ARTICLES

TOOLS FOR PREPARING SHORT-TERM PROJECTIONS OF EURO AREA INFLATION

Assessing the short-term evolution of inflation entails identifying the driving forces of inflation and interpreting their nature. In particular, it is important to assess whether such forces have only temporary effects on inflation or are likely to be more persistent and thus relevant for monetary policy. Within the Eurosystem, short-term inflation projections form the starting-point for the medium to longer-term inflation projections, making timely use of disaggregated and detailed information that is not always easy to incorporate in more stylised structural macroeconomic models. This article focuses on two short-term forecasting tools used at the ECB: one which models prices in specific sectors separately in terms of their macroeconomic determinants, and another which uses an integrated approach, allowing also for the interactions among different sectoral prices. A comparative analysis of the forecasts produced using the different models supports the cross-checking of the outcomes of different tools when assessing the short-term outlook for inflation.

1 INTRODUCTION

The objective of monetary policy in the Eurosystem is to preserve price stability in the medium term. Owing to the lags with which monetary policy operates, it is important to assess and interpret the nature of the forces driving inflation in a timely manner. For this reason, short-term inflation projections (which for the purposes of this article cover horizons up to one year ahead) provide an important input into the monetary policy decision-making process. Assessing the short-term evolution of inflation entails identifying the driving forces of inflation and interpreting their nature. In particular, it is important to assess whether such forces have only temporary effects on inflation or are likely to be more persistent (for example, whether an increase in oil prices is likely to trigger persistent inflationary pressures by not only affecting energy consumer prices, but also other consumer prices and nominal wages, indirectly).

The short-term assessment of inflation draws heavily on a considerable degree of expert judgement on the detailed components of inflation. However, in order to guarantee consistency in the evaluation of the relationship between inflation and its determinants, such judgement should be supported by a modelling framework.[1] At the ECB, several tools have been developed for the short-term forecasting of inflation. Such tools have been designed with two aims in mind. First, they should make it possible to take into account the maximum amount of available information on inflation at any given point in time. This may include information about recent and expected developments in the main determinants of inflation, potentially drawing on other projections for these variables or on market expectations, and announced government policy measures (for instance on indirect taxes). Second, they should provide a good interpretation of short-term inflation fluctuations, including the evolution of individual HICP components (i.e. unprocessed food, processed food, non-energy industrial goods, energy and services). For example, the recent fluctuations in oil and food commodity prices should be evident at least in the developments in energy and food HICP inflation respectively.

This article describes some of the short-term inflation forecasting tools that are used at the ECB. The first section reviews the role of such tools, examining in particular how they support the analysis of inflation developments prepared by ECB staff in the context of the Eurosystem/ECB staff projection exercises. The following section describes two forecasting approaches, one of which has recently been developed. The

1 For more details on the role of models and judgement in institutional forecasts, see the article entitled "Short-term forecasts of economic activity in the euro area" in the April 2008 issue of the Monthly Bulletin and B. Fischer, M. Lenza, H. Pill and L. Reichlin, "Monetary analysis and monetary policy in the euro area 1999-2006", Journal of International Money and Finance, 2009.

use of these tools in practice is then illustrated, in order to highlight the challenges encountered in short-term inflation forecasting and the signals that can be extracted using different modelling approaches.

2 THE ROLE OF SHORT-TERM FORECASTING TOOLS IN THE PROJECTION EXERCISES

In order to capture price dynamics, a large set of determinants and interactions across variables should be taken into account. The main advantage of short-term inflation tools is that they enable the timely use of disaggregated and detailed information on inflation that is not always easy to incorporate into the large and more stylised structural macroeconomic models (e.g. information relating to indirect taxes or administered prices). Such large-scale macroeconomic models are typically used as "workhorse" models when constructing medium-term projections, in the sense that they can incorporate information, judgement and projections from other tools.[2]

The Eurosystem staff macroeconomic projections are produced jointly by experts from the ECB and from the euro area NCBs on a biannual basis in June and December of each year.[3] The ECB staff macroeconomic projections, which are produced in March and September, complement these Eurosystem exercises and use similar techniques. Short-term inflation forecasting tools are used to help frame the short-term inflation outlook within these projection exercises. To this end, the tools are generally used in order to prepare conditional forecasts, i.e. projections of inflation that are based on historical data and are conditioned on an assumed future path of a set of inflation determinants. Such conditioning variables include, for example, fiscal variables whose path is partly known in advance owing to the implementation lags of fiscal policy and assumptions regarding oil prices and exchange rates.

"Base effects" typically play an important role in explaining the short-term inflation outlook in terms of annual rates of change. Base effects occur when variations in the annual growth rate of an economic indicator depend on some atypical influence that affected movements in the indicator 12 months earlier, rather than being caused by more recent developments. Over the past two years base effects related to energy and food prices have accounted for much of the sharp fluctuations in projected and realised annual HICP inflation.[4]

The short-term forecasting approaches, which have been developed within the ECB, are also often used for scenario and simulation exercises, as well as for mechanical updates of projections in the intervals between the quarterly projection rounds. This "mechanical" use of the tools means that no expert judgement is used to adjust the purely model-based outcome. However, the projection exercises often also include specific expert judgements to capture elements which cannot easily be introduced in an econometric model.

3 TWO DIFFERENT APPROACHES AT THE ECB

Short-term inflation forecasting tools need to take into account a potentially very large set of determinants and interactions in order to capture price dynamics. Consequently, a modelling and estimation problem arises related to the difficulty in identifying the interlinkages among all relevant economic variables. In essence, there is a need to reduce the number of parameters to be estimated, given that the euro area was only established in 1999 and harmonised statistics often exist only for a relatively short sample.

The Eurosystem has at its disposal a wide range of time-series techniques for analysing inflation and is certainly not limited to the approaches that are described in this article. For illustrative

2 See G. Fagan and J. Morgan (eds.), "Econometric models of the euro area central banks", Edward Elgar Publishing, 2005.
3 For more details on the projection process, see "A guide to Eurosystem staff macroeconomic projection exercises", ECB, June 2001.
4 For more details, see the box entitled "Base effects and their impact on HICP inflation in 2010" in the January 2010 issue of the Monthly Bulletin.

purposes and the sake of brevity, this section focuses on just two approaches developed at the ECB which tackle the issue of limiting estimation uncertainty in quite distinct ways. The first uses an individual equation framework and has until now been the main short-term inflation forecasting tool employed by the ECB. The second, a Bayesian Vector Autoregression (BVAR) model, has been developed more recently and suggests potentially promising new avenues for capturing a wider range of economic interactions and their impact on the short-term HICP inflation outlook.

3.1 MODELLING THE MAIN SECTORAL COMPONENTS OF THE HICP

Inflation forecasting can be approached by modelling each HICP component separately, a method which implicitly assumes that there is no interaction between components. One rationale for such an approach is that standard methods, which model all components simultaneously, were not previously found to improve the forecast of aggregate inflation for the euro area.[5] Six equations have been developed by ECB staff,[6] one for each of the main HICP components (unprocessed food, processed food, energy, non-energy industrial goods and services) and one for the consumer goods Producer Price Index (PPI); the latter is then used as an input for the equations for the main HICP components. All equations are specified in terms of the seasonally adjusted month-on-month rates of increase of the variables.[7] The size of the equations is kept manageable by including only a few variables (four at most) which are drawn from three broad groups. The first group consists of assumptions regarding the external environment, including oil and non-oil commodity prices (including food), for which futures prices are used over the forecast horizon, and the exchange rates (both the EUR/USD exchange rate and the effective exchange rate of the euro), which are assumed to be constant over the forecast horizon. The second group entails further conditioning variables provided by available information on fiscal measures, such as VAT changes. Finally, wages, unit labour costs and GDP are assumed to evolve according to the latest macroeconomic projections.

These equations are used regularly to update earlier inflation projections, but also to serve as a starting-point for discussion at the beginning of every quarterly projection exercise. The advantage of these equations is that they provide a simple way of interpreting inflation fluctuations, making it possible to forecast inflation conditional on the specific future paths of the determinants listed above and permitting a focus on the heterogeneity of the HICP sub-components. They also allow for the inclusion of judgement and other information. However, the inherent lack of interaction between determinants and particularly among HICP components may limit the ability of the model to capture the pass-through mechanism of certain prices to others and to overall inflation. In particular, independence across components implies limited "indirect effects" associated with commodity price changes, while the exogeneity of assumptions on wages and unit labour costs limits the ability of the tool to capture "second-round effects".[8] Such effects can be introduced ad hoc, through the inclusion of expert judgement. However, the extent to which their impact persists beyond the very short-term evolution of inflation would be difficult to gauge without a relevant model structure. In addition, the reliance on a set of exogenous assumptions implies that the model can only forecast inflation

5 For an evaluation of the accuracy of methods of forecast aggregation, see K. Hubrich, "Forecasting euro area inflation: does aggregating forecasts by HICP component improve forecast accuracy?", *International Journal of Forecasting*, vol. 21(1), 2005.

6 For more details on the individual equations, see N. Benalal, J.L. Diaz del Hoyo, B. Landau, M. Roma and F. Skudelny, "To aggregate or not to aggregate? Euro area inflation forecasting", ECB Working Paper No 374, 2004. The approach described in this article and in the box is based on an update of the approaches developed in this paper.

7 The HICP data used are seasonally adjusted to account for regular volatility in the series occurring around the same period within a year and to a comparable extent. See also the box entitled "Seasonal patterns and volatility in the euro area HICP" in the June 2004 issue of the Monthly Bulletin.

8 For a discussion of the effects of oil prices on inflation, see the article entitled "Oil prices and the euro area economy" in the November 2004 issue of the Monthly Bulletin.

when an assumed path for the full set of these variables is available.

These considerations have led to efforts to enhance the short-term forecasting toolbox. Some alternative modelling techniques are described in the next sub-section, while the box below describes how recent fluctuations in food commodity prices and the related effects on components of the HICP have pointed to areas for further improvement within the framework of individual equations.

Box

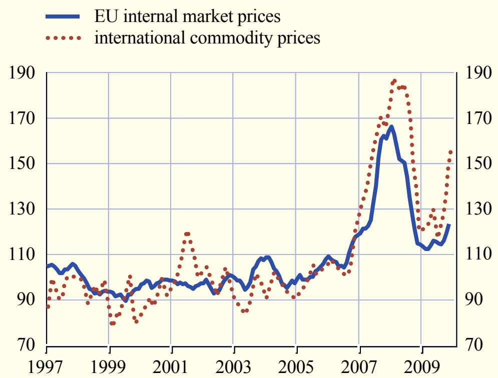
MODELLING THE PASS-THROUGH OF THE RECENT FOOD COMMODITY PRICE SHOCKS

Modelling the transmission from food commodity prices to HICP inflation in the euro area is not straightforward. For example, an index of international food commodity prices derived from the Hamburg Institute of International Economics (HWWI) dataset, which is widely used in empirical analyses of commodity price developments, has been significantly more volatile than HICP food prices. A key feature of the HWWI index is that it only includes prices quoted in global markets. However, for a number of food commodities produced directly in the EU (such as meat, milk and cereals), prices in international markets have historically been somewhat lower and significantly more volatile than those prevailing in the EU. To a large extent, the difference reflects the existence of the EU's Common Agricultural Policy (CAP), which tends to cushion the transmission of global shocks to EU internal prices through its mechanisms of intervention prices, price support, import tariffs and quotas. The existence of the CAP may be an important reason why, in the past, international food commodity prices appeared not to be closely related to food prices at the retail level in the euro area.[1] To control for this factor, it is possible to construct and use a food commodity index that combines prices quoted in international markets for those commodities that are not subject to CAP intervention prices (e.g. cocoa, coffee) and EU internal market prices for commodities that are produced in the EU (e.g. wheat, milk). The latter data can be drawn from a dataset collected by the Directorate General Agriculture of the European Commission.

The chart compares this combined index with an index based on international commodity prices. It shows that while international commodity prices have historically been significantly more volatile than EU internal market prices, the two indicators have been more closely correlated during the past two to three years, a period in which there was initially a surge and then a downward correction in global commodity prices. This observation is consistent with the idea that the CAP provides a price stabilisation mechanism to cushion against price changes whenever prices tend to

Food commodity indices

(index: 2005 = 100)



Sources: European Commission, HWWI and ECB calculations.

1 See the reference in footnote 6.

fall below the threshold intervention prices that are embedded in the CAP. Analysis conducted using the two indices suggests that the transmission of shocks in international commodity prices to consumer prices in the euro area is dampened by the presence of the CAP. The CAP plays an important role in determining the size of the pass-through from food commodities to consumer prices and controlling for it is very important for forecasting purposes.

Overall, the recent volatility in HICP food prices had been difficult to explain on the basis of the previously existing tools for short-term inflation forecasting – even when the unanticipated changes in the conditioning assumptions for food commodities were accounted for. This was because the sensitivity of overall HICP food prices to changes in international food commodity prices, such as those contained in the HWWI index, is limited in these models. However, once the intervention prices of the CAP are included in the picture, a simple model of pass-through is able to explain most of the changes in HICP food prices in recent years.

3.2 A MORE INTEGRATED APPROACH TO MODELLING HICP COMPONENTS

An alternative approach to modelling short-term inflation developments, which tackles the difficulty of identifying the interlinkages between all relevant economic variables in a different way, has recently been developed and is currently being tested in real time. The general aim of this approach is to model the components and determinants of inflation described above in an integrated manner, such that the need for expert judgement in order to capture interactions across variables is reduced. This has been done in particular using a large BVAR which models the interaction between variables in a largely unrestricted way.[9] Although BVAR models have been used for forecasting purposes for some time, they tended to be estimated only for a small number of variables in order to avoid the proliferation of parameters to estimate. It is only recently that such techniques have been shown to be capable of handling large datasets.[10]

The novelty of the approach described in this sub-section compared to the individual equations is that, while the BVAR approach uses the same set of variables as the individual equations-based model described above, it takes account of a wider range of interactions across the sub-components and determinants of HICP inflation.[11] The BVAR can also provide a statistical distribution for the projections, making it easier to assess the uncertainty surrounding them. As well as allowing for interactions across variables and components, as discussed in the following sections, the BVAR model can be used to compute projections, i.e. forecasts conditional on particular assumptions regarding the future path of specific variables in the model. Alternatively, the tool can be used to generate its own forecasts for these variables and hence provide "unconditional" forecasts of inflation.

4 USING INFLATION TOOLS IN PRACTICE

In order to show how the tools described in Section 3 can be used in practice, two illustrative and purely mechanical exercises are reported. It should be noted that, unlike the ECB and Eurosystem staff projections, these illustrations exclude any expert judgement.

9 For more details, see D. Giannone, M. Lenza, D. Momferatou and L. Onorante "Short-term inflation forecasting: A Bayesian VAR approach", CEPR Discussion Paper No 7746, March 2010.

10 T. Doan, R. Litterman and C. Sims, "Forecasting and conditional projection using realistic prior distribution", *Econometric Reviews*, vol. 3, 1984 is the first application of Bayesian techniques in the context of VAR estimation, while M. Bańbura, D. Giannone and L. Reichlin, "Large Bayesian VARs", *Journal of Applied Econometrics*, vol. 25(1), shows how Bayesian techniques may be used in order to handle large datasets.

11 Under such a framework, Bayesian techniques are used to limit estimation error by combining a "naive" prior model that does not require estimation with the more complex model allowing for the full set of interactions between inflation and its determinants. The naive model is assumed to be the random walk model with drift, which excludes rich dynamics and cross-correlation among variables since each variable at any given point in time depends only on a constant, its own first lag with a coefficient equal to one and a stochastic disturbance.

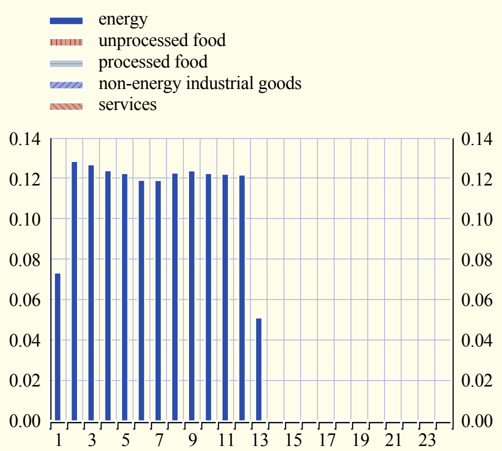
A first exercise shows how an increase in oil prices feeds through to the HICP components. This exercise shows the mechanisms through which shocks are propagated in the different models and highlights how, and to what extent, different tools capture the consequences of specific shocks in the short term, but also potentially further ahead, thus providing an outlook for the evolution of inflation towards the medium term. Chart 1 reports the results for the individual equations, while Chart 2 shows the outcome using the BVAR. The charts report the effects of a one-off 10% increase in oil prices on the annual inflation rates (vertical axis) up to 24 months ahead (horizontal axis). A horizon of 24 months, which is longer than the definition of a short-term horizon used in this article, is considered to show the ability of different modelling frameworks to capture persistent effects of economic shocks and hence gauge their relevance for monetary policy. For each month, the effect on overall HICP inflation is broken down into the weighted [12] contributions from the five components.[13]

In both models, it can be seen that, on impact, overall HICP inflation increases by slightly less than 0.1 percentage point, which is fully accounted for by the contribution of energy prices. However, the subsequent propagation of the increase in oil prices clearly differs across the two modelling approaches. In the simulations based on the individual equations, the impact on annual inflation comes only via energy prices, it reaches its peak after one month and disappears after slightly more than a year owing to base effects. In the BVAR model, the direct impact of the oil price increase through energy prices is very much in line with that in the individual equations, largely fading away by the 13th month ahead. However, the more complex pass-through mechanism allowed for in the BVAR can be seen in the responsiveness of the non-energy industrial goods and services components. These contributions increase along the horizon as the oil price shock feeds through, as a result of the higher energy costs implied (indirect effects) and the impact of higher wages caused by the initial increase in HICP inflation (second-round effects). By the end of the projection horizon, the impact from energy prices has vanished, but the contribution

12 They are weighted according to the consumer spending weights of the five sub-components of the overall HICP.
13 The impact of a change in oil prices is analysed here only in the context of the models described in this article. A much wider set of tools is used within the Eurosystem in order to analyse the impact of oil prices on activity and consumer price inflation.

Chart 1 Individual equations – effects of a 10% increase in oil prices on HICP inflation

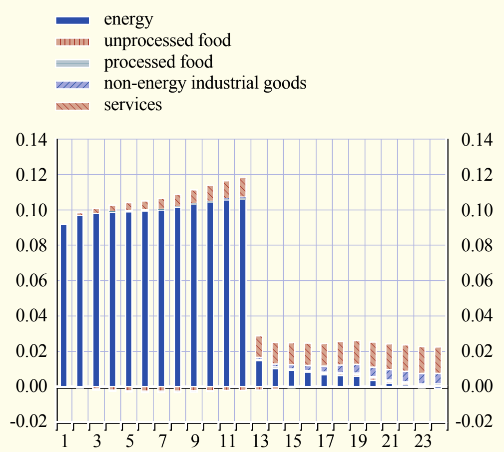
(percentage point contributions to HICP annual growth rate)



Source: ECB.

Chart 2 BVAR – effects of a 10% increase in oil prices on HICP inflation

(percentage point contributions to HICP annual growth rate)



Source: ECB.

from non-energy industrial goods and services persists at around 0.02 percentage point.[14]

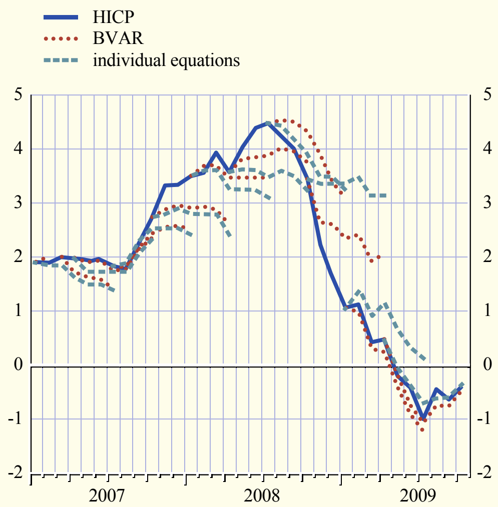
In terms of the direct impact of oil price shocks, this BVAR approach is largely consistent with the results of other models used both inside and outside the Eurosystem.[15] It should be noted, however, that the additional impact from indirect and second-round effects may be somewhat greater within larger, structural models better equipped to capture medium to longer-term dynamics.[16] Nevertheless, the purpose of this illustration is to show how the BVAR model can capture the interactions between different price components. To sum up, the BVAR differs from the individual equation approach because, as well as capturing the transmission of the oil price shock through the direct effect on energy prices, it also accounts for the indirect and second-round effects reflected in other components of the HICP and wage growth. This example illustrates that enhancing the inflation toolbox may help to better interpret the dynamics of nominal variables.

The second exercise illustrates how the different models can be employed to analyse recent economic developments. It should again be noted that the projections produced in the context of this exercise provide an illustrative example and do not correspond to any particular ECB or Eurosystem staff projections. First, Chart 3 compares the purely mechanical forecasts from the individual equations and those from the BVAR, conditional on the standard set of macroeconomic assumptions, which are listed in detail in Section 3.1 and refer to a broad set of macroeconomic variables.[17] It reports the actual annual rate of HICP inflation from January 2007 to October 2009 (blue solid line), together with the corresponding individual equation forecasts (petrol blue dashed line) and the conditional BVAR forecasts (red dotted line). In each case, forecasts from one to six months ahead are reported, and these are based on the information that would have been available at the starting-point of each forecast.

Annual euro area HICP inflation over the past two years has moved in a range between -0.7% and 4%, and has therefore displayed considerably

Chart 3 HICP real-time conditional BVAR and individual equation forecasts

(annual percentage changes)



Sources: Eurostat and ECB.

more variability than in previous years since the start of EMU. A first observation is that neither model accurately predicted the upturn in inflation in 2007 or the downturn in 2008. This suggests that turning-points in inflation pose a challenge to forecasters, as the accuracy of all models worsens around such points.[18] Moreover, while the forecasts are fairly similar in 2007, the BVAR forecasts are closer on

14 Some slight negative contribution from unprocessed food can also be discerned in Chart 2, but it is negligible and of no economic importance, as unprocessed food prices are found to be essentially neutral to oil price changes in the context of the BVAR.
15 See the reference in footnote 8.
16 See the reference in footnote 2. In addition, there may be non-linearities in the relationship between oil prices and inflation, which could lead to an amplification of the impact of oil prices on consumer prices when the level of oil prices is higher than a certain threshold.
17 For the purpose of this exercise, the assumed future paths for wages and unit labour cost are derived by using the BVAR.
18 The turning-point in mid-2009 seems to be an exception since it was captured in a timely manner by all models. However, developments around this turning-point were particularly driven by base effects owing to the strong decline in oil prices in the course of the second half of 2008 dropping out of the annual rates of HICP inflation. Such base effects are mechanically captured by all of the models described here. Indeed, this turning-point was accurately predicted well in advance, precisely on the basis of such base effects (see the article entitled "Accounting for recent and prospective movements in HICP inflation: the role of base effects" in the December 2008 issue of the Monthly Bulletin).

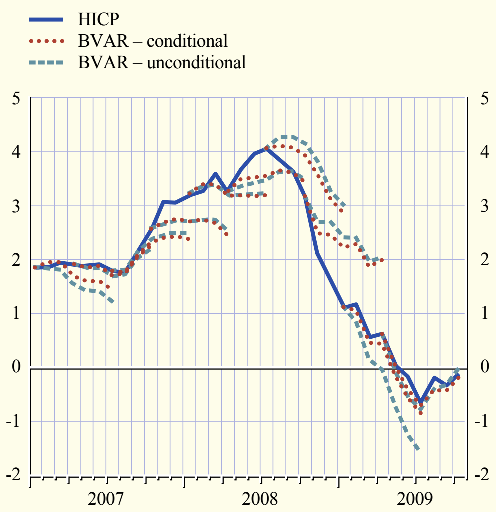
average to the observed inflation rate in 2008 and 2009. This may suggest that it is important to take into account interaction across the determinants and sub-components of the HICP. However, the individual equations occasionally seem to provide more accurate inflation projections. As mentioned above, this suggests the usefulness of cross-checking different tools when assessing the short-term outlook for inflation.

All the forecasts in Chart 3 are projections, i.e. forecasts conditional on a standard set of macroeconomic assumptions. Another option, however, is to produce unconditional forecasts, which do not assume any particular future development of specific variables. One of the reasons for producing projections rather than unconditional forecasts is that forecasters can exploit valuable information which is available about the future (for example, when fiscal packages have been approved but not yet implemented, as in the case of the increase in German VAT in 2007).

In order to illustrate this point, Chart 4 compares two different sets of forecasts: the unconditional forecasts from the BVAR (petrol blue dashed line), free of any conditioning assumptions; and the conditional forecasts from the BVAR (red dotted line), which account for the future evolution of all the variables included in the standard set of macroeconomic assumptions.[19]

Chart 4 HICP and real-time unconditional and conditional BVAR forecasts

(annual percentage changes)



Sources: Eurostat and ECB.

The results in Chart 4 suggest that the performance of the unconditional and conditional forecasts is, in most cases, very close. However, conditioning at times appears to produce forecasts which are closer to the actual outcomes, suggesting some added value embedded in the conditioning assumptions.[20] Ultimately, the benefits of conditioning in terms of the accuracy of the short-term inflation forecasts will depend on whether the conditioning variables themselves can be more accurately forecast outside the model in question. If this is the case, then relying on assumptions developed outside the model will tend to enhance the accuracy of the inflation projections.

5 CONCLUSION

Short-term forecasting models provide a framework which allows a timely assessment of the evolution of inflation in the near future. Such tools serve to disentangle the effects of temporary and permanent sources of fluctuations in inflation in the short term and can thus provide indications of the likely evolution of inflation in the medium term. For this reason, the development of such tools can make a significant contribution to the analysis supporting the conduct of a medium-term stability-oriented monetary policy. While factors such as base effects, which can at times play a major role in shaping annual inflation rates, are relatively

19 Chart 4 focuses on the BVAR because, in order to produce unconditional forecasts, the model used needs to be able to produce on its own a future path for all the variables in the system. This is not possible for the individual equations, which assume that those inflation determinants are exogenous.

20 In the interests of brevity, the charts focus only on recent experience. For a more formal and thorough analysis supporting the forecasting evaluation of the models described in this article, see the reference in footnote 9.

easy to capture, inflation dynamics can be affected by a broad range of determinants and interactions. The Eurosystem/ECB staff inflation projections are the product of a wide variety of tools, which provide a framework that ensures the consistency of the evolution of projected inflation and its determinants and incorporate expert judgement, making it possible to capture information, mechanisms and features that the intrinsic limitations of models cannot account for. This article has surveyed two such tools developed at the ECB: an individual equation approach already in use, including some specific considerations for the food and energy components, and a large BVAR, which has recently been developed and is currently being tested in real time.

The models presented in this article are to be considered complementary. It would be unwise to rely solely on any one given method or modelling approach; indeed, practical experience supports the simultaneous use of different models and the cross-checking of each one against the others. Against this background, ECB staff continuously review the available techniques for short-term forecasting. Promising additional approaches currently under investigation include the use of factor models and the development of methods that allow the results from different short-term inflation forecasting models to be combined in order to provide a more accurate assessment of the inflation outlook.