britain in the Exchange Rate Mechanism (ERM). During its ERM membership, October 1990 to September 1992, when Britain had contracted out its monetary policy to Europe, it

[7] The weights obtained from principal component analysis is given in Appendix D
[8] Not reported here for reasons of brevity but are available upon request from the authors.

suffered its worst recession, as measured by total output lost, in sixty years, unemployment doubled, three-quarter million homes were thrown into negative equity and 100,000 businesses went bankrupt. But once the UK left the ERM, its economy recovered immediately. Leaving the ERM proved to be a blessing for the UK, however, Euro membership is irrevocable and there is no guarantee of success. Therefore the UK, which is the world's fifth largest economy, has to be extremely cautious for every step it takes towards the Euro. It seems to be the case at the moment, given that the UK has not joined the Euro area yet as four of the five tests, introduced by the Chancellor of the Exchequer of Britain to analyse the possibility of Britain joining the Euro, have failed. In this paper we try to provide some further tentative evidence on whether or not the UK the Euro area.

Firstly on comparing the number of cycles in Tables 3 and 4, it can be noticed that in the majority of cases, the number of cycles in the Euro area series is higher than in their UK counterparts, implying that the UK economic cycles will be out of phase with those of the Euro area. This finding is consistent with those of studies like Artis and Zhang (1999), Artis et al. (1999) and Barrios et al., (2002). The UK inflation series being out of phase with the Euro area inflation series, as shown in Figure 5 in Appendix E, is of even greater interest from a monetary-policy viewpoint. It can be seen that there are times when the UK economy enters recession the Euro area economy enters recovery and vice versa. If the UK unites with the Euro area and such divergences were to occur in the future, the UK would have to endure interest rates that are quite inappropriate to the phase of the UK economic cycle. More specifically, if for example the UK is still in recession but the Euro area economy is growing, the ECB would certainly want to raise interest rates, to slow down the Euro area boom. Such an action could bring the UK economy further down. On the other hand if the UK economy is growing fast while the Euro area economy is in recession, the ECB might want to cut interest rates. Such an action could have a disastrous effect on the British economy- for example this could fuel a house price explosion. Therefore, the initial conclusion is that the UK should not join the Euro area. However, the diverging behaviour of UK and Euro inflation cycles could be due to different macroeconomic policies. Membership of the UK to the Euro area might force the cycles to converge.

The CLIs in Table 9 consists of economic series which are considered to have UK inflation information content and will be referred to as UK CLIS. The CLIs in Table 10, in addition to containing the component series of their UK CLIs counterparts, also consists of appropriate CLIs of the inflation turning point for the Euro area[9], these CLIs will be referred to as Euro-based UK CLIs. The residual tests are given in Table 11 and 12 based on residuals obtained from models in Table 9 and 10 respectively. Here also the residuals test indicate that presence of autocorrelation, but a graphical inspection suggests that the cycles of the indicators and that of inflation are not out of synchronisation and the prediction error covariance of each model decreases asymptotically. On comparing the corresponding CLIs (for example, SM4 Short from Table 9 is compared to SM4 Short in Table 10), it is found that all the CLIs from Table 8 show a closer relationship to the inflation cycle than those in Table 10. Such a finding suggests that Euro area series with information content about the Euro area inflation do not help in constructing superior CLIs for UK inflation. Therefore the conclusion we draw from our finding is that, if the UK unites with the Euro area, ECB measures to combat inflationary pressures might not have the same

[9] The component CLI of, for example, UK SM4 Short CLI is Euro SM3 Short CLI and so on.

corrective effect on the UK as would measures taken based on future UK inflation information. Therefore we can tentatively conclude that the UK would be better off on its own as long as it pursues a sensible monetary policy strategy. This reinforces our initial conclusion based on graphical inspection.

Table 8: Correlations of UK CLIs with inflation reference cycle for the UK

CLIs	Correlation with Inflation Cycle	Weights
SM4 Short	0.99998924	E
DM4 Short	0.99998926	E
SM4 Long	0.99999046	E
DM4 Long	0.99998906	E

Under the heading 'Weight', P indicates the component series of the CLI were aggregated using principal components weights, while E indicates equal (unity) weights were used in the aggregation.

Table 9: Correlations of Euro-based UK CLIs with inflation reference cycle for the UK

CLIs	Correlation with Inflation Cycle	Weights
SM4 Short	0.99998879	E
DM4 Short	0.99998890	E
SM4 Long	0.99998754	E
DM4 Long	0.99998674	E

Under the heading 'Weight', P indicates the component series of the CLI were aggregated using principal components weights, while E indicates equal (unity) weights were used in the aggregation.

Table 10: Residual analysis between UK inflation reference cycle and UK CLIs

	SM4 Short	DM4 Short	SM4 Long	DM4 Long
Durbin Watson	0.000066	0.000066	0.000260	0.000280

Table 11: Residual analysis between UK inflation reference cycle and Euro-based UK CLIs

	SM4 Short	DM4 Short	SM4 Long	DM4 Long
Durbin Watson	0.000063	0.000062	0.000357	0.000370

4. Summary and Conclusions

In this paper short and long composite leading indicators of the inflation turning points for the Euro Area are constructed using Fourier analysis and Kalman filters. Empirical performances of Simple Sum and Divisia aggregates are also compared in the composite leading indicator framework. The same framework and graphical analysis are also used to provide a tentative answer to the issue of whether or not the UK should join the Euro area.

On the whole the cyclical patterns of the different CLIs are rather similar and closely reflect the cycles on the inflation series. Such a finding suggests that Fourier analysis and Kalman filters can be combined with the traditional NBER methodology to construct sophisticated CLIs. The finding also lends support to the similar seminal study for the UK carried out by Binner and Wattam (2003). It is also of great importance to policymakers and should form the basis of future research for constructing leading indicators of inflation cycle or business cycles.

Regarding the appropriate use of monetary aggregates for policy purposes in the Euro area, the results are suggestive that the Simple Summation technique is inherently flawed as Divisia based CLIs are found to be more closely related to the inflation cycle than Simple Sum based CLIs. This finding is consistent with earlier evidence provided by Binner et al., (1999) and Binner and Wattam (2003). These findings therefore suggest that the behaviour of the Divisia monetary aggregate should be taken more seriously by both policy makers and academics.

Based on findings from graphical analysis and CLI analysis it might also be concluded that the UK is better out of the Euro area as the monetary policy strategy of the ECB to maintain price stability in the Euro area might not be stabilising for the UK. Membership of the UK to the Euro area, however, might lead to converging behaviour of inflation cycles and economic cycles and hence ECB's monetary policy strategy would have the desired effect on the UK economy.

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Appendix A

MonetaryPolicy and Divisia Aggregates in the Euro Area

Monetary policy in the Euro area is carried out under the so-called two pillars. Firstly, given the widely held belief that development in the price level is a monetary phenomenon, development in the amount of money held by the public may reveal useful information about future price development and be a useful leading indicator of inflation. Therefore, in its first pillar the ECB has given broad monetary aggregate M3 a prominent role for guiding monetary policy. More specifically, the growth rate of M3 is closely monitored (see ECB, 1999a, b and 2000 for a more detailed explanation). The second pillar analyses a broad range of other economic and financial time series indicators relevant to future price developments.

Given that M3 is constructed by simple summation, its use as macroeconomic policy tool is highly questionable. More specifically, this form of aggregation weights equally and linearly assets as different as cash and bonds. This form of aggregation involves the explicit assumption that the excluded financial assets provide no monetary services and the included balances provide equal levels of monetary services, whether they are cash or 'checkable' deposits or liquid savings account balances. It is clear that all components of the monetary aggregates do not contribute equally to the economy's monetary services flow. Obviously, one hundred euros currency provides greater transactions services than the equivalent value in bonds. Thus, this form of aggregation is therefore producing a theoretically unsatisfactory definition of the economy's monetary flow.

In the last two decades many countries, such as the UK, have relegated the role of monetary aggregates from macroeconomic policy control tool to indicator variables. Barnett (1978, 1980) attributes to a great extent the downgrading of monetary aggregates to the use of Simple Sum aggregates[10] as they have been unable to cope with financial innovation. By drawing on statistical index number theory and consumer demand theory, Barnett advocates the use of chain-linked index numbers as a means of constructing a weighted Divisia index number measure of money. The potential advantage of the Divisia monetary aggregate is that the weights can vary over time in response to financial innovation. Barnett et al., (1992) provide a survey of the relevant literature, whilst Drake et al., (1997) review the construction of Divisia indices and associated problems. The discrete (Tornqvist –Theil) approximation to the Divisia index is given by

$$\Delta \log M_t^D = \sum_{i=1}^{n} 1/2(s_{it} + s_{it-1})\Delta \log m_{it} \qquad \text{(A.1)}$$

where $s_{it} = \pi_{it} m_{it} / \sum_{k=1}^{n} \pi_{kt} m_{kt}$ and m_{it} is the i^{th} monetary asset at time t

and $$\pi_{it} = (R_t^B - r_{it})/(1 + R_t^B) \qquad \text{(A.2)}$$

where

[10] Simple Sum aggregates are aggregates constructed using the simple summation technique.

r_{it} = return on m_{it} and R_t^B = benchmark rate[11]

The index represents the log change of monetary services provided by the monetary assets. The levels of the monetary services are obtained by normalization.

Financial innovation is certainly not over yet. From a theoretical point of view and considering the unsuccessful experience of many countries having used Simple Sum monetary aggregates for policy purposes, it is highly likely that financial innovation, largely driven by liberalization and increased competition, is going to make the interpretation of the movements in M3 difficult. In turn, this is likely to undermine their usefulness as a tool for guiding monetary policy in the Euro area (Drake *et al*., 1997). Therefore proponents of the Divisia monetary aggregate, such as Drake et al., (1997) have suggested constructing and monitoring the behaviour of a Euro Divisia monetary aggregate.

[11] The benchmark rate is a rate of return on asset which provides no monetary services whatsoever. It is held solely for the purpose of transferring wealth intertemporally. Obviously no such asset exists on the market. A long run interest rate is normally used as a proxy for the benchmark rate. Accordingly, the benchmark rate used in this study is a 10-year government bond yield and we have added 2 % points to it to avoid obtaining negative user costs.

Appendix B

$\phi = \begin{cases} \\ \\ \\ \\ \\ \end{cases}$	$\tan^{-1}(-B/A)$, $\tan^{-1}(-B/A)-\pi$, $\tan-1(-B/A)+\pi$, $-\pi/2$, $\pi/2$, arbitrary,	$A>0$, $A<0, B>0$, $A<0, B\leq 0$, $A=0, B>0$, $A=0, B<0$, $A=0, B=0$.

Appendix C

Given the measurement and updating equations

$$x_t = \mathbf{h}_t^T \boldsymbol{\theta}_t + \eta_t$$

and

$$\boldsymbol{\theta}_t = \mathbf{G}_t \boldsymbol{\theta}_{t-1} + \mathbf{w}_t$$

and suppose a time series is observed up to time $t-1$ and $\hat{\boldsymbol{\theta}}_{t-1}$ is the best estimator for $\boldsymbol{\theta}_{t-1}$ based on the information up to this time. Supposing further that the variance-covariance matrix of $\hat{\boldsymbol{\theta}}_{t-1}$, denoted by $\mathbf{P}_{t-1}$ has been evaluated. In a first step, $\boldsymbol{\theta}_t$ is forecasted from time $t-1$, and the resulting estimator is denoted by $\hat{\boldsymbol{\theta}}_{t|t-1}$ and can be represented as

$$\hat{\boldsymbol{\theta}}_{t|t-1} = \mathbf{G}_t \hat{\boldsymbol{\theta}}_{t-1} \quad (10.11)$$

with the variance-covariance matrix

$$\mathbf{P}_{t|t-1} = \mathbf{G}_t \mathbf{P}_{t-1} \mathbf{G}_t^T + \mathbf{W}_t \quad (10.12)$$

Equations (10.11) and (10.12) are referred to as the prediction equations. The estimator of $\boldsymbol{\theta}_t$ is updated when a new observations becomes available. The prediction error is then given by

$$e_t = x_t - \mathbf{h}_t^T \hat{\boldsymbol{\theta}}_{t|t-1}$$

and the updating equations are given by

$$\hat{\boldsymbol{\theta}}_t = \hat{\boldsymbol{\theta}}_{t|t-1} + K_t e_t \quad (10.13)$$

and

$$\mathbf{P}_t = \mathbf{P}_{t|t-1} - K_t \mathbf{h}_t^T P_{t|t-1} \quad (10.14)$$

where

$$K_t = \mathbf{P}_{t|t-1} \mathbf{h}_t / [\mathbf{h}_t^T \mathbf{P}_{t|t-1} \mathbf{h}_t + \sigma]_n^2 \quad (10.15)$$

K_t is called the Kalman gain.

Appendix D

Table x shows the factor loadings of the first principal component of the leading indicator series. The weights are directly proportional to the size of the factor loadings. Given that the sum of the factor loadings xx, the weight of Real Simple Sum M3 is calculated as 0.78/(0.78+0.78)=0.5.

Factor loadings derived from principal component analysis and weights of leading indicators for the Euro Area for short CLI for Simple Sum

Leading indicators	Factor loadings	Weights in leading indicators
Real Simple Sum M3	0.780	0.5
Effective Exchange Rate	0.780	0.5

Factor loadings derived from principal component analysis and weights of leading indicators for the Euro Area for short CLI for Divisia

Leading indicators	Factor loadings	Weights in leading indicators
Real Divisia M3	0.663	0.5
Effective Exchange Rate	0.663	0.5

Factor loadings derived from principal component analysis and weights of leading indicators for the Euro Area for long CLI for Simple Sum

Leading indicators	Factor loadings	Weights in leading indicators
Real Simple Sum M3	0.498	0.163
Unemployment	0.958	0.313
Unit Labour Costs	0.656	0.214
Commodity Prices	0.950	0.310

Factor loadings derived from principal component analysis and weights of leading indicators for the Euro Area for long CLI for Divisia

Leading indicators	Factor loadings	Weights in leading indicators
Real Divisia M3	0.534	0.171
Unemployment	0.844	0.271
Unit Labour Costs	0.769	0.246
Commodity Prices	0.973	0.312

Appendix E

The inflation reference cycle compared with Kalman generated CLIs for Euro area. The long and short term leading indicators are lagged by their average lag and plotted against inflation.

Figure 1 Simple Sum as Short Leading Indicator
Inflation reference cycle against Simple Sum short

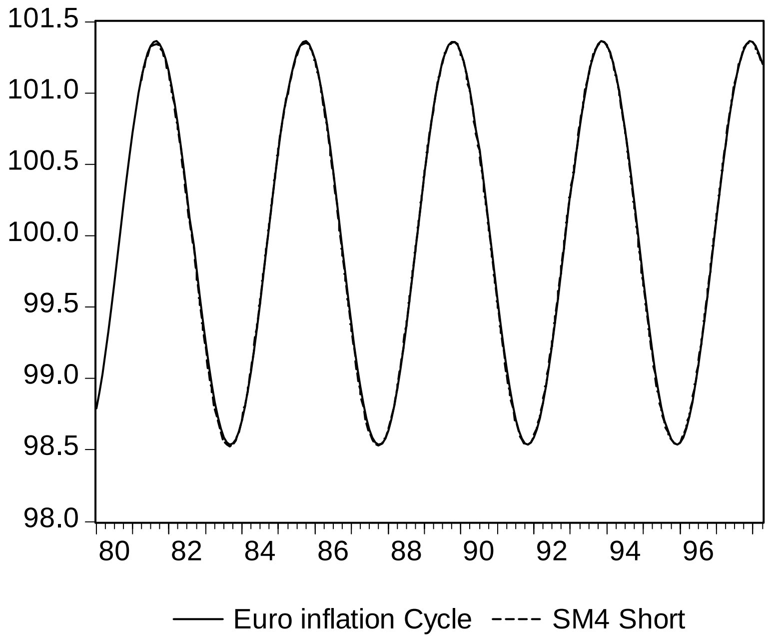


Figure 2 Divisia as Short Leading Indicator
Inflation reference cycle against Divisia short

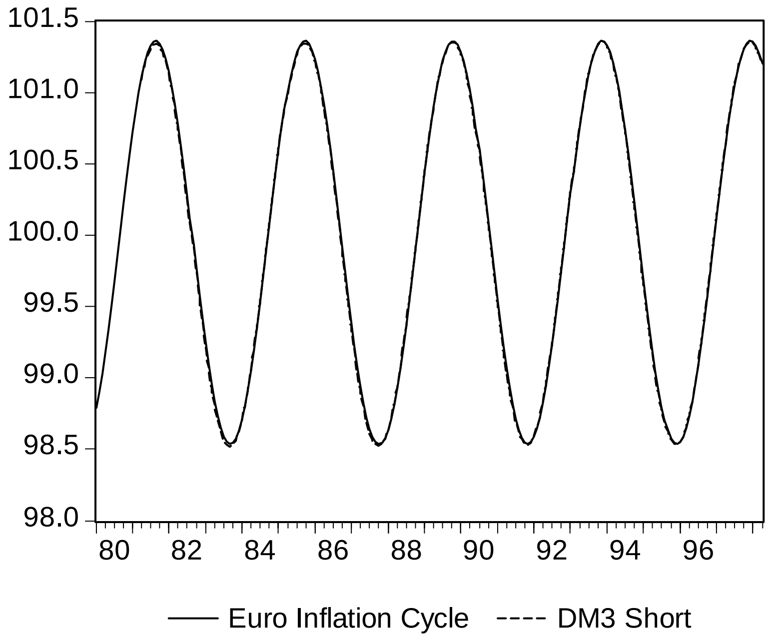


Figure 3 Simple Sum as Long Leading Indicator
Inflation reference cycle against Simple Sum Long

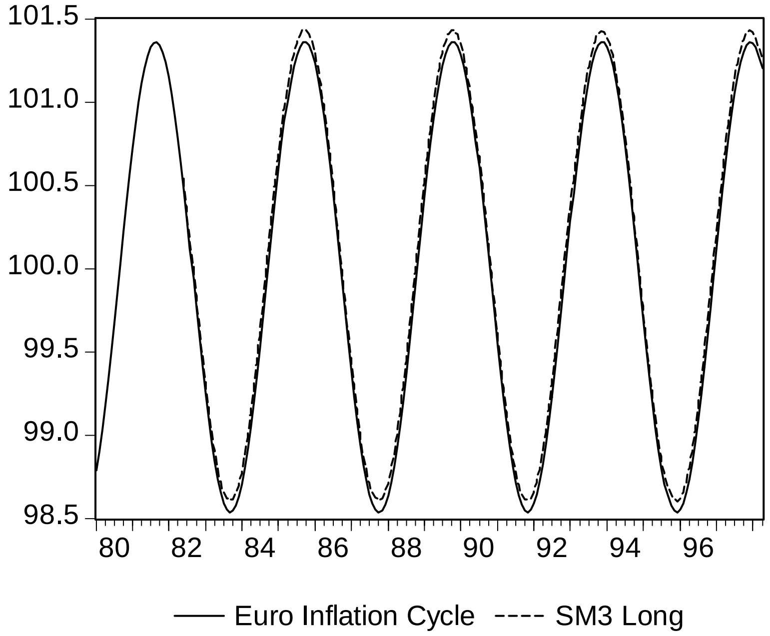
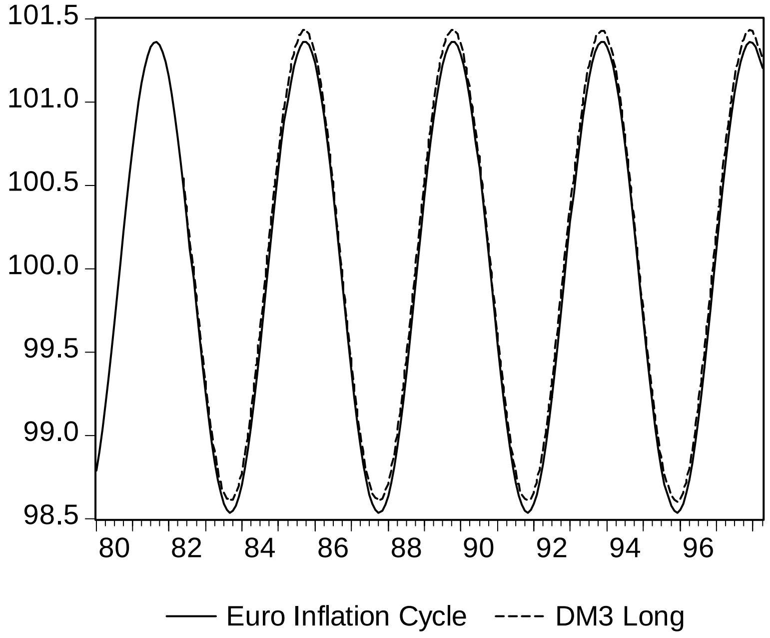


Figure 4 Divisia as Long Leading Indicator
Inflation reference cycle against Divisia long



UK and Euro area inflation cycle compared

Figure 5: UK and Euro inflation Cycle