Short-Term Inflation Projections:
a Bayesian Vector Autoregressive approach

Domenico Giannone[1,2,3]
Michele Lenza[1,2]
Daphne Momferatou[1]
Luca Onorante[1,4]

[1]European Central Bank
[2]Universite' Libre de Bruxelles
[3]Universitá LUISS, Roma
[4]Central Bank of Ireland

16th Annual Inflation Targeting Seminar
Banco Central do Brasil
Rio de Janeiro, May 2014

The views expressed in this paper are those of the authors and do not necessarily reflect those of the ECB or the Eurosystem

Forecasting Inflation in the Eurosystem (see also Monthly Bulletin article April 2010)

Quarterly Eurosystem/ECB projections (published on the ECB monthly bulletin)

Eurosystem staff macroeconomic projections produced jointly by experts from the ECB and from the euro area NCBs on a biannual basis (June and December). ECB staff complements these exercises in the intervening quarters

Short-term inflation forecasting tools

- Starting-point for the medium to longer-term inflation projections, interpretation of the nature of the forces driving inflation
- Timely use of disaggregated and detailed information not always easy to incorporate in stylised structural macroeconomic models
- Update projections between the quarterly staff projections to incorporate incoming disaggregated and detailed (monthly) information on price developments

Releases of the Harmonized Index of Consumer Prices (HICP):

Few days after the end of the month: Flash estimate for the overall index
Third week of the next month: final release for overall HICP and Components

Features of short term inflation projections: a conditional forecasting exercise

Predict a near future path (up to 14/15 months) for the **HICP and components** based on a set of **conditioning assumptions**

Conditioning assumptions ensure compatibility with other projection exercises

HICP components (target)

- Unprocessed Food
- Processed Food
- Non Energy Industrial Goods
- Energy
- Services

Inflation determinants (conditioning assumptions)

Macro: Unit Labor Cost, Gross Domestic Product, Compensation per Employee

External: Oil price, Food commodity prices, Commodity prices ex food, EUR/USD exchange rate and Nominal effective exchange rate

Features of short term inflation projections: a conditional forecasting exercise

1) Several components of inflation
2) Several determinants
3) Potentially complex dynamic interrelationships

Complex estimation problem: the general unrestricted model requires too many parameters to estimate

Solution so far: impose exact exclusion restrictions!

Individual equations and exogenous assumptions

Regressors	Unprocessed food	Processed food	Non-energy ind. goods	Energy	Services	PPI Cons. goods
Lags	1 to 12	1 to 2	5 to 6		1 to 5	1 to 4
Oil price				0 to 1		
Non-Oil Comm. Prices						6
Food Comm. Price		9				
USD/Euro				0 to 1		
Effective exchange rate			1			4
Real GDP			0			1
Unit Labor Costs		5				
Wages					3,9	
Taxes		Tobacco	VAT	Energy		
PPI Consumer Goods				5	5,7	

Predictors (and lags) are selected by optimizing the forecast accuracy over pre sample 99-04 (Benalal, Diaz del Hoyo, Landau, Roma and Skudelny, 2004)

Individual equations and exogenous assumptions

Simple approach implies:

- Restricted lag dynamics
- No “indirect effects” (e.g Energy prices affect HICP only because they are a component of the total index and do not pass-through to other components)
- No “second-round effects” (e.g. higher wages affect some components but no feed-back from prices to wages)

Impairment in the ability of the model to interpret inflation dynamics. We do not need to do that!!

Our approach

System approach (Vector Autoregression) to allow for all possible dynamic interactions between between HICP components and their determinants e.g: direct, indirect, second-round effects

Suitable for

I. Conditional and unconditional forecasting

II. Computing measures of uncertainty surrounding forecasts

III. Risk assessment via scenario analysis

Remark: Rich model reduces the need for the inclusion of judgement

The Model: Vector Autoregression (VAR)

X(i,t): price components and their determinants

$$\mathbf{X}(i,t) = \mathbf{X}(i,t|t-1) + E(i,t)$$

$$\mathbf{X}(i,t|t-1) = \text{Proj}\{ \mathbf{X}(i,t) \mid \mathbf{X}(j,t-s),\ j=1,\ldots n,\ s=1,2,\ldots,p\}$$

This is the most general forecasting model which allows for all possible (linear) interactions

Our approach: keep complexity/interaction by imposing inexact restrictions

- mixed estimation: combine complex data structure with naïve/parsimonious (prior) model

Our estimation approach: BVAR

Mixed estimation: combine complex data structure with naïve/parsimonius model

- Naïve (prior) Model: $\mathbf{X}(i,t|t-1) = c + \mathbf{X}(i,t-1)$
- The unrestricted model: VAR(13)
- We must select the weight to give to the Naïve model (tightness of the Minnesota and sum-of-coefficients prior)
- Stable and reliable estimation of complex and large model if data co-move
  - See Banbura, Giannone and Reichlin (2010); De Mol, Giannone and Reichlin (2008).
- The entire posterior distribution of the conditional forecasts is obtained by using Kalman Filtering techniques (simulation smoother).
  - See Banbura, Giannone and Lenza, 2014.
- Prior Selection
  - Giannone, Lenza and Primiceri (2012): hierarchical approach, takes into account uncertainty surrounding prior selection

A closer look at the data

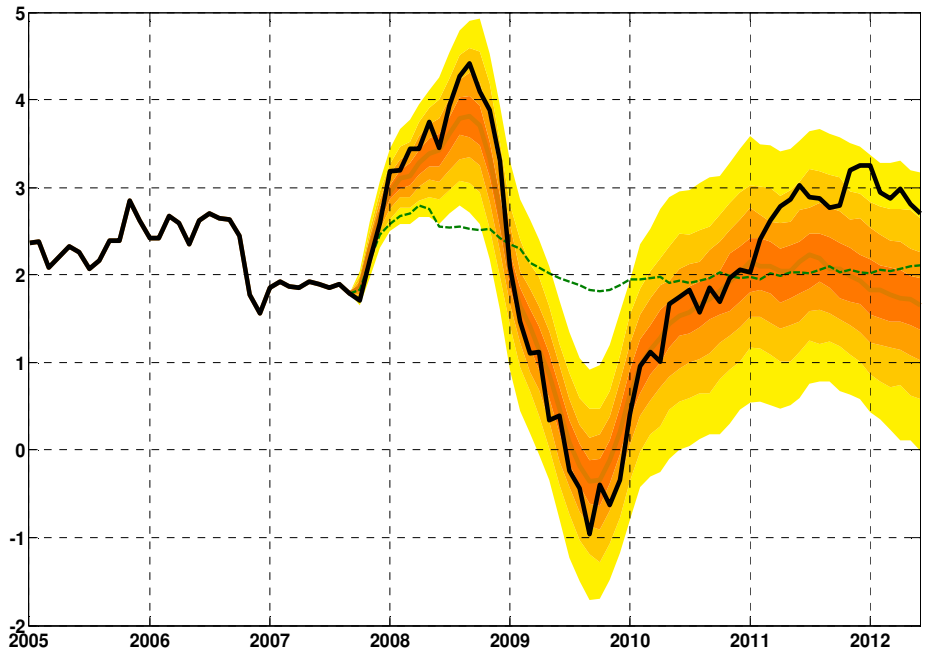
Our monthly-frequency dataset is based on the single equation dataset and thus includes 14 variables:

- HICP by component (5 variables)
- PPI Consumer goods
- ULC, GDP, CPE (interpolated to get monthly frequency)
- Oil in USD, Food commodity prices, Commodity prices ex food, EUR/USD exchange rate and Nominal effective exchange rate (standard external assumptions in the quarterly projections)

Our sample range is from January 1992 to June 2012

Real-time approach, with 41 vintages of data available for the corresponding quarterly projection exercises from the March 2002 MPE to the June 2012 BMPE.

Transmission mechanisms: Phillips correlations



Note: The figure shows the distribution of the annual HICP inflation forecasts (sampled monthly) conditional to observed real GDP in the sample August 2007 to June 2012. The green dashed line represents the unconditional BVAR HICP inflation forecasts. The black solid line represents observed inflation in the sample January 2005 – June 2012. Figures on the vertical axes are expressed in percentage points.

- Considering information on the economic cycle in the post-August 2007 period determines a major improvement in tracking inflation

- The euro area economy presents a relevant inflation-output relationship, in contrast with the evidence that the Phillips curve relation has almost disappeared

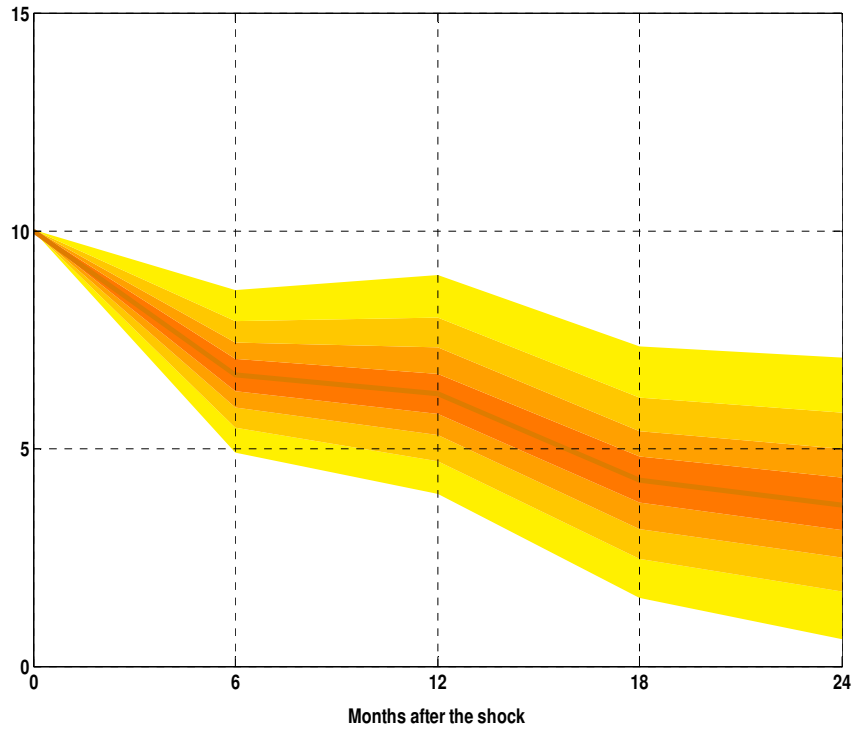
Transmission mechanisms: Oil shock

The exercise:

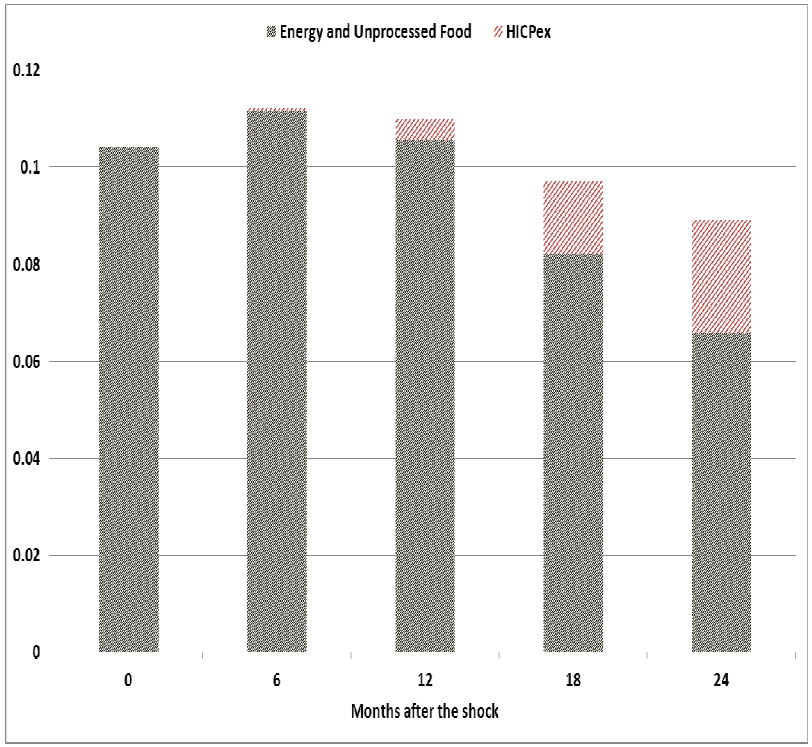
- Exogenous increase of oil price by 10% at time t from the baseline (unconditional) forecast. The dynamics for the subsequent months are left unrestricted
- Assess the effects over the two subsequent years on HICP and its components
- Identification (recursive scheme)
  - No restriction on the effect on energy prices and exchange rates (potentially fast variables)
  - At time t prices, wages and real variables are not allowed to react (slow variables).
    - The dynamics for the subsequent months are left unrestricted

Transmission mechanisms: Oil shock

IRF of the oil price



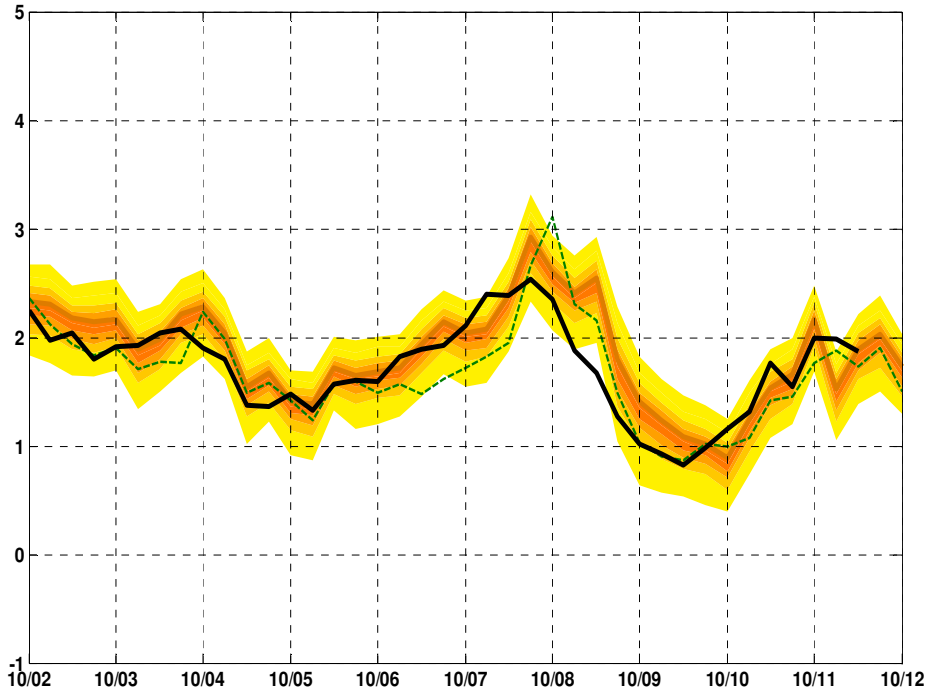
IRF of HICP (and components)



•Almost immediate direct impact in HICP energy, stabilising after about a year. Gradually intensifying pass-through to NEIG and services - HICPex (indirect/second-round effects)

Note: The figures show the distribution of the impulse response function (IRF) of the oil price (left panel, distribution) and the log-level of HICP (right panel, median) to a shock amounting to a 10% increase of the oil price. On the vertical axis, figures are expressed on percentage points.

Model evaluation: 6-month ahead forecasts
HICP excluding energy and unprocessed food

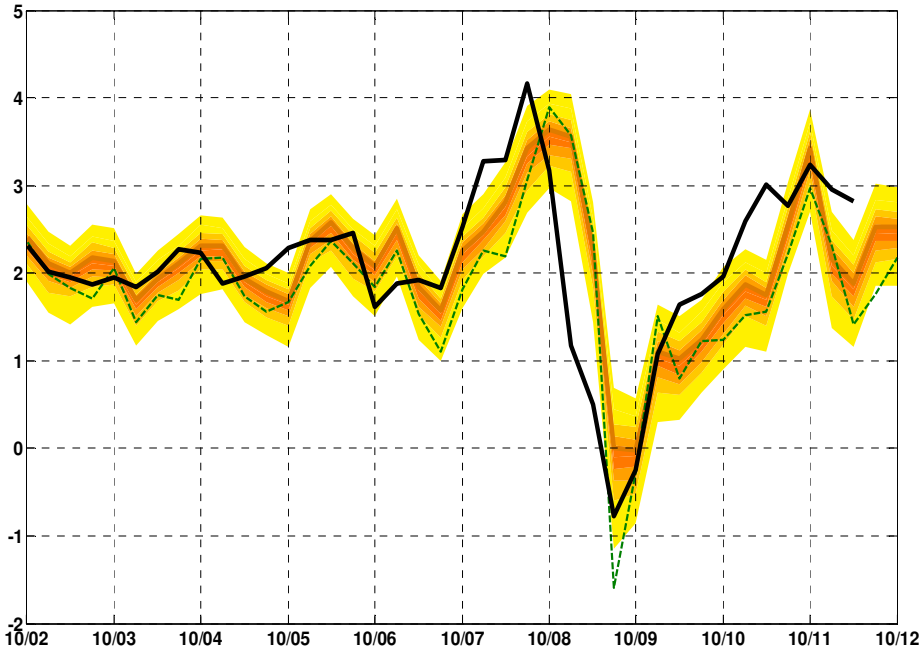


Note: The figure shows the distribution (trimming the upper and lower 2.5% quantiles) of the six months ahead conditional BVAR forecasts produced in 41 quarterly exercises carried out from 2002Q1 to 2012Q2. The forecasts are produced for the period October 2002 to October 2012 (as reflected in the horizontal axis) and relate to the annual change in HICP excluding energy and unprocessed food prices. The black solid line represents observed inflation in the available sample (ending in June 2012), while the dashed green line is the median of the distribution of the unconditional BVAR forecasts. Figures on the vertical axes are expressed in percentage points.

- Forecast pretty accurate.
- The decline in inflation that has accompanied the global recession has been a surprise for the model, after few months the model adapted.

Remark: we do not take into account the uncertainty around the conditioning assumptions, treated as if they were data. Moreover, we do not allow for stochastic volatility (Clark, 2010)

Model evaluation: 6-month ahead forecasts
HICP excluding energy and unprocessed food



Note: The figure shows the distribution (trimming the upper and lower 2.5% quantiles) of the six months ahead conditional BVAR forecasts produced in 41 quarterly exercises carried out from 2002Q1 to 2012Q2. The forecasts are produced for the period October 2002 to October 2012 (as reflected in the horizontal axis) and relate to the annual change in HICP. The black solid line represents observed inflation in the available sample (ending in June 2012), while the dashed green line is the median of the distribution of the unconditional BVAR forecasts. Figures on the vertical axes are expressed in percentage points.

- Forecast less accurate than previous for HICPex.
- The decline in inflation that has accompanied the global recession has been a big surprise for the model.

Remark: we do not take into account the uncertainty around the conditioning assumptions, treated as if they were data. Moreover, we do not allow for stochastic volatility (Clark, 2010)

Model evaluation: MSFEs

Models	3m ahead		6m ahead		9m ahead		12m ahead	
	HICPex	HICP	HICPex	HICP	HICPex	HICP	HICPex	HICP
Random Walk	0.56	2.96	0.40	1.78	0.37	1.24	0.36	0.94
Unconditional BVAR	0.56	4.63	0.29	2.56	0.34	2.14	0.40	1.92
Conditional BVAR	0.49	2.23	0.32	1.77	0.33	1.53	0.34	1.34

- The VAR forecasts generally outperform the RW model for HICPex.

- Conditioning on future information helps to forecast, particularly HICP (for which we need conditional information to outperform the RW at short horizons)

Summary and conclusions

- A general and flexible model for short term inflation projections, allowing for all possible interactions between HICP components and determinants (e.g. direct, indirect, second-round effects)

  Interactions matter and improve forecast performance

- We assess the role of some of the conditioning variables typically used in the Eurosystem projection exercises

  Conditioning increases accuracy and supports the presence of a euro area Philips curve

- Finally, we allow for scenario analysis

  Other possible applications include reverse engineering (e.g. finding the path of oil prices to avoid deflation, most likely path of short-term inflation and its determinants that lead to medium-term price stability)