ALICE: A NEW INFLATION MONITORING TOOL*

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ABSTRACT

This paper develops Area-wide Leading Inflation CyclE (ALICE) indicators for headline and core inflation in the euro area. The main aim of the two leading indicators is to provide early signals about turning points in inflation. The applied methodology follows that of traditional composite leading indicators and the underlying indicators are carefully selected from a large dataset. An asymmetric band pass filter is used to extract the cyclical components of the time series. Nine series are selected for the headline ALICE with an effective lead time of 3 months. The core ALICE includes seven series and is designed to effectively lead the reference cycle by 5 months. Extensions of these indicators increase the effective lead times to 6 and 9 months, respectively. Both indicators identify main turning points in the inflation cycle *ex post* and they also perform well in a pseudo real-time exercise. ALICE performs better than other forecasts in terms of forecasting the direction of future inflation developments. In terms of quantitative forecast accurracy, random walk forecasts often performed better than ALICE but that was over some periods less clearly the case for forecasts from private and public sector organisations.

JEL classification: C32, C52, C53, E31, E37

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* The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank.

NON-TECHNICAL SUMMARY

In the period following the global financial crisis, many institutions and professional forecasters tended to systematically under- or over-predict inflation in the euro area and elsewhere calling existing forecasting models into question. Consequently, the issue of inflation has been receiving increased attention from researchers, analysts and policy makers. While most commonly used approaches aim at quantitative inflation forecasts, this study focuses on composite leading indicators and qualitative inflation signals. Such composite leading indicators may serve as a complementary tool to gauge future developments in inflation and may provide additional insights to steer inflation forecasts. Composite leading indicators primarily aim to predict turning points in the inflation cycle rather than to directly forecast the level of inflation.

The paper develops Area-wide Leading Inflation CyclE (ALICE) indicators for euro area headline inflation and HICP inflation excluding the more volatile food and energy components as a representative of core inflation. The applied methodology follows that of traditional composite leading indicators. Conceptually, the indicators focus on the deviation cycle of inflation, defined as cyclical movements of inflation around its long-term trend. An asymmetric band pass filter is used to extract the cyclical components of the series. The two composite leading indicators are derived as an arithmetic average of carefully pre-selected time series, which reliably correlate with and lead the inflation reference cycles.

The dataset covers a broad range of economic, financial and survey-based information from a variety of sources. In total, around 160 candidate leading series have been examined individually over the sample period starting in the 1960s and ending in late 2016. Nine series are selected to compose the headline ALICE: the composite leading indicator for euro area economic activity from the Organisation for Economic Co-operation and Development (OECD), oil prices, the money-to-GDP ratio, global food raw materials prices, building permits, selling price expectations, non-energy non-food commodity prices, farm-gate and wholesale prices and an inflation-linked swap rate as a measure of market-based inflation expectations. The combination of these series is designed to effectively lead the inflation cycle by 3 and, based on a sub-set of component series with stronger leading properties, by up to 6 months. Seven series are combined together to obtain the core ALICE: the OECD composite leading indicator for euro area

economic activity, oil prices, real GDP, money supply, monetary financial institutions loans outstanding, nominal effective exchange rate and producer prices of non-food consumer goods. This composite indicator has an effective lead time of 5 months that extends to up to 9 months when the longer forward version of the core ALICE based on fewer leading series is considered.

The main results are as follows. Both ALICE indicators demonstrate the ability to identify and anticipate major cyclical turns in the corresponding inflation measure in an *ex post* analysis, especially for the period since 1999. ALICE provides timely signals of upcoming turning points in the inflation cycle also in a pseudo real-time setting and these signals are not substantially revised over time. These are two essential preconditions for the practical applicability of such indicators. Moreover, ALICE performs better than other forecasts in terms of forecasting the direction of future inflation developments two or three quarters ahead. In terms of quantitative forecast accurracy, random walk forecasts often performed better than ALICE over this horizon but that was over some periods less clearly the case for forecasts from private and public sector organisations.

INTRODUCTION

In the period following the global financial crisis, the issue of inflation has been receiving increased attention from researchers, analysts and policy makers. Existing forecasting models have been called into question due to systematic under- or over-predictions of inflation in recent years. . While most commonly used approaches aim at quantitative inflation forecasts, this study focuses on composite leading indicators and qualitative inflation signals. Such composite leading indicators may serve as a complementary tool to gauge future developments in inflation and may provide additional insights to steer inflation forecasts. Composite leading indicators primarily aim to predict turning points in the inflation cycle rather than to directly forecast the level of inflation. They provide early signals about the general direction of the movement in inflation. Typically, a composite index of leading indicators is compiled such that it combines the cyclical information from several different economic series into one single leading series that correlates well with and leads the cycle of a reference series.

The cyclical indicator methodology was pioneered by research staff at the National Bureau of Economic Research (NBER) with the focus on the business cycle. Since the seminal work by Burns and Mitchell (1946), there have been numerous studies analysing and predicting cycles in economic time series as well as further developing the methodology (see, among others, Lahiri and Moore 1991). Two broad categories of cyclical indicators can be distinguished. There are, first, so called model based indicators, which are typically constructed using dynamic factor models or Markov switching models and focus on extracting the common component as a representation of the business cycle or providing probabilities for different business cycle stages (Marcellino, 2006). The second class of non-model based cyclical indicators includes composite coincident and composite leading indicators (CLIs). Such CLIs require filtering and deriving the cyclical components of the considered individual series and then combining them into a single index. Typically, the included series are selected according to pre-specified criteria, such as dynamic correlations with the target series, and are then aggregated together. These CLIs have the advantage of being relatively easy to derive. They are widely used for business cycle analysis in practice. Institutions such as the Organisation for Economic Co-operation and Development (OECD) and the Conference Board are regularly compiling and publishing CLIs for the business cycle.

By contrast, CLIs for the inflation cycle are rare, especially for the euro area. The first CLIs for the inflation cycle were developed by Geoffrey Moore at the Centre for International Business Cycle Research and Michael Niemira at PaineWebber for US inflation. In general, these early indicators were found to be relatively good at anticipating major turning points in the inflation cycle *ex post* (Roth, 1991; Garner, 1995). Several studies for other countries followed this early US work. Artis et al. (1995) derives short and long leading indicators for headline inflation in the UK. The component series are selected on the basis of several criteria, such as smoothness/irregularity, economic coverage, leading properties, and graphical turning point analysis. Binner et al. (1999) also construct a leading indicator for inflation in the UK. A CLI for Irish inflation is constructed by Quinn and Mawdsley (1996) based on similar selection criteria as in Artis et al. (1995). Bikker and Kennedy (1999) build short- and long-lead CLIs for inflation in seven EU countries. Gibson and Lazaretou (2001) study leading indicators to predict turning points in Greek inflation. Binner et al. (2005) provide a CLI for inflation in the euro area as a whole. However, they do not follow a careful procedure to select component series, but choose them based on series used in previous studies. Furthermore, the sample period in their study ends before the start of the monetary union and the creation of the euro area in 1999 and data availability for the euro area has greatly improved since then.

Our study makes several important contributions to the existing literature on CLIs for euro area inflation applying a deviation cycle approach. Firstly, this is the first study to construct CLIs for both headline inflation as calculated based on the Harmonised Index of Consumer Prices (HICP) as well as HICP inflation excluding the volatile energy and food components as a representative of core inflation. Secondly, the applied sample period goes well beyond the late 1990s, the end of the sample used in Binner et al. (2005), and includes the Great Recession as well as the euro area debt crisis, i.e. two highly interesting periods from the perspective of cyclical analysis. This also allows taking advantage of actual euro area data in addition to "synthetic" euro area data that in part go back to the 1960s, and exploiting the greatly improved dataset for the euro area. In line with that, the third contribution is a careful and systematic analysis of over 160 potential leading series covering different parts of the economy in order to select component series for the CLI. Fourth, besides the standard *ex post* analysis of the CLI, we also provide a pseudo real-time evaluation of the performance of the two constructed indicators. Finally, we also explore the potential use of the two indicators for quantitative inflation forecasting in a pseudo real-time analysis.

Our findings are promising and provide a sound starting point for future work in this field. The constructed leading indicators for the euro area headline and core inflation cycles proved to perform well *ex post* in identifying and leading the major cyclical movements of the inflation series, especially for the period since the start of the monetary union in 1999. These results are confirmed in a *pseudo real-time* analysis, which in particular highlights the timeliness of the provided signals and the absence of major revisions of the signals over time. These are two essential preconditions for the practical applicability of such indicators. Besides their qualitative use, the ALICE indicators have also been analysed in terms of their quantitative forecasting ability. They performed better than other forecasts in terms of forecasting the direction of future inflation developments two or three quarters ahead. In terms of quantitative forecast accuracy, the random walk model often performed better than ALICE over this horizon but this was less clearly the case for forecasts from private and public sector organisations.

METHODOLOGY

Reference cycle

As a first step, the inflation cycle has to be defined in order to be able to measure it, because it is not directly observable. Unfortunately, there is no widely accepted published benchmark for the dating of the inflation cycle, such as the one for the US business cycle provided by the NBER or the one for the euro area by the Centre for Economic Policy Research (CEPR). Earlier research work is typically based on the growth rate cycle definition. In this framework, the growth rate of prices is examined directly and the turning points in inflation are determined according to a set of rules to distinguish periods of increasing and decreasing inflation rates (Roth, 1991; Artis et al., 1995; Binner et al., 1999; Gibson and Lazaretou, 2001). Typically, several dating rules are applied in the literature (Roth, 1991; Artis et al., 1995; Binner et al., 2005). Firstly, peaks (troughs) should always follow troughs (peaks). Secondly, the length of an upswing or downturn phase should last for at least a specified number of months or quarters. Another commonly imposed rule is that a turning point must be the most extreme value lying between two adjacent regimes. In addition, one may impose a rule regarding the minimum absolute change between a peak and a trough (Gibson and Lazaretou, 2001). Alternatively, Bikker and Kennedy (1999) measure the price cycle in terms of the deviations of the consumer price index from its trend, i.e. they apply a deviation cycle concept. The turning points are then dated using the algorithm by Bry and Boschan (1971). Similarly, the deviation cycle definition with respect to inflation is applied in Binner et al. (2005). In their analysis the cyclical component of inflation is dated according to the rules suggested by Artis et al. (1995). In line with Binner et al. (2005), we apply the deviation cycle definition with respect to the euro area inflation.

Next, to operationalise the chosen concept of the inflation cycle, reference series, which will serve as a benchmark for the leading indicators, must be chosen. The price stability objective of the ECB is defined in terms of year-on-year growth rates in the Harmonised Index of Consumer Prices (HICP). Thus, this series is chosen to determine the reference headline inflation cycle. As HICP inflation is subject to a high degree of volatility, which may blur information on the underlying inflation trend, we in addition compile a "core" reference inflation cycle. A simple representative of a core inflation measure is HICP inflation excluding the volatile components energy and food. We choose this measure, which has proven to contain information about the underlying medium-term inflation trend (ECB, 2016), as basis for our reference "core" inflation cycle.

Finally, the methodology to extract the cyclical component of the reference series has to be chosen. There are several approaches which are typically used in order to measure the cycle of economic series: the Phase Average Trend (PAT) method developed by the NBER, the HP filter by Hodrick and Prescott (1997) and band pass filters (Massmann et al., 2003; Zarnowitz and Ozyildirim, 2006). The PAT approach may be viewed as rather subjective due to its supervised (manual) mode. With respect to the HP filter, it has been shown that it produces a less smooth cyclical series as compared to band pass filters. The band pass filters are used to isolate the component of time series that lies within a chosen range of frequencies and are based on linear moving averages of the data. Thus, not only the trend is removed but also high-frequency noise is eliminated to obtain a smooth cyclical component (Baxter and King, 1999; Christiano and Fitzgerald, 2003). The random walk filter proposed by Christiano and Fitzgerald (2003) (CF) is an asymmetric filter that uses full sample data to calculate the filtered values at each data point. Also, it works well for many economic time series that may follow a random walk and typically performs well in real-time applications.

The random walk CF filter is employed in the current paper to obtain the cyclical components of the reference series. This filter has also been used in the business and financial cycle literature (de Bondt and Hahn, 2010; Drehmann et al., 2012). We remove from the series the frequencies that are higher than 12 months and lower than 120 months. This choice is in line with the OECD system of CLIs for the business cycle that is based on the double HP filter with 12-month and 120-month lower and upper limits for frequency bands. According to unit root tests both annual inflation series are non-stationary over the sample period over they are available. The drift is eliminated prior to the analysis for non-stationary series, because the formulas for the CF random walk filter assume that there is no drift in data.

Area-wide Leading Inflation CyclE indicator (ALICE)

The inflation cycle CLIs are constructed based on a number of indicators that contain information about future developments in the reference series. More specifically, the cyclical components of these individual series should correlate well with and lead the respective reference cycle. This section explains how the component series included in our composite ALICE for headline and core inflation are selected from a large data set of around 160 potential leading indicators for inflation.

The starting point of the analysis is the compilation of a large dataset of (synthetic) euro area data that go in part back to as far as the 1960s. The data is obtained from the ECB Statistical Data Warehouse (SDW) and comes from a variety of sources. The dataset is constructed such that it reflects different areas of the economy and drivers of inflation: measures of external factors (commodity prices, exchange rates, global indicators, etc.); domestic price and cost variables (such as wages and producer prices); “soft” data from surveys (Purchasing Manager Index (PMI) and European Commission (EC) surveys on prices, employment expectations, confidence, etc.); inflation expectations (survey and market-based measures over different forecast horizons); economic activity variables (production, euro area business cycle indicator, various productivity measures, etc.); and financial variables (interest rates, monetary aggregates, asset prices, bank lending, etc. (see Forni et al., 2003 for euro area empirical evidence and Chen and Ranciere, 2016 for international evidence). The chosen data frequency for the indicators is monthly. For the vast majority of the series in the dataset monthly data is directly available. With respect to series for which only quarterly data is available, each month in a quarter is set to carry the same quarterly value. Given that the focus of the analysis is on the cyclical components, the choice of the method for frequency conversion should not have much impact on the results. Indeed, test results based on the cubic spline interpolation method resulted in virtually identical cyclical components.

The series in the dataset are grouped according to the starting date of the availability of the time series. In total, seven groups are distinguished with the series beginning in approximately 1960, 1970, 1980, 1985, 1990, 1995 and 1999. The candidate series are then filtered to measure their cyclical components applying the same filtering method as for the reference series. The filtered series are subsequently standardised by subtracting their sample mean and dividing by their standard deviation. The selection of the series for the CLI is, hence, conducted in terms of the standardised cycles of the candidate leading series vis-à-vis the reference cycle. A general-to-specific selection procedure based upon three main criteria to identify the best leading series is followed as it is done with respect to the euro area business cycle leading indicator in de Bondt and Hahn (2014). These selection criteria are applied group by group starting with the series that are available over the longest period.

The first selection criterion refers to the leading properties of the candidate series with respect to the reference series. More specifically, the lead time should be sufficiently long and relatively stable over time. We set the minimum value of the lead time to be 3 months. Moreover, we also require that the effective lead time is also at least 3 months. The effective lead time is defined in the most restrictive sense and takes into account not only the lead/lag relationship of the candidate series with the HICP data but also the publication lag of candidate series with respect to the flash release of the HICP figures at the end of month.[1] The second criterion requires that the correlation coefficient between the reference cycle and the candidate series cycle is at least 0.55. This rule is applied with respect to the sample period starting in

[1] Note that for the included quarterly data the effective lead time slightly differs for different months of a quarter due to differences in the availability of this data.

1999, because actual euro area data are only available from that point onwards. In addition, this is the most relevant period for the practical application of the tool taking into account that there may have been changes in the data characteristics over time. While having long backward series is an advantage when estimating a cycle, it should be treated with caution as it is based on "synthetic" euro area data. To evaluate the first two criteria we conduct a dynamic correlation analysis over the earlier mentioned different periods starting with the longest sample period and ending in November 2016. The chosen average optimal lead time for each candidate series is defined as the one where the series has the maximum correlation with the reference cycle without taking publication lags into account. The lead time of the composite indicator is equal to the minimum lead time among the selected component series. In addition to the above two selection requirements, the selected series for the composite indicator should reflect diverse information, i.e. they should contain information from different parts of the economy or drivers of inflation and, preferably, should come from different sources to enhance the robustness of the ALICE.

Once the shortlisting with respect to the first two criteria is completed, the standardised cyclical components are synchronised and aligned with the reference cycle. That is, prior to combining the series together, all series are shifted according to their average optimal lead time and series with negative correlation coefficients are multiplied by -1 to induce a positive relationship with the reference cycle. The selected series are combined together into a CLI by taking a simple average as it is usually done in the related literature (Gibson and Lazaretou, 2001; Binner et al., 2005; de Bondt and Hahn, 2014).

$$CLI_t = \frac{1}{n}\sum_{i=1}^{n} LS_{i,t-l_i} \qquad (1)$$

where LS_i represents the leading series i with the optimal lead time l_i and n denotes the number of series included in the CLI_t.

Turning to the dataset, within the group of series starting in 1960, the shortlisted candidate series that has the highest correlation with the reference cycle is selected as the first component series to be included in the ALICE. Next, by simple averaging we combine the remaining candidate series one by one with the first component according to how strongly they correlate with the inflation cycle. If a new combination has a higher correlation with the reference cycle than the first component, then the series is retained and combined together with the first component. The next series are tested against this new CLI. If the correlation does not improve sufficiently, the candidate series is discarded. The remaining candidates are tested group by group, thus, once the first group is tested, the process is continued in the next sample group. Such a process enables to also address the third selection criteria as it provides an indication of the similarity of the candidate series. In addition, a visual inspection is carried out by comparing developments in the reference cycle versus the cycles of candidate series over time.

RESULTS

Reference cycles

This section presents the cyclical components of the euro area HICP headline and core inflation rates generated using the asymmetric random walk band pass filter as described earlier. The respective reference cycles are dated according to rules suggested by Artis et al. (1995): i) a cyclical peak (trough) is always followed by a cyclical trough (peak); ii) the length of an upswing or downswing phase should be at least nine months; iii) a turning point must be the most extreme point between two adjacent phases; iv) if there are two or more equal values that satisfy the above rules, then the most recent one is chosen. The cycle peaks at time *t* if:

$$RC_{t-k} < \cdots < RC_{t-1} < RC_t^P > RC_{t+1} > \cdots > RC_{t+k} \tag{2}$$

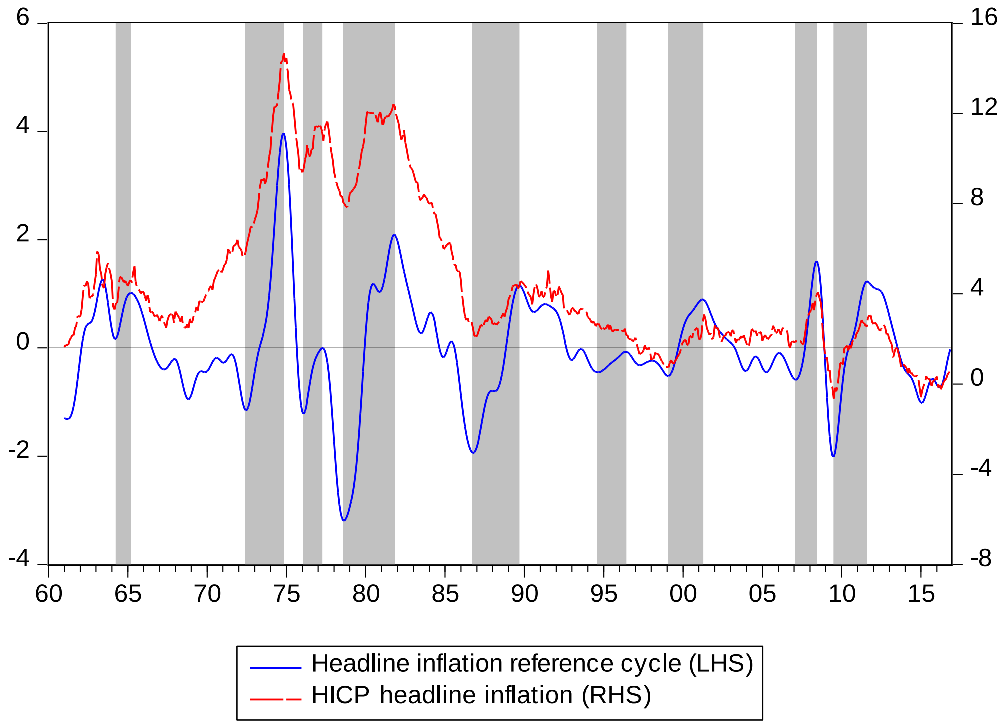
and it reaches a trough if:

$$RC_{t-k} > \cdots > RC_{t-1} > RC_t^T < RC_{t+1} < \cdots < RC_{t+k} \tag{3}$$

where RC_t denotes the value of the reference cycle at time *t* and *k* is set to 9 months.

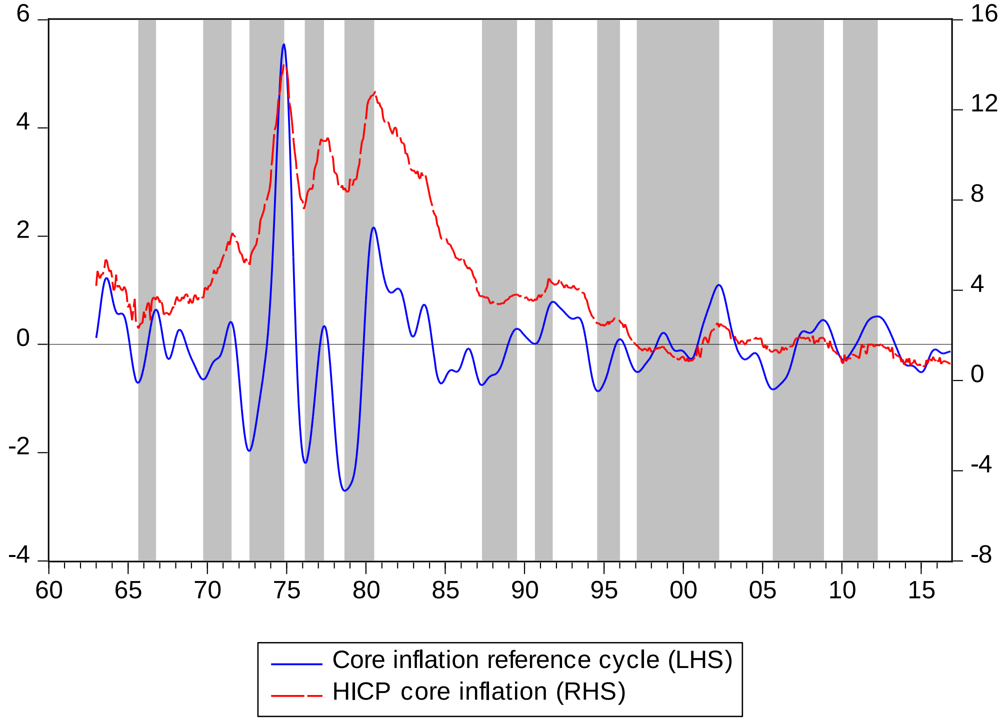
Figure 1 plots the cyclical component of headline inflation together with annual HICP inflation and Figure 2 presents the core inflation cycle and annual HICP inflation excluding energy and food. The shaded areas represent the periods of cyclical upturns in inflation based on the respective reference cycle as defined above. The beginning of a shaded area, hence, denotes a trough while a subsequent peak is represented by the end point of the shaded area. The two figures show that major turning points in the euro area inflation cycles are identified reasonably well using the above described dating rule. The shadings include the high inflation episodes of the 1970s and early 1980s. The upturn in inflation in late 1980s is also picked up with respect to both headline and core inflation; however, actual inflation increases are more noticeable in the case of headline inflation during that period. In the early 1990s there is another small cycle identified for the core inflation that is consistent with an uptick in actual inflation. Furthermore, the shaded areas indicate the acceleration in both inflation measures in the beginning of the 2000s. Similarly, two periods of increasing headline as well as core inflation are identified for the last decade of the sample period.

Figure 1. HICP inflation and the corresponding reference cycle



Notes: This figure plots annual percentage changes in the HICP as well as its cyclical component estimated using the random walk band pass filter for periods of oscillation between 12 and 120 months. The shaded areas denote the periods between a trough and a peak in the inflation cycle.

Figure 2. HICP inflation excluding energy and food and the corresponding reference cycle



Notes: This figure plots annual percentage changes in the HICP excluding energy and food as well as its cyclical component estimated using the random walk band pass filter for periods of oscillation between 12 and 120 months. The shaded areas denote the periods between a trough and a peak in the inflation cycle.

Several other observations can be made from Figures 1 and 2. Firstly, the amplitude of the cyclical components is greater in the first half of the sample period that is characterised by stronger inflationary pressures. On the contrary, the deviations from the trend become smaller in the second half of the period, especially in the case of core inflation. Secondly, the cyclical movements of the two inflation measures are similar. Nevertheless, the duration and timing of upturn and downturn phases do not coincide entirely. Also, there are two cycles more identified with respect to core inflation. Finally, with regard to both inflation measures, the upturns and downswings vary in length over time as does the duration of the full inflation cycles.

Headline ALICE

The selection of leading series for the headline ALICE indicator starts within the group of series available since 1960. Table 1 summarises the selection results whilst Table A.1 in the

Appendix reports a detailed overview of the empirical results underlying the selection process. The lead times reported in both tables do not account for publication lags. The first two selection criteria are met by the OECD CLI for the euro area with an optimal lead time of 7 months, the annual percentage change in industrial production excluding construction with an optimal 5-month lead, and the OECD CLI for the OECD countries with a 7-month lead time. All three series can be viewed as measuring the (global) output gap. Guérin et al. (2011) and the studies cited therein provide empirical evidence on the predictive power of output gaps for inflation in the euro area. There is a change in the optimal lead time of the series following the 1970s. Such changes in the relationships between the economic variables may be related to the significant decline in the level of inflation since the 1970s. The first series included in the headline ALICE is the OECD CLI for the euro area as it has the highest correlation coefficient with the inflation cycle in the period 1999 – 2016. Next, the two other shortlisted series are combined with the OECD CLI one by one taking simple averages. For each combination we calculate a correlation coefficient between the composite indicator and the reference cycle over the full sample available for this group of series and the sample spanning 1999 – 2016. As compared to the OECD CLI alone, adding these new series does not improve the correlation of the composite indicator with the reference cycle and these series are therefore discarded. This may be the case as all three candidate leading series are measures of economic activity. It is therefore likely that they contain a considerable amount of overlapping information. Besides these series, we also test the inclusion of the annual growth rate in oil prices in euros as an additional variable in the composite indicator. Its correlation with the reference cycle is below 0.55 (but close to 0.5), but oil prices are known to be important drivers of inflation. In addition, information on oil prices is promptly available from financial markets and is not revised. The annual growth rate of oil prices shows a stable and sufficient optimal lead time of 4 months. The combination of oil price inflation and the OECD CLI leads to an increase in the correlation coefficient with the reference cycle as it is shown in Table 1 which confirms the choice of this variable.

With respect to the series beginning in 1970, three variables meet the correlation and lead time criteria, namely, the ratio of monetary aggregate M1 to GDP, the difference between annual percentage changes in M1 and GDP, and the ratio of monetary aggregate M3 to GDP (all in nominal terms). This finding confirms that monetary trends may provide signals about future inflationary pressures, with some studies arguing in favour of a decreasing role in the recent period (Berger and Osterholm, 2011; Stavrev and Berger, 2012) and others for an increasing one (Falagiarda and Sousa, 2017). The M1/GDP ratio has the highest correlation in the recent period among the three series as well as in other sample periods. The optimal lead time of 19 months is stable over time. Its inclusion to the composite indicator results in a considerably higher correlation coefficient with the reference cycle (see Table 1). The two remaining monetary variables do not contain much additional information not yet reflected in the M1/GDP ratio.

For the 1980 group, we pick annual percentage changes in the import-weighted world raw material price index for food and tropical beverages (in euros) and annual growth rate in the euro area building permits for residential buildings. The average optimal lead times of these series are 4 and 17 months, respectively. The economic reason for the inclusion of raw material prices is straightforward. Strauss (2013) shows that building permits reflect and are significantly related to consumer expectations about future income. The latter, in turn, can be expected to lead inflationary pressures. Among the series starting in 1985, we select selling price expectations for the months ahead from the EC Industry Survey. The lead time is stable over time but relatively short, i.e. 3 months. Its inclusion leads to a notably stronger correlation in the full sample period, albeit there is no change in the correlation in the most recent period. Further advantages of this variable are that it is not revised and does not suffer from a publication lag.

Among the variables available from 1990 we do not find any series that satisfies the correlation criterion and at the same time exhibits sufficient leading properties. For the group of series starting in 1995, we choose the annual percentage changes in the non-food component of the import-weighted ECB non-energy commodity price index (in euros) that has a long lead of 17 months. Finally, two series are selected to be included in the headline ALICE from the variables that become available around 1999 or later: annual percentage changes in farm-gate and wholesale market prices and the one-year forward one year ahead inflation-linked swap rate. They improve the correlation of the composite leading indicator with the reference cycle further. The respective lead times are 5 and 3 months, but the sample period is too short to evaluate reliably the stability of the lead time. As the swap rate is available for a very short period only, it is tested as the final component after other series in the group were examined.

To summarise, the headline ALICE consists of nine series in total. Selling price expectations and inflation expectations based on the inflation-linked swap rate have the shortest lead time of 3 months which is also their effective lead time. Both series are available at the end of the current month when the flash estimate of HICP inflation is released. Consequently, the composite indicator also has a 3-month effective lead time.

Table 1: Correlation coefficients between the composite indicators and the reference cycle for headline inflation

Composite leading series	***Full-sample***	***1999 – 2016***
Group 1960		
OECD CLI (7) and annual oil price inflation (4)	0.50	0.62
Group 1970		
Adding M1/GDP ratio (19)	0.58	0.75
Group 1980		
Adding inflation in world raw material prices of food & tropical beverages (4) and the growth rate of EA building permits (17)	0.69	0.79
Group 1985		
Adding selling price expectations from the industry survey (3)	0.73	0.79
Group 1990		
-	-	-
Group 1995		
Adding non-energy non-food commodity price inflation (17)	0.80	0.80
Group 1999		
Adding annual inflation in farm-gate and wholesale market prices (5) and 1 year-forward 1 year ahead inflation-linked swap rate (3)	-	0.85

Notes: This table reports the calculated correlation coefficients between the respective composite leading indicators and the reference cycle for headline inflation over the full sample and the sample period January 1999 – November 2016. The full sample starts according to the starting point of the shortest available series included in the composite indicator. The cyclical components are estimated only once using the whole sample period available for each series. The average optimal lead time is reported in parentheses.

Core ALICE

The equivalent selection approach is applied in order to construct the ALICE for the chosen euro area core inflation indicator (core ALICE). The detailed empirical results for the selection of components for core ALICE are reported in Table A.2 in the Appendix. The correlation coefficients between the respective composite leading indicators and the reference cycle are summarised in Table 2. Again we begin the selection with the group that has the longest available time series. The OECD CLI for the euro area is the first component series to be selected for the composite indicator, as it fulfils the correlation criteria for the most recent sample and has a sufficiently long optimal lead time of 17 months that remains constant over time. In line with the headline ALICE, we include annual oil price inflation – with a lead time of 25 months – regardless of a correlation coefficient that is a bit below the threshold for the recent period (0.47). This indicator may at times be very relevant for core inflation as well. Looking at the time series starting in 1970, the correlation and lead time criteria are met by real GDP and nominal M1 stock series with an average optimal lead time of 11 and 23 months, respectively. The two series can be viewed as the output and money "gaps", respectively. Both the inclusion of real GDP and of the monetary aggregate lead to an improvement in the correlation coefficient with the reference cycle; hence, both are retained as leading series. From the group of series that are available since 1980, we select on the basis of the three selection criteria the outstanding amount of MFI loans and the level of the nominal effective exchange rate (NEER) of the euro vis-a-vis 38 trading partners. The exchange rate series are extended backwards using data for the NEER vis-à-vis 12 trading partners. Recent empirical evidence on the exchange rate pass-through to euro area inflation is reported by Ben Cheikh and Rault (2016) and Özyurt (2016). The optimal lead time of MFI loans is 6 months, while the NEER leads the inflation cycle by 16 months. The next series included is the annual percentage change in the Producer Price Index (PPI) for non-food consumer goods from the 1985 group. Its correlation with the reference cycle is very high in more recent sample periods and the average lead time of 6 month is sufficient as well as relatively stable. The inclusion of this PPI-based measure of inflationary pipeline pressures for HICP inflation excluding energy and food does not increase the correlation in the period since 1999, but it leads to a higher correlation over the full sample. Among the remaining groups of time series, we do not find any indicator that fulfils all three selection criteria.

In sum, the final version of the core ALICE includes the seven component series discussed above. It has a lead time equal to the minimum lead of the series included, i.e. 6 months. However, due to the publications lags of the included series, the effective lead time of the composite indicator is 5 months.

Table 2: Correlation coefficients between the composite indicators and the reference cycle for core inflation

Composite leading series	*Full-sample*	*1999 – 2016*
Group 1960 OECD CLI (17) and annual oil price inflation (25)	0.32	0.65
Group 1970 Adding real GDP (11) and M1 (23)	0.57	0.79
Group 1980 Adding MFI loans outstanding (6) and NEER (16)	0.67	0.86
Group 1985 Adding PPI non-food consumer goods price inflation (6)	0.78	0.85
Group 1990/1995/1999 -		

Notes: This table reports the calculated correlation coefficients between the respective composite leading indicators and the reference cycle for core inflation over the full sample and the sample period January 1999 – November 2016. The full sample starts according to the starting point of the shortest available series included in the composite indicator. The cyclical components are estimated only once using the whole sample period available for each series. The average optimal lead time is reported in parentheses.

Backward and forward extension of ALICE

In order to obtain long historical time series of ALICE, the component series must be combined together taking into account their different starting points. This is done by calculating the ALICE indicators backwards using the composite indicators of the subsets of the selected series that are still available accepting a loss in the quality of the indicator over these extended periods. With respect to the headline indicator, we start with a simple average of all nine selected series over the period for which all series are available (June 2005 to February 2017). In June 2005 the time series of the shortest available component, the inflation-linked swap rate, ends. The full-set ALICE, calculated using Equation (1), is then linked backwards to the average of the remaining eight series from May 2005 backwards. The value of the composite indicator for May is calculated as the sum of its value in June and the monthly change in the average of the remaining cyclical components between May and June. We continue adding monthly changes in the subset indicator to the level of the ALICE until the point in time when another component series drops out, i.e. annual percentage changes in the non-energy non-food commodity price index in June 1998. The same linking procedure as before is applied at this step. Consequently, the backward linked ALICE is based on progressively fewer leading series. Equation (4) describes how the ALICE is extended backwards based on progressively fewer series starting at time *t* when all component series are still available:

$$ALICE_{t-m} = ALICE_{t-m+1} + \left(CLI_{t-m}^{j-1} - CLI_{t-m+1}^{j-1}\right) \quad (4)$$

where CLI_t^j is the composite leading indicator consisting of *j* series as defined in Equation (1); $m > 0$ and $j = 2, \ldots, 9$ for the headline ALICE. The same linking procedure is applied with respect to the core ALICE, where all of the selected series together are available since the mid-1980s up to April 2017 and $j = 2, \ldots, 7$ in Equation (4).

In addition to the backward extension, a similar linking procedure is also used to calculate the ALICE forwards with the aim to extend the lead time of the indicator starting from the point where the component series with the shortest lead time becomes unavailable. The ALICE based on the full set of component series is extended using an average of the four series with the longest lead. The forward extension of the core ALICE is based on the five series with the longest lead time. The procedure for the forward extension of the lead horizon is summarised in Equation (5):

$$ALICE_{t+m} = ALICE_{t+m-1} + \left(CLI_{t+m}^{j} - CLI_{t+m-1}^{j}\right) \quad (5)$$

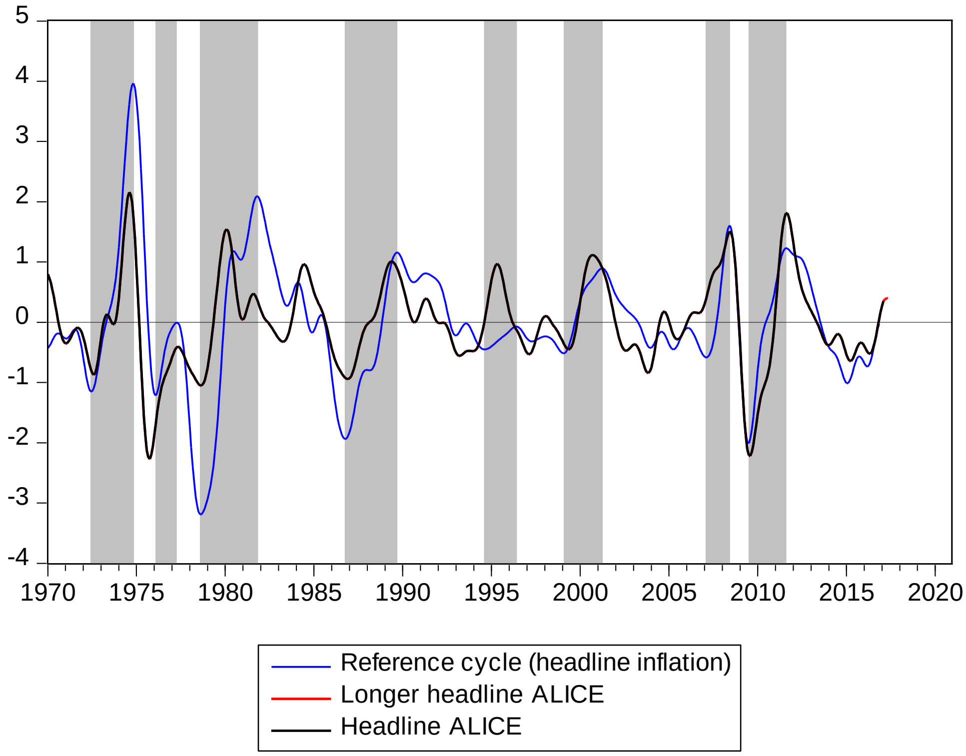
where $m = 1, \ldots, 3$ and $j = 4$ for the headline ALICE and $m = 1, \ldots, 4$ and $j = 5$ for the core ALICE.

Ex post evaluation of ALICE

Figure 3 plots the headline ALICE and the reference cycle for headline inflation over the period since 1970. The shaded areas represent the periods of increasing inflation based on the reference cycle as described earlier. We start in 1970 so that ALICE includes at least three leading series. In the 1970s ALICE moves broadly in line with the reference cycle and identifies the periods of high inflation rates. Over the next two decades another three component series become available. While deviations between the composite leading indicator and reference cycle are present, they become smaller and major upturns in the inflation cycle are picked up. As of the late 1990s, eight out of the nine selected series are included in headline ALICE, further improving its performance in tracking the reference cycle. Finally, the inflation-linked swap rate is included in 2005. The turning point and the period of rising inflation ahead of the global financial crisis is picked-up and reflected by a steep increase in ALICE since the end of 2006. Likewise, headline ALICE indicates the turning point at the start of the financial crisis in 2008 and the subsequent disinflation period. In line with the inflation cycle, the indicator drops sharply and reaches a trough in the second half of 2009. Subsequently, it peaks again in autumn 2011 closely co-moving with the headline inflation cycle and also identifies the disinflation period in the euro area after 2012 well. Thereafter, the headline ALICE indicator and the reference cycle are hovering around zero for some time. At the end of the horizon, ALICE, based on the full set of series, is available for three additional months compared to the reference cycle (i.e. until February 2017) and for further three months up to May 2017 (6-month effective lead) based on a reduced set of four longer leading series (OECD CLI, building permits, money supply to GDP ratio, and non-energy non-food commodity prices). It indicates a continued pick-up in the headline inflation cycle with some very tentative signs of a moderation or turning point at the very end.

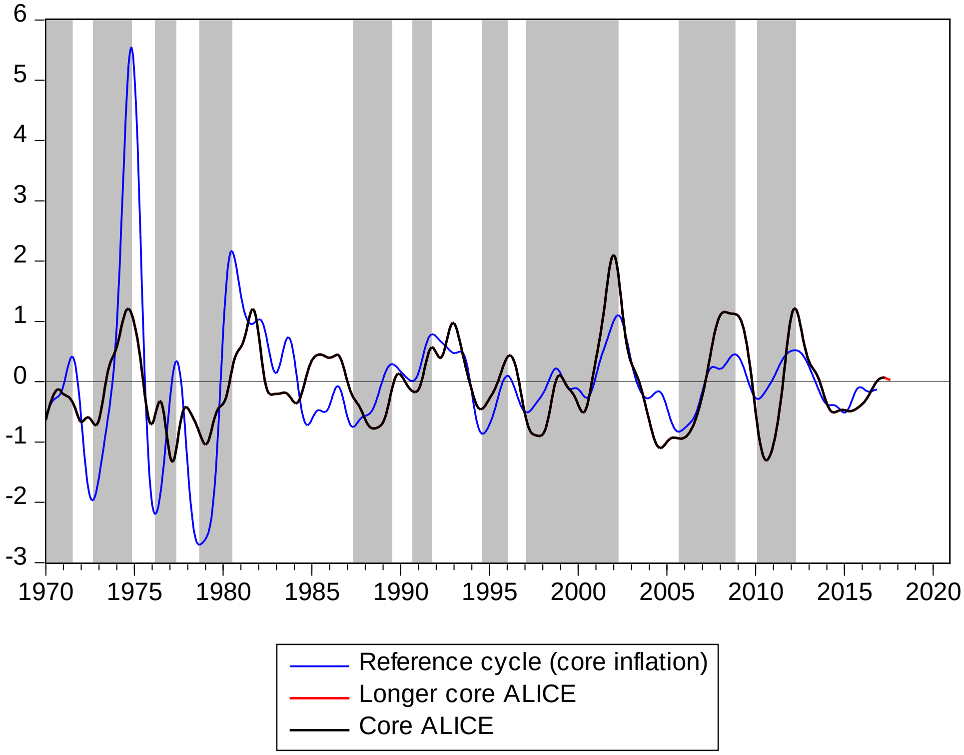
Figure 4 plots the core ALICE indicator together with the reference cycle for core inflation. In the early period the co-movement between the two series is evidently weaker due to the smaller number of component series included which reduces the quality of the indicator during that period. Prior to the early 1980s, the composite indicator consists of four series, namely, the cyclical components of oil price inflation, the OECD CLI, real GDP and M1. Nevertheless, also over this period in most cases the indicator moves upwards in line with the shaded areas picking up the upswings in the core inflation cycle. As three more series are included during the 1980s, the core ALICE performance improves and it aligns more closely with the reference cycle. Looking at more recent major cyclical turning points, the core ALICE identifies well the peaks and troughs of the core inflation cycle which distinguish the periods of strengthening and weakening developments in the chosen core inflation indicator around the times of the financial and sovereign debt crises. Over the most recent period both the reference core cycle and core ALICE edged up somewhat before flattening again, overall hovering around zero. Neither of the two indicators yet indicates a trough in the respective inflation cycle since the most recent peak according to the rule in Equation (3). At the time of the current analysis, the reference cycle for euro area core inflation is available until November 2016. The full-set core ALICE is available until April 2017 and the longer leading ALICE based on five series (oil price inflation, OECD CLI, real GDP, M1 and NEER) extends up to August 2017, reflecting the 9-month effective lead time of the component series. Also, over the (extended) lead period of the core ALICE no signal of an upcoming major turning point can be derived.

Figure 3. Headline ALICE and the corresponding reference cycle



Notes: This figure plots the headline ALICE together with the corresponding reference cycle. The shaded areas denote the periods between a trough and a peak in the headline inflation cycle.

Figure 4. Core ALICE and the corresponding reference cycle



Notes: This figure plots the core ALICE together with the corresponding reference cycle. The shaded areas denote the periods between a trough and a peak in the core inflation cycle.

Pseudo real-time evaluation of ALICE

This section presents the results from a pseudo real-time analysis of the performance of the headline and core ALICE indicators. It takes into account the reporting lag of the series in real time. In addition, the cyclical components are re-estimated in each step and also the standardisation of the leading series is re-calculated over the expanding sample period, because they may be sources of revisions in real time. Revisions of the leading series themselves over time might also introduce revisions in ALICE, but these are not accounted for in this pseudo real-time analysis as the final vintages of the data are used. However, the leading series considered are not all subject to revisions over time and often only revised slightly especially in terms of their cyclical components.

The starting point of the exercise is February 2010. At this point in time, the reference cycles and both ALICE indicators are estimated based on the respective data length that would be available in real time in the middle of February, i.e. in the middle of the quarter first quarter of the year. Both the (core) ALICE based on the full set of leading series[2] and the respective extension based on leading series with a longer lead time (i.e. for ALICE: OECD CLI, building permits, money to GDP ratio and non-energy non-food commodity prices; and for core ALICE: oil prices, OECD CLI, real GDP, M1 and NEER) are calculated. The effective lead times of headline ALICE and its extension with regard to the reference cycle should on average amount to 3 and 6 months, and that of core ALICE and its extension to 5 and 10 months[3], respectively. These pseudo real-time calculations are conducted for the middle of each quarter over the period until mid-November 2016.

Figure 5 depicts the pseudo real-time developments in the headline inflation reference cycle and the (longer leading) ALICE in the considered quarters over time. Following a trough in 2009, ALICE persistently signals a continuation of the cyclical improvements for the headline reference cycle until May 2011. In line with the signals from ALICE, the references cycle is gradually increasing over this period. In August 2011, ALICE signals a peak in the inflation cycle and this signal is confirmed in November 2011, where a clear cyclical downswing is already predicted. Indeed, the inflation cycle turned clearly in February 2012, i.e. in the data vintage six months after the initial signal and has already started to fall at that point in time.

The decline in both series continues until May 2013 when ALICE provides a first indication of an upcoming trough. Even though this signal becomes stronger over the next few quarters, the reference cycle continues to decline, albeit at a somewhat slower pace. The pick-up in ALICE however remains modest and as of May 2014 ALICE turns again while the reference cycle flattens and appears to have reached ground. ALICE signals some cyclical sideward movements up to November 2015 which are broadly followed by the reference cycle. Thereafter a clearer strengthening in ALICE predicts some cyclical improvements for the headline reference cycle which are apparent in the indicator in November 2016. Overall, the pseudo real-time analysis shows that the headline ALICE performs well as additional data become available. It

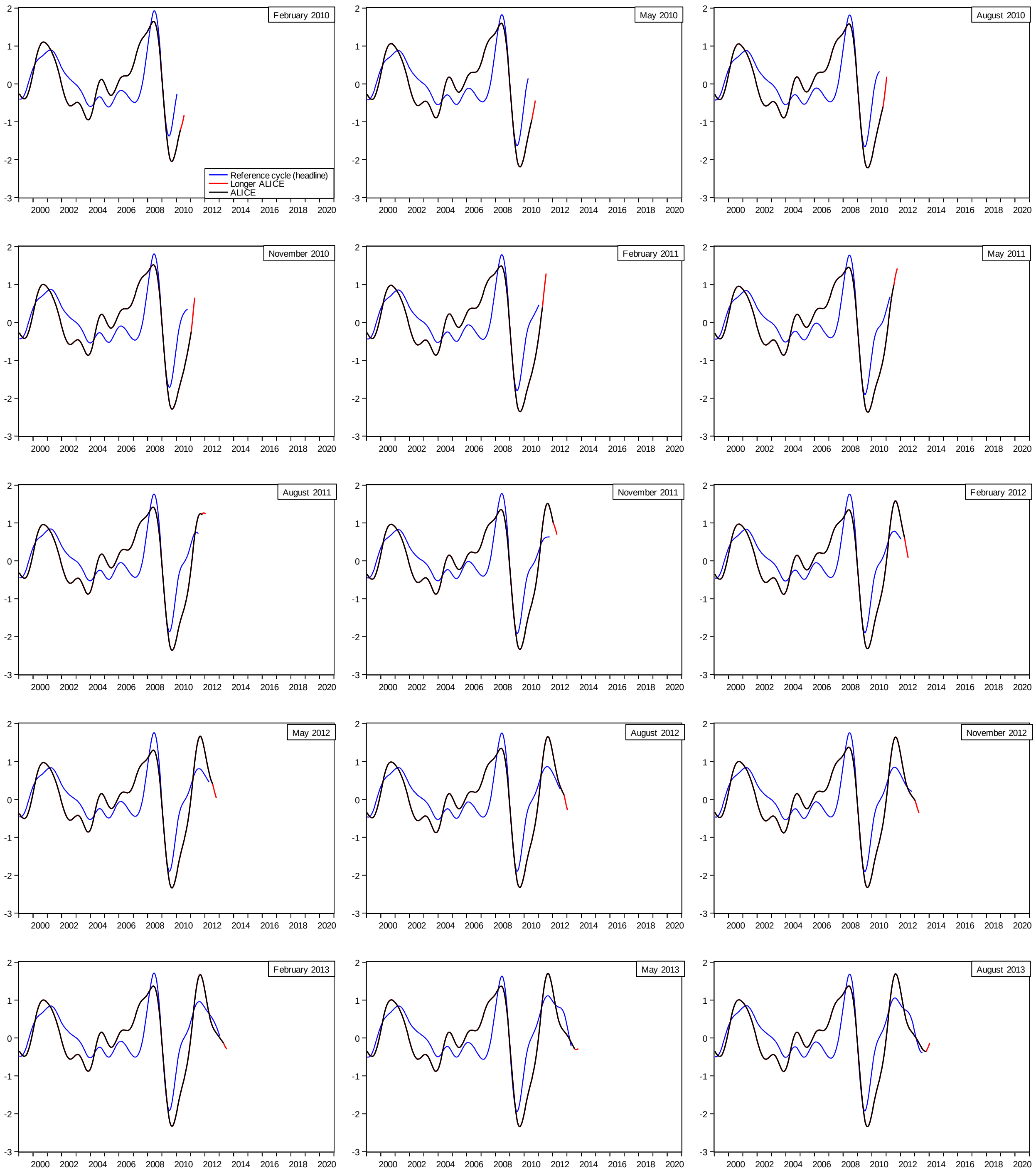
[2] Note that the inflation-linked swap rate in the case of headline ALICE is only available in 2005 and therefore included since May 2015 (to allow 10 years of data to estimate the cycle).

[3] Note that the effective lead time for the longer core ALICE is now one month longer than the previously reported effective lead time in the ex post analysis. This is due to the use of a slightly different timing of the dataset used in the pseudo real time analysis.

leads the headline reference cycle and does (as the reference cycle) not suffer from major revisions. Also, the timing of the identified turning points does not shift substantially over time.

Figure 6 illustrates the pseudo real-time performance of the (longer term) core ALICE and the corresponding reference cycle. In February 2010 ALICE anticipates a turning point (trough) for the reference cycle that indeed materialises after two quarters in the reference cycle. The two series move upwards until August 2011 when ALICE signals a peak, which is at that time also temporarily visible in the reference cycle but revised away in the next data vintage. Nevertheless, the core ALICE turning point signal is reinforced in the next quarters as the indicator continues to decrease. This signal is followed by the reference cycle in February 2012. Thereafter both indicators decline gradually until the end of 2013 with the core ALICE leading the reference cycle. In November 2013, ALICE anticipates a trough in the core inflation cycle in the near future. This signal also shows up through the next quarter but the indicator flattens afterwards anticipating correctly the upcoming stabilisation in the reference cycle. The upturn signal of ALICE temporarily strengthens at the end of 2015 before continuing to point sideward broadly in line with the movements observed in the core reference cycle. Overall, also for the core inflation cycle the two indicators tend to move together with the core ALICE leading the reference cycle.

Figure 5. Pseudo real-time developments of headline ALICE and the reference cycle



Notes: This figure plots the ALICE (black line) together with the longer ALICE (red line) for headline inflation and the reference cycle (blue line) in pseudo real-time over the period February 2010 – November 2016.

Figure 5. (continued)

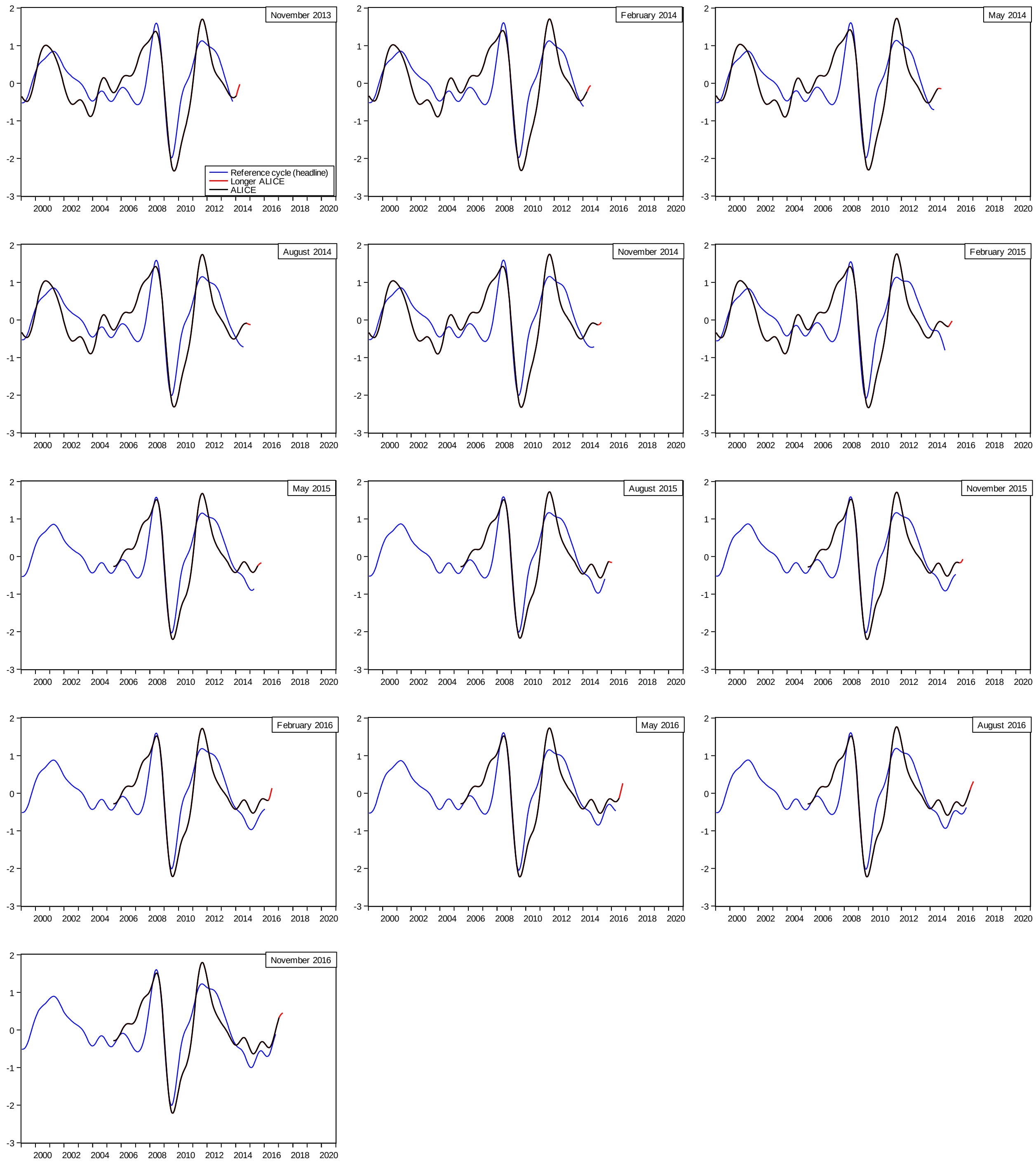
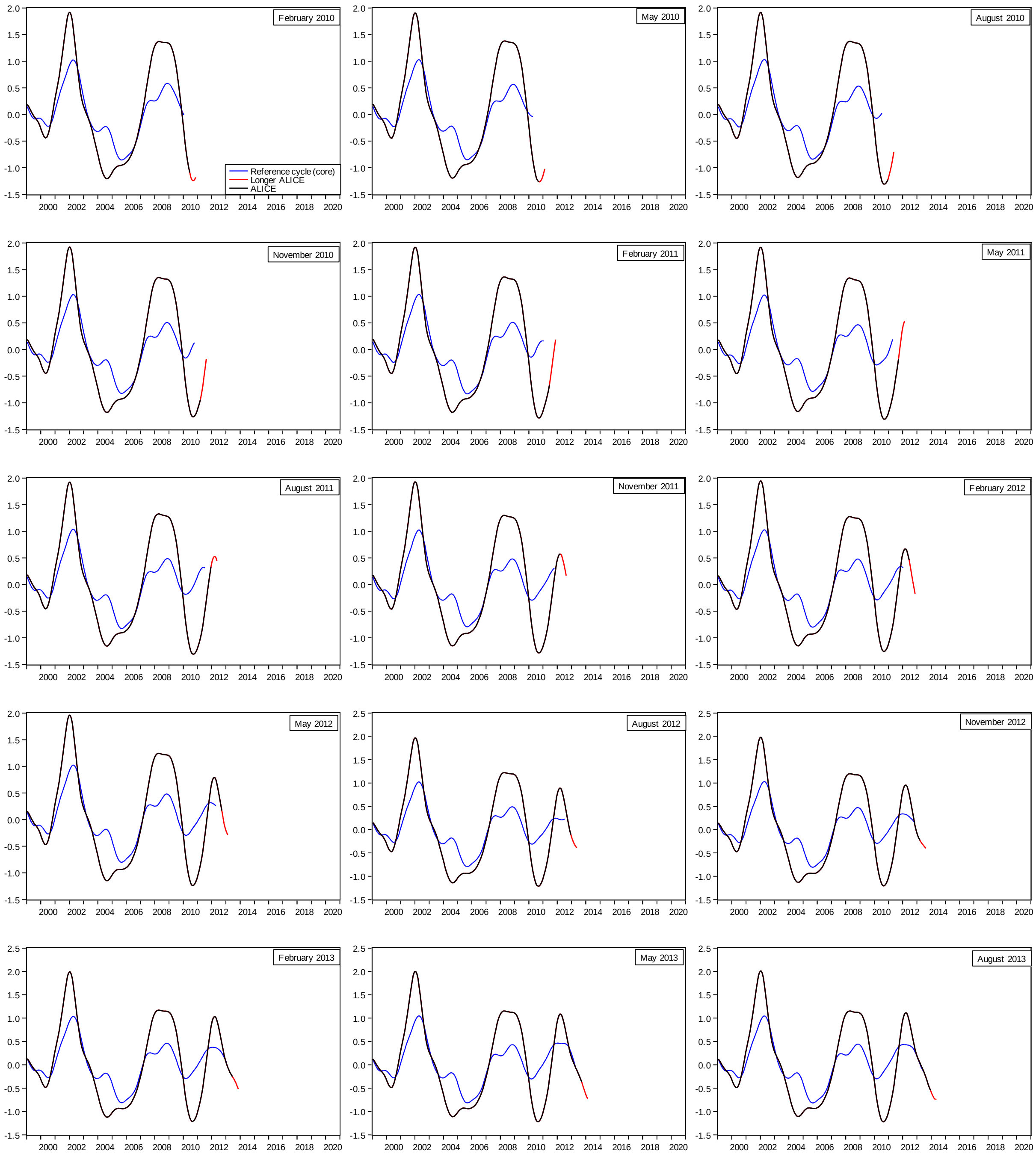
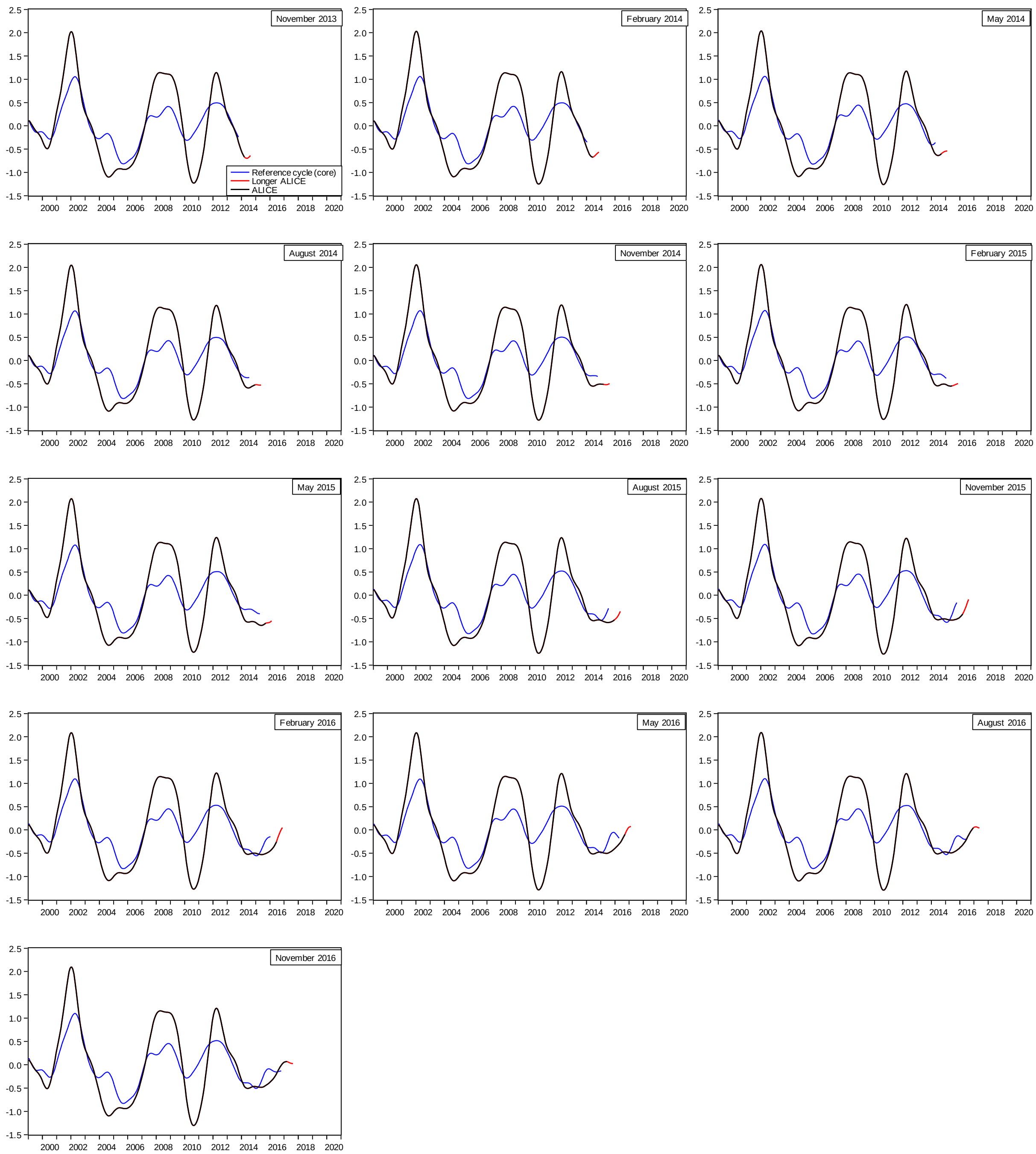


Figure 6. Pseudo real-time developments of core ALICE and the reference cycle



Notes: This figure plots the ALICE (black line) together with the longer ALICE (red line) for core inflation and the reference cycle (blue line) in pseudo real-time over the period February 2010 – November 2016.

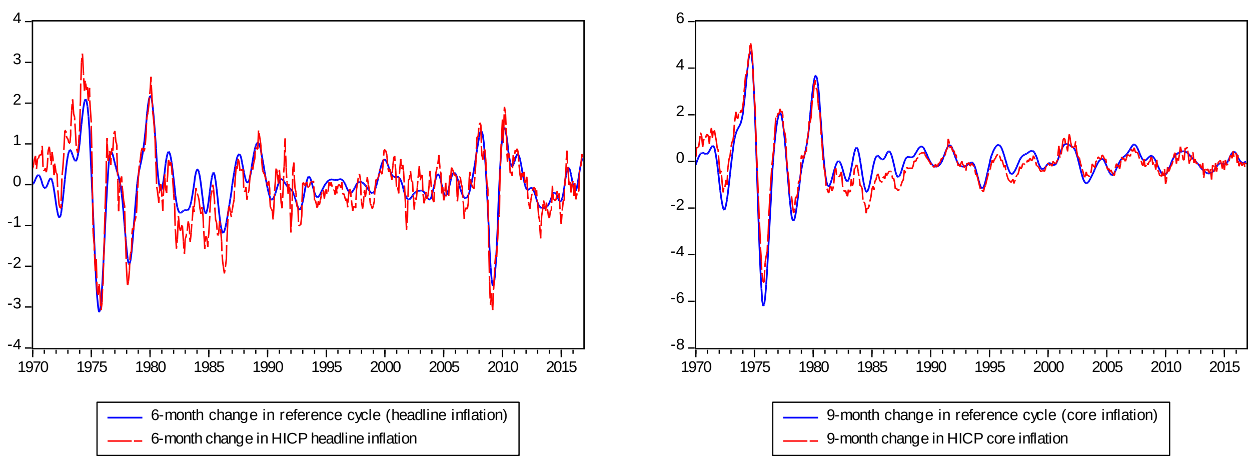
Figure 6. (continued)



Quantitative inflation forecasts with ALICE

This section reports quantitative inflation forecasts based on the pseudo real-time ALICE dataset discussed above. While the main aim of CLIs like ALICE is to provide qualitative information concerning turning points in the inflation cycle, such indicators may nevertheless have predictive power also in quantitative terms. This is explored below. As mentioned above, the pseudo real-time dataset for ALICE refers to the middle of each quarter such that the headline (core) ALICE is available 6 (10) months ahead compared to the latest data point available for the corresponding inflation measure and its reference cycle. Consequently, changes in headline (core) inflation rate could be predicted 2 (3) quarters ahead using changes in the headline (core) ALICE. Figure 7 shows that changes in the reference cycle tends to move broadly in line with those in actual inflation, as one would expect under the assumption of no significant change in the trend component during the short horizon considered. As a result, also changes in ALICE may have predictive power for changes in the corresponding inflation measures.

Figure 7. Changes in the reference cycle and inflation



Notes: This figure plots 6-month changes in the headline reference cycle against 6-month changes in the HICP inflation rate (left panel) and 9-month changes in the core reference cycle against 9-month changes in the HICP inflation rate excluding energy and food (right panel).

We conduct and evaluate 2 (3)-quarter ahead quantitative forecasts for 2 (3)-quarter changes in the headline (core) inflation rates, using the real-time ALICE dataset over the period

2010Q1 - 2016Q3. More specifically, based on the data available in the middle of each quarter, we calculate 6 (9)-month changes in the real-time headline (core) ALICE for each month in the subsequent quarter (quarter following the next one). These calculated changes in the headline (core) ALICE represent the forecasts for changes in the headline (core) inflation rates. Quarterly forecasts are derived by averaging the monthly forecasts for the respective quarters.

For instance, looking at the first vintage of our dataset, in mid-February 2010, HICP data are available up to January 2010. The 2-quarter-ahead forecast for the 2-quarter change in the headline HICP inflation rate is constructed by averaging the changes in the headline ALICE in April 2010 versus October 2009, May 2010 versus November 2009, and June 2010 versus December 2009. Similarly, the 3-quarter-ahead forecast for the 3-quarter change in HICP inflation excluding energy and food is derived as the average of changes in the core ALICE in July 2010 versus October 2009, August 2010 versus November 2009, and September 2010 versus December 2009. The quarterly forecast errors are calculated as the difference between the actual changes in the inflation measures over that period and the changes in the corresponding ALICE.

Formally, the calculations of forecasts for 2-quarter changes in headline inflation 2 quarters ahead ($\Delta_6\pi^{f}_{2q}$) and forecasts for 3-quarter changes in core inflation 3 quarters ahead ($\Delta_9\pi^{f}_{3q}$) in the reference month *t* (i.e. February, May, August, or November) are derived as shown in the Equations (6) and (7):

$$\Delta_6\pi^f_{2q} = \frac{1}{3}\big((ALICE_{t+2} - ALICE_{t-4}) + (ALICE_{t+3} - ALICE_{t-3}) + (ALICE_{t+4} - ALICE_{t-2})\big) \quad (6)$$

$$\Delta_9\pi^f_{3q} = \frac{1}{3}\big((ALICE_{t+5} - ALICE_{t-4}) + (ALICE_{t+6} - ALICE_{t-3}) + (ALICE_{t+7} - ALICE_{t-2})\big) \quad (7)$$

The forecast performance of ALICE is assessed by comparing it to alternative inflation forecasts. Firstly, the random walk (RW) model for inflation is considered. It is a standard tool for the evaluation of inflation forecasts in the literature. In this model the predicted annual inflation rate *n*-periods ahead equals the current annual inflation rate (Atkeson and Ohanian, 2001). It is generally hard to outperform simple univariate models, such as the RW or autoregressive models with more elaborate forecasting methods, but the relative performance of these models tend to vary over time (Banerjee et al., 2005; Cristadoro et al., 2005; Russell and Banerjee, 2006; Stock and Watson, 2009; Hubrich and Skudelny, 2016). In our case, the RW approach is equivalent to assuming that the future *h*-period change in inflation rate is zero.

Secondly, we compare the ALICE-based predictions with euro area inflation projections from the monthly Euro Zone Barometer (EZB) survey by MJEconomics and from the quarterly Eurosystem/ECB staff macroeconomic projection exercise (MPE). Whilst the majority of publicly available surveys and forecasts provided by institutions are typically focused on one-year or longer horizons and whole calendar years, the EZB survey and the MPE projections (since December 2013) also publish quarterly forecasts with respect to the euro area HICP headline inflation, albeit not for HICP inflation excluding energy and food. A further reason for the comparison with the MPE is that it has in the past slightly outperformed the inflation forecasts by other international institutions and professional forecasters, such as the OECD, International Monetary Fund, European Commission, Economic Consensus and Survey of Professional Forecasters (ECB, 2013).

For the forecast comparison with ALICE, the real-time forecasts of the EZB and the MPE published closest to the pseudo real-time dating of ALICE in the middle of each quarter are chosen. The EZB is released around the middle of every month, such that the EZB forecasts in February, May, August and November should include a broadly comparable information set to the pseudo real-time ALICE forecasts abstracting from data revisions included in the ALICE dataset. The quarterly MPE projections are published at the beginning of the third month of the quarter but the cut-off date of these projections is typically around the middle of the quarter so that this timing is very much comparable with the other two forecasts as well. To have the comparable measure as derived from the ALICE, the level inflation forecasts from the EZB and MPE are transformed into 2 (3) quarter changes.

The forecast performance is evaluated in three ways. First, it is assessed in terms of the directional accuracy. This is defined as the relative frequency of the forecasts which correctly forecasted the direction of the future change in inflation (over the considered 2 or 3 quarters). The second and third performance measures are the mean absolute error (MAE) and the root mean squared error (RMSE). These are depicted for all forecasts in relative terms to those of the ALICE-based forecasts, such that a ratio above 1 indicates that ALICE has outperformed the alternative forecasts of the RW, EZB or MPE, and a ratio below 1 that ALICE has underperformed. For both the RMSE and MAE we report the outcomes per calendar year.

Panel A of Table 3 reports the results for the period 2010Q1 - 2016Q3. With respect to headline inflation, the directional accuracy of the headline ALICE is 73%, i.e. in 7 out of 10 times it predicts correctly the direction of a change in inflation two quarters ahead, whereas this is only the case in 54% of the EZB-based forecasts. However, the RW and EZB-based forecasts have a lower average absolute error than the headline ALICE. Nevertheless, the RW underperforms the ALICE in terms of the RMSE over the whole period from 2010 to 2016, while the EZB forecast performs similarly as the ALICE for that measure. The relative RMSE by calendar year show that the relative forecast performance of the different methods is strongly time-varying. The RW beats the headline ALICE in 2011, 2012 and 2014. The EZB survey forecasts are more accurate in 2010 – 2014. However, in the final two years the headline ALICE performs clearly better than the EZB forecasts and similar to the RW. This is also largely confirmed by MAE. For HICP inflation excluding energy and food, the directional accuracy of core ALICE is at 68% almost as high as for headline inflation. However, for core inflation the RW demonstrates a superior performance to ALICE in terms of both the MAE and the RMSEs.

Panel B summarises the results for the period 2013Q4 - 2016Q3, which includes now also the comparison with the MPE projections for headline inflation. The directional accuracy of ALICE deteriorates for both headline and core inflation compared to the longer sample period, but remains higher than for the EZB and is also better than in the MPE. In quantitative terms, the RW models outperform the headline and core ALICE as their MAE and RMSE are generally below those of the ALICE indicators. However, neither the EZB nor the MPE forecasts are better than the ALICE predictions over this period. The results also confirm an earlier finding that the MPE inflation forecasts are on average somewhat more accurate than those from the EZB (ECB, 2013).

To summarise, this section illustrates that the headline and core ALICE may be a useful complementary tool to cross-check quantitative inflation forecasts. In particular, both ALICE indicators perform on average better than the other forecasts with respect to predicting the direction of future changes in inflation over the considered 2 or 3 quarters. In quantitative terms, the RW often performed better but this was less clearly the case for the EZB and MPE projections. The interpretation of the relative performance of the ALICE, however, also deserves a note of caution as the ALICE forecasts are based on a pseudo real-time analysis as compared to a fully-fledged real-time analysis in the case of the other forecasts, although it is not clear whether this implied a measurable advantage. Also, the performance varies considerably over time as it is often found in the literature for many forecasting models.

Table 3. Forecasting ability of RW, EZB, and MPE relative to ALICE

Panel A:			*2010 Q1 – 2016 Q3*			
	Headline HICP				HICP excl. energy and food	
	ALICE	RW	EZB		ALICE	RW
Directional accuracy (%)	73.1	NA	53.8		68.1	NA
MAE (overall)	1	0.94	0.95		1	0.51
RMSE (overall)	1	1.03	0.99		1	0.48
RMSE / MAE 2010	1 / 1	1.99 / 1.85	0.86 / 0.85		1 / 1	0.13 / 0.12
RMSE / MAE 2011	1 / 1	0.80 / 0.79	0.91 / 0.89		1 / 1	0.72 / 0.82
RMSE / MAE 2012	1 / 1	0.51 / 0.38	0.67 / 0.60		1 / 1	0.16 / 0.13
RMSE / MAE 2013	1 / 1	1.57 / 1.64	0.92 / 0.80		1 / 1	0.92 / 1.17
RMSE / MAE 2014	1 / 1	0.72 / 0.67	0.71 / 0.72		1 / 1	0.76 / 0.68
RMSE / MAE 2015	1 / 1	1.00 / 0.85	1.61 / 1.67		1 / 1	0.94 / 0.91
RMSE / MAE 2016	1 / 1	1.01 / 1.11	2.89 / 2.73		1 / 1	0.41 / 0.45
Panel B:			*2013 Q4 – 2016 Q3*			
	Headline HICP				HICP excl. energy and food	
	ALICE	RW	EZB	MPE	ALICE	RW
Directional accuracy (%)	45.5	NA	27.3	36.4	46.7	NA
MAE (overall)	1	0.77	1.24	1.03	1	0.67
RMSE (overall)	1	0.82	1.21	1.01	1	0.66
RMSE / MAE 2014	1 / 1	0.72 / 0.67	0.71 / 0.72	0.69 / 0.68	1 / 1	0.72 / 0.61
RMSE / MAE 2015	1 / 1	1.00 / 0.85	1.61 / 1.67	1.14 / 1.17	1 / 1	0.94 / 0.91
RMSE / MAE 2016	1 / 1	1.01 / 1.11	2.89 / 2.73	2.59 / 2.46	1 / 1	0.41 / 0.45

Notes: This table summarises the inflation forecast evaluation results for the RW, EZB and MPE projections relative to the headline (left) and core (right) ALICE. Panel A presents the directional accuracy of the ALICE and EZB (headline inflation only) as well as the mean absolute errors (MAE) and root mean squared errors (RMSE) for the RW- and EZB-based (headline inflation only) forecasts relative to ALICE. Panel B presents the directional accuracy of the ALICE, EZB and MPE as well as the mean absolute errors and RMSEs for the RW, EZB and MPE relative to ALICE. NA denotes not applicable.

CONCLUSIONS

This study develops leading indicators for the inflation cycles of headline and HICP excluding energy and food inflation in the euro area. The applied methodology follows that of traditional CLIs and the underlying data are carefully selected from a large euro area dataset of potential leading series. The two composite leading indicators for the euro area headline and core inflation cycles, (core) ALICE, consist of nine, respectively, seven leading series. The selected leading series have a broad economic coverage, ranging from external determinants, prices and costs measures, economic activity variables, "soft" survey data, financial variables, and market-based inflation expectations.

The findings are promising. The headline and core ALICE identify major cyclical movements in inflation in an *ex post* analysis very well, especially since 1999. An *ex ante* pseudo real-time analysis confirms these findings and shows that the ALICE for both headline and core inflation indicate turning points of the reference cycle in advance and do not suffer from major revisions over time. These are two essential preconditions for the practical applicability of such indicators. Besides their qualitative use, the ALICE indicators have also been analysed in terms of their quantitative forecasting ability. They performed better than other forecasts in terms of forecasting the direction of future inflation developments two or three quarters ahead. In terms of quantitative forecast accuracy, the RW often performed better but this was less clearly the case for the EZB and MPE projections, particularly in the most recent years. To what extent this may hinge on the pseudo real-time nature of the ALICE forecast compared to the true real-time nature of the other two forecasts is unclear. The observed time-varying forecasting performance of ALICE is in line with the evidence provided in the literature for many forecasting models. Overall, ALICE is a new tool that has the potential to provide useful input for the real-time monitoring, analysis and forecasting of inflation in the euro area. It may be used as complementary tool to traditional inflation models to cross-check and steer quantitative inflation forecasts.

A number of interesting points remain open for future work. It would be of great interest to apply this methodology to euro area countries rather than the aggregated euro area. A further avenue for future work would be to focus more specifically on the main sub-components of HICP inflation, i.e. services, non-energy industrial goods, energy and food.

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Appendix

Table A1. Overview of the selection of leading series for headline ALICE

Sample period: 1960.1 - 2016.11	*Correlation, sample starting in*					*Optimal lead, sample starting in*					*Criteria*			*Comments*
	1960	*1970*	*1980*	*1990*	*1999*	*1960*	*1970*	*1980*	*1990*	*1999*	*C1*	*C2*	*C3*	
PPI Industry excl. construction (ann. % chg.)	0.78	0.80	0.77	0.82	0.85	3	3	1	0	0	+	-		Lead time too short
PPI Manufacturing (ann. % chg.)	0.76	0.80	0.74	0.82	0.84	4	4	2	2	2	+	-		Lead time too short
Industrial production excl. construction (log)	0.45	0.49	0.56	0.58	0.74	7	7	2	2	2	+	-		Lead time too short
OECD euro area composite leading indicator	**0.36**	**0.40**	**0.50**	**0.50**	**0.64**	**14**	**14**	**7**	**7**	**7**	**+**	**+**	**+**	**Highest correlation; economic activity**
Industrial production excl. construction (ann. % chg.)	0.21	0.25	0.38	0.51	0.63	11	10	5	5	5	+	+	-	Covered by euro area CLI
OECD composite leading indicator (global)	0.25	0.27	0.44	0.51	0.61	18	17	7	7	7	+	+	-	No additional information
Brent crude oil price in EUR (ann. % chg.)	**0.55**	**0.57**	**0.46**	**0.49**	**0.47**	**5**	**5**	**3**	**4**	**4**	**-**	**+**	**+**	**Important inflation driver; stable lead**
10-year government bond yield (German/euro area)	0.72	0.77	0.55	0.33	0.35	3	5	1	1	0	-			Correlation too low
EUR/USD exchange rate (ann. % chg.)	0.28	0.28	0.29	0.29	0.33	0	1	5	28	27	-			Correlation too low
US unemployment rate	0.23	0.27	0.19	0.19	0.33	36	36	3	0	0	-			Correlation too low
Nominal stock price index (ann. % chg.)	0.01	0.04	0.04	0.13	0.32	23	22	10	12	11	-			Correlation too low
EUR/USD exchange rate (log)	0.01	0.02	0.29	0.23	0.24	0	0	0	21	15	-			Correlation too low
Sample period: 1970.1 - 2016.11														
Global inflation (OECD)		0.72	0.34	0.74	0.88		2	2	0	0	+	-		Lead time too short
Import deflator for goods and services (ann. % chg.)		0.82	0.66	0.67	0.69		0	1	2	2	+	-		Lead time too short
PPI MIG Intermediate goods (ann. % chg.)		0.53	0.59	0.59	0.66		4	2	2	1	+	-		Lead time too short
Real GDP (log)		0.55	0.58	0.53	0.64		8	2	3	2	+	-		Lead time too short
M1 to GDP ratio		**0.47**	**0.57**	**0.59**	**0.62**		**22**	**19**	**19**	**18**	**+**	**+**	**+**	**Financial (monetary) variable**
M1 growth less GDP growth (ann. % chg.)		0.35	0.49	0.59	0.61		28	30	30	30	+	+	-	Captured by M1/GDP
Compensation per employee (ann. % chg.)		0.75	0.46	0.26	0.60		0	0	0	0	+	-		No lead time
Real GDP (ann. % chg.)		0.28	0.39	0.46	0.59		12	5	6	5	+	-		Effective lead time too short
M3 to GDP ratio		0.29	0.35	0.56	0.55		25	32	33	34	+	+	-	Captured by M1/GDP
M1 stock (log)		0.47	0.45	0.51	0.54		21	13	17	15	-			Correlation too low
M1 (ann. % chg.)		0.31	0.42	0.49	0.52		27	28	29	29	-			Correlation too low
M3 stock (log)		0.08	0.13	0.42	0.44		0	0	36	36	-			Correlation too low
GDP price deflator (ann. % chg.)		0.76	0.36	0.33	0.42		0	0	0	0	-			Correlation too low
Unit labour cost (ann. % chg.)		0.65	0.16	0.29	0.37		0	0	36	36	-			Correlation too low
Compensation per employee (log)		0.43	0.22	0.26	0.32		0	0	0	0	-			Correlation too low
M3 growth less GDP growth (ann. % chg.)		0.21	0.24	0.35	0.30		32	36	36	36	-			Correlation too low
M3 (ann. % chg.)		0.06	0.36	0.20	0.30		36	0	0	0	-			Correlation too low
Sample period: 1980.1 - 2016.11														
PPI Consumer goods (annual % change)			0.84	0.91	0.94			0	0	0	+	-		No lead time
PPI Energy (annual % change)			0.72	0.73	0.74			1	1	0	+	-		Lead time too short
World raw material prices - food (ann. % chg.)			**0.49**	**0.63**	**0.69**			**5**	**3**	**4**	**+**	**+**	**+**	**External price pressures**
Building permits (ann. % chg.)			**0.52**	**0.54**	**0.68**			**17**	**17**	**16**	**+**	**+**	**+**	**Expected income/inflation pressures**
MFI loans to households (log)			0.66	0.56	0.66			0	2	1	+	-		Lead time too short
M2 to GDP ratio			0.47	0.60	0.63			28	28	29	+	+	-	Captured by M1/GDP
MFI loans flows (log)			0.56	0.49	0.62			5	5	5	+	+	-	No additional relevant information
Residential property price index (ann. % chg.)			0.50	0.46	0.62			8	6	5	+	-		Effective lead time too short
World raw material prices - total (ann. % chg.)			0.55	0.61	0.59			3	4	3	+	-		Effective lead time too short
PPI Capital goods (ann. % chg.)			0.58	0.54	0.57			0	0	0	+	-		No lead time
World raw material prices - energy (ann. % chg.)			0.50	0.54	0.52			3	4	3	-			Correlation too low
World raw material prices - industrial (ann. % chg.)			0.41	0.47	0.52			16	17	18	-			Correlation too low
World raw material prices - excl.energy (ann. % chg.)			0.43	0.51	0.52			7	5	5	-			Correlation too low
MFI loans outstanding (ann. % chg.)			0.54	0.30	0.50			1	1	1	-			Correlation too low
MFI loans to households (ann. % chg.)			0.45	0.39	0.49			11	8	7	-			Correlation too low
World raw material prices - crude oil (ann. % chg.)			0.46	0.50	0.49			3	4	4	-			Correlation too low
M2 stock (log)			0.09	0.39	0.45			0	35	36	-			Correlation too low
Building permits in euro area (log)			0.41	0.36	0.45			10	9	8	-			Correlation too low
MFI loans outstanding (log)			0.41	0.36	0.44			0	0	0	-			Correlation too low
Nom. effect. exchange rate NEER-12 (log)			0.34	0.40	0.42			2	9	11	-			Correlation too low
MFI loans to non-fin. corporations (ann. % chg.)			0.49	0.23	0.41			0	0	0	-			Correlation too low
M2 growth less GDP growth (ann. % chg.)			0.31	0.42	0.39			34	36	36	-			Correlation too low
Unemployment rate			0.47	0.27	0.37			0	2	1	-			Correlation too low
Nom. effect. exchange rate NEER-12 (ann. % chg.)			0.31	0.26	0.36			10	25	17	-			Correlation too low
Nom. effect. exchange rate NEER-38 (log)			0.34	0.30	0.36			0	2	2	-			Correlation too low
Nom. effect. exchange rate NEER-19 (log)			0.34	0.29	0.30			0	2	0	-			Correlation too low

Notes: This table summarises the results from the general-to-specific approach to select leading series for the headline ALICE. For each group, the correlation coefficients in absolute size and optimal lead times are reported for periods starting in 1960, 1970, 1980, 1985, 1990, 1995 and 1999. The cyclical components of series are re-estimated in each decade to obtain the correlation and lead times. Groups are based on the starting point of individual time series that may or may not coincide with the start of the decade. The selected series are denoted in bold. C1, C2, and C3 refer to selection criterion 1, 2 and 3 as defined in the text, respectively. Entries "+" / "-" indicate the criterion is fulfilled/not fulfilled. EC CS, EC IS, EC RTS and EC SS stand for the European Commission surveys of consumers, industry, retail trade and services, respectively. ZEW Financial Market survey data is denoted by ZEW FS.

Table A1. (continued)

MFI loans outstanding to GDP ratio	0.33	0.28	0.27	0	24	0	-			Correlation too low
MFI loans to non-fin. corporations (log)	0.34	0.24	0.24	0	0	0	-			Correlation too low
MFI loans flows (ann. % chg.)	0.22	0.30	0.23	26	26	28	-			Correlation too low
MFI loans growth less GDP growth (ann. % chg.)	0.28	0.26	0.20	0	36	0				Correlation too low
M2 (ann. % chg.)	0.21	0.11	0.17	0	36	0	-			Correlation too low
Nom. effect. exchange rate NEER-38 (ann. % chg.)	0.34	0.16	0.26	5	28	14	-			Correlation too low
Nom. effect. exchange rate NEER-19 (ann. % chg.)	0.29	0.21	0.25	6	27	18	-			Correlation too low
Sample period: 1985.1 - 2016.11										
PPI Consumer nondurable goods (ann. % chg.)	0.78	0.91	0.94	0	0	0	+	-		No lead time
PPI Consumer food goods (annual % change)	0.80	0.90	0.92	0	0	0	+	-		No lead time
EC CS: price trends over next 12 m.	0.75	0.77	0.82	1	1	0	+	-		Lead time too short
EC IS: selling price expectations - consumer goods	0.77	0.73	0.80	2	2	2	+	-		Lead time too short
EC IS: employment expectations	0.62	0.51	0.74	4	5	4	+	+	-	No additional information
EC IS: selling price expectations	**0.67**	**0.62**	**0.73**	**3**	**3**	**3**	**+**	**+**	**+**	**Survey measure**
Capacity utilisation	0.58	0.55	0.71	1	1	1	+	-		Lead time too short
PPI Nonfood consumer goods (ann. % chg.)	0.38	0.54	0.66	0	0	0	+	-		No lead time
EC IS: selling price expectations - intermediate goods	0.54	0.52	0.64	5	4	4	+	+	-	Covered by selling price expect. (tot.)
EC IS: production expectations	0.51	0.46	0.63	7	6	7	+	+	-	No additional information
Business climate indicator	0.52	0.46	0.64	6	5	5	+	+	-	No additional information
PPI Consumer durables goods (ann. % chg.)	0.36	0.55	0.58	0	0	0	+	-		No lead time
Economic sentiment indicator	0.51	0.37	0.58	8	8	7	+	+	-	No additional information
EC CS: unemployment expectations over next 12 m.	0.48	0.43	0.57	6	6	5	+	+	-	No additional information
EC RTS: expected business conditions	0.33	0.34	0.56	11	6	7	+	+	-	No additional information
Capacity utilisation (ann. % chg.)	0.40	0.43	0.52	5	4	4	-			Correlation too low
EC CS: consumer confidence indicator	0.46	0.40	0.52	10	10	8	-			Correlation too low
EC CS: general economic situation over next 12 m.	0.42	0.38	0.47	13	13	11	-			Correlation too low
EC CS: major purchases over next 12 m.	0.39	0.19	0.30	11	11	9	-			Correlation too low
Euro area Baltic Dry index (ann. % chg.)	0.19	0.26	0.24	8	8	8	-			Correlation too low
Sample period: 1990.1 - 2016.11										
PPI Industry excl. constr. & MIG energy (ann. % chg.)		0.72	0.80		1	1	+	-		Lead time too short
Construction sector input prices (ann. % chg.)		0.65	0.69		0	0	+	-		No lead time
Negotiated wage rates excl. bonuses (abs. ann. chg.)		0.14	0.69		0	0	+	-		No lead time
Negotiated wage rates (abs. ann. chg.)		0.12	0.64		0	0	+	-		No lead time
Construction sector material costs (ann. % chg.)		0.60	0.64		0	0	+	-		No lead time
3-month EURIBOR rate		0.42	0.52		0	0	-			Correlation too low
ZEW FS: expect. short-term interest rate (6 m.)		0.30	0.50		15	14	-			Correlation too low
European Monetary Union Cons. goods index (ann. % chg.)		0.22	0.46		9	9	-			Correlation too low
HICP - Industrial goods excl. energy (ann. % chg.)		0.37	0.37		0	0	-			Correlation too low
European Monetary Union Cons. services index (ann. % chg.)		0.24	0.35		14	13	-			Correlation too low
MSCI EMU Index - Long Term Growth Forecast		0.35	0.33		8	6	-			Correlation too low
Construction sector labour costs (ann. % chg.)		0.35	0.31		0	36	-			Correlation too low
Negotiated wage rates excl. bonuses		0.15	0.29		36	0	-			Correlation too low
Real effect. exchange rate EER-19 - CPI defl. (log)		0.16	0.29		9	9	-			Correlation too low
Negotiated wage rates		0.14	0.25		36	36	-			Correlation too low
Real effect. exchange rate EER-19 - CPI defl. (ann. % chg.)		0.18	0.24		28	24	-			Correlation too low
Sample period: 1995 - 2016.11										
Labour productivity per persons (log)		0.64	0.74		3	3	+	-		Effective lead time too short
Labour productivity per hours worked (log)		0.66	0.71		4	4	+	-		Effective lead time too short
Import deflator of goods (ann. % chg.)		0.71	0.69		2	2	+	-		Lead time too short
ECB Commodity Price index - food (ann. % chg.)		0.59	0.62		4	5	+	+	-	Covered by raw material prices of food
Labour productivity per hours worked (ann. % chg.)		0.53	0.57		7	9	+	+	-	No additional information
ECB Commodity Price index - non-food (ann. % chg.)		**0.50**	**0.57**		**17**	**17**	**+**	**+**	**+**	**External price pressures**
Labour productivity per persons (ann. % chg.)		0.52	0.57		6	7	+	+	-	No additional information
Import deflator of services (ann. % chg.)		0.52	0.54		3	2	-			Correlation too low
Total employment - hours worked (ann. % chg.)		0.44	0.53		4	4	-			Correlation too low
Total employment - persons (ann. % chg.)		0.40	0.51		4	3	-			Correlation too low
ECB Commodity Price index - non-energy (ann. % chg.)		0.44	0.50		7	16	-			Correlation too low
Total hours worked per persons		0.40	0.50		2	3	-			Correlation too low
Unit profits		0.42	0.46		2	2	-			Correlation too low
Total hours worked per persons (ann. % chg.)		0.39	0.45		4	4	-			Correlation too low
Total employment - hours worked (log)		0.38	0.45		1	1	-			Correlation too low
ECB Commodity Price index - agric. raw materials (ann. % chg.)		0.36	0.39		14	16	-			Correlation too low
Total employment - persons (log)		0.32	0.38		1	0	-			Correlation too low
Real effect. exchange rate EER-19 - PPI defl. (log)		0.30	0.31		12	13	-			Correlation too low
Real effect. exchange rate EER-19 - PPI defl. (ann. % chg.)		0.20	0.30		28	27	-			Correlation too low
MSCI EMU Index - 12-m forward Y-O-Y growth in earnings		0.19	0.19		17	18	-			Correlation too low

Table A1. (continued)

Sample period: 1999 - 2016.11						
SPF 1-year-ahead inflation expectations	0.85	0	+	-		No lead time
PMI RTS: prices for paid goods	0.84	1	+	-		Lead time too short
EC RTS: selling price expectations for 3 m. ahead	0.83	2	+	-		Lead time too short
SPF 2-year-ahead inflation expectations	0.82	0	+	-		Lead time too short
Farm-gate and wholesale market price index (ann. % chg.)	**0.82**	**5**	**+**	**+**	**+**	**Additional pipeline pressure inform.**
EC SS: selling price expectations for 3 m. ahead	0.81	2	+	-		Lead time too short
Inflation-linked swap rate (1Y1Y)	**0.77**	**3**	**+**	**+**	**+**	**Market-based inflation expectations**
PMI Composite: prices charged	0.76	2	+	-		Lead time too short
PMI Services: input prices	0.74	2	+	-		Lead time too short
PMI Manufacturing: prices charged	0.72	3	+	+	-	No additional information
PMI Services: prices charged	0.67	3	+	+	-	No additional information
PMI Composite: input prices	0.64	3	+	+	-	No additional information
PMI Manufacturing: input prices	0.58	4	+	+	-	No additional information
Extra euro area PMI Composite: input prices	0.56	3	+	-		Effective lead time too short
Inflation-linked swap rate (1Y2Y)	0.55	2	+	-		Lead time too short
PMI Manufacturing (total)	0.54	8	-			Correlation too low
PMI Services: future business activity expectations	0.54	12	-			Correlation too low
PMI Retail Trade Survey: gross margins	0.53	14	-			Correlation too low
PMI Composite: output	0.53	9	-			Correlation too low
PMI Composite: new orders	0.52	9	-			Correlation too low
PMI Composite: productivity	0.50	19	-			Correlation too low
PMI Services: productivity	0.50	18	-			Correlation too low
Extra euro area import prices - MIG interm. goods (ann. % chg.)	0.49	15	-			Correlation too low
PMI Manufacturing: new orders/stock of finished goods	0.47	18	-			Correlation too low
PMI Manufacturing: productivity	0.47	21	-			Correlation too low
Extra euro area PMI Composite: output	0.44	9	-			Correlation too low
ZEW FS: expected inflation rate (6 m.)	0.43	10	-			Correlation too low
Forward break-even inflation rate (1Y4Y)	0.38	4	-			Correlation too low
ZEW FS: expected economic situation (6 m.)	0.35	26	-			Correlation too low
Extra euro area import prices - MIG durbl. cons. g. (ann. % chg.)	0.32	26	-			Correlation too low
Inflation-linked swap rate (1Y5Y)	0.29	36	-			Correlation too low
Inflation-linked swap rate (1Y3Y)	0.27	1	-			Correlation too low
Extra euro area PMI Composite: prices charged	0.27	0	-			Correlation too low
Extra euro area import prices - consumer goods (ann. % chg.)	0.26	0	-			Correlation too low
Forward break-even inflation rate (1Y5Y)	0.18	36	-			Correlation too low
Inflation-linked swap rate (1Y4Y)	0.17	36	-			Correlation too low
Inflation-linked swap rate (1Y9Y)	0.11	0	-			Correlation too low
Forward break-even inflation rate (5Y5Y)	0.08	1	-			Correlation too low
Forward break-even inflation rate (1Y9Y)	0.08	36	-			Correlation too low

Table A2. Overview of the selection of leading series for core ALICE

Sample period: 1960.1 - 2016.11	*Correlation, sample starting in*					*Optimal lead, sample starting in*					*Criteria*			*Comments*
	1960	*1970*	*1980*	*1990*	*1999*	*1960*	*1970*	*1980*	*1990*	*1999*	*C1*	*C2*	*C3*	
OECD euro area composite leading indicator	**0.46**	**0.52**	**0.48**	**0.51**	**0.55**	**17**	**17**	**18**	**17**	**17**	**+**	**+**	**+**	**Highest correlation; economic activity**
EUR/USD exchange rate (log)	0.12	0.10	0.20	0.44	0.54	0	36	10	19	15	-			Correlation too low
Industrial production excl. construction (log)	0.50	0.56	0.49	0.51	0.54	11	11	12	12	10	-			Correlation too low
Industrial production excl. construction (ann. % chg.)	0.29	0.33	0.32	0.41	0.47	14	14	17	16	16	-			Correlation too low
Brent crude oil price in EUR (ann. % chg.)	**0.50**	**0.51**	**0.38**	**0.43**	**0.47**	**7**	**7**	**25**	**25**	**26**	**-**	**+**	**+**	**Important inflation driver; long lead**
EUR/USD exchange rate (ann. % chg.)	0.12	0.11	0.37	0.39	0.46	0	0	24	24	27	-			Correlation too low
PPI Industry excl. construction (ann. % chg.)	0.72	0.75	0.34	0.36	0.40	6	6	13	12	13	-			Correlation too low
PPI Manufacturing (ann. % chg.)	0.70	0.74	0.30	0.36	0.39	6	6	13	12	15	-			Correlation too low
Nominal stock price index (ann. % chg.)	0.18	0.21	0.24	0.21	0.35	26	25	29	24	24	-			Correlation too low
OECD composite leading indicator (global)	0.41	0.44	0.27	0.29	0.35	20	20	22	19	20	-			Correlation too low
10-year government bond yield (German/euro area)	0.60	0.65	0.48	0.53	0.33	6	5	13	12	10	-			Correlation too low
US unemployment rate	0.33	0.33	0.30	0.13	0.18	17	17	25	36	13	-			Correlation too low
Sample period: 1970.1 - 2016.11														
GDP price deflator (ann. % chg.)		0.79	0.52	0.52	0.79		1	1	1	3	+	-		Lead time too short
Real GDP (log)		**0.64**	**0.63**	**0.65**	**0.66**		**11**	**11**	**11**	**10**	**+**	**+**	**+**	**Economic activity**
M1 stock (log)		**0.50**	**0.53**	**0.65**	**0.55**		**23**	**22**	**23**	**22**	**+**	**+**	**+**	**Financial (monetary) variable**
Compensation per employee (log)		0.42	0.26	0.64	0.55		0	0	0	1	+	-		No lead time
Compensation per employee (ann. % chg.)		0.74	0.52	0.55	0.54		2	6	10	9	-			Correlation too low
M1 to GDP ratio		0.42	0.49	0.55	0.52		23	24	24	24	-			Correlation too low
Unit labour cost (ann. % chg.)		0.79	0.52	0.42	0.51		0	0	0	0	-			Correlation too low
Real GDP (ann. % chg.)		0.38	0.41	0.46	0.50		15	18	18	17	-			Correlation too low
M3 to GDP ratio		0.25	0.35	0.40	0.49		28	0	0	0	-			Correlation too low
PPI MIG Intermediate goods (ann. % chg.)		0.37	0.28	0.39	0.48		9	13	12	15	-			Correlation too low
Import deflator for goods and services (ann. % chg.)		0.72	0.43	0.38	0.46		0	18	18	18	-			Correlation too low
M3 (ann. % chg.)		0.19	0.38	0.30	0.45		19	7	4	4	-			Correlation too low
M3 stock (log)		0.23	0.45	0.52	0.42		12	0	0	0	-			Correlation too low
M1 growth less GDP growth (ann. % chg.)		0.31	0.36	0.39	0.41		28	33	33	34	-			Correlation too low
M1 (ann. % chg.)		0.30	0.41	0.43	0.37		27	32	31	32	-			Correlation too low
Global inflation (OECD)		0.74	0.26	0.31	0.36		2	11	10	10	-			Correlation too low
M3 to GDP ratio		0.29	0.14	0.24	0.25		19	0	34	36	-			Correlation too low
Sample period: 1980.1 - 2016.11														
MFI loans to households (log)			0.50	0.58	0.67			11	11	12	+	+	-	MFI loans outstanding preferred
MFI loans outstanding (log)			**0.60**	**0.65**	**0.67**			**2**	**6**	**6**	**+**	**+**	**+**	**Financial (credit) variable**
Nom. effect. exchange rate NEER-38 (log)			**0.33**	**0.47**	**0.62**			**5**	**16**	**16**	**+**	**+**	**+**	**External factors**
Nom. effect. exchange rate NEER-12 (log)			0.30	0.54	0.61			15	19	17	+	+	-	Captured by broader NEER-38
Unemployment rate			0.73	0.63	0.61			8	10	9	+	+	-	Captured by real GDP
PPI Consumer goods (ann. % chg.)			0.48	0.57	0.60			8	7	8	+	+	-	No additional relevant information
MFI loans to non-fin. corporations (log)			0.56	0.67	0.59			0	5	5	+	-		Part of MFI loans; no lead time in 1980s
PPI Capital goods (ann. % chg.)			0.57	0.62	0.59			3	4	5	+	-		Effective lead time too short
Nom. effect. exchange rate NEER-19 (log)			0.29	0.51	0.59			7	18	16	+	+	-	Captured by broader NEER-38
World raw material prices - industrial (ann. % chg.)			0.24	0.45	0.57			21	20	23	+	+	-	No additional information
World raw material prices - energy (ann. % chg.)			0.23	0.50	0.56			18	18	20	+	+	-	No additional information
Nom. effect. exchange rate NEER-38 (ann. % chg.)			0.37	0.46	0.55			22	24	25	+	+	-	Captured by broader NEER-38
Nom. effect. exchange rate NEER-12 (ann. % chg.)			0.41	0.53	0.55			23	23	25	+	+	-	Captured by broader NEER-38
MFI loans outstanding to GDP ratio			0.50	0.47	0.54			3	9	10	+	-		Covered by MFI loans outstanding
Nom. effect. exchange rate NEER-19 (ann. % chg.)			0.39	0.50	0.53			23	24	25	-			Correlation too low
MFI loans to non-fin. corporations (ann. % chg.)			0.60	0.46	0.48			12	12	11	-			Correlation too low
World raw material prices - food (ann. % chg.)			0.17	0.40	0.48			15	16	13	-			Correlation too low
MFI loans flows (log)			0.44	0.40	0.48			15	15	14	-			Correlation too low
World raw material prices - crude oil (ann. % chg.)			0.37	0.42	0.47			25	25	26	-			Correlation too low
World raw material prices - energy (ann. % chg.)			0.35	0.40	0.44			25	24	26	-			Correlation too low
MFI loans outstanding (ann. % chg.)			0.57	0.42	0.44			13	14	13	-			Correlation too low
Residential property price index (ann. % chg.)			0.52	0.38	0.43			26	19	15	-			Correlation too low
World raw material prices - total (ann. % chg.)			0.31	0.39	0.43			24	22	24	-			Correlation too low
MFI loans to households (ann. % chg.)			0.36	0.26	0.43			29	18	21	-			Correlation too low
M2 growth less GDP growth (ann. % chg.)			0.18	0.24	0.41			35	35	0	-			Correlation too low
M2 to GDP ratio			0.30	0.42	0.39			30	30	34	-			Correlation too low

Notes: This table summarises the results from the general-to-specific approach to select leading series for the core ALICE. For each group, the correlation coefficients in absolute size and optimal lead times are reported for periods starting in 1960, 1970, 1980, 1985, 1990, 1995 and 1999. The cyclical components of series are re-estimated in each decade to obtain the correlation and lead times. Groups are based on the starting point of individual time series that may or may not coincide with the start of the decade. The selected series are denoted in bold. C1, C2, and C3 refer to selection criterion 1, 2 and 3 as defined in the text, respectively. Entries "+" / "-" indicate the criterion is fulfilled/not fulfilled. EC CS, EC IS, EC RTS and EC SS stand for the European Commission surveys of consumers, industry, retail trade and services, respectively. ZEW Financial Market survey data is denoted by ZEW FS.

Table A2. (continued)

M2 (ann. % chg.)	0.22	0.20	0.35	32	34	1	-			Correlation too low
PPI Energy (ann. % chg.)	0.35	0.30	0.35	17	17	17	-			Correlation too low
M2 stock (log)	0.31	0.29	0.32	0	0	0	-			Correlation too low
Building permits (ann. % chg.)	0.12	0.09	0.30	21	21	21	-			Correlation too low
Building permits (log)	0.28	0.18	0.28	19	19	18	-			Correlation too low
MFI loans growth less GDP growth (ann. % chg.)	0.31	0.32	0.18	6	36	36	-			Correlation too low
MFI loans flows (ann. % chg.)	0.09	0.14	0.18	12	29	15	-			Correlation too low
Sample period: 1985.1 - 2016.11										
PPI Nonfood consumer goods (ann. % chg.)	**0.55**	**0.72**	**0.74**	**5**	**6**	**7**	**+**	**+**	**+**	**Domestic price pressures**
EC RTS: expected business conditions	0.56	0.58	0.67	18	18	16	+	+	-	No additional relevant information
PPI Consumer durables goods (ann. % chg.)	0.49	0.61	0.62	4	4	5	+	-		Effective lead time too short
EC IS: selling price expectations - consumer goods	0.65	0.63	0.60	11	12	12	+	+	-	No additional information
EC CS: price trends over next 12 m.	0.64	0.62	0.60	8	8	9	+	+	-	No additional information
EC CS: consumer confidence indicator	0.56	0.51	0.59	17	17	17	+	+	-	No additional information
PPI Consumer nondurable goods (ann. % chg.)	0.49	0.54	0.59	7	7	8	+	+	-	No additional information
EC IS: employment expectations	0.57	0.46	0.58	14	14	13	+	+	-	No additional information
Economic sentiment indicator	0.56	0.48	0.57	17	16	17	+	+	-	No additional information
EC CS: unemployment expectations over next 12 m.	0.53	0.50	0.56	15	15	15	+	+	-	No additional information
PPI Consumer food goods (ann. % chg.)	0.45	0.49	0.56	7	8	9	+	+	-	No additional information
EC CS: general economic situation over next 12 m.	0.47	0.42	0.53	19	18	19	-			Correlation too low
Business climate indicator	0.48	0.42	0.52	16	16	17	-			Correlation too low
EC IS: production expectations	0.48	0.42	0.49	17	17	18	-			Correlation too low
EC IS: selling price expectations	0.53	0.48	0.47	14	14	16	-			Correlation too low
Capacity utilisation	0.46	0.38	0.47	11	11	10	-			Correlation too low
EC IS: selling price expectations - intermediate goods	0.46	0.45	0.45	15	15	19	-			Correlation too low
Capacity utilisation (ann. % chg.)	0.32	0.34	0.43	15	15	15	-			Correlation too low
EC CS: major purchases over next 12 m.	0.47	0.37	0.38	18	16	15	-			Correlation too low
Euro area Baltic Dry index (ann. % chg.)	0.02	0.03	0.03	20	19	20	-			Correlation too low
Sample period: 1990.1 - 2016.11										
HICP - Industrial goods excluding energy (ann. % chg.)		0.90	0.91		0	1	+	-		Lead time too short
MSCI EMU Index - Long Term Growth Forecast		0.52	0.66		16	17	+	+	-	No additional information
Real effect. exchange rate EER-19 - CPI defl. (log)		0.57	0.61		18	16	+	+	-	Nominal rate is preferred
ZEW FS: expect. short-term interest rate (6 m.)		0.31	0.58		22	24	+	+	-	No additional information
Negotiated wage rates		0.51	0.57		0	0	+	-		No lead time
3-month EURIBOR rate		0.66	0.54		7	9	-			Correlation too low
Real effect. exchange rate EER-19 - CPI defl. (ann. % chg.)		0.51	0.53		24	25	-			Correlation too low
Negotiated wage rates excl. bonuses		0.53	0.49		0	0	-			Correlation too low
Negotiated wage rates (abs. ann. chg.)		0.28	0.48		10	3	-			Correlation too low
PPI Industry excl. constr. & MIG energy (ann. % chg.)		0.46	0.47		10	12	-			Correlation too low
Negotiated wage rates excl. bonuses (abs. ann. chg.)		0.31	0.42		10	6	-			Correlation too low
Construction sector material costs (ann. % chg.)		0.45	0.41		12	14	-			Correlation too low
Construction sector input prices (ann. % chg.)		0.42	0.38		14	11	-			Correlation too low
Construction sector labour costs (ann. % chg.)		0.45	0.37		0	0	-			Correlation too low
European Monetary Union Cons. services index (ann. % chg.)		0.31	0.35		24	25	-			Correlation too low
European Monetary Union Cons. goods index (ann. % chg.)		0.19	0.26		19	18	-			Correlation too low
Sample period: 1995 - 2016.11										
Labour productivity per hours worked (log)		0.54	0.61		12	12	+	+	-	No additional information
Labour productivity per persons (log)		0.52	0.59		12	11	+	+	-	No additional information
Real effect. exchange rate EER-19 - PPI defl. (log)		0.66	0.59		17	18	+	+		Nominal rate is preferred
ECB Commodity Price index - non-energy (ann. % chg.)		0.55	0.58		19	21	+	+	-	No additional information
ECB Commodity Price index - non-food (ann. % chg.)		0.54	0.56		22	23	+	+	-	No additional information
Labour productivity per hours worked (ann. % chg.)		0.49	0.55		19	20	+	+	-	No additional information
Euro area total employment - persons (log)		0.58	0.55		9	8	+	+	-	Captured by real GDP
Unit profits		0.37	0.54		5	6	-			Correlation too low
Real effect. exchange rate EER-19 - PPI defl. (ann. % chg.)		0.48	0.53		24	27	-			Correlation too low
Euro area total employment - hours worked (log)		0.55	0.53		10	9	-			Correlation too low
ECB Commodity Price index - food (ann. % chg.)		0.50	0.49		14	16	-			Correlation too low
Labour productivity per persons (ann. % chg.)		0.42	0.49		17	18	-			Correlation too low
Import deflator of services (ann. % chg.)		0.51	0.48		18	19	-			Correlation too low
Import deflator of goods (ann. % chg.)		0.48	0.45		18	18	-			Correlation too low
ECB Commodity Price index - agric. raw materials (ann. % chg.)		0.45	0.45		21	22	-			Correlation too low
Total employment - persons (ann. % chg.)		0.38	0.41		14	14	-			Correlation too low
Total employment - hours worked (ann. % chg.)		0.36	0.41		14	14	-			Correlation too low
Total hours worked per persons		0.31	0.32		10	10	-			Correlation too low
Total hours worked per persons (ann. % chg.)		0.24	0.31		13	14	-			Correlation too low
MSCI EMU Index - 12-m forward Y-O-Y growth in earnings		0.06	0.01		0	19	-			Correlation too low

Table A2. (continued)

Sample period: 1999 - 2016.11						
EC RTS: selling price expectations for 3 m. ahead	0.85	8	+	+	-	No additional information
PMI RTS: prices for paid goods	0.74	6	+	+	-	No additional information
EC SS: selling price expectations for 3 m. ahead	0.71	8	+	+	-	No additional information
PMI Composite: prices charged	0.64	10	+	+	-	No additional information
Extra euro area import prices - MIG interm. goods (ann. % chg.)	0.60	15	+	+	-	No additional information
PMI Manufacturing: prices charged	0.56	10	+	+	-	No additional information
PMI Manufacturing: new orders/stock of finished goods	0.55	23	+	+	-	No additional information
PMI Composite: output	0.55	22	+	+	-	No additional information
PMI Retail Trade Survey: gross margins	0.53	17	-			Correlation too low
PMI Manufacturing (total)	0.53	21	-			Correlation too low
PMI Services: prices charged	0.53	15	-			Correlation too low
ZEW FS: expected economic situation (6 m.)	0.53	28	-			Correlation too low
PMI Composite: new orders	0.53	22	-			Correlation too low
PMI Manufacturing: productivity	0.51	26	-			Correlation too low
SPF 2-year-ahead inflation expectations	0.50	3	-			Correlation too low
Farm-gate and wholesale market price index (ann. % chg.)	0.49	13	-			Correlation too low
PMI Services: future business activity expectations	0.48	23	-			Correlation too low
Inflation-linked swap rate (1Y1Y)	0.47	6	-			Correlation too low
ZEW FS: expected inflation rate (6 m.)	0.46	25	-			Correlation too low
Euro area PMI Manufacturing: input prices	0.45	21	-			Correlation too low
Inflation-linked swap rate (1Y2Y)	0.44	0	-			Correlation too low
SPF 1-year-ahead inflation expectations	0.43	7	-			Correlation too low
PMI Composite: productivity	0.43	24	-			Correlation too low
PMI Composite: input prices	0.42	21	-			Correlation too low
Extra euro area import prices - MIG durbl. cons. g. (ann. % chg.)	0.38	32	-			Correlation too low
PMI Services: input prices	0.38	16	-			Correlation too low
Inflation-linked swap rate (1Y3Y)	0.36	0	-			Correlation too low
PMI Services: productivity	0.34	23	-			Correlation too low
Inflation-linked swap rate (1Y5Y)	0.29	36	-			Correlation too low
Forward break-even inflation rate (1Y5Y)	0.27	36	-			Correlation too low
Inflation-linked swap rate (1Y4Y)	0.25	0	-			Correlation too low
Extra euro area import prices - consumer goods (ann. % chg.)	0.23	36	-			Correlation too low
Forward break-even inflation rate (1Y9Y)	0.23	36	-			Correlation too low
Inflation-linked swap rate (1Y9Y)	0.21	0	-			Correlation too low
Extra euro area PMI Composite: output	0.21	26	-			Correlation too low
Forward break-even inflation rate (1Y4Y)	0.19	1	-			Correlation too low
Forward break-even inflation rate (5Y5Y)	0.18	36	-			Correlation too low
Extra euro area PMI Composite: prices charged	0.16	15	-			Correlation too low
Extra euro area PMI Composite: input prices	0.14	20	-			Correlation too low