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**Forecasting in Eurosystem Central Banks
– Overview and Challenges**

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1 Introduction

It is a pleasure for me to open this conference on new developments in economic forecasting. I would like to welcome the presenters, discussants and other guests who have come to Eltville to take part in the conference.

Forecasting is nowadays a central element in the decision-making process of central banks. This conference aims to present and discuss new insights gained from academic research which might help to improve the current practice of forecasting, with the aim of using these insights to develop further the forecasting tools employed by the Bundesbank and the Eurosystem.

To start with, it might be helpful to take stock. Therefore, in my introductory remarks, I shall be discussing various aspects of the forecasting procedures employed at central banks with a special focus on the Eurosystem and the Bundesbank.

There is a straightforward reason why central banks have a strong interest in forecasting: because of lags in the effects of monetary policy on macroeconomic activity monetary policy cannot affect current inflation and

output.¹ Owing to these lags, it is widely recognised that monetary policy should be forward-looking and have a medium-term perspective. As a consequence, monetary policy decisions are, to some extent, dependent on forecasts.

Future developments in inflation and output are of key interest in central banks' forecast exercises. The relevance of price developments stems from the fact that the primary objective of many central banks is to establish and maintain price stability. Their interest in forecasting output, or, more generally, some measure of broad macroeconomic activity, results from their influences on future prices. Moreover, many central banks take real developments into consideration for another reason: the objectives of these central banks explicitly include real variables such as unemployment and output.

But even for central banks, such as the Eurosystem, which have a more hierarchical ordering of objectives, and pursue price stability as the primary objective, output developments play an important role: Focusing exclusively on price stability, regardless of the type of shock hitting the economy, would otherwise have the undesirable consequence of increasing output volatility to inefficiently high levels. In the end, this may complicate the preservation of price stability.

As part of their communication strategy, many central banks have decided to publish their forecasts in order to increase transparency. In a forward-looking environment, fostering transparency by means of published forecasts is more than an end in itself. It also serves to guide expectations of future monetary policy actions, thus making the central bank more effective in fulfilling its duties. For this reason, the quality of the forecasts

¹ A rough benchmark for the euro area is that monetary policy affects output in about a year and inflation in about two years. See Angeloni, Kashyap and Mojon (2003).

is crucial not only under reputation aspects but also for reasons of policy effectiveness.

As a result, central banks have a natural interest in applying the best forecasting methods available. This necessitates to continuously incorporate the latest academic developments in forecasting into the models used by economic and research departments at central banks. In my following remarks, I shall discuss some of the recent developments.

2 Recent developments in forecasting

One way of distinguishing the main developments in forecasting methods is to focus on the amount of information used for specifying forecast models:²

- Forecasting in data-rich environments with as much information as is available:
 - Factor forecasting with large datasets,
 - Forecast pooling or combination, and
 - Disaggregation versus aggregation of data,

- Forecasting with reduced information:
 - Theory-based forecasting: for example DSGE models,
 - Model selection: general-to-specific modelling strategies

² See the overview article Clements and Hendry (2005), Guest Editors' Introduction: Information in Economic Forecasting, *Oxford Bulletin of Economics and Statistics* 67, issue s1, p. 714.

To highlight the diversity of models within both the limited information and full-information approaches, I have included some examples of methods in the above listing which may be of potential use for central bank forecasting.

2.1 Forecasting tools in central banks: some stocktaking

What kind of forecasting approaches have been adopted by central banks? As outlined in Sims (2002) and in Pagan & Robertson (2002), most of the central banks employ traditional macroeconomic models, sometimes replaced by medium-scale DSGE models, as core or workhorse models for forecasting and policy analysis. These models have a well-specified theoretical framework in statistical and economic terms that helps providing some economic interpretation of the forecast.³

Although most of the central bank work typically devotes around a single core model, alternative macroeconomic or DSGE models of differing size or with different regional coverage are also employed.

Additionally, a number of econometric time series models with little explicit economic content are used for short-term forecasting, as they can be used to employ higher-frequency data and different datasets than the traditional macroeconomic or DSGE models.

Finally, 'judgement' in terms of outside-model information is additionally used.

How are these forecasts used in practice? In general, forecasts from different types of models are simultaneously taken into account in monetary policy practice. As an example, the Bank of England has recently developed a suite of short-term forecasting models for GDP

³ See Issing (2004), p. 730.

containing, among others, large-scale factor models and non-linear models.⁴ Forecasting results for combined forecasts with these models are reported in addition to the forecasts obtained by the Bank of England Quarterly Model (BEQM). In a recent study by the Bank of Sweden, both a non-theoretical BVAR and a DSGE model are used for forecasting and policy analysis.⁵ These examples show that not in all cases a single-model approach is followed, but rather a 'suite-of-models' approach.

2.2 Arguments in favour of the suite-of-models approach

What are the reasons for central banks following these multi-model approaches? Why is it important to apply a variety of models in central banks rather than only a few, especially for forecasting?

1) Information loss: Using only one specification or model implies that some indicators and information are left aside and ignored for policy decisions. There are good reasons for thinking that this may not be a good strategy.⁶

In applied econometrics typically alternative specifications are initially tried, and the specification, estimation and testing steps are re-iterated a number of times.⁷ In this way, a 'good' forecasting model is obtained by an extensive specification search. By checking a large number of possible models, and choosing exclusively the best-performing one, specifications with only slightly inferior empirical performance are subsequently ignored in the forecast comparison. As a consequence, there is the danger that a good forecast performance is less the result of the model's actual forecasting ability, but more so just luck in the selection procedure. Better

⁴ See Kapetanios, Labhard, and Price (2005).

⁵ See Adolfson, Andersson, Lindé, Villani, and Vredin (2005).

⁶ See Granger and Jeon (2004), pp. 324-5.

testing procedures should consider more general specification search criteria such as “the benchmark’s forecast performance should not be inferior to any alternative forecast”. Forecast comparison tests considering this general requirement have recently been proposed by White (2000) and Hansen (2005), and take into account a large number of candidate models for forecasting.⁸

A similar idea is adopted in the ‘model confidence set’ (MCS) approach proposed by Hansen, Lunde and Nason (2003). This procedure represents a general approach to model selection which allows for finding a group (set) of forecasting models. This is appealing because it often cannot be ruled out *a priori* that more than one of the competing model is equally good.⁹ *

Therefore, a sensible solution in the forecasting model selection context is to consider many competing models, and not just a few.

2) Model uncertainty: Policymakers face a wide range of uncertainty, and so do modellers. There is considerable model uncertainty, and there is no consensus among policymakers concerning the one true model. As an example, consider the different approaches to modeling expectations; some authors favour backward-looking models while others prefer forward-looking models, and a third camp advocates hybrid models. Therefore, model equations may be misspecified in terms of functional form or omitted variables. Additionally, structural breaks have been

⁷ See Spanos (2001).

⁸ Taking into account more than one benchmark model makes the null of equal forecast accuracy harder to reject. See, for example, White (2000), table 1, p. 1113.

⁹ Construction of an MCS involves a sequence of tests for equal predictive ability. This restricts the set of candidate models by deleting models that are found to be significantly inferior, and the set of remaining models is the MCS. An MCS can be used to construct combination forecasts by pooling the forecasts of the models in the MCS. If the number of models in the MCS is large, a reasonable way to proceed is to weigh the individual forecasts equally. The reason for this is that the MCS consists precisely of the models that cannot be rejected as being equally good. See Hansen, Lunde and Nason (2003), p. 841.

identified as crucial sources of forecast failure. Finally, data uncertainty might affect models in different ways.

Information loss and model uncertainty are closely interdependent: Models are, by definition, a reduction of reality. For example, single models can capture only a few aspects of the monetary transmission mechanism. Since many transmission channels are likely to matter in reality, a “one model fits all” approach seems inappropriate.

3) Forecast pooling performs well in empirical applications: Forecast combination methods often work well, and, in particular, better than single-model forecasts. Recent examples of the empirical success of forecast pooling are Stock and Watson (2004) and Marcellino (2004). Intriguingly, the combination methods with the lowest forecast errors are the simplest – for example, with equal weights. This indicates that estimating forecast weights might be difficult in practice, but in itself again is probably method sensitive.

Forecast pooling may be particularly useful under structural changes or breaks and misspecification: Following theoretical considerations, combinations of forecasts are unnecessary when forecasts use the correct conditional expectation in a weakly-stationary process. In other words, a departure from perfect knowledge is necessary to explain gains from combination, see Clements and Hendry (2002) and Timmermann (2005):

- A pro-diversification argument states that some combination of two-model forecasts might perform better than either alone, if the two models provide partial, but not overlapping, explanations.¹⁰
- Owing to model uncertainty, using the correct conditional expectation for forecasting is unrealistic, and, in reality,

¹⁰ See Timmermann (2005), p. 3.

departures from the correct model may be expected to be the rule rather than the exception.

- If structural breaks occur, forecasts from individual models may be affected differently, possibly on account of differing degrees of misspecification. Combinations of forecasts might then outperform forecasts from individual models.¹¹

To summarize: There are good reasons why monetary policy pursues full-information strategies and “looks at everything” in terms of a broad set of information from data and models. The recent sizable literature on robust policies in various model environments also emphasises the merits of model combination and averaging.¹²

Therefore, selecting a single model for monetary policy may be inappropriate, since conditioning monetary policy decisions on one model ignores the role of model uncertainty. It also disregards the favourable empirical results from the forecast combination literature, and thus leaves aside potentially important information.

3 Eurosystem forecasting

The Governing Council of the Eurosystem bases its comprehensive assessment of the risks to price stability and its policy decisions on a broad set of information provided by two analytical tools: the economic analysis and the monetary analysis.

¹¹ See Clements and Hendry (2002).

¹² For example, Brock, Durlauf and West (2003, 2006) propose a model averaging approach that derives optimal policy given a policy maker’s preferences – for example, a loss function – and given a variety of possibly relevant models affecting the central bank’s target values. Apart from forecast averaging, a multiple model approach helps to address other issues where model uncertainty matters. For example, a policymaker may be interested in policies whose effects are relatively insensitive to which model is the correct one.

The monetary analysis assesses medium to long-term developments in inflation based on the close relationship between money and prices over long horizons. Monetary analysis takes into account developments in a wide range of monetary indicators including M3, its components and counterparts, notably credit, and measures of excess liquidity.

The economic analysis identifies short to medium-term risks to price stability. It includes regular monitoring of a broad set of non-monetary economic and financial variables, such as labour costs, fiscal policy statistics and financial market indicators.¹³

Additionally, the projections of key macroeconomic variables carried out by Eurosystem staff are an integral part of the economic analysis. Moreover, a range of non-central bank forecasts are taken into consideration. Forecasts, however, are not an all-encompassing tool for the conduct of monetary policy in the Eurosystem.

The monetary and economic analyses provide complementary analytical frameworks, and, by means of cross-checking, they support the robustness of the Governing Council's assessment of risks to price stability.

Eurosystem forecasts are carried out under the sole responsibility of the Eurosystem staff, and not of the Governing Council. This makes the forecasts different from those of other central banks, such as the forecasts of the Bank of England, where the MPC is responsible for the forecasts and their assumptions.

The regular staff projections are carried out as a collaboration between the ECB and the national central banks of the euro area. This ensures the full

¹³ See Issing (2004), p. 725.

consideration of all information and expertise available in the Eurosystem for forecasting, in addition to aggregate information at the area-wide level.

Empirical results from the forecasting literature also support the argument that disaggregated information in terms of national time series is more useful for forecasting than aggregated information (area-wide time series) in the euro area.¹⁴

Concerning the forecast methods, various approaches are employed, and the Eurosystem pursues a suite-of-models approach. Regarding the level of aggregation, the Eurosystem employs econometric models for single euro area member countries in addition to area-wide approaches.

Traditional structural macroeconometric models still play a key role in forecasting – for example, the Area-wide-model (AWM) of the ECB – and the econometric models of the euro-area central banks.

Recently, DSGE models have been developed in the Eurosystem. Some of these models are still under construction and some are already used for policy simulations. However, they have not been widely used for forecasting so far.

In addition, Eurosystem staff makes use of time series models for short-term forecasting, such as different VAR models and large factor models.

However, Eurosystem forecasts are not fully model-based. In the forecast exercises conducted by the Eurosystem, a complex interaction of information takes place between models and judgmental information from outside the models.

¹⁴ See Marcellino, Stock and Watson (2004).

3.1 The role of short-term interest rates in central bank projections

One practical difficulty in forecast exercises is the appropriate conditioning of the forecasts. A particularly subtle problem for central banks concerns the appropriate choice of a consistent short-term interest-rate projection. This topic plays a key role in the recent discussion on central bank forecasting. The short-term rate is the policy instrument under the control of the central bank; via the expectation channel, its future path influences current economic circumstances and decisions. Specifying a trajectory of future rates in today's projections is therefore a delicate problem with regard to the signals about the future course of monetary policy given to outside observers. There are basically three ways of specifying the future interest rate path.

Firstly, a constant short-term interest rate (CIR) assumption can be employed. The inflation projection being higher (lower) than the inflation target at some given horizon has been interpreted as indicating that, sooner or later, the instrument rate needs to be raised (lowered).¹⁵ An advantage of this assumption is that it can easily be communicated. CIR is an obviously technical assumption with no risk of central bank commitment to following the assumed constant interest rate path.

One drawback is that many current asset prices depend on market expectations of the future short-term interest rate path – the most prominent example being the long-term interest rate which, via the term structure, depends on expectations of future short term rates. And, typically, the market prices of these assets are used as other inputs in projection exercises rather than the hypothetical asset prices that would result if market participants actually expected a constant interest rate. Hence, the forecasts are of a hybrid nature as they use the CIR together with inputs which are inconsistent with the CIR assumption.

Secondly, an alternative is using the market expectations of future short-term interest rates, the so-called market interest rates approach (MIR), where these are typically derived from the yield curve. Compared with the CIR, the MIR assumption in principle preserves a higher degree of internal consistency as it is in line with the other asset price inputs for the forecasts. Therefore, it could be expected to be a better estimate of future outcomes than projections based on the CIR assumption, while remaining a technical assumption and not a policy commitment on the part of the central bank as regards the future evolution of its policy rate.

Until now, the Eurosystem forecasts have been carried out under the assumptions of a CIR. Starting in June 2006, Eurosystem and ECB staff macroeconomic projections will be based on the technical assumption that short-term market interest rates will move in line with market expectations and thus follow the MIR approach.¹⁶

Note that the change to MIR is of a purely technical nature. It should not be misunderstood as a commitment of future interest rate policy to the rates assumed in the projections. The MIR is being introduced in order to bring about a further improvement in the quality and internal consistency of the macroeconomic projections, and does not imply any change in the monetary policy strategy of the Eurosystem or in the role of projections within it. The Governing Council will continue to base its assessment of the risks to price stability and its policy decisions on a broad set of information provided by the economic and monetary analyses.

A third possible concept to treat the short-term rate in central bank's projections is the 'own instrument projection'. It reflects the central bank's own assumed interest rate path (OIR), i.e. the interest rate path that is supposed to achieve the central bank's objectives best under certain

¹⁵ See Svensson (2005).

¹⁶ ECB (2006).

model- and judgment-based assumptions concerning the functioning of the economy.

The OIR approach necessitates the commitment of the decision-making body to this conditional forecast. Given that the Eurosystem staff projections are under the sole responsibility of the staff, and not the Governing Council, the adoption of a OIR forecast is no viable option for the Eurosystem.

Moreover, although the OIR has the appealing property of being fully consistent with the central bank's targets and other inputs there are several problems with this approach. They can explain why only very few central banks are pursuing this alternative. The OIR is highly dependent on the specific analytical framework from which it is derived; in particular, a core forward-looking model and a monetary policy loss function. In light of additional model-uncertainty and the necessary integration of judgment in the forecasting process the optimal interest rate is therefore surrounded by difficult-to-quantify uncertainties which make it somewhat problematic to communicate. Moreover, the OIR might be interpreted as an unconditional commitment to the future path. Therefore, communicating the conditional nature of the assumption is more demanding than for the other two assumptions.

3.2 Future Challenges for Eurosystem forecasting

Looking to the future, the Eurosystem will face various challenges with respect to forecasting. Of course, in order to provide the best possible forecasts as inputs for monetary policy decisions, there is a constant need for the use of the latest forecast methods in the Eurosystem macroeconomic projection exercises. For this purpose, extensive evaluation studies of recently developed forecasting methods are

necessary, which might lead to extensions of the forecasting toolkit where appropriate.

In this regard, an important question will be how to integrate new approaches into the forecasting procedures. For example: What are the benefits and risks of recently developed DSGE models for forecasting – and for policy analysis? Can they be integrated into the forecasting procedures, and how can the results be communicated?

Moreover, another central direction for future work might be the adoption of formal forecast and model combination methods to take account of model uncertainty in an effective manner and to make efficient use of the large datasets that are nowadays available for forecasting at central banks. Research projects on dimension reduction using model selection, large factor modelling or systematic forecast and model combination are already under way and might also play an important role in the future.

These topics are particularly useful for short-term economic forecasting in the Eurosystem in order to identify short to medium-term risks to price stability under the economic analysis.

With regard to longer-term horizons and forecasting, two possible innovations may be considered valuable for future work.

Firstly, owing to the well-established empirical relationship between money and future price developments,¹⁷ money-based inflation forecasts could be envisaged as an additional tool to support the monetary analysis of future risks to price stability.

¹⁷ See, for example, the various approaches used to establish the role of money for future inflation by Gerlach and Svensson (2003), Gerlach (2004), Gerlach-Kristen (2005), and Hofmann (2006).

Secondly, conditional on implementing the former it might also be worth investigating the usefulness of model averaging approaches for refining the overall formal background of the ECB strategy.

As discussed earlier, the ultimate goal of the Eurosystem's two-pillar strategy is the efficient utilisation of available information for monetary policy decisions under the monetary and economic analyses. One possible extension might be found in a more strongly formalised combined assessment of the information included in both pillars for future inflation developments at various time horizons (short, medium and long-term).

Of course, the advantages and pitfalls of a more formalised forecasting combination have to be investigated thoroughly, and research activities are needed for that.

4 Bundesbank forecasting within the Eurosystem

The Bundesbank, as part of the Eurosystem, carries out forecasts on a regular basis for the key German macroeconomic variables. These forecasts are an input for the Eurosystem staff projections, where the national predictions are discussed and aggregated with other national forecasts into area-wide forecasts. Furthermore, the forecasts serve as quantitative background information for explaining monetary policy on a national level, and for comments on economic and fiscal policy issues.

From a methodological viewpoint, forecasts are carried out as a combination of model-based forecasting and judgmental forecasting. The core model for policy forecasting is the structural macroeconometric model, which is used in the Eurosystem staff projection exercises.

To date, only the Bundesbank model has served as the main model forecasting tool, but further steps towards a suite-of-models approach are being explored and likely to be implemented in the near future.

Current research projects aim at developing DSGE models for policy simulation. However, owing to the limited forecast accuracy of these models so far, they will probably serve only as a tool for analysing particular policy-relevant issues apart from being used, for now, in regular forecast exercises.

Short-term forecasting in the Bundesbank is carried out with bridge equations and other time series models. However, in order to enhance these models, efforts are being made to develop models suitable for forecasting in real time – in particular, large factor models and VAR models and their applications in real time.

Moreover, the Bundesbank is devoting considerable research activities to the further development of the monetary analysis. In particular, ongoing research projects are investigating the information content of various monetary aggregates for future inflation.

5 Outlook for the conference

As you can see, topics concerning forecasting methodology are always at the top of the research agenda for Eurosystem central banks. I have highlighted some aspects that lie at the heart of each and every central bank engaged in forecasting, and I have mentioned a number of issues that are particularly relevant to the state of play in the Eurosystem in general and the Bundesbank in particular. Of course, there are still more open questions than issues resolved. But if it were the other way round,

conferences like this would be superfluous. In this respect, we look forward to hearing of new approaches during this conference.

I wish you stimulating discussions and a productive meeting. Thank you for your attention.

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