# 8th EABCN Workshop

# "Changes in Inflation Dynamics and Implications for Forecasting"

**Paris, 6-7 September 2007**

## SUMMARY

The Eighth EABCN workshop focused on the characterisation and the consequences of changes in inflation dynamics and, in particular, the impact of such changes for forecasting inflation. The workshop, co-organised by the EABCN, the CEPR and the Banque de France, was held in Paris on 6th and 7th of September. The organisers, **Carlo Favero,** Università Bocconi and CEPR, **Kirstin Hubrich**, European Central Bank and **Jean-Pierre Villetelle**, Banque de France, arranged the programme around five topics: 'Changes in inflation dynamics and monetary regime', 'Inflation expectations and financial markets', 'International transmission of shocks and inflation' and 'Forecasting changing inflation' and 'Forecasting inflation with disaggregate information',. Ten papers were presented and discussed. The workshop finished with a panel discussion.

The Paris workshop received a very large number of submissions, with many interesting papers unfortunately declined. There were also a significant number of requests, after the deadline, from people who wished to participate. Most had to be declined due to capacity constraints.

***Session 1: Changes in inflation dynamics and monetary regime***

**Timothy Cogley** (University of California, Davis) presented a paper written together with Thomas Sargent (New York University) which, in the vein of other contributions by these authors provides a body of evidences that inflation-gap persistence has changed in the US since the Great Inflation. Two models were presented; first a time-varying univariate autoregression, that incorporates a stochastic volatility model for the innovation of the state equations (that gives the law of motion of the time varying parameters); second, a multivariate model (VAR) is specified along the same lines but exploits in addition the previous finding of changes in the autocorrelations of the inflation gap together with changes in cross-correlations with lags of other variables. The measure of persistence use relates to the inflation-gap predictability (following Barsky (1987) and Diebold and Kilian (2001)). Both models are estimated by Bayesian Markov Chain Monte Carlo methods. Because of different conditioning variables, the innovation variances differ across models, with inflation volatility following more or less the profile of trend inflation according to the univariate model, whereas it is more stable over the sample according to the VAR. As regards the inflation gap persistence, the estimation technique allows in particular to consider the joint distribution of the autoregressive coefficient across pairs of time periods. Although more clearly for PCE inflation than for GDP inflation, both measures point to a rise in inflation gap persistence between 1960 and 1980 and a

decline thereafter. With the VAR, the results are more clear cut: over short horizons, the inflation gap persistence measure points to a statistically significant increase in inflation-gap predictability during the Great Inflation and also to a statistically significant decline after the Volcker disinflation.

**Hervé Le Bihan** (Banque de France) and **Giorgio Primiceri** (Northwestern Univesrity) discussed this paper. Although the goal of the authors was explicitly to focus on evidences that inflation persistence has changed, not why it has changed, the discussants were curious about the reasons that could have been at the root of such results. A regime shift, and more explicitly a change in the central bank's inflation target could be the explanation.

**Roger Farmer** ( UCL) then presented a paper written with Tao Zha (Federal Reserve Board of Atlanta) and Daniel Waggoner (Federal Reserve Board of Atlanta). The paper considers a New-Keynesian model, hence with forward-looking ingredients in the IS and in the Phillips curves but with, in addition, a policy rule that follows a Markov-switching process. The monetary regime can thus change from an active regime to a passive one. Considering this issue, Davig and Leeper (2005, 2006b) claimed to give a necessary and sufficient condition for uniqueness (and hence also for nonuniqueness) of equilibrium in the Markov-switching New-Keynesian model. With determinacy in the active regime and indeterminacy in the passive one, the logic of their argument implies that if the active regime is persistent enough, cross-regime spillovers may cause the equilibrium to be unique. The economic intuition for this switch to determinacy is that agents in the passive regime take into account the probability that monetary policy will become active. Elaborating on Davig-Leeper, Farmer Waggoner and Zha prove that the Davig-Leeper condition is necessary but not sufficient, and that there are conditions based only on the parameters of a single regime that imply indeterminacy in every regime. Hence, there are no possible values for the parameters of the interest rate and output-gap response coefficients of the Taylor rule in the active regime that can restore determinacy. The authors argue that this result is not simply a theoretical curiosity by showing that a model calibrated to the value estimated by Lubik and Shorfeide (2004) and augmented by a switching monetary rule, gives rise to sunspot solutions.

**Gianni Amisano** (European Central Bank) and **Julien Matheron** (Banque de France) discussed this paper. Some issues were raised regarding the model since, as it relies on some reduced form equations, the cause of a shift in the parameters of the Taylor rule is not clear. In particular, this absence of identification of the reasons of the shift prevents from introducing some learning behaviour in the model, on the side of the private agents. In this respect, the results so far plead in favour of anchoring the private agents' expectations.

***Session 2: Inflation expectations and financial markets***

**Andrew Ang** (Columbia Business School) presented a paper written together with Geert Bekaert (Columbia Business School and CEPR) and Min Wei (Federal Reserve Board). Although it is a common view that the nominal interest rate can virtually be decomposed as the sum of unobservable real interest rate, inflation expectation and inflation risk premium, the literature has yielded few generally accepted stylized facts about their behaviour. The authors seek to fill the gap in this domain and to determine the relative importance of these various components for determining the U.S. nominal term structure. The model used accommodates for regime-switching behaviours that attempt to identify the real and nominal sources of the shift in regimes and also time varying risk premia, crucial for matching time varying bond premia. The results obtained point to: 1/ unconditionally, the term structure of real rates assumes – except in some regimes in which the real rate curve is downward sloping – a fairly flat shape around 1.3%, with a slight hump, peaking at a 1-year maturity; 2/ real rates are quite variable at short maturities but smooth and persistent at long maturities. There is no significant real term spread. 3 / the model matches an unconditional upward-sloping nominal yield curve by generating an inflation risk premium that is increasing in maturity; 4/ the decompositions of nominal yields into real yields and expected inflation at various horizons indicate that variation in expected inflation and inflation risk premiums explain about 80% of the variation in nominal rates at both short and long maturities; 5/ inflation risk is the main determinant of nominal interest rate spreads.

**Mikhail Chernov** (London Business School and CEPR) and **Refet Gurkaynak** (Bilkent University and CEPR) discussed the paper. The model helps to describe the data and, actually, examining the Treasury Inflation Protected Securities (TIPS) fits the conclusions of the model but this one still leaves unexplained the sources of regime shifts. More generally, referring to structural models, although less able to fit the data, would help to interpret the estimated parameters and allow for conducting policy experiments. In another respect, fitting the model to UK data would be interesting, since this country experienced several shifts in regime.

***Session 3: International transmission of shocks and inflation***

**Denise R. Osborn** (University of Manchester) presented a paper written with Erdenebat Bataa (University of Manchester), Marianne Sensier and Dick van Dijk (Erasmus Scholl of Economics, Rotterdam). The authors examine the international links between inflation rates in the G7 countries and the euro area during the period 1960-2006 by analysing causal relationships in mean and volatility. They first identify a set of breaks, taken into account in the models estimated thereafter, individual AR models, VAR models – for Canada, the euro area, UK and US on the one hand, and France, Germany, Italy on the other hand. From the univariate models, inflation persistence exhibits substantial reduction over time in some countries and, for many countries, high inflation volatility occurs alongside high mean inflation, with volatility declining from the 1980s or 1990s. With the VARs, breaks in the early 1970s clearly appears, the other breaks being, in general, less clearly related to any country specific results. As regards causality, despite the

general increase in international inflation correlations seen over time in the individual series, the joint tests of Granger mean causality provide little evidence of significant causal links between inflation in different countries over the identified sub-samples. Nevertheless, where such links exist, the results point to a transmission from the euro area to the other countries, although evolving over time. Within the euro area countries considered in the second VAR, no individual country is clearly identified as a source of inflationary pressures. Finally, when volatility causality relationships are examined, Italy plays a central role in this transmission between euro area countries. Also, inflation volatility also runs from the euro area to the UK. These relationships presumably reflect the monetary policies pursued by the countries of Europe and the move towards monetary union. In addition, it is found that inflation uncertainty in the US is transmitted to both Canada and the Euro Area.

**Fabrice Collard** (GREMAQ-Université de Toulouse) and **Tony Yates** (Bank of England) discussed the paper. Some methological issues were raised, in particular the treatment of individual series prior to running the multivariate analysis, making impossible to exhibit possible common breaks. In addition, the causality analysis is conditional on the results of the previous steps of the analysis and the level of the causality tests is hence unknown. In another respect, the authors collect a big number of empirical findings which would deserve further explanations in economic terms, referring for instance to the functioning of a monetary union, the impact of increasing openness, changes in tradable sector price-setting behaviour, etc. This would be all the more appreciated since some of the results are sometimes at odds with previous findings.

**Paolo Surico** (Bank of England) presented the second paper in this session, written together with Haroon Mumtaz (Birbeck College, London). Inflation in many industrialised countries shares the same pattern: high and volatile in the 1970's but low and stable as of the mid1980s. Using a dynamic factor model, distinguishing between a world factor, common to the inflation dynamics in all countries, and a country specific factor, with in addition time-varying coefficients and stochastic volatility, the authors tries to identify the source of these stylised facts. The study shows first that the decline in the level and persistence of inflation is an international common feature. The world factor plays a prominent role, the domestic factor having an explanatory power in some occasions at the beginning of the sample only. The country specific factors nevertheless still largely explain the inflation variability, which changes over time is in addition not synchronised across countries. These latter results may be linked to the existence of country specific shocks to inflation and/or different responses across countries to common shocks. The model also allows to measure inflation persistence and to make a distinction between the contribution of the world and the domestic components. Thus, it is shown that the international component of inflation persistence is, almost in all countries, significantly larger than the country specific components, and that the decline in the persistence of national inflation rates is a global phenomenon, driven by the decline in persistence of the world factor. Correlatively, the reduction in inflation persistence is accompanied by a fall in inflation predictability. Finally,

the relatively larger contribution of the world factor in the recent past has not translated into large inflation fluctuations.

**Benoît Mojon** (Federal Reserve Bank of Chicago) and **Vanessa Smith** (Cambridge University) discussed the paper. The necessary identification constraints, together with some specification features – like the choice of having time-varying coefficients in the dynamics of the factors, whereas the factor loadings in the inflation equation are fixed – would deserve some theoretical considerations. The empirical consequences of these characteristics of the model would also deserve to be analysed. Some methodological issues were also raised, as regards the use of the MCMC algorithm to generate random draws from the joint posterior distribution of the objects of interest. It was also felt than additional information would be needed in order to gauge the prior-to-posterior change induced by the information content of the data set and to evaluate the general model predictive ability. Finally some additional links with the existing literature could be made.

### *Session 4: Forecasting changing inflation*

**Jim Stock** (Harvard University) opened the session on 'Forecasting Changing Inflation' with the paper '*Inflation Forecasting and Time Varying Factor Models*' co-authored with Mark Watson (Princeton University). The paper provides some theoretical and empirical results concerning the estimation of dynamic factors and their use for forecasting when there is structural instability in the underlying factor model. In particular the paper studies three different types of structural instability: breaks in factor loadings, in factor dynamics and in the idiosyncratic dynamics. The authors prove that, under some conditions on the dependence between the idiosyncratic term and time variation in the factor loadings, the principal component estimator of the factors still spans the space of the true factors despite time variation in the factor loadings. The main empirical finding from an investigation conducted on the US experience is that there seems not to be a systematic advantage in using the sub-sample estimates of the factors over the full sample estimates as long as one allows for a break in the forecasting regression coefficients.

**Raffaella Giacomini** (University College London) and **Jan Groen** (Bank of England) discussed the paper. Some general considerations were raised, such as the fact that non-linearity could be confused with instability (see Kim and Nelson 1998). Turning to the issues of how to handle instability by looking for robust methods and the use of large datasets, the comparison of forecast combination versus factor models was presented, on the basis of a simulation experiment in case of a time-varying factor loadings in the one hand and breaks in the regression coefficients on the other hand. The results from the experiment highlight that time varying factor loadings have no effect on any model forecast performance while coefficient instability affects largely the combination forecast. The lesson from this experiment is that factor models are more robust than combination of forecasts to structural instability. Nevertheless it was stressed that, in reality, given the degree of overlap across series in the large data sets usually used, the occurrence of co-

breaking is probably frequent and questions the hypothesis of independent breaks in the data set that leads to the conclusion in favour of the factor models in such cases. The discussion made clear that estimation uncertainty is more difficult to address than structural breaks.

**Massimiliano Marcellino** (Bocconi University) resumed the session on 'Inflation Forecasting under structural change and in real time' on the morning of the 7th of September with the paper '*Forecasting Macroeconomic Variables Using Diffusion Indexes in Short Samples with Structural Change*', joint work with Anindya Banerjee (EUI) and Igor Masten (University of Ljubljana). The paper studies the sensitivity of the forecasting performance of factor and non factor methods to the time and longitudinal dimension and it evaluates the forecast accuracy of diffusion index-based methods in short samples with structural changes. The study carries out both a simulation and an empirical investigation. The simulation exercise includes a broad range of data generating processes in order to account for different time and longitudinal dimensions and to mimic different types of structural changes. The empirical analysis focuses on the Euro area and Slovenia for which time series are available only for short samples and are likely to be characterized by structural changes related to the introduction of the euro. The main results from the simulation, confirmed also by the empirical analysis, is that factor models outperform the AR model, taken as benchmark, in the majority of the experiments carried out even in short samples subject to changes.

The paper was discussed by **Domenico Giannone** (European Central Bank). He discussed the sources of structural change considered in the paper and summarized the results obtained in the simulation exercise as follows: The effect of change in unobserved common factors on the observed predictors are more problematic than the variation in the dynamics of the common factors over time but they both are of second order importance when there are many predictors. The change of the intercept and the slope is the most important source of instability in short samples. In light of this observation he argued that the simulation exercise should include experiments with time varying coefficients of the forecasting equation. The discussant suggested that another important issue not addressed in the paper is the optimal estimation sample size in presence of instability. He argued that the more unstable the economic environment is the less important are past data, hence short samples (about 10 years of observations) could provide more accurate information than long samples. He then raised a general question about the reliability of MC experiments and he argued that they are not useful unless they are calibrated to match the problem at hand. Last he suggested to try to use Maximum Likelihood as estimation technique of common factors. Massimiliano Marcellino responded to the comments stressing that the analysis for variation in the coefficients of the forecasting equation has been implemented but excluded from the paper as it goes beyond the scope of the paper. He also stressed that the MLE approach was not used as it might not be feasible in short samples.

**Simon Potter** (Federal Reserve Bank of New York) presented the paper '*Real time underlying inflation gauges for monetary policy makers*', written with Marlene Amstad (Swiss National Bank). This paper develops underlying

measures of inflation for both the CPI and PCE indices through a dynamic factor approach which extracts information from a broad range of nominal, real and financial variables. The most common approaches used to extract underlying inflation take into account only the cross-sectional dispersion of prices but disregard the time series properties of individual prices. The author stressed that the unobserved component model adopted in this paper (UIG) considers also the time dimension of the data and tries to extract a persistent component of inflation. Moreover this measure of underlying inflation can be updated daily and is not sensitive to data revision or seasonal adjustment revisions. The authors compare general features of the most popular measures of underlying inflation and find that the UIG suggested in the paper provides the smoothest signal, while the other measures provide a signal with remaining high frequency volatility. The authors also compare the UIG to traditional core measures for forecasting inflation and show that UIG outperforms those measures for different samples and forecast horizons.

**Martin Ellison** (University of Warwick) acted as discussant for this paper. After a brief summary of the paper he highlighted the advantages of the measure of underlying inflation developed, which is not subjected to data revision or seasonal adjustment revisions. He welcomed also the fact that when only price data are used the underlying factor is almost flat while when using a broader range of data, the factor is much more volatile. This suggests that not only the nominal variables should be considered when looking at underlying inflation. He then pointed out few critiques: The authors claim that they use series not subject to revisions, but they just seem to ignore the revisions. He wondered what the benefit of maintaining a daily updated UIG is vis-à-vis an indicator updated less frequently or one based on a smaller dataset. He also argued that in a factor model the policymaker's objective is undefined. In light of this observation the discussant urged the need to bridge the gap between DFM and DSGE, embodying restrictions consistent with law of motions unobservable in a DSGE model. The plenary discussion agreed on the need to fill up the gap between DFM and DSGE models.

### *Session 5: Forecasting Inflation with disaggregate information*

**Kirstin Hubrich** (European Central Bank) opened this session presenting the paper '*Combining Disaggregate Forecasts or Disaggregate Information to Forecast an Aggregate*' co-authored by David Hendry (Oxford University). The paper aims at comparing the forecast accuracy of first, forecasting the aggregate based only on aggregate information, second, aggregating component forecasts and third, including and combining disaggregate information in the aggregate model. The author started her talk presenting new analytical results on the effects of changing coefficients, mis-specification, estimation uncertainty and changing weights on the relative forecast accuracy of the discussed forecast methods. Forecast origin location shifts and slope changes are found not to affect the relative forecast accuracy, i.e. structural changes do not affect the choice between those methods. The paper also provides conditions under which a unique ranking is possible. She then briefly outlined the simulation results, which confirmed and extended the theoretical findings. Finally she turned to the empirical application which

analyses the relative forecast accuracy of the above methods to forecast aggregate US inflation. The empirical results indicate that overall the direct forecast of the aggregate is more accurate than the indirect, i.e. that combining disaggregate information tends to outperform combining disaggregate forecasts.

**Olivier De Bandt** (Banque de France) stressed the high relevance of the paper for practitioners and complimented the authors for the completeness of the paper which incorporates analytical, simulation and empirical results. He restated one main result of the paper, which is the fact that slope mis-specification and estimation uncertainty are main sources of forecast error differences. He suggested two extensions for the paper: First, to expand the empirical analysis to the regional dimension, and second, to present the forecast accuracy test results, mentioned in the presentation, in the paper. He stated that the empirical result that the direct forecast of the aggregate outperforms aggregating component forecasts could be more closely compared with some additional literature. He then focused on a more specific issue, suggesting to investigate further the effect of exogenous variables considered in the theoretical part in the empirical analysis. Kirstin Hubrich replied to the comments by pointing to comparisons with other empirical studies in the paper focussing on different countries and samples and by mentioning that the suggested extensions to the paper are work in progress in two additional papers on regional inflation dynamics and on forecast accuracy tests.

The last paper presented at the workshop was '*Forecasting inflation through a bottom up approach: How bottom is bottom*' by **Antonio Rua** (Banco de Portugal) and Claudia Duarte (Banco de Portugal). In this paper the authors compared the forecast accuracy of aggregating disaggregate component forecasts with forecasting aggregate inflation for horizon of up to twelve months. The novelty of the paper is the use of a higher level of disaggregation than the one used in many previous empirical studies on aggregation and forecasting. This poses modeling challenges overcame through the use of Factor-Augmented SARIMA models, which allow to incorporate in the models for CPI a unique factor as exogenous variable, extracted from almost sixty price index subcomponents. The out-of sample forecast exercise for Portugal showed that for a very short forecast horizon aggregating forecasts performs better than forecasting the aggregate using disaggregate information in terms of RMSFE comparison, while the opposite holds for longer forecast horizons.

**Christian Schumacher** (Deutsche Bundesbank) started his discussion by highlighting that this empirical paper, in contrast to most other studies, does not use seasonally adjusted data. He questioned the validity of the results for other samples, for example after 2004, as inflation dynamics have changed showing a lower inflation rate and lower volatility. Subsequently he pointed out that the overall debate on aggregation versus disaggregation disregards the time-varying nature of inflation and it focuses instead only on the cross-section dimension. Next, the discussant wondered why no macro series other than price indexes were used to extract the exogenous common factor. Furthermore, he indicated that seasonality is treated inconsistently and suggested using seasonally adjusted data also for the forecast equation.

Finally, he pointed at scope for further research on pooling versus aggregation.

### *Panel discussion: Issues on inflation forecasting in central banks*

In the panel discussion at the end of the workshop, **Jim Stock** (Harvard University) opened the discussion, arguing that for forecasting inflation it is hard to improve over judgemental forecasts by model-based inflation forecasts. He then provided some historical perspective referring to Nelson (1972) who found that judgemental forecasts did better than time series models (ARIMA), which in turn improved over structural model forecasts. After the Lucas critique the focus shifted to instability and time varying parameter models (see e.g. Nelson & Schwert (1977), IMA (1,1) models). Important questions in forecasting inflation are how to exploit the information in many time series when the model is unstable, which is the relevant information set to include in modelling inflation, and how to model time variation. Finally, he turned to some lessons which can be drawn from the papers presented during the workshop: Factors seem to be robust to time-variation, variable selection procedures could be explored further in this context; rolling window regressions might be able to tackle time-variation in some situations, time-varying coefficient models (e.g. TV factor models) might help; disaggregate information does help in many situations.

**Lucrezia Reichlin** (European Central Bank) was the second panelist. She first pointed out that the decline in predictability in the great moderation sample (post 1984) applies not only to inflation but also to real variables. Furthermore, she stressed that the decline in predictability is a relative decline, i.e. RMSFE of the model under analysis over the RMSFE of the RW model. (see e.g. D'Agostino, Giannone and Surrico, 2006). She then illustrated the main methodologies of modelling changes in inflation in the current literature on forecasting: First, as in Stock and Watson (2007) and Cogley and Sargent (2007), decomposing inflation in a trend and a gap and allowing the variances of the innovations to be time varying. Hence, if the variance of the innovation decreases in the post 1984 sample, then inflation becomes more like a random walk. An identification issue arises in the trend-cycle decomposition. The information set used is important (see e.g. Evans and Reichlin, 1994). Second, time varying factor models are used, as in Stock and Watson (2007). The last approach consists in smoothing the target (Cristadoro, Forni, Reichlin and Veronese 2001 and Amstad and Potter, 2007): Inflation is decomposed into a smooth low frequency/long run component and a volatile high frequency/short run component. She concluded her presentation suggesting that now-casting inflation, i.e. the forecast at quarter zero, using financial and disaggregate data might be an interesting direction for further research.