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ALICE: A new inflation monitoring tool

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ABSTRACT

This paper develops Area-wide Leading Inflation CyclE (ALICE) indicators for euro area headline and core inflation with an aim to provide early signals about turning points in the respective inflation cycle. The series included in the two composite leading indicators are carefully selected from around 160 candidate leading series using a general-to-specific selection process. The headline ALICE includes nine leading series and has a lead time of 3 months while the core ALICE consists of seven series and leads the reference cycle by 4 months. The lead times of the indicators increase to 5 and 9 months, respectively, based on a subset of the selected leading series with longer leading properties. Both indicators identify main turning points in the inflation cycle ex post and perform well in a simulated real-time exercise over the period from 2010 to the beginning of 2018. They also have performed well in forecasting the direction of inflation. In terms of the quantitative forecast accurracy, the headline ALICE has on average performed broadly similarly to the Euro Zone Barometer survey, slightly worse than the Eurosystem/ECB Staff macroeconomic projections and better than the Random Walk model, albeit this is not the case for the core ALICE.

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

Keywords: euro area inflation, trend-cycle decomposition, band pass filter, leading indicators, forecasting

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 received increasing 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. Composite leading indicators primarily aim to predict turning points in the inflation cycle rather than to directly forecast the level of inflation. They may therefore serve as a complementary tool to gauge future developments in inflation and may provide additional insights to steer inflation forecasts.

This paper develops Area-wide Leading Inflation CyclE (ALICE) indicators for euro area headline inflation based on the Harmonised Index of Consumer Prices (HICP) and for 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, where available, 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 months and, based on a sub-set of component series with longer leading properties, by 5 months. Seven series are combined to obtain the core ALICE: the OECD composite leading indicator for euro area economic activity, oil prices, real GDP, money supply M1, monetary financial institutions (MFI) loans outstanding, the nominal effective exchange rate and producer prices of non-food consumer goods. This composite indicator has an effective lead time of 4 months that extends to 9 months when the longer forward version of the core ALICE based on fewer leading series is considered.

The main results for the qualitative and quantitative forecasting performance 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 also provides timely signals of upcoming turning points in the inflation cycle in a simulated real-time setting from 2010 to early 2018 and these signals are shown to not be substantially revised over time. These are two essential preconditions for the practical applicability of such indicators. The robustness of the qualitative forecasting ability is checked by applying a different sample period for the selection of leading series as well as by evaluating the role of oil prices given its importance for inflation. Both robustness checks show relatively little impact on the development and signals provided by the ALICE indicators. Besides their use to predict turning points, the ALICE indicators have also been analysed in terms of their ability to forecast the direction of inflation movements as well as the quantitative inflation outcome. Both performed well in terms of forecasting the direction of inflation developments two or three quarters ahead, although the directional accuracy was somewhat lower in recent years. In terms of quantitative forecast accurracy, the headline ALICE on average performed better than the Random Walk (RW), similarly to the Euro Zone Barometer (EZB) survey but somewhat less well when compared to the Eurosystem/ECB Staff macroeconomic projections. Nevertheless, the differences between these forecasts and that from the headline ALICE are not statistically significant. This is not the case for the core ALICE where the RW model is found to have superior forecasting abilities.

1. INTRODUCTION

In the period following the global financial crisis, the issue of inflation has received increasing 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 qualitative inflation signals from composite leading indicators. 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 in such a way 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. The first group includes so-called model-based indicators, which are typically constructed using dynamic factor models or Markov switching models. These indicators 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 includes composite coincident and composite leading indicators (CLIs). Such CLIs require filtering and deriving the cyclical components of the considered individual series prior to combining them into a single index. Typically, the included series are selected according to some pre-specified criteria, such as dynamic correlations with the target series, and are then aggregated together. CLIs are widely used for business cycle analysis. For instance, the Organisation for Economic Co-operation and Development (OECD) and the Conference Board are regularly compiling and publishing CLIs for the business cycle in the euro area and other countries.

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 (Roth, 1986; Roth, 1991; Garner, 1995). In general, these early indicators were found to be relatively good at anticipating major turning points in the inflation cycle ex post. 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 and leading properties as well as 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 the data availability for the euro area has greatly improved since then.

Our study makes five contributions to the 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 calculated using the HICP as well as HICP inflation excluding the volatile energy and food components as a representative of core inflation. Secondly, the 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 about 160 potential leading series covering different parts of the economy in order to select component series for the CLI. Moreover, besides the standard ex post analysis of the performance of the CLI, we also provide a simulated real-time evaluation of the performance of the two constructed indicators. Finally, we explore their potential use for quantitative euro area inflation forecasting based on the compiled real-time dataset.

Our findings are promising and provide a sound starting point for future work in this field. The leading indicators for the euro area headline and core inflation cycles prove 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 simulated real-time analysis, which in particular illustrates 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. Robustness checks concerning the selection of the leading series based on a different sample period show that the selection varies to different degrees for the headline and core ALICE but with relatively little impact on the development and signals provided by the ALICE indicators.

Besides their use to identify inflation turning points, the ALICE indicators have also been analysed in terms of their ability to forecast the direction of the inflation movements as well as the quantitative inflation outcome. Both ALICE indicators performed well in terms of forecasting the direction of inflation developments two or three quarters ahead, although the directional accuracy was somewhat lower in recent years. In terms of the quantitative forecast accurracy, the headline ALICE on average performed better than the Random Walk (RW) and similarly to the Euro Zone Barometer (EZB) survey, but is slightly outperformed by the Eurosystem/ECB Staff macroeconomic projections. Nevertheless, the difference between the headline ALICE-based forecasts and the alternatives over the period considered is not statistically significant. This is not the case for the core ALICE where the RW model is found to have superior forecasting abilities.

2. METHODOLOGY

2.1 Reference cycle

In a first step, the inflation cycle and its turning points have to be defined. Unfortunately, there is no widely accepted published benchmark for the dating of the inflation cycle, such as the one for business cycles as e.g. provided by the NBER for the U.S. or by the Centre for Economic Policy Research (CEPR) for the euro area. We use two reference series to develop our benchmark inflation cycles for the leading indicators. The price stability objective of the ECB is defined in terms of the year-on-year growth rate of the Harmonised Index of Consumer Prices (HICP). Thus, this series is chosen to develop 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 consider a reference “core” inflation cycle in addition. As basis for this indicator we select the year-on-year inflation rate of the HICP excluding the volatile energy and food components. This is a simple representative of a core inflation measure, which has also proven to contain information about the underlying medium-term inflation trend (ECB, 2016a).

Turning to the applied concept of the inflation cycle, earlier research work on inflation cycles has typically been based on the so-called growth rate cycle definition which focuses on the percentage change of the price index. Turning points in inflation are then determined according to variants of the algorithm by Bry and Boschan (1971), as also applied by Roth (1991), Artis et al. (1995), Binner et al. (1999) and Gibson and Lazaretou (2001). First, peaks (troughs) should always follow troughs (peaks). Second, 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). By contrast, Bikker and Kennedy (1999) and Binner et al. (2005) apply the deviation cycle concept. In this framework, filtering methods are applied to extract the price cycle in terms of the deviations of the consumer price index from its trend. Subsequently, the studies date the turning points in the inflation cycle according to the rules suggested by Bry and Boschan (1971) or Artis et al. (1995). We apply the deviation cycle definition with respect to the euro area inflation rate.

There are several approaches which are typically used in order to measure the cycle in economic series: the Phase Average Trend (PAT) method developed by the NBER, the filter by Hodrick and Prescott (HP filter) (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 than band pass filters.

We therefore use a band pass filter to isolate the component of the time series that lies within a chosen range of frequencies. 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).

We use the random walk filter proposed by Christiano and Fitzgerald (2003) (CF filter). The filter is asymmetric in order to exploit the full sample in calculating the filtered values at each data point. The filter works well for many economic time series that may follow a random walk and typically performs well in real-time applications. It has been used in the business and financial cycle literature (Drehmann et al., 2012; de Bondt and Hahn, 2014). 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, respectively, for frequency bands. According to unit root tests both annual inflation series are non-stationary over the sample period over which they are available. The drift is eliminated prior to the analysis of non-stationary series, as the formulas for the CF random walk filter require that there is no drift in the data.

Finally, we date the turning points in the reference cycles for headline and core inflation using the 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. Thus, the cycle peaks at time *t* if:

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

and it reaches a trough if:

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

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

2.2 Candidate leading series

The starting point of the construction of the CLI is the compilation of a large dataset of around 160 potential leading series, including (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 to reflect different areas of the economy and abroad set of 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.). Forni et al. (2003) report euro area empirical evidence that financial variables help forecasting inflation and Chen and Ranciere (2016) provide international evidence.

The series in the dataset are grouped according to the starting date of the time series. In total, the following seven groups of variables are distinguished: namely, groups of variables starting around 1960, 1970, 1980, 1985, 1990, 1995 and 1999. The end date for most series is November 2016.

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 the 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 showed cyclical components that are virtually identical to those based on constant values.

In terms of data transformations, the cyclical components of the candidate series are used. These are extracted based on the same filtering techniques and setup as in the case of the reference series. The filtered series are in addition standardised to make them comparable by subtracting their sample mean and dividing them by their standard deviation.

2.3 Selection of the leading series

A general-to-specific selection procedure based upon three criteria is followed to identify the best leading series, similar to de Bondt and Hahn (2014) for the euro area business cycle leading indicator. The three selection criteria are as follows.

1. The first criterion demands that the correlation coefficient between the candidate leading series and the reference cycle is at least 0.55. The series in each group are then ranked according to their correlation coefficient in the 1999 to 2016 sample. The selected threshold for the correlation coefficient reflects the trade-off between ensuring a sufficiently high, meaningful co-movement of the series on the one hand and allowing for a sufficiently large number of possible candidate series on the other hand. The correlation coefficient for each candidate series is derived in a dynamic correlation analysis. That is, it reflects the maximum correlation of the candidate series with the reference series among the lead/lag relationships.

2. The second selection criterion refers to the leading properties of the candidate series with respect to the reference series. More specifically, it is required that the lead time is sufficiently long and relatively stable over time. The required minimum value of the lead time is set to three months. The lead time for each candidate series corresponds to that of the maximum correlation of the candidate series with the reference series derived in the dynamic correlation analysis. In order to fulfil this selection criterion, in addition to the lead/lag relationship of the candidate series with the HICP data, we also take into the account the publication lag of the candidate series with respect to the flash release of the HICP figures at month-end.[1] That is, the required three month lead time is defined in effective terms. The lead time of the CLI will then correspond to the minimum lead time among the selected component series.

3. The third selection criterion is that the series for the composite indicator should reflect diverse information. That is, they should contain information on different parts of the economy or drivers of inflation and should, preferably, come from different sources to enhance the robustness of the CLI.

The three selection criteria are applied step by step for each of the sample groups defined above starting with the group of series that includes the longest historical data. The series in each

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

group are evaluated not only over the full sample period available but also over the sub-sample periods with a particular attention paid to the period from 1999 onwards, which is common for all series. This proceeding accounts for the fact that the sample from 1999 onwards is advantageous as it provides evidence for the “true” euro area and is not based on synthetic euro area data. Meanwhile the samples based on longer back data have the advantage of covering more turning points and of providing additional information on the stability of the relationships.

More specifically, the selection of the series proceeds as follows. For the group of series starting in 1960, the shortlisted candidate series that surpassed the first two criteria and has the highest correlation with the reference cycle since 1999 is selected as the first component series to be included in the CLI and represents the initial CLI. Next, we successively include the remaining candidate series of that group that fulfil the three criteria one by one (in the order of the magnitude of their correlation coefficient over 1999 – 2016) in the respective current CLI. The series are kept in the CLI if the new CLI has a higher correlation with the reference cycle than the current CLI looking at the full sample period and the period since 1999. While we tend to put more emphasis on the latter, the full sample correlations also matter. This procedure is successively applied for all sample groups of series that start at the later points in time until all series are tested. The final derived CLI represents the ALICE.

2.4 Construction of the composite leading indicators

The construction of the CLIs throughout the selection process as well as that of the final CLI (i.e. ALICE) based on the selected leading series proceeds as follows.

Prior to including the leading series into the CLI, in order to align their signals, the series are shifted according to their 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 then combined in the CLI by taking a simple average in line with the related literature (Gibson and Lazaretou, 2001; Binner et al., 2005; de Bondt and Hahn, 2014).

$$CLI_t = \frac{1}{n}\sum_{i=1}^{n} LS_{i,t-l_i} \qquad (3)$$

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

For the final CLIs, i.e. the ALICE indicators, a backward linking procedure is applied to obtain long historical time series. As outlined above, the leading series included in the ALICE indicators start at different points in time and a joint sample period for all included leading series is only available over a shorter period of time. Thus, to obtain long historical time series the ALICE indicators are extended backwards based on changes in the respective available CLIs of the subsets of the selected leading series that are still available at the respective points in time. Equation (4) shows the calculation of the backward linked ALICE which is based on progressively fewer leading series.

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

where CLI_t^j is the composite leading indicator consisting of j series as defined in Equation (3) and $m > 0$. For headline ALICE $j = 2, \ldots, 9$ as two series are available from 1960 and the full set of leading series equals nine. For core ALICE, $j = 2, \ldots, 7$ as, again, two series are available from 1960 and the full set of included leading series is seven.

In addition, a similar forward linking procedure is applied to extend the lead time of the ALICE indicators. The lead time of the ALICE indicators is determined by the minimum lead time of the included leading series. By dropping the leading series with the shortest lead times we extend the ALICE indicators forward based on the changes in the remaining leading series. This results in a longer overall lead time. As the signals of these extended indicators are based on a reduced number of series compared to the complete ALICE, this extension comes at the cost of a higher degree of uncertainty of the signal which limits the scope for a reduction of the number of series.

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

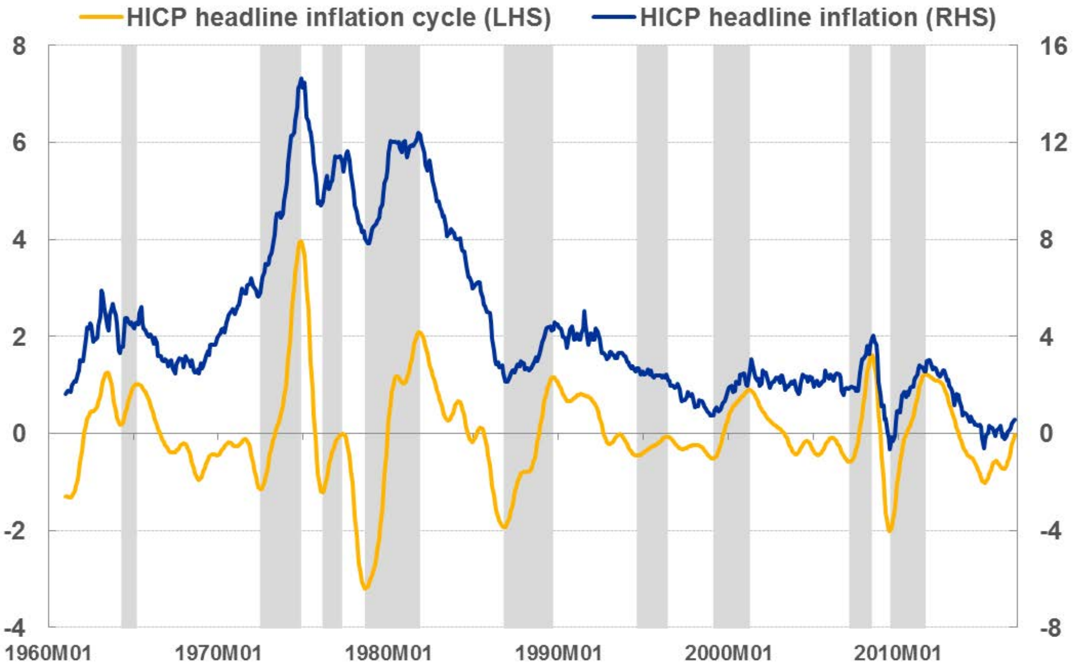
3. RESULTS

3.1 Reference cycles

This section presents the reference cycles for euro area headline and core inflation. The reference cycles for the two inflation indicators, derived from the asymmetric random walk band pass filter as described in Section 2.1, are plotted in Figures 1 and 2 together with the corresponding annual inflation rates. The shaded areas represent the periods of cyclical upturns in the two inflation indicators spanning from troughs to peaks as defined according to the dating rules outlined above applied on the respective reference cycle. The figures show that the reference cycles and applied dating rules identify major turning points and cyclical phases in euro area headline and core inflation reasonably well. The shaded areas include the pick-up in the inflation indicators of the 1970s as well as early and late 1980s. In the early 1990s there is another small cycle identified for the core inflation that is consistent with an uptick in the actual inflation rate. Furthermore, the shaded areas indicate the increase in the two inflation measures at the beginning of the 2000s. Finally, two periods of increasing headline as well as core inflation before and after the Great Recession are identified for the last decade of the sample period.

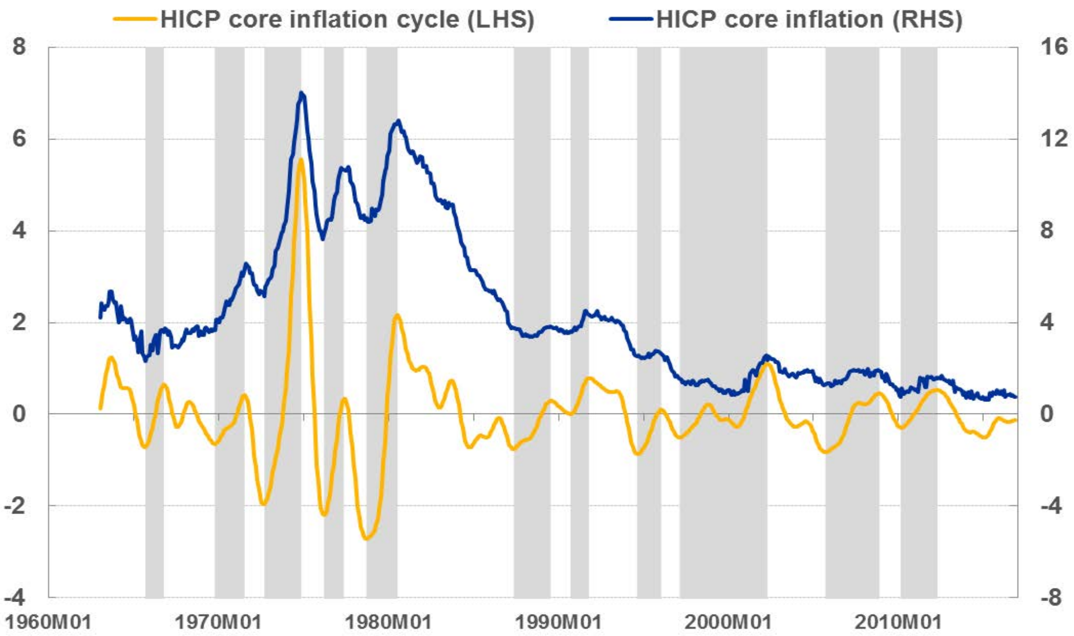
Several further observations emerge from Figures 1 and 2. Firstly, the amplitude of the cyclical components is greater in the first half of the sample period that is characterised by stronger inflationary pressures. The deviations from the trend become smaller in the second half of the period, especially for 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 cycle.

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.

3.2 Headline ALICE

Table 1 provides an overview of the leading series selected for the headline ALICE and information on how the correlation of the CLI with the reference cycle improves as further series are added. Detailed results for the individual candidate leading series are shown in Table A.1 in the Appendix.

For the group of variables starting in the 1960s, the first series included in the headline ALICE is the OECD CLI for the euro area. This series is selected as it has the highest correlation coefficient with the inflation cycle in the period from 1999 to 2016 among the series of this group that also fulfil the lead criterion (see Table A1). Its lead time amounts to 7 months. Compared to the OECD CLI alone, adding two other series that fulfil the first two selection criteria, namely, the annual percentage change in industrial production excluding construction and the OECD CLI for the OECD countries, does not improve the correlation of the CLI with the reference cycle. This likely reflects the fact that these three series contain overlapping information, as they can all be viewed as measuring the (global) output gap (Guérin et al., 2011) and these series are therefore discarded. We also test the inclusion of the annual growth rate of oil prices in euro as an additional variable in the CLI. The annual growth rate of oil prices shows a stable and sufficiently long lead time of about 4 months. The correlation of this variable is slightly lower than the required 0.55 threshold (see Table A.1) but we make an exception for this variable given its known high importance for developments in HICP inflation (see, among others, Hahn and Mestre, 2011; Castro et al., 2016; Hasenzagl et al., 2018). Oil prices are important drivers of headline inflation given their strong impact on the HICP energy component via their effect on the prices of fuels and heat energy. In addition, they affect HICP inflation excluding energy and food via indirect effects on the production costs of the goods and services included in this index. A positive aspect of the inclusion of this variable in the CLI is also that data on oil prices are promptly available and not revised. The inclusion of oil prices leads to an increase in the correlation coefficient of the CLI with the reference cycle supporting this choice and fulfilling the third criterion.

With respect to the 1970 group, three variables meet the correlation and lead time criteria, namely, the ratio of the monetary aggregate M1 to GDP, the difference between the annual percentage changes in M1 and GDP, and the ratio of the monetary aggregate M3 to GDP.

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 lead time of about 19 months is stable over time. Its inclusion to the CLI results in a considerably higher correlation coefficient with the reference cycle in both the recent and the full sample (see Table 1). The two remaining monetary variables do not contain additional information not yet reflected in the M1/GDP ratio and are hence not considered.

For the 1980 group, we pick the inflation rate of the import-weighted world raw material price index for food and tropical beverages (in euro) and the annual growth rate of euro area building permits for residential buildings. These are the only series of this group that fulfil the correlation and lead time criteria and add additional information. The lead times of the two series amount to about 4 and 17 months, respectively. The economic reason for the inclusion of raw material prices is straightforward. Meanwhile, 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. The CLI including these series shows an increase in the correlation with the reference cycle for both the full and the recent sample period.

Among the series starting in 1985, we select selling price expectations for the months ahead from the EC Industry Survey. This is the only series of this group that fulfils the correlation and lead time criteria and adds additional information. The lead time of the series is stable over time but relatively short (3 months). An advantage of this variable is also that it does not suffer from a publication lag and is not revised. The inclusion of this survey indicator in the CLI leads to a notably stronger correlation with the reference cycle in the full sample period and seems hence to provide additional information, although this does not hold for the recent sample of 1999 to 2016.

Among the variables available from 1990 no series exhibits a high enough correlation coefficient and at the same time sufficient leading properties.

With regard to the group of series starting around 1995, we choose the annual percentage change of the non-food component of the import-weighted non-energy commodity price index (in euro) as it is in line with the correlation and lead time criteria (17 months) and adds further information. No other series of this group fulfils all criteria. With this extension the correlation of the CLI rises further in both the full and the 1999 to 2016 sample.

Finally, two series of the variables that become available around 1999 or later fulfil all three selection criteria and are, hence, included in the CLI: the annual growth rate of farm-gate and wholesale market prices and the one-year forward inflation-linked swap rates one year ahead. The respective lead times are 5 and 3 months. Their inclusion improves the correlation of the CLI with the reference cycle further to 0.85.

To summarise, the headline ALICE consists of nine series: (1) the OECD CLI for the euro area, (2) oil prices, (3) the M1/GDP ratio, (4) world raw material prices for food and tropical beverages, (5) building permits, (6) EC selling price expectations for the industrial sector, (7) non-energy non-food commodity prices, (8) farm-gate and wholesale market prices, and (9) the one-year forward inflation-linked swap rates one year ahead. EC 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 as both series are available at the end of the month when the HICP flash estimate for that month is released. Consequently, the headline ALICE also has a 3-month effective lead time at the time of the HICP flash release.

Table 1. Selected leading series and correlations of the respective composite indicators with the reference cycle for headline inflation

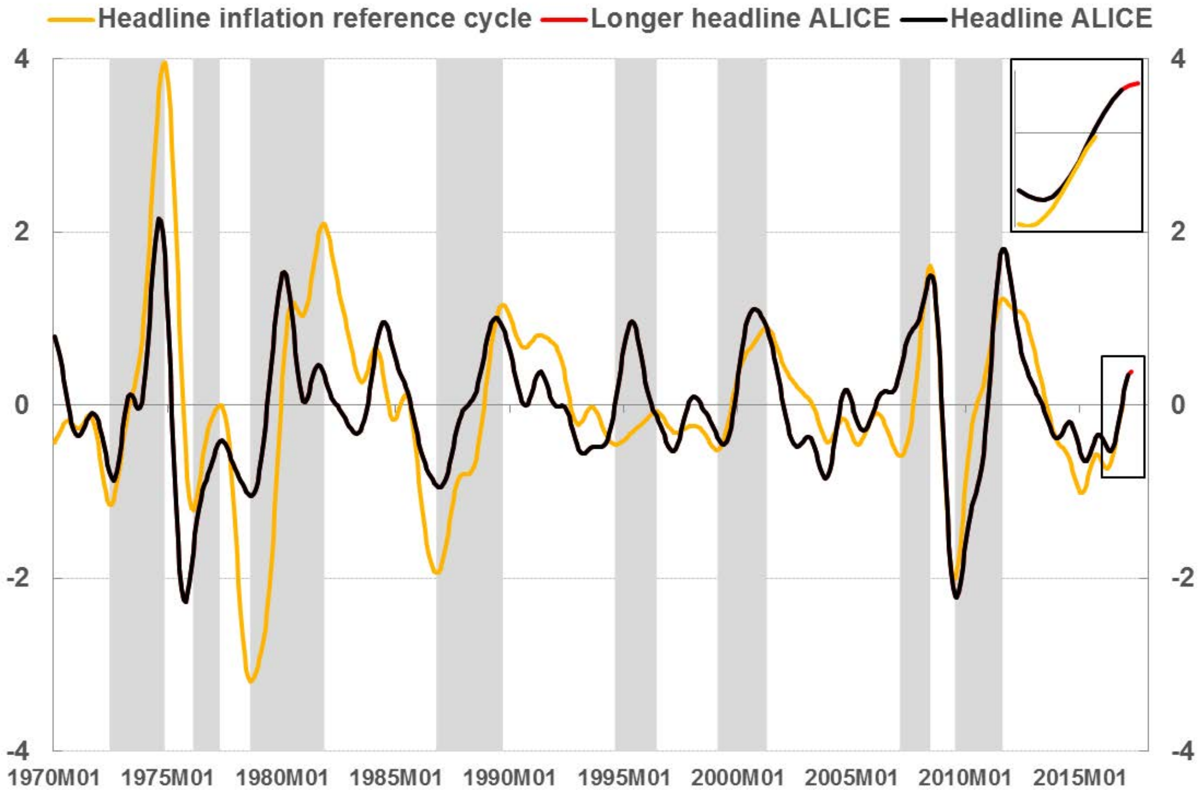
	Single leading series	Composite leading indicator	
	Lead time in months	Correlation 1999 – 2016	Correlation Full sample
Group 1960		0.62	0.50
OECD CLI for the euro area	7		
Oil price in EUR, annual percentage change	4		
Group 1970		0.75	0.58
M1/GDP ratio	19		
Group 1980		0.79	0.69
World raw material prices of food and tropical beverages, annual percentage change	4		
Building permits, annual percentage change	17		
Group 1985		0.79	0.73
Selling price expectations from the industry survey	3		
Group 1990		-	-
-			
Group 1995		0.80	0.80
Non-energy non-food commodity price, annual percentage change	17		
Group 1999		0.85	-
Farm-gate and wholesale market prices, annual percentage change	5		
One-year forward inflation-linked swap rate one year ahead	3		

Notes: The average lead time shown in the table refers to the empirical lead/lag relationship of the indicators and does not account for publication lags. The starting point of the full sample corresponds to that of the shortest available series included in the composite indicator respectively. The cyclical component of each series is estimated over the full sample.

Figure 3 plots the headline ALICE and the corresponding reference cycle over the period since 1970. Periods of cyclical upturns in inflation are marked again by the shaded areas. For the 1970s ALICE includes at least three leading series. ALICE moves broadly in line with the reference cycle and identifies the periods of cyclical inflation upturns. Over the next two decades the coverage of the ALICE is extended by three additional leading series. While deviations between the CLI 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 the headline ALICE, which further improves 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, the 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 rises again and peaks in autumn 2011 closely co-moving with the headline inflation cycle and identifying the disinflation period in the euro area after 2012 well. Following this decline, the headline ALICE indicator and the reference cycle are hovering sideways for some time. At the end of the period, the ALICE, based on the full set of series, is available for three additional months (until February 2017) compared to the reference cycle (November 2016). The indicator, moreover, extends for a further two months up to April 2017 (5-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.[2] This longer leading headline ALICE is indicated by the red line. At the end of the horizon, headline ALICE indicates a continued pick-up in the headline inflation cycle with some tentative signs of a moderation or turning point at the end.

[2] The forward extension was applied for the headline ALICE by dropping the five series with the shortest lead times and keeping the four series j with the longer lead times (i.e. j = 4 in Equation 5). This implied an extension of the lead time by two months (i.e. m = 1, 2) from three to five months when calculated end of November 2016.

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.

3.3 Core ALICE

Table 2 reports the results on the selection of the leading series for the core ALICE and the improvements in the correlation of the CLI with the reference cycle as further series are added to the CLI. The detailed results for the individual candidate leading series are summarised in Table A.2 in the Appendix.

Among the group of series starting in the 1960s, the OECD CLI for the euro area is the first component series to be selected for the CLI. This series fulfils the correlation criteria in the 1999 to 2016 sample in contrast to all other series of this group and it has a sufficiently long lead time of 17 months that remains constant over time. Given the relevance of oil prices also for developments in core inflation on account of indirect effects, as before, we make an exception for the annual growth rate of oil prices and include this series in the CLI although its correlation coefficient is slightly below the defined threshold. Its lead time amounts to about 25 months and it adds further information to the CLI and strengthens the correlation with the reference cycle.

Looking at the group of series starting around 1970, the correlation and lead time criteria are met by real GDP and the stock of M1 with lead times of about 11 and 23 months, respectively. The two series can be viewed as the output and money "gaps", respectively. The inclusion of the series leads to an improvement in the correlation coefficient of the CLI with the reference cycle in both the full and the recent sample period from 1999 to 2016.

From the group of series that are available since 1980, we select 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 on the basis of the three selection criteria.[3] Recent empirical evidence on the exchange rate pass-through to euro area inflation is reported by Ben Cheikh and Rault (2016), ECB (2016b) and Özyurt (2016). The lead time of MFI loans is 6 months, while the NEER leads the inflation cycle by 16 months. The inclusion of these variables lifts the correlation of the CLI with the reference cycle further.

From the 1985 sample group the annual percentage change in the Producer Price Index (PPI) for non-food consumer goods is the next series included in the CLI. Its correlation with the reference cycle is very high in more recent sample periods and its lead time of about 6 month is sufficiently long as well as relatively stable. The inclusion of this PPI-based measure of pipeline pressures for HICP inflation excluding energy and food leads to a significantly higher correlation of the CLI with the reference cycle over the full sample; although the correlation since 1999 is broadly unchanged (it decreases by 0.01). The other variables of this group do not add additional information.

Among the series of the remaining groups (starting around 1990, 1995 and 1999, respectively) none fulfils all three selection criteria.

In sum, the core ALICE includes seven variables: (1) OECD CLI for the euro area, (2) oil prices, (3) real GDP, (4) M1, (5) MFI loans outstanding, (6) the nominal effective exchange rate and (7) the PPI non-food consumer goods. Its lead time equals the minimum lead time of the series included, i.e. 6 months. However, due to the publication lags of the included series with the shortest lead times, the effective lead time of the core ALICE is 4 months when calculated at the time of the HICP flash release.

[3] The time series of the exchange rate is extended backwards using data for the NEER vis-à-vis 12 trading partners.

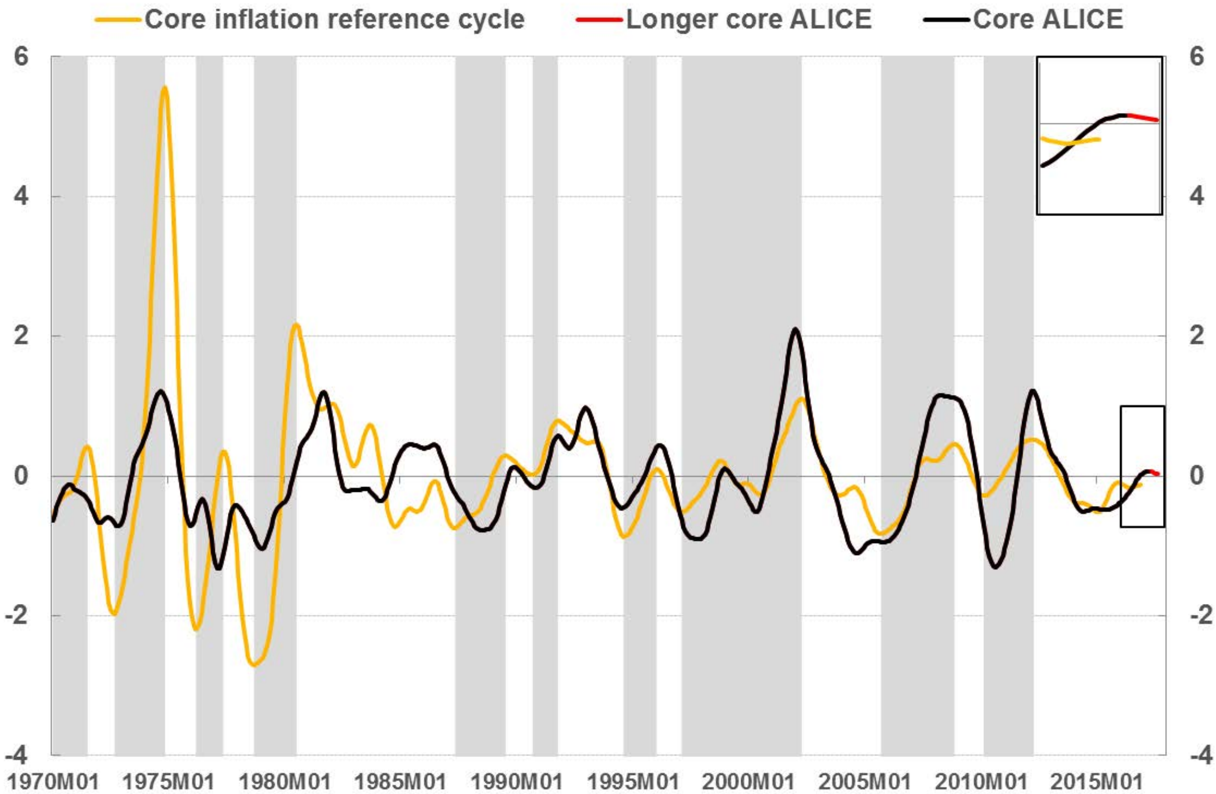
Table 2. Selected leading series and correlations of the respective composite indicators with the reference cycle for core inflation

	Single leading series	Composite leading indicator	
	Lead time in months	Correlation 1999 – 2016	Correlation Full sample
Group 1960		0.65	0.32
OECD CLI for the euro area	17		
Oil price in EUR, annual percentage change	25		
Group 1970		0.79	0.57
Real GDP	11		
M1	23		
Group 1980		0.86	0.67
MFI loans outstanding	6		
Effective exchange rate	16		
Group 1985		0.85	0.78
PPI non-food consumer goods price, annual percentage change	6		
Group 1990/1995/1999		-	-
-			

Notes: The average lead time shown in the table refers to the empirical lead/lag relationship of the indicators and does not account for publication lags. The starting point of the full sample corresponds to that of the shortest available series included in the composite indicator respectively. The cyclical component of each series is estimated over the full sample.

The development of the core ALICE together with the reference cycle is depicted in Figure 4. 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. Prior to the early 1980s, the composite indicator consists of four series, namely, the oil prices, the OECD CLI, real GDP and M1. Nevertheless, also over this period in most cases the indicator picks up the upswings in the core inflation cycle as indicated by the shaded areas. With the inclusion of three more series during the 1980s, the performance of the core ALICE 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 around the times of the financial and sovereign debt crises. In the most recent period both the reference core cycle and the core ALICE edged up somewhat before flattening again, overall hovering around zero. At the end of the horizon of Figure 4, the reference cycle for euro area core inflation is available until November 2016. The core ALICE based on all components is available until March 2017 (4 months effective lead time) and the forward extended longer ALICE based on five series (oil prices, OECD CLI, real GDP, M1 and nominal effective exchange rate) extends up to August 2017 and has hence a 9-month effective lead time.[4] Based on this information, the reference cycle does not indicate a trough in the inflation cycle since the most recent peak applying the rules proposed in Equation (2) and the core ALICE also shows no clear signs of an upcoming major turning point at the end of the horizon.

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.

In sum, the ex post analysis of Section 3 shows that the two ALICE indicators capture the cyclical movements and identify major turning points in the reference inflation cycles well, in particular over the period since 1999.

[4] For the core ALICE the two series with the clearly shorter lead time were discarded and ALICE was calculated forward based on the remaining five series (j = 5 in equation 5). This resulted in a gain in the lead time of five months (m = 1, …, 5) from four to nine months.

4. EVALUATION

In the practical application of the indicators their real-time performance matters. In this section we study three aspects of the real-time performance of the two ALICE indicators. Section 4.1 evaluates the real-time performance over the period 2010Q1 to 2018Q1 based on a real-time dataset of the included leading series. However, the design of our analysis in section 4.1 differs from that of a true real-time application in that the period over which the component series have been selected (up to November 2016) and the evaluation period (2010 to the beginning of 2018) overlap. This might overstate the performance of the indicators. In order to develop the best possible leading indicators for the euro area inflation cycles, however, the use of the most up-to-date information is necessary. Our preferred indicators are therefore those selected from the full sample such that this flaw in the setup of the real-time analysis cannot be avoided. In order to get some insights on how strongly this choice might impact on the results, we analyse in Section 4.2 how strongly the selection of the leading series for the ALICE indicators and their developments change when the leading series are selected from a non-overlapping sample, i.e. over the period ending in 2009. Section 4.3 inspects the role of oil prices in more detail. It conducts a further robustness check for the ALICE indicators with respect to the selected variables by taking out the oil price variable for which an exception in the selection process was made and to explore how this affects their developments.

4.1 Real-time performance of ALICE

For the simulation exercise of the real-time performance of the ALICE indicators, we compile a real-time dataset of the leading series that are included in the headline and core ALICE from 2010 to the beginning of 2018. If the entire series was not available in a certain period in the past, as was the case for farm-gate and wholesale market prices before April 2011, the series is not included in the dataset and, hence, in ALICE over that period. A related issue concerns the inflation-linked swap rate used for the headline ALICE. This series is available from 2005 onwards but in contrast to the series on farm-gate and wholesale market prices without back data. Given the need for sufficiently long time series to get meaningful estimates of the cycle it is therefore included in the ALICE indicators only from 2015 onwards (estimating the cycle based on 10 years of data). Over the period 2010 to 2016 the analysis represents a simulated real-time exercise as this period, as mentioned above, overlaps with the period used to select the leading series for the ALICE indicators. For the period from 2017 to the beginning of 2018, the analysis reflects a fully-fledged real-time analysis as the ALICE indicators were already constructed at that time and then updated with the newly incoming data in real time.

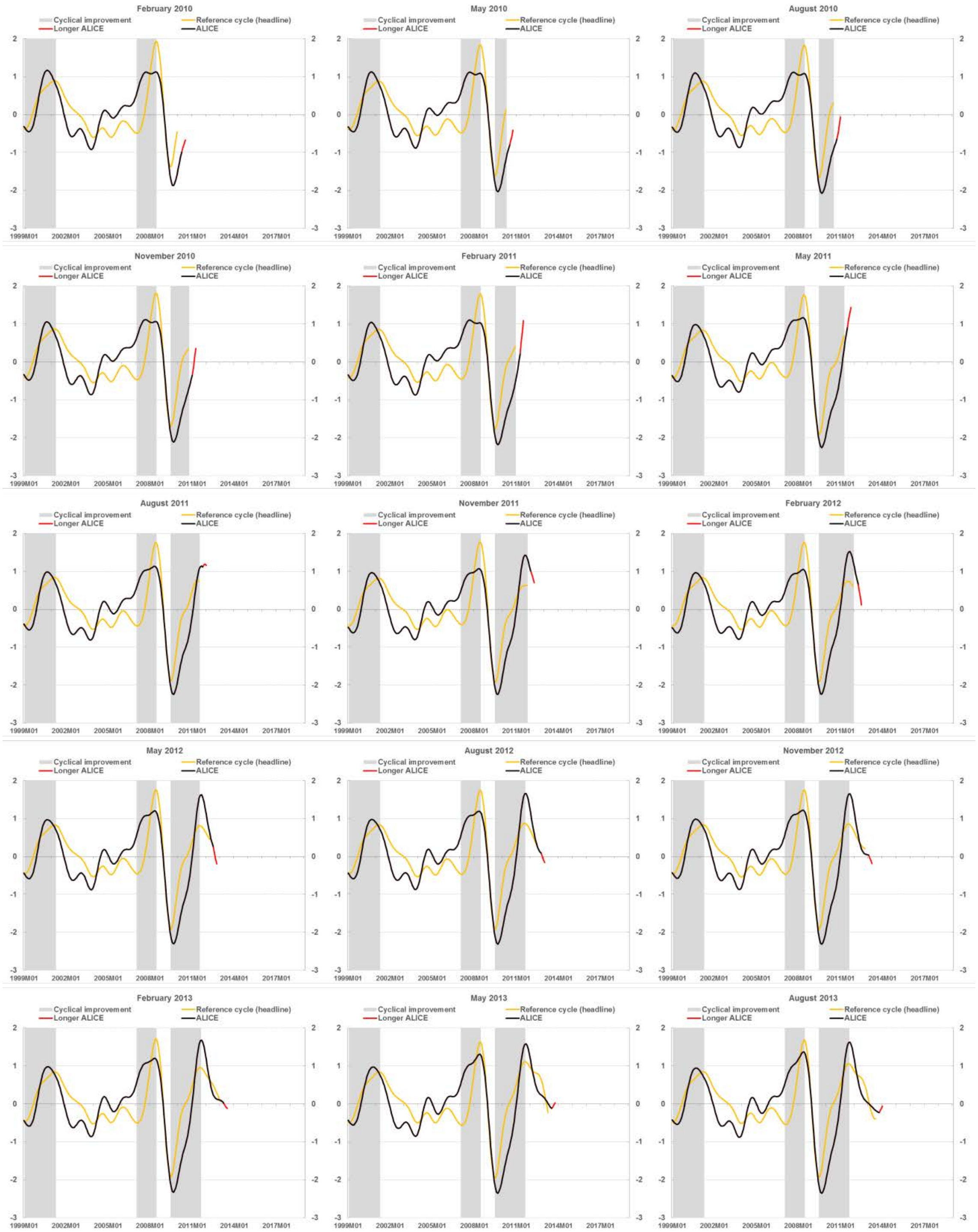
The real-time exercise is conducted at quarterly frequency over the period from the first quarter of 2010 to the first quarter of 2018 and the timing within the quarter refers to the middle of the quarter. That is, the collected real-time data vintages represent the data that were available in the middle of the second month of each quarter starting with the middle of February 2010 to the middle of February 2018. Due to the slightly different timing within the month and quarter used in the dataset of the real-time analysis as compared to the timing end of the month (December 2016) in the ex post analysis and the irregular release time of quarterly data from a monthly perspective, the lead times of the indicators are slightly different in the real-time analysis compared to the ex post analysis. The mid-month timing in the real-time analysis was chosen to allow for having a comparable set of information to that available for other inflation forecasts to which the ALICE indicators are compared in the quantitative forecast exercise in Section 5.

The (simulated) real-time developments of the headline inflation reference cycle and the (longer leading) headline ALICE in the quarters from 2010 to the beginning of 2018 are depicted in Figure 5. Following a trough in 2009, ALICE persistently signalled a continuation of the cyclical improvements for the headline reference cycle in the period from February 2010 to May 2011. In line with the signals from ALICE, the references cycle has gradually increased over this period. In August 2011, ALICE signalled a peak in the inflation cycle and this signal was confirmed in November 2011, where a clear cyclical downswing was already predicted. Indeed, the inflation cycle turned clearly in February 2012, i.e. in the data vintage six months after the initial signal of ALICE and already started to fall at that point in time. The decline in both series continued in the subsequent quarters until ALICE provided a first indication of an upcoming trough in May 2013. While this signal became stronger in the next few quarters, the reference cycle continued to decline, albeit at a somewhat slower pace. The pick-up in ALICE however remained modest and as of May 2014 ALICE turned again while the reference cycle flattened and appeared to have reached ground. ALICE signalled some cyclical sideward movements up to

November 2015 which are broadly followed by the reference cycle. In November 2015 a trough for January 2015 in the headline inflation cycle is identified for the first time according to our dating rules. Thereafter a clearer strengthening in ALICE predicted some cyclical improvements for the headline reference cycle which became apparent in the reference indicator in November 2016. In February 2017 the headline ALICE provided a first signal that a peak might have been reached and moved sideways in the subsequent quarters up to February 2018. These developments are closely followed by the headline inflation cycle. Overall, the (simulated) real-time analysis shows that the headline ALICE performs well as additional data become available. It leads the headline reference cycle and (as the reference cycle) does not suffer from major revisions. This applies notably also to the timing of the identified turning points which do not shift substantially over time.

The (simulated) real-time performance of the (longer leading) core ALICE and the corresponding reference cycle is illustrated in Figure 6. In February 2010 ALICE anticipated a trough for the reference cycle that indeed materialised two quarters later in the reference cycle. The two series moved upwards until August 2011 where ALICE signalled a peak, which was at that time also temporarily visible in the reference cycle but revised away for that indicator in the next data vintage. Nevertheless, the turning point signal was reinforced by the core ALICE in the next quarters as the indicator continued to decrease and this signal was then also followed by the reference cycle in February 2012. Thereafter both indicators declined gradually until the end of 2013 with the core ALICE leading the reference cycle. In November 2013, ALICE anticipated a trough in the core inflation cycle. This signal was also visible in the data vintage of the next quarter but the indicator flattened thereafter anticipating correctly the upcoming stabilisation in the reference cycle. The upturn signal of ALICE temporarily strengthened at the end of 2015. In February 2016 a trough for January 2015 in the core inflation cycle is identified for the first time. From 2016 onwards the ALICE continued to point sideways broadly in line with the movements observed in the core reference cycle and a further slight improvement is indicated by the longer leading core ALICE at the beginning of 2018. Overall, also for the core inflation cycle the two indicators tend to move together in real time and the core ALICE appears to provide leading signals for the reference cycle while revisions appear to be confined.

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



Notes: This figure plots the ALICE together with the longer-leading ALICE for headline inflation and the reference cycle in a simulated real-time exercise over the period February 2010 to February 2018.

Figure 5. (continued)

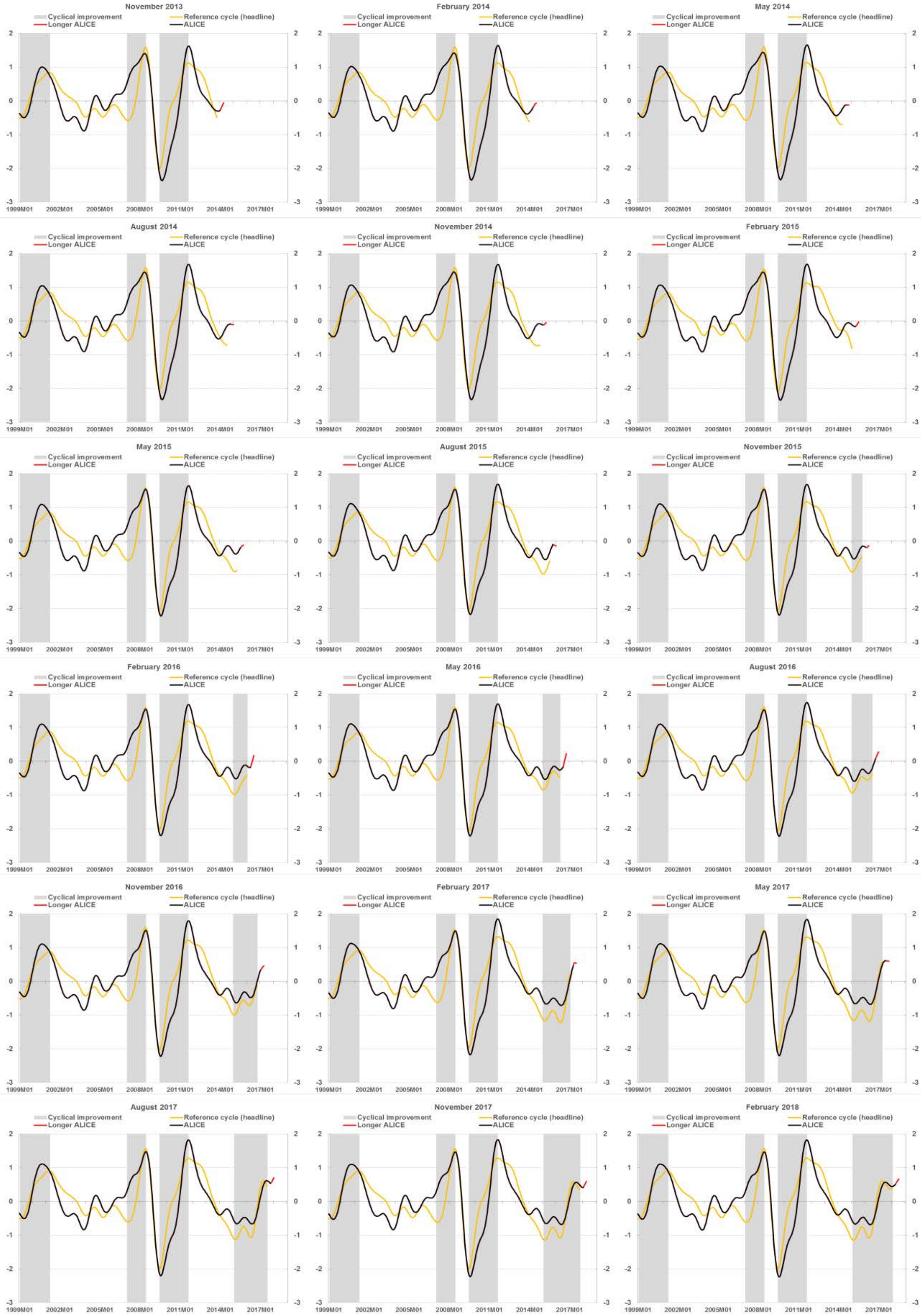
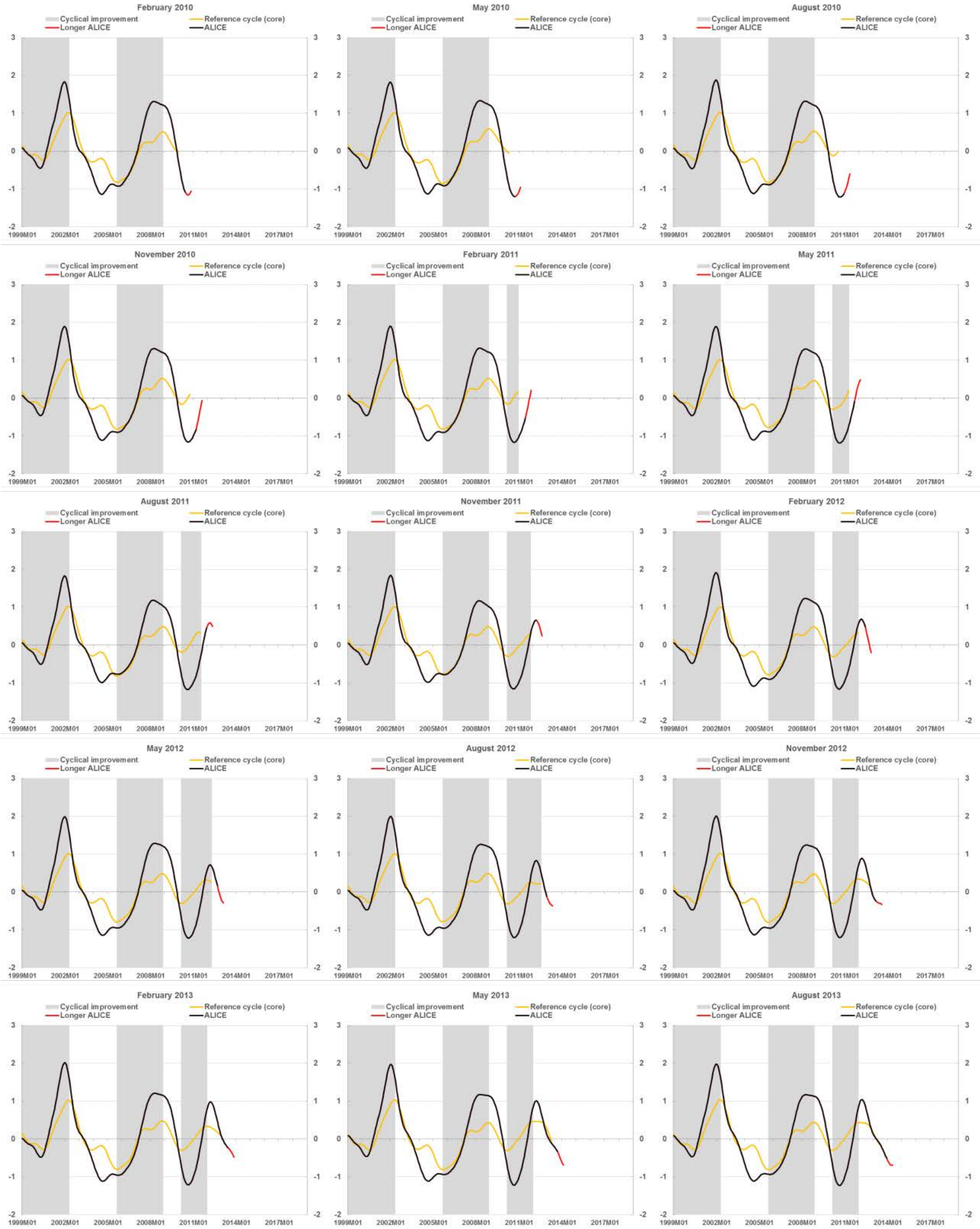
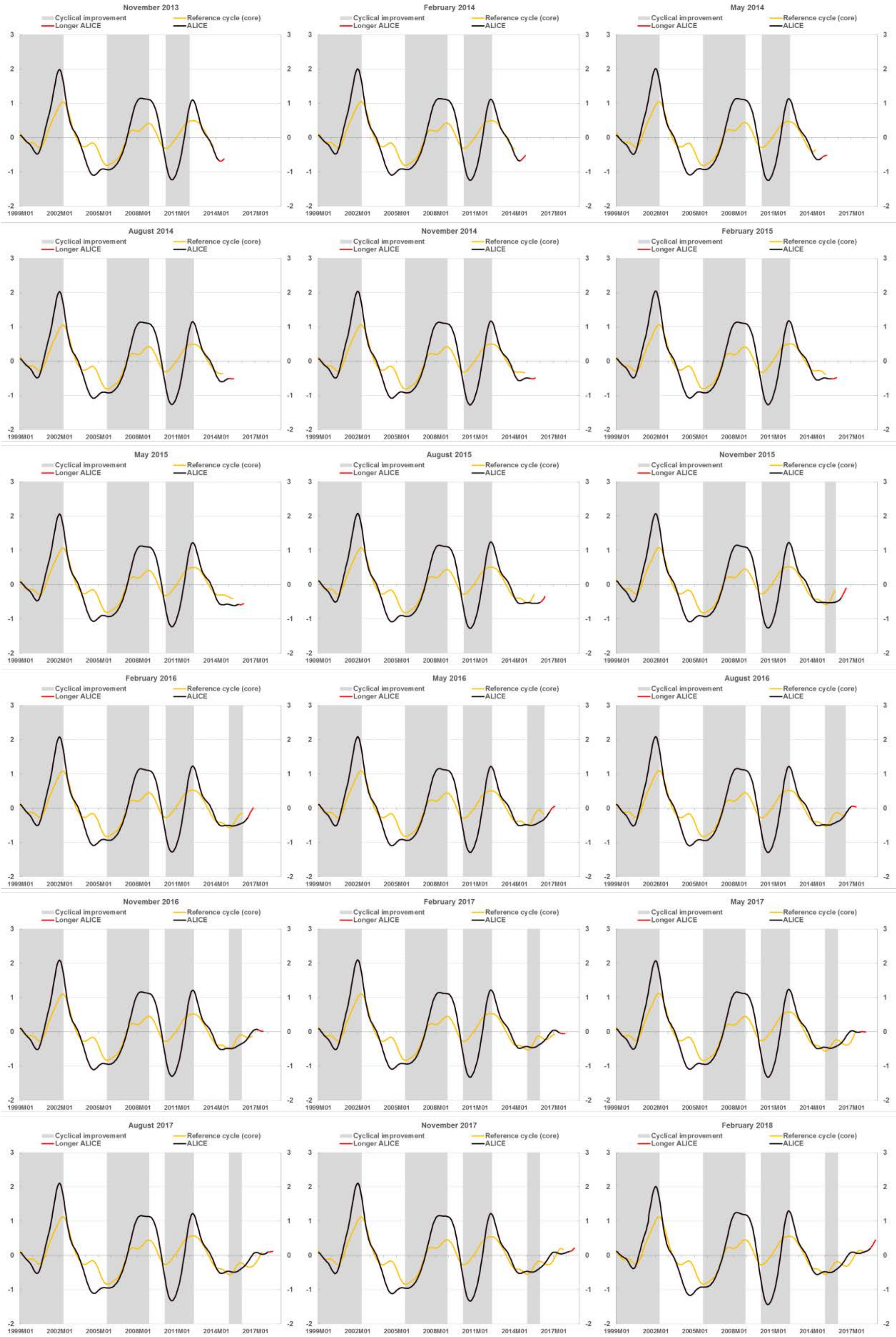


Figure 6. Simulated real-time developments of core ALICE and the reference cycle



Notes: This figure plots the ALICE together with the longer-leading ALICE for core inflation and the reference cycle in a simulated real-time exercise over the period February 2010 to February 2018.

Figure 6. (continued)



4.2 Different selection period

The selection of series for the headline ALICE based on the sample period up to 2009 leads to only small changes in the composition of the CLI compared to the previous analysis (see Table A3 in the Appendix).

Starting with the series available since the 1960, as in the sample period up to 2016, the OECD composite leading indicator for the euro area meets the correlation and lead time criteria and shows the highest correlation among the series that fulfil the criteria in this group. It is hence again included as the first series in the CLI. Adding further activity indicators that likewise fulfil the first two criteria does not improve the correlation of the CLI with the reference cycle. Oil prices, by contrast, for which we again make an exception in terms of the magnitude of the correlation (0.48), significantly improve the correlation of the CLI with the reference cycle for the full sample period up to 2009 and leave it broadly unchanged for the sample 1999 to 2009. We therefore include this series again in the CLI.

Looking at the group of series starting in the 1970s, the previously selected M1 to GDP ratio does not fulfil the criteria in the sample up to 2009 on account of a too low correlation. However, two series of the remaining ones in this group, namely, the annual growth rate in M1 and the growth rate differential between M1 and GDP, satisfy the criteria. From these two series we include the annual growth rate of M1 as this series has the higher correlation and its inclusion in the CLI increases the correlation with the reference cycle substantially.

With regard to the series starting in the 1980s, the previously selected series of world raw material prices of food has a very high correlation also in the sample up to 2009, but its lead time drops slightly and is now too low to be included in the CLI as the series is published with some delay. Among the remaining series in this group three fulfil the correlation and lead time criteria. These are, as before, the growth rate of building permits and, in addition, the level of building permits and MFI loan flows. As the correlations are clearly above the required threshold for all of the three indicators but growth in building permits has the by far longest lead time we again choose this series for the CLI. This lifts the correlation of the CLI with the reference cycle further for the full sample up to 2009, but reduces it slightly in the sample 1999 to 2009, which might reflect the rather limited length of this 10 year sample period.

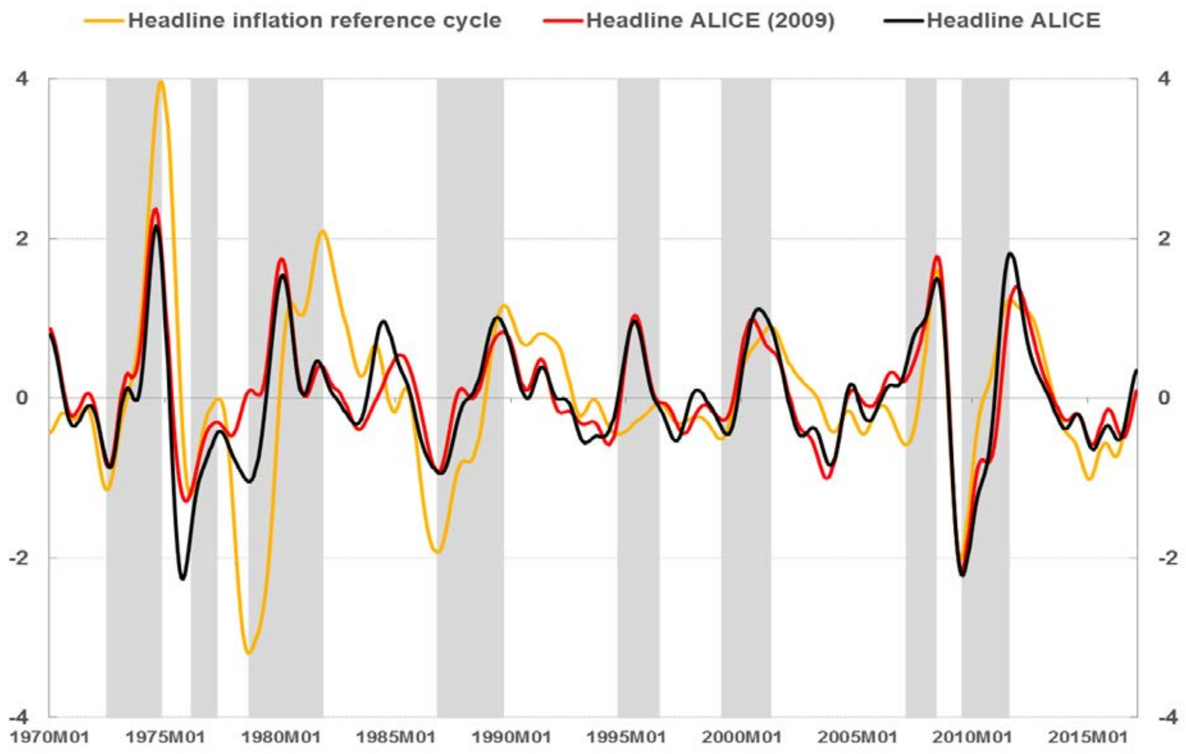
In the group starting in 1985, the previously selected series of selling price expectations in manufacturing does not qualify on account of a too short lead time in the sample period up to 2009, but a number of other survey indicators do. From these we pick selling price expectations for intermediate goods. This reflects the application of our criteria to ensure a broad diversity of indictors to be included in the CLI. The selected series includes information on price setting while the other survey indicators are more activity related and their information content is hence more redundant to the previously included variables. The inclusion of the series lifts the correlation with the reference cycle further in the full sample up to 2009 and leaves it broadly unchanged in the 1999 to 2009 sample.

While, as in the sample up to 2016, no series from the group starting in the 1990s qualifies, among the series starting around 1995, non-energy non-food commodity prices and labour productivity fulfil the correlation and lead time criteria. We choose the former given its substantially longer lead time and larger diversity from previously selected indicators. Its inclusion raises the correlation with the reference cycle further for both the full sample up to 2009 as well as the sample 1999 to 2009.

Finally, for the series starting around 1999, as before the inflation rate of farm-gate and whole sale market prices and the inflation linked swap rate show the highest correlations and sufficiently long lead times and at the same time imply a further diversification of the CLI. Concerning the latter indicator we choose the one-year forward one-year ahead inflation swap rate while some swap rates for different horizons appear equally good. This extension of the CLI lifts the correlation with the reference cycle significantly further to 0.89. This correlation is higher than the one found for the headline ALICE derived over the sample period 1999 to 2016 (0.85) which probably relates to the fact that the 1999 to 2009 period is focused on the Great Recession and the sharp cyclical movements over this period boost all correlations.

To sum up, the headline ALICE chosen based on data up to 2009 contains the following eight series: (1) Euro area OECD CLI, (2) annual growth in oil prices, (3) annual growth in M1, (4) annual growth rate in building permits, (5) selling price expectations for intermediate goods, (6) annual percentage change in non-food commodity prices, (7) annual growth in farm-gate prices, and (8) the one-year-forward inflation-linked swap rate one year ahead. This choice includes three changes compared with the headline ALICE selected based on data up to 2016, namely the inclusion of M1 instead of the M1 to GDP ratio, of the survey of selling price expectations for intermediate goods instead of that for total manufacturing, and the omission of the series of world raw material prices of food and tropical beverages. These changes in the composition of the headline ALICE imply only small changes for the development of this leading indicator (see Figure 7).

Figure 7. Headline ALICE based on sample up to 2016 versus sample up to 2009



Notes: This figure plots the headline ALICE compiled based on the sample up to 2016 together with the headline ALICE compiled based on the sample up to 2009 and the corresponding headline inflation reference cycle. The shaded areas denote the periods between a trough and a peak in the headline inflation cycle.

For the core ALICE, the selection of series based on the sample period up to 2009 leads to somewhat larger changes in the composition of the CLI than for the headline ALICE (see Table A3 in the Appendix).

Looking at the series available since the 1960s, oil prices and the EUR/USD exchange rate, the latter both in level and growth rates, fulfil the criteria, but the OECD composite leading indicator for the euro area – previously selected for the sample up to 2016 – no longer. We include only oil prices from this group, because we have in a later group even better fitting and more encompassing information on exchange rate effects from the nominal effective exchange rate. The fact that oil prices clearly fulfil the required correlation for this sample period corroborates the importance of this variable for headline and even core inflation developments in certain periods and hence the earlier decision of its inclusion in the CLI despite a correlation in the sample up to 2016 somewhat below the defined threshold.

Turning to the group of series starting in the 1970s, import prices show the highest correlation and fulfil the lead time requirements but lead to a deterioration of the CLI and are therefore discarded. From the previously included series of this group, i.e. real GDP and M1, only the former fulfils the required correlation and lead time criteria and is hence included in the CLI raising the correlation with the reference cycle significantly in both the full sample up to 2009 and the 1999 to 2009 period. Replacing M1 with the series of M3 which fulfils the requirements in the considered sample leads to deteriorations of the CLI and hence a rejection. The last variable of this group that matches the criteria is compensation per employee growth and its inclusion lifts the correlation of the CLI significantly further particularly in the full sample up to 2009.

In the group of series starting in the 1980s, the variable showing the highest correlation and sufficient lead time is the NEER of the euro vis-à-vis 38 trading partners. This variable is also a component of the core ALICE constructed based on the sample up to 2016 and improves the correlation with the reference cycle substantially further in both sample periods up to 2009. The previously included series of MFI loans outstanding is outperformed in the sample up to 2009 by the ratio of MFI loans outstanding to GDP. Including this series improves the correlation of the CLI further for both samples up to 2009. A category of indicators not covered yet in the CLI but in principle fulfilling the criteria is raw material prices excluding energy. Among the available series, world raw material prices of industrial goods has the highest correlation with the core inflation cycle but its inclusion in the CLI leads to a deterioration of the correlation with the cycle and hence a rejection of the series.

In the group of series starting around 1985, as in the sample up to 2016, the PPI non-food consumer goods series has the highest correlation, a sufficiently long lead time and refers to a set of information not yet considered. The inclusion of this series boosts the correlation with the reference cycle significantly further. A further class of series in this group fulfilling the criteria are surveys and the best of them, the EC survey on selling price expectations of consumer goods, lifts the correlation with the cycle somewhat further in the full sample period up to 2009.

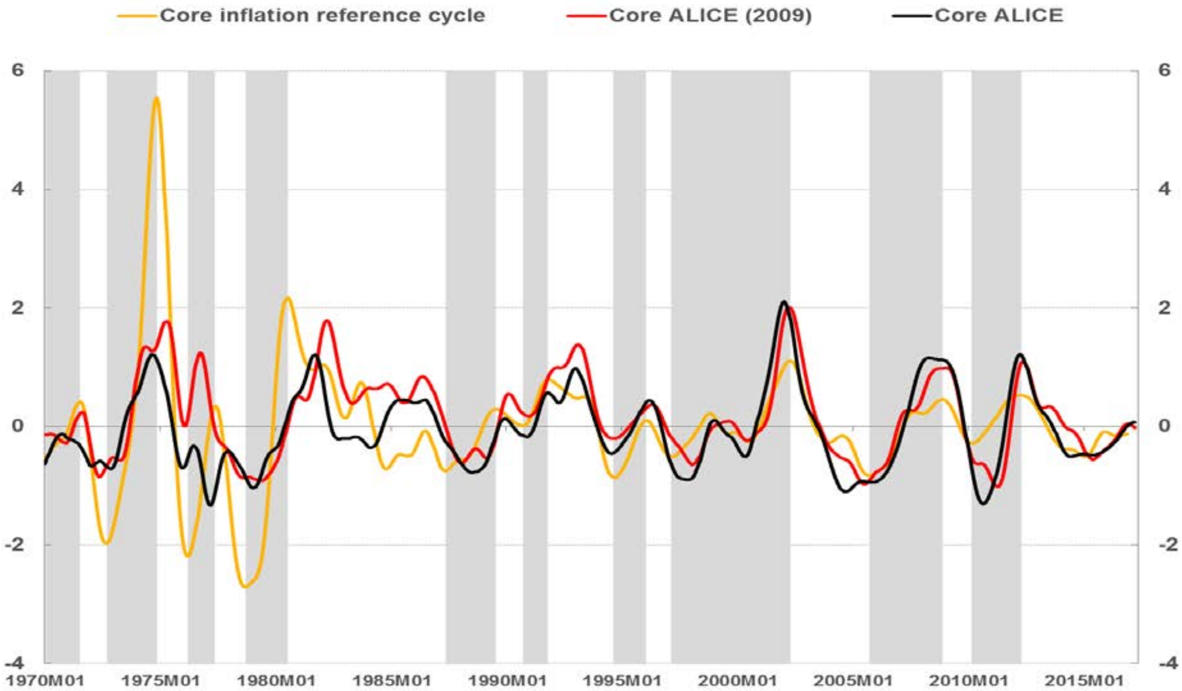
With respect to the series starting in the 1990s and principally fulfilling the three selection criteria, the ZEW survey on short-term interest rate expectations leads to the greatest improvements of the correlations of the CLI in the full sample to 2009 and is therefore included in the indicator.

Looking at the series starting around 1995, only import prices comply with the correlation and lead time criteria and provide additional information. Of these series import prices of services have the highest correlation and improve the correlations of the CLI with the cycle further and are hence included in the CLI.

Among the series starting in 1999 and complying with the selection criteria, only the inclusion of the PMI survey on retail sales prices paid for goods leads to a further improvement of the CLI and is hence considered.

Overall, the core ALICE based on data up to 2009 contains the following ten series: (1) annual growth in oil prices, (2) real GDP, (3) compensation per employee, (4) the ratio of loans to GDP, (5) the NEER, (6) the PPI non-food consumer goods, (7) EC surveys selling price expectations for consumer goods, (8) the ZEW survey on short-term interest rate expectations, (9) import prices of services, and (10) PMI survey on prices paid for goods in retail sales. This composition of the indicator entails changes in more than half of the series included compared to the core ALICE selected based on the sample period up to 2016. Newly included series are compensation per employee, the ratio of loans to GDP (basically replacing loans outstanding), EC selling price expectations, the ZEW expectations for short-term interest rates, import prices of services, and the PMI survey on prices paid for goods in retail sales. Nevertheless, as Figure 8 shows, the developments of this leading indicator are still quite similar over the past 20 years to those of the core ALICE selected based on data up to 2016. For earlier periods there are somewhat larger differences but the direction of the movements remains (in most cases) similar.

Figure 8. Core ALICE based on sample up to 2016 versus sample up to 2009



Notes: This figure plots the core ALICE compiled based on the sample up to 2016 together with the core ALICE compiled based on the sample up to 2009 and the corresponding core inflation reference cycle. The shaded areas denote the periods between a trough and a peak in the core inflation cycle.

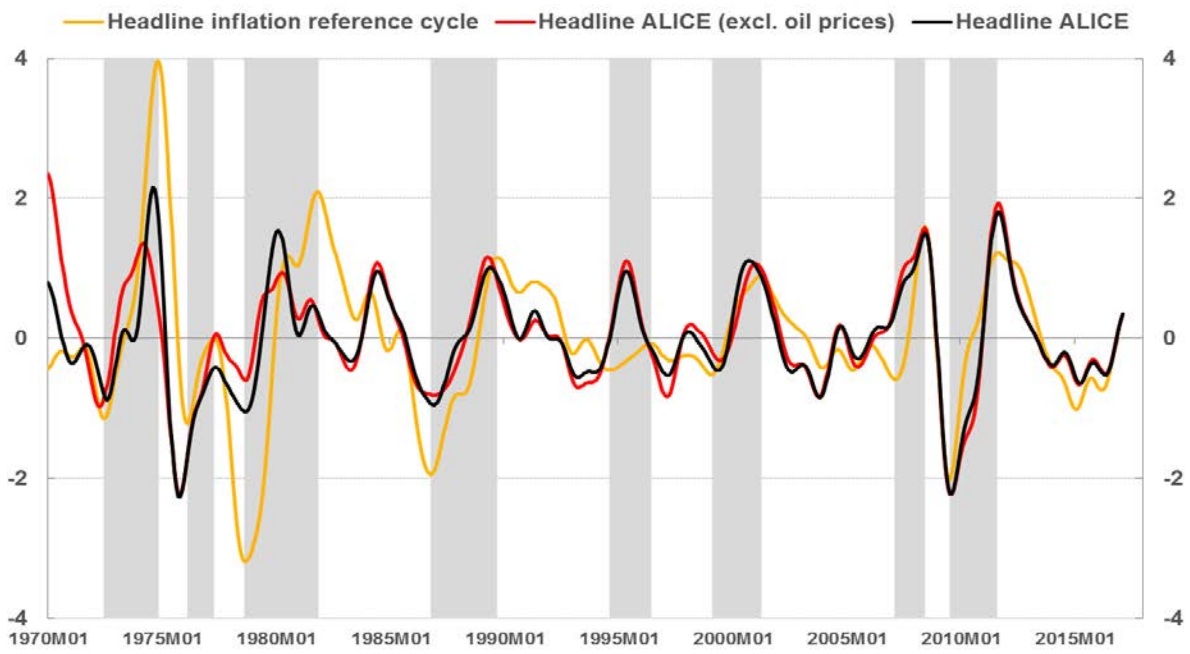
In sum, the ultimate outcomes for both ALICE indicators are rather insensitive to the period over which the leading component series are chosen. The inflationary pressures signalled by the selected series are similar, despite a different composition of the selected leading series of up to a half.

4.3 Impact of oil prices on the ALICE

In the following we examine the impact of the oil price variable on the ALICE indicators given the exception that has been made for this variable in terms of the required magnitude of the correlation coefficient. The developments for both the headline and the core ALICE are overall very similar to the corresponding indicator excluding the oil price variable (see Figures 9 and 10). Somewhat larger differences arise primarily in the 1970s where oil prices fluctuated particularly strongly in the context of oil crises.

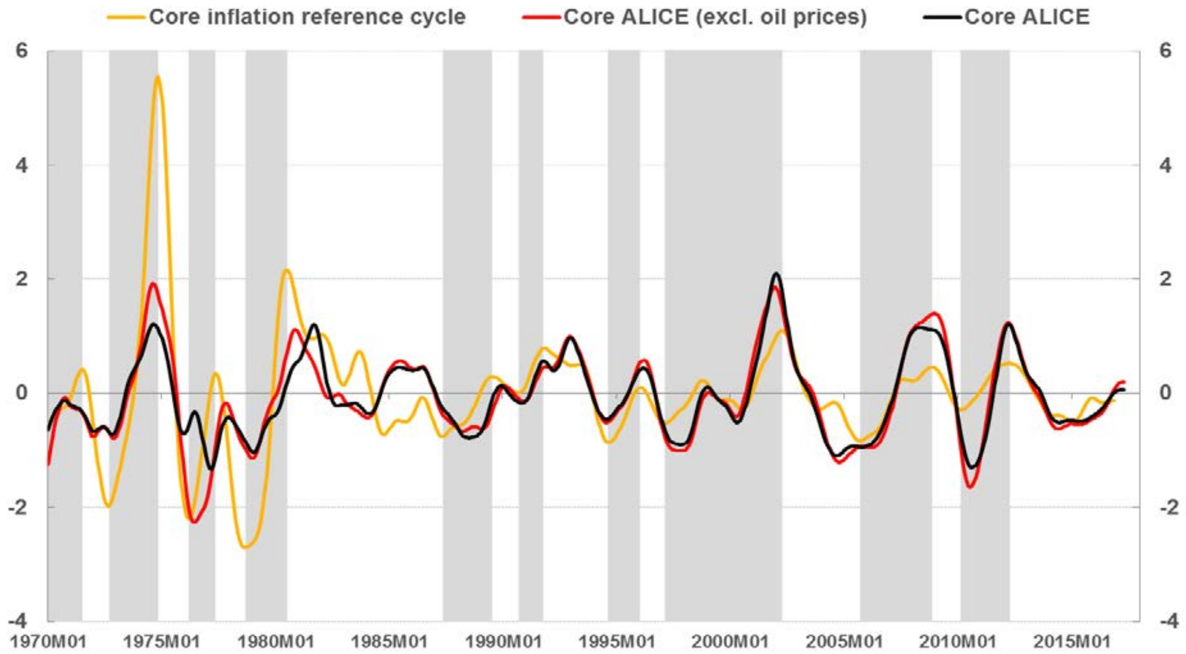
For the headline ALICE the inclusion of the oil price variable brought it closer and seemed to have helped it to track the reference inflation cycle better in the 1970s, but the differences between the two indicators are small thereafter. An important factor behind this is, of course, the high relevance of oil price developments for inflation in the 1970s given the oil crises. Also for the core ALICE the differences between the indicator including and excluding oil prices are larger in the 1970s and relatively small thereafter. Oil prices seem to add some value and relevant information to the core ALICE since the 1980s. As the impact of oil prices on core inflation is, in contrast to the headline ALICE, to a lesser extent captured by other variables, oil prices seem to help detecting turning points in the core inflation cycle more clearly than for headline inflation when there are strong changes in this variable. This is visible in the turning point at the time of the inception of the Great Recession in 2008 when oil prices dropped significantly and also in slight improvements of the indicator at other turning points.

Figure 9. Headline ALICE compared to headline ALICE excluding oil prices



Notes: This figure plots the headline ALICE together with the headline ALICE where the oil price series has been taken out. The shaded areas denote the periods between a trough and a peak in the headline inflation cycle.

Figure 10. Core ALICE compared to core ALICE excluding oil prices



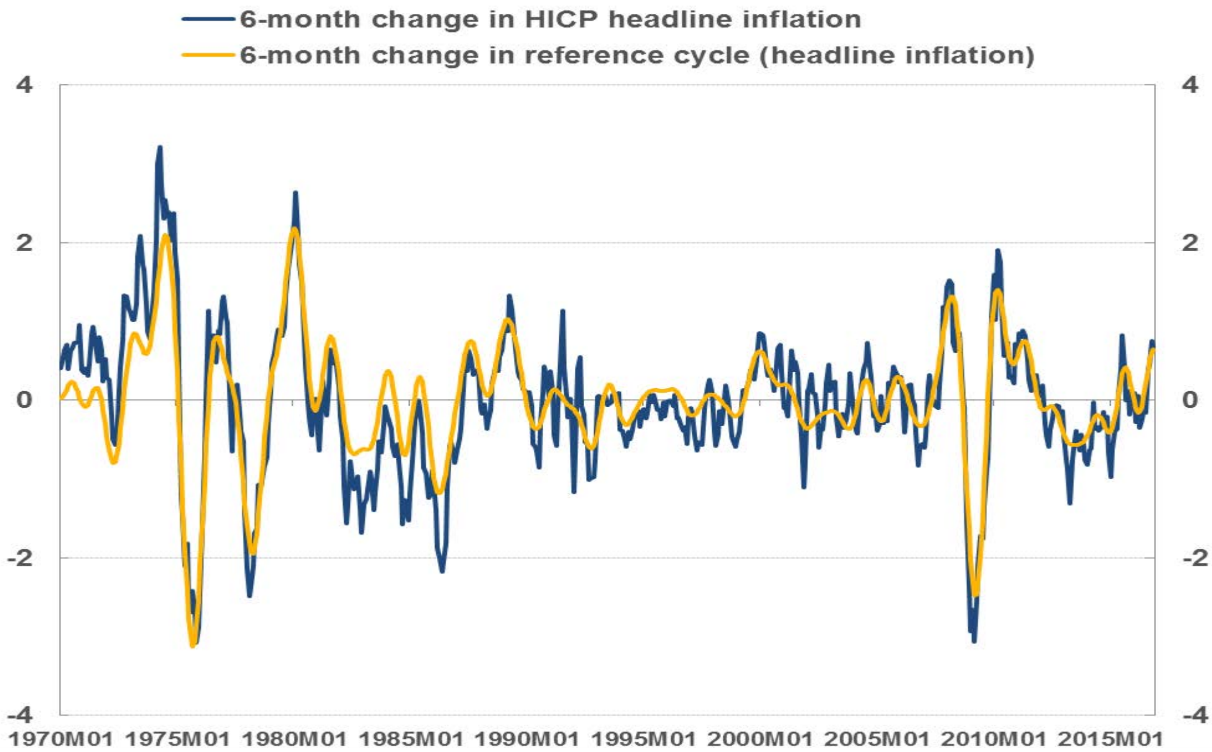
Notes: This figure plots the core ALICE together with the core ALICE where the oil price series has been taken out. The shaded areas denote the periods between a trough and a peak in the core inflation cycle.

All in all, while for the headline ALICE oil prices appear not to add too much additional information to the indicator over the past few decades (in contrast to the 1970s), for core inflation oil prices seem to be able to add relevant information at times of strong oil price changes as their impact is to a lesser extent covered by other variables. As the oil price variable in addition does not seem to harm the developments of the two leading indicators at other times and future large swings in oil prices can't be excluded, our preferred indicators remain those including oil prices.

5. QUANTITATIVE FORECASTS

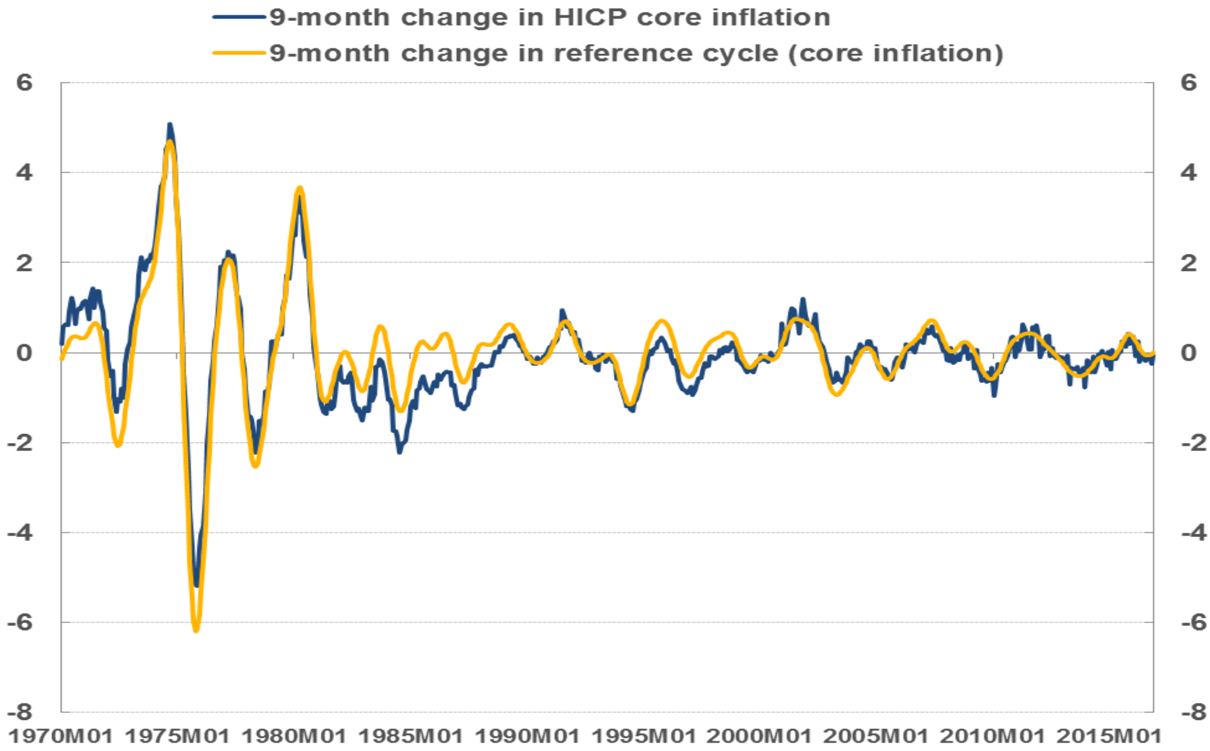
This section analyses the potential value added of the ALICE indicators for forecasting the direction of inflation movements and quantitative inflation forecasts. This contrasts the previous section where the ability to provide qualitative information concerning turning points in the reference cycle was assessed. Figures 11 and 12 show that changes in the headline and core reference cycles tend to move broadly in line with actual inflation changes, as one would expect under the assumption of no significant change in the trend component during the short horizon considered. Consequently, changes in the ALICE indicator may have predictive power for changes in the corresponding inflation rate. This section explores this possibility and reports quantitative inflation forecasts based on the (simulated) real-time ALICE indicators introduced in Section 4.1. More specifically, we evaluate 2 (3)-quarter ahead forecasts for 2 (3)-quarter changes in the headline (core) inflation rates over the forecast period 2010Q2 (Q3) – 2018Q1.

Figure 11. Changes in the headline reference cycle and inflation



Notes: This figure plots 6-month changes in the headline reference cycle (standardised) against 6-month changes in the year-on-year HICP inflation rate (percentage points).

Figure 12. Changes in the core reference cycle and inflation



Notes: This figure plots 9-month changes in the core reference cycle (standardised) against 9-month changes in the year-on-year HICP inflation rate (percentage points) excluding energy and food.

The real-time forecasts based on the longer ALICE indicators are again calculated in the middle of the second month 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.[5] Based on the data available in 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 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.

The first vintage of our dataset refers to the middle of February 2010 when 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 between April 2010 and October 2009, between May 2010 and November 2009, and between

[5] The differences in the lead times of the (longer) ALICE indicators compared to the previously indicated lead times are accounted for by the different timing in the month and quarter.

June 2010 and 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 between July 2010 and October 2009, between August 2010 and November 2009, and between September 2010 and 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 indicator. 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 shown in Equations (6) and (7), respectively:

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

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

The forecast performance of ALICE is assessed by comparing it to inflation forecasts from alternative models and sources. 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 (ARs), with more elaborate forecasting methods. However, it is important to note that 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; Lenza and Warmedinger, 2011; 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 (broad) macroeconomic projection exercise ((B)MPE). The majority of publicly available surveys and forecasts provided by institutions are focused on one-year or longer horizons (also whole calendar years). Thus, one reason to compare our forecasts to the EZB and (B)MPE projections is that quarterly forecasts with respect to euro area HICP headline inflation are also published (in (B)MPE since December 2013), albeit they are not available for HICP inflation excluding energy and food. A further reason for the comparison with the (B)MPE is that in the past it has 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 (B)MPE published closest to the real-time dating of the ALICE in the middle of each quarter are chosen. The EZB is released around the middle of every month and its forecasts in February, May, August and November should thus include a set of information that is broadly comparable to that available for the ALICE indicators. The quarterly (B)MPE projections are published at the beginning of the third month of a quarter, but the cut-off date of these projections is typically around the middle of the quarter implying a comparable information set with that of the other two forecasts. Finally, in order to have inflation forecasts comparable to the ones derived using the ALICE, the level inflation forecasts from the EZB and (B)MPE are transformed into 2 (3)-quarter changes.

The forecast performance is evaluated in three ways and summarised in Table 3. Firstly, it is assessed in terms of the directional accuracy. This is defined as the percentage of forecasts which correctly predicted the direction of the change in inflation (over the considered 2 or 3 quarter horizon) out of the total number of forecasts. The second and third performance measures are the mean absolute error (MAE) and the root mean squared error (RMSE) of the quantitative forecasts. These are depicted for the RW, EZB and (B)MPE forecasts in relative terms with respect to the ALICE-based forecasts. Thus, a ratio above (below) 1 indicates that the ALICE indicator has outperformed (underperformed) the alternative forecasts of the RW, EZB or (B)MPE. In addition to the forecast accuracy over the full forecast period, the MAE and RMSE outcomes are also shown for the individual calendar years.

Panel A of Table 3 reports the results for the headline (core) ALICE over the forecast period 2010Q2 (Q3) to 2018Q1. With respect to the first performance evaluation aspect, the directional accuracy of the headline ALICE is 71%, i.e. in 7 out of 10 times it predicts correctly the direction of a change in the HICP inflation rate two quarters ahead, whereas this is the case in 59% of the EZB forecasts. Furthermore, the forecasts of the headline ALICE have a lower MAE and RMSE over the whole considered period than the RW model, but a somewhat higher one when compared to the EZB forecasts. The Diebold-Mariano (DM) test, however, indicates that the predictive accuracy of the headline ALICE is not significantly different from the two alternative forecasts. The relative MAE and RMSE by calendar year show that the relative forecast performance of the different forecasts is strongly time-varying. The ALICE-based forecasts have much lower MAE and RMSE in 2010, 2013, 2016 and 2017 than the RW forecasts, while the RW performed better in 2012, 2014 and 2018 (based on one observation only), and overall similarly in 2011 and 2015. Compared to the EZB forecasts, the headline ALICE performed better for the years 2010, 2011, 2015 and 2016, and worse in 2012, 2013, 2014, 2017 and 2018.

With respect to HICP inflation excluding energy and food, the directional accuracy of the core ALICE is almost as high as for headline inflation at 65%. Different to the results for HICP inflation, the RW performs better than core ALICE in terms of both the MAE and RMSE and the differences in the two forecasts are also statistically significant according to the DM test. Looking at calendar years, the relative forecast performance is less time-varying for HICP inflation excluding energy and food as the ALICE-based forecasts outperformed or performed similar to the RW model only in one of these years.

Quarterly forecasts from the (B)MPE are publicly available as of December 2013 for headline HICP inflation, albeit not for HICP inflation excluding energy and food. Thus, Panel B of Table 3 summarises the results for both ALICE indicators for the period since 2014, including for headline inflation also the comparison with the (B)MPE projections. The directional forecast accuracy of ALICE is lower for both headline and core inflation in the shorter period starting in 2014 than in the full sample period but remains higher than that of the EZB survey. The (B)MPE forecast for headline inflation, however, shows the best performance in this respect. In quantitative terms, for headline inflation, the ALICE forecasts are on average over these years better than the RW forecasts, similar to the EZB and worse than the (B)MPE forecasts, but these differences are not statistically significant. For core inflation, in line with the results over the whole period, the RW model significantly outperforms the core ALICE. Looking at individual calendar years, while the (B)MPE performed better than headline ALICE over the whole period, the headline ALICE nevertheless outperformed the (B)MPE in 2015 and 2016, i.e. in about half of the cases. The good performance of the (B)MPE is in line with earlier findings of on average somewhat more accurate inflation forecasts in the (B)MPE compared to the EZB (ECB, 2013), although we find that the differences are not statistically significant. In part, the on average better performance of forecasts like the (B)MPE compared to the ALICE might reflect calendar effects like differences in the timing of Easter in two successive years. Such effects are not taken care of in indicators like the ALICE but they can have a notable impact on the year-on-year inflation rate of the HICP and HICP excluding energy and food in certain months and quarters of the year.

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

Panel A:	*2010 Q2 – 2018 Q1*				*2010 Q3 – 2018 Q1*	
	Headline HICP				HICP excl. energy and food	
	ALICE	RW	EZB		ALICE	RW
Directional accuracy (%)	70.8	NA	59.4		64.5	NA
MAE (overall)	1	1.13	0.92		1	0.56
RMSE (overall)	1	1.20	0.96		1	0.54
Diebold-Mariano test (p-value)	-	0.22	0.77		-	0.02
MAE / RMSE 2010	1 / 1	2.72 / 2.90	1.26 / 1.25		1 / 1	0.14 / 0.16
MAE / RMSE 2011	1 / 1	1.08 / 0.95	1.21 / 1.09		1 / 1	0.91 / 0.80
MAE / RMSE 2012	1 / 1	0.42 / 0.53	0.65 / 0.70		1 / 1	0.14 / 0.17
MAE / RMSE 2013	1 / 1	1.27 / 1.25	0.62 / 0.73		1 / 1	1.22 / 0.96
MAE / RMSE 2014	1 / 1	0.70 / 0.75	0.75 / 0.75		1 / 1	0.69 / 0.78
MAE / RMSE 2015	1 / 1	0.83 / 0.97	1.64 / 1.57		1 / 1	0.85 / 0.90
MAE / RMSE 2016	1 / 1	1.69 / 1.90	1.63 / 2.07		1 / 1	0.40 / 0.38
MAE / RMSE 2017	1 / 1	1.64 / 1.57	0.45 / 0.46		1 / 1	0.73 / 0.82
MAE / RMSE 2018	1 / 1	0.80 / 0.80	0.04 / 0.04		1 / 1	0.65 / 0.65
Panel B:	*2014 Q1 – 2018 Q1*				*2014 Q2 – 2018 Q1*	
	Headline HICP				HICP excl. energy and food	
	ALICE	RW	EZB	(B)MPE	ALICE	RW
Directional accuracy (%)	51.0	NA	47.1	58.8	43.8	NA
MAE (overall)	1	1.10	0.97	0.90	1	0.61
RMSE (overall)	1	1.22	1.01	0.88	1	0.65
Diebold-Mariano test (p-value)	-	0.36	0.94	0.49	-	0.03
MAE / RMSE 2014	1 / 1	0.70 / 0.75	0.75 / 0.75	0.71 / 0.72	1 / 1	0.59 / 0.69
MAE / RMSE 2015	1 / 1	0.83 / 0.97	1.64 / 1.57	1.16 / 1.11	1 / 1	0.85 / 0.90
MAE / RMSE 2016	1 / 1	1.69 / 1.90	1.63 / 2.07	1.96 / 1.92	1 / 1	0.40 / 0.38
MAE / RMSE 2017	1 / 1	1.64 / 1.57	0.90 / 0.46	0.59 / 0.53	1 / 1	0.73 / 0.82
MAE / RMSE 2018	1 / 1	0.80 / 0.80	0.04 / 0.04	0.07 / 0.07	1 / 1	0.65 / 0.65

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

To summarise, this section illustrates that the headline and core ALICE may be a useful complementary tool to cross-check quantitative inflation forecasts. This applies in particular in terms of providing guidance on the direction of inflation forecasts. In quantitative terms, for headline inflation, the (B)MPE performed best, followed by the EZB and an on average similar performance of the ALICE, while the RW was the worst, but none of these differences were statistically significant. For core inflation, the RW performed significantly better than core ALICE. Moreover, in line with the findings in the literature, the relative performance of the forecasts under consideration varied considerably over time.

6. CONCLUSIONS

This study develops leading indicators for the cycles of HICP inflation and HICP inflation excluding energy and food 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 around 160 potential leading series. The two developed CLI for the euro area headline and core inflation cycles, the headline and the core ALICE, consist of nine and seven leading series, respectively. 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 well, especially for the period since 1999. A simulated 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. Robustness checks concerning the selection of the leading series based on a different sample period show that the selection varies to different degrees for the headline and core ALICE but with relatively little impact on the development and signals provided by the ALICE indicators. A further robustness check concerned the elimination of the oil price variable from the two ALICE indicators in view of the more favourable treatment of this variable when selecting the leading series. This analysis showed that oil prices appear not to have added too much additional information to the headline ALICE over the past few decades (in contrast to the 1970s oil crises period), while for core ALICE oil prices seemed to be able to add relevant information at times of strong oil price changes over the past decades as their impact is to a lesser extent covered by the other selected leading series.

Besides their use to predict turning points, the ALICE indicators have also been analysed in terms of their ability to forecast the direction of the inflation movements as well as the quantitative inflation outcome. They performed in particular well in terms of forecasting the direction of inflation developments two or three quarters ahead. In terms of quantitative forecasts, the headline ALICE performed better than the RW model and on average similarly to the EZB, while the (B)MPE tended to be somewhat more accurate. Looking at calendar years, the headline ALICE outperformed the (B)MPE in about half of the cases. In addition, the Diebold-Mariano test indicates that the forecast accuracy does not differ significantly across the considered forecasts for headline inflation. Only for core inflation, where the RW model is found to have performed better, the differences were also statistically significant.

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 provide complementary information to other models to help 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

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

Notes: This table summarises the results from the general-to-specific approach to select leading series for the headline ALICE. The groups of series are defined based on the starting point of the included individual time series which does, however, not for all individual series exactly match the starting point defined for the groups. For each group of series, the correlation coefficients in absolute size and the lead times are reported for periods starting in 1960, 1970, 1980, 1990 and 1999. The lead time refers to the empirical lead/lag relationship of the indicators and does not account for publication lags. The cyclical components of the series are estimated separately for each of the considered sample periods to obtain the correlation and lead times. C1, C2, and C3 refer to a correlation between the leading series and the reference cycle of at least 0.55 since 1999, a stable lead time of at least 3 months, and diversity of the selected indicators based on broadness in economic terms which then also implies a higher correlation between the CLI and the reference cycle, 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. The selected series are denoted in bold.

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

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

Notes: This table summarises the results from the general-to-specific approach to select leading series for the core ALICE. The groups of series are defined based on the starting point of the included individual time series which does, however, not for all individual series exactly match the starting point defined for the groups. For each group of series, the correlation coefficients in absolute size and the lead times are reported for periods starting in 1960, 1970, 1980, 1990 and 1999. The lead time refers to the empirical lead/lag relationship of the indicators and does not account for publication lags. The cyclical components of the series are estimated separately for each of the considered sample periods to obtain the correlation and lead times. C1, C2, and C3 refer to a correlation between the leading series and the reference cycle of at least 0.55 since 1999, a stable lead time of at least 3 months, and diversity of the selected indicators based on broadness in economic terms which then also implies a higher correlation between the CLI and the reference cycle, 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. The selected series are denoted in bold.

Table A3. Robustness analysis: Selection of leading series for headline and core ALICE based on sample period up to 2009

	Single leading series	Composite leading indicator	
	Lead time in months	Correlation 1999 - 2009	Correlation full sample up to 2009
Headline ALICE			
Group 1960		0.64	0.46
OECD CLI for the euro area	7		
Annual oil price inflation	3		
Group 1970		0.81	0.52
Annual percentage change of M1	30		
Group 1980		0.76	0.60
Annual percentage change of EA building permints	18		
Group 1985		0.75	0.65
Selling price expectations survey for intermediate goods	3		
Group 1990		-	-
-			
Group 1995		0.78	0.78
Annual percentage change of commodity price index (non-food)	20		
Group 1995		0.89	-
Annual inflation in farm gate and wholesale market prices	6		
1 year-forward 1 year-ahead inflation-linked swap rate	3		
Core ALICE			
Group 1960		0.60	0.03
Annual oil price inflation	28		
Group 1970		0.83	0.45
Real GDP	11		
Group 1980		0.95	0.65
Nominal effective exchange rate	17		
Ratio MFI loans outstanding to GDP	11		
Group 1985		0.95	0.83
PPI non-food consumer goods	8		
EC survey selling price expectations for consumer goods	14		
Group 1990		0.94	0.89
ZEW survey on short-term interest rate expectations	27		
Group 1995		0.94	0.92
Annual percentage change of import deflator for services	22		
Group 1999		0.95	-
PMI survey on prices paid for goods in the retail sector	6		

Notes: The starting point of the full sample corresponds to that of the shortest available series included in the composite indicator respectively. The average lead time shown in the table refers to the empirical lead/lag relationship of the indicators and does not account for publication lags.

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