Results of the questionnaire: "The role of macroeconomic forecasting models in the central bank's forecasting process"

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The article provides a comprehensive anonymised evaluation of the survey. The compilers designed the questionnaire and, in late spring 2024, contacted 22 inflation-targeting central banks (CBs), asking them to complete a questionnaire on ***"The role of macroeconomic forecasting models in the central bank's forecasting process."*** *All 22 CBs sent in their responses, and the authors also included the results for the Czech National Bank in the aggregate results. The article is divided into three parts. The first part presents key information about the survey, the second part examines responses relevant to all CBs, and the third part focuses on responses from CBs that use multiple models concurrently in their forecasting process. The article also includes two appendices that provide detailed information from the individual CBs on how the process of preparing their forecast is organised, as well as a brief overview of the use of models in their forecasting process.*

1. Introduction

Participating CBs (23): Australia, Brazil, Canada, Chile, Colombia, Czech Republic, ECB, Hungary, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Poland, Romania, South Africa, South Korea, Sweden, Switzerland, UK, Uruguay and USA.

Aim of the questionnaire: To follow up on the Czech National Bank's autumn 2023 survey "Monetary policy decision-making and the role of models" in order to better understand the internal processes and external communication underlying the preparation of each central bank's model-based forecast, particularly when several macroeconomic forecasting models are used (see box for definition).

Box: Macroeconomic forecasting model

By macroeconomic forecasting models, we mean **full-scale models** that independently generate mutually consistent paths of the main macroeconomic variables. In other words, we mean models that produce medium-term forecasts of key domestic economic variables such as inflation, GDP, the exchange rate and interest rates (including the option of exogenous interest rates). These are typically Dynamic Stochastic General Equilibrium (DSGE) models, gap quarterly prediction models (QPMs) or structural macroeconomic models. We are not referring to: (i) partial models that only forecast a single or narrow set of macroeconomic variables, such as the (equilibrium) exchange rate or the labour market, the balance of payments or the fiscal area; (ii) near-term forecast (NTF) models, the outputs of which are integrated into the macroeconomic forecasting model during the forecasting process; (iii) "out-of-the-box" macroeconomic structural models such as NiGEM (NIESR) and GPM6 (IMF), which, according to our information, tend to be used to prepare exogenous assumptions (usually about the foreign environment) for forecasts of domestic economic variables.

Structure of the questionnaire: In the section relevant to CBs using two or more models, we asked about: the equivalence of models in the preparation of forecasts and scenarios, internal monetary policy (MP) processes, external communication of model forecasts, the preparation of CB forecasts in terms of the level of independence of individual forecasting teams, ex-post evaluations of forecast accuracy, the creation of (un)conditional forecasts, the method of compiling the (partial) forecasts of individual models, and the identification of the types of models used (DSGE, QPM, other).

For all central banks (whether using one or multiple models), common questions focused on: the use of models for other forecasting exercises (e.g. for the purposes of the work of financial stability departments), the length of the model's monetary policy (MP) horizon and the frequency of any changes to it, the time of convergence of the model to the *steady state*, the role of models in formulating MP recommendations, the origin of the model (internally developed by CB staff or outsourced), the size of the modelling teams and the time required to produce forecasts, the frequency of model recalibration, the existence of a system for refining the modelling framework and its development, the impact of the Covid experience on the modelling framework, the

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communication style of model paths (e.g. fan charts), including a question on the possibility of introducing a "dot plot" summarising the individual outlooks of MP decision-makers (à la Fed), the use of artificial intelligence (AI) in economic modelling, the stability of their current modelling framework (i.e. whether they are considering changing or modifying it), and a description of their own "story" of using models in the MP process.

2. Aggregate results of the questionnaire relevant to all central banks

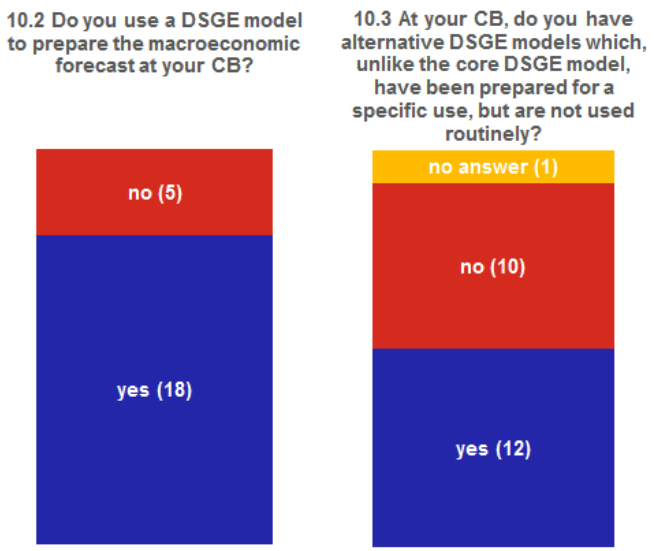
Table: Number of macroeconomic forecasting models and the use of DSGE models in preparing forecasts

		Use of DSGE models for forecasting	
		Use DSGE models	**Do not use** DSGE models
Number of macroeconomic forecasting models	**One** model	4 CBs	4 CBs
	Two or more models	14 CBs (of which 7 use two or more models, with one of these models being a DSGE model)	1 CB

The majority of CBs (15) in the sample of 23 surveyed countries prepare their macroeconomic forecasts using two or more macroeconomic forecasting models, while around one-third (8) use just one model. Additionally, DSGE models are typically used for macroeconomic forecasting, as reported by 18 central banks. However, only 11 CBs use DSGE models as their main forecasting model.

Types of models

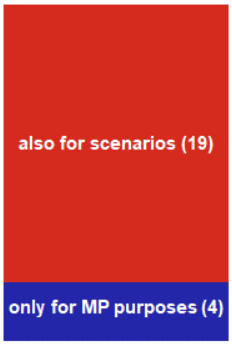
Most of the CBs surveyed (18) have a Dynamic Stochastic General Equilibrium (DSGE) model as part of their macroeconomic forecasting toolkit, though it is not always the main model (7 CBs), nor is it necessarily used in their macroeconomic forecasting process. Additionally, more than half of the CBs (12) have DSGE models for specific purposes, such as preparing alternative scenarios and simulations or addressing climate change policy issues. As previously mentioned, almost half (7) of the 15 central banks with two or more macroeconomic models use a DSGE model as their main model type. The remaining 8 central banks with two or more models, which do not use the DSGE model as their main model, often employ semi-structural models, with 3 CBs indicating more specifically the use of quarterly prediction models (QPM).



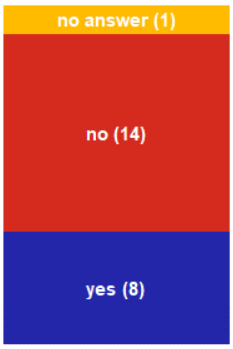
Use of the models in other areas

Almost one-fifth of central banks use a macroeconomic forecasting model or models exclusively for monetary policy purposes, i.e., for preparing domestic macroeconomic forecasts (inflation, GDP, interest rates, exchange rates, etc.). Most central banks (19) also use these models to prepare the macroeconomic framework for financial stability scenarios. Additionally, about one-third of central banks (8) have a forecasting model developed specifically for the purposes of macroeconomic stress scenarios for the financial sector.

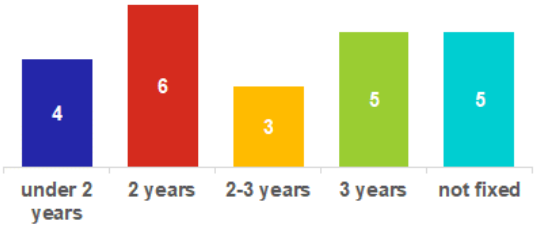
11.1 Macroeconomic forecasting models (or model) and their use within other fields.



11.2 Does your CB have a macroeconomic forecasting model developed specifically for the purposes of macroeconomic stress scenarios for the financial sector?



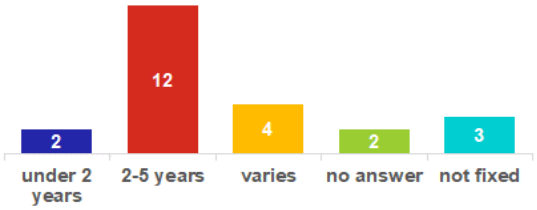
12.1 What monetary policy horizon (horizon for bringing inflation back to the target) do you use?



Monetary policy horizon

The most common monetary policy horizon (the horizon of most effective transmission) is exactly 2 years. Often central banks do not have a fixed monetary policy horizon, and it can change depending on the current situation. A horizon shorter than two years is uncommon. Additionally, over 70% of the CBs surveyed (17) have not changed their monetary policy horizon in the last 5 years. However, from our sample of 23 central banks, there is no evidence that the length of the monetary policy horizon differs between those using DSGE models and those that do not.

13.1 How long (number of quarters) does it take your model(s) to converge close to the steady state?



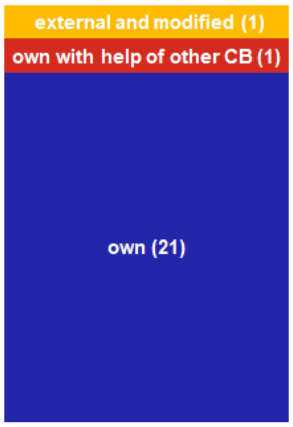
Time of convergence of the model to the steady state

In about half of the central banks surveyed (12), the models converge to the steady state within 2 to 5 years. In exceptional cases, models reach the steady state level in less than 2 years. Some central banks indicated that the time of convergence depends on the nature of shocks, making it difficult to specify a fixed convergence period.

Role of the model in formulating monetary policy recommendations

We also asked central banks about the usual deviation of the model interest rate path from the actual monetary policy recommendation on interest rates. A total of 14 CBs responded: 13 that prepare an unconditional interest rate forecast and 1 that prepares a conditional forecast. Of the 13 CBs using an unconditional forecast, 9 reported that the deviations are usually within the range of one "standard change" in interest rates, i.e., up to 25 bp. Three CBs stated that deviations are typically greater than 25 bp, while 1 CB noted that the deviation may be either less or greater than 25 bp.

15.1 Your macroeconomic forecasting model(s):



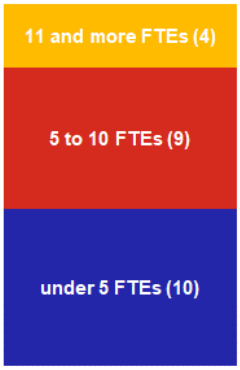
Own model or outsourcing

In the vast majority of countries surveyed, the model (or models) was developed by the staff of the respective CB. There are only two exceptions. In the first case, the CB's staff developed the core model with the technical

help of other central banks. In the second case, the CB uses a model bought from an external provider, which it later modified in-house.

Size of the modelling teams

16.1 How many FTEs (full-time equivalents) operate the main forecasting model?



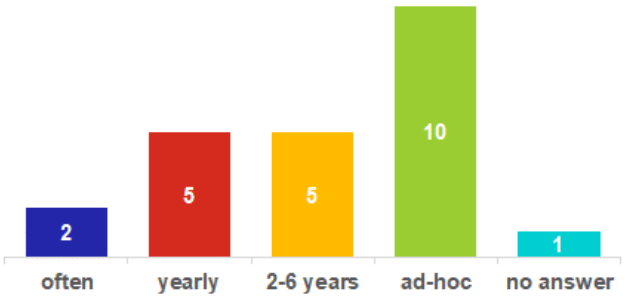
16.2 How many days on average does it take to prepare a forecast from kick-off meeting to submission of the final forecast report to the Board?

A total of 10 central banks, representing around 40% of the countries surveyed, have up to 5 FTEs (full-time equivalents) operating their main forecasting model, while one fewer central bank (9 in total) has teams of 5 to 10 FTEs. Only four CBs out of the 23 surveyed have larger teams with more than 11 FTEs operating the model. With these team sizes, the process of preparing a forecast from the kick-off meeting to its approval takes an average of 2 to 4 weeks for two-thirds of the CBs surveyed. Only one CB can complete the process in less than 2 weeks. For the remaining almost one-third of central banks, the process takes more than a month.

Recalibration of the models

More than 40% of central banks recalibrate the parameters of their macroeconomic forecasting model(s) on an ad-hoc basis, typically when there is a specific reason or impetus for doing so. Another significant number of central banks recalibrate their models at regular intervals, either annually (5 CBs) or once every 2 to 6 years (5 CBs). Two central banks indicated that they recalibrate their model frequently. If CBs use additional models (besides the core model), they also recalibrate them on an ad-hoc basis or within a 2 to 6 year period.

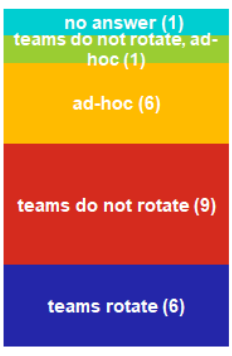
17.1 How often do you recalibrate your macroeconomic forecasting model(s)?



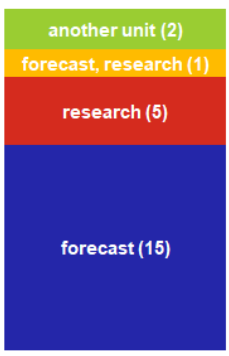
Refinement of the modelling framework

In almost two-thirds of CBs (15), the refinement of the modelling framework is typically carried out by a permanent team, with one group responsible for preparing the macroeconomic forecast and the other focused on maintaining the model(s), testing existing model linkages, and incorporating new ones. These teams either rotate (6 CBs) or do not rotate (9 CBs). In the remaining countries of the sample, the refinement of the modelling framework occurs occasionally (on an ad-hoc basis), with a team usually put together to incorporate new linkages or test the existing ones in the model(s). The teams developing the models are mostly (15) part of the department which prepares the macroeconomic forecast. In more than one-fifth of the countries (5), these teams are in the economic research department while in two CBs, they are in another organisational unit compared to the other two groups mentioned above.

18.1 Which system for refining the modelling framework is characteristic of your CB?



19.1 In which department is the team that develops models located at your CB?

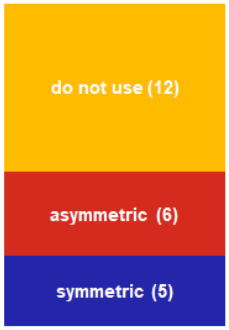


The Covid crisis, the future

The majority of the CBs (13) stated that the turbulent episodes of this decade (the Covid and energy crises) have not prompted them to introduce, or plan to introduce, another alternative or complementary macroeconomic forecasting model into their modelling framework. However, 10 CBs have already made or plan to make changes to their modelling framework.

Communication of model paths

21.1 Do you use fan charts to communicate the model paths of the main forecasted variables (inflation, GDP and any others)?



21.3 Are you considering introducing a communication tool similar to the Fed's dot plot?

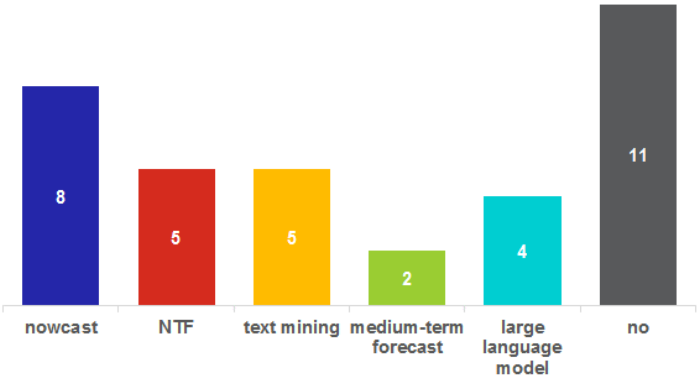
A total of 11 out of 23 CBs surveyed use fan charts to communicate the model paths of the main forecasted variables (inflation, GDP and any others). Five of them use symmetric fan charts, while the remaining six use asymmetric ones. The remaining 12 CBs do not use fan charts for communication at all. Central banks use various approaches to the set confidence intervals for forecasts, the most common being the consideration of historical forecast errors.

The vast majority of central banks surveyed (19) do not plan to introduce a communication tool similar to the "dot plot." Only one CB indicated already using such a communication tool. In the case of two CBs, discussions on its possible introduction appear to be underway.

Artificial intelligence (AI)

More than half (12) of the CBs surveyed are already using AI tools in the forecasting process. A closer look at these CBs reveals that the most common use for machine learning methods is in the preparation of nowcasts (8 CBs). AI is also popular for preparing near-term forecasts (NTFs) (5 CBs) and for text mining (5 CBs). AI is used minimally to prepare medium-term forecasts (only 2 CBs in the sample). Large language models, such as ChatGPT and Gemini, are still in the early stages of adoption among the CBs surveyed (4 CBs). The most extensive use, involving several (at least three) AI tools simultaneously, is reported by 5 CBs. However, the field of AI is evolving very rapidly.

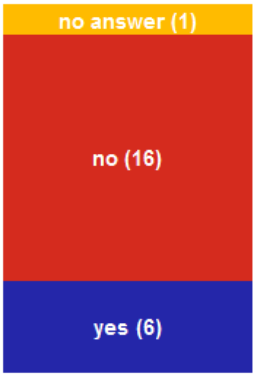
22.1 Do you use AI tools in the forecasting process?



Future of the modelling framework

Almost 70% of the CBs surveyed (16) do not regard their current modelling state (one/more than one model) as permanent. Central banks in this area most often plan various improvements to their existing modelling frameworks over the next two and five years, rather than replacing them. If relevant, they may also introduce an additional "new" model. Given the rapid pace of change in automation, big data processing, and artificial intelligence, CBs also anticipate new opportunities for their modelling frameworks. A total of 6 CBs consider their situation relatively stable.

23.1 Do you regard your current state (one/more than one model) as permanent? What are your plans for this area over the next two and five years?



3. Results for central banks using multiple models

Multiple models and the motivation for their existence

As mentioned, almost two-thirds (15) of the 23 CBs surveyed use more than one full-scale model to prepare their macroeconomic forecasts. Therefore, the following description examines the situation in these 15 CBs.

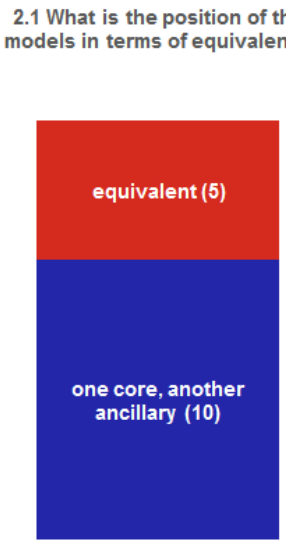
All 15 CBs report using multiple alternative economic concepts as the reason for implementing more than one model, with the majority (11) also using the alternative model to provide a different level of detail. Other reasons for implementing multiple models include increasing the robustness of forecasts, providing a different perspective on supply and demand, or focusing on certain uncertainties. Multiple models are also used for alternative scenarios, to address specific economic issues, or to validate the results of the main model.

Six CBs responded affirmatively when asked whether they have "discontinued or considered discontinuing one or more alternative forecasting models," but their comments indicate that this was mostly due to the development of new models or organisational reasons, rather than the unsuitability of the existing set-up.

Equivalence of the models (forecasting and scenario creation) and internal monetary policy processes

In CBs that use two or more models, the most common approach (in 10 CBs) is to regard one model as the core model, with the other one(s) regarded as ancillary. The remaining third of CBs treat their models as equivalent in terms of their use in the forecasting and decision-making process. The status of the models is mostly communicated to the public and to experts, but not always in the same way they are used and understood within the CB.

In CBs where one model is considered the core model (10 CBs), for the vast majority (9 CBs), the ancillary models mostly have a control role or are considered when fine-tuning the baseline scenario produced by the core model. According to the questionnaire, the ancillary models mainly play a supporting role, and their forecasts are not prepared with the same level of detail as the core model. In cases where the models are equivalent, their individual projections are directly combined to form the baseline scenario by averaging (arithmetic or weighted average, where expert judgement is most often used to determine the weights).

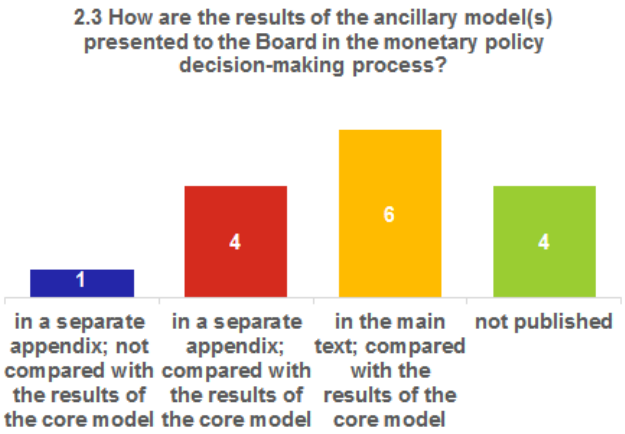


It is worth noting that in 2 CBs, the model output is not considered binding for the baseline scenario; instead, the scenario is primarily based on expert judgement, which is based more or less on the model output. In this context, 5 CBs reported that they do not publish the direct outputs of their models.

When preparing scenarios, a total of 10 CBs reported using both models, while the remaining 5 CBs use only the core model for this purpose.

Communication of the model forecasts to the Board

The outputs of the ancillary model(s) are most often communicated to the Board (MPC) in the main text describing the forecast or in a separate appendix, and they are compared with the results of the core model. Some CBs do not regularly communicate the results of the ancillary models, either because they serve only as inputs for the baseline scenario or are used in averaging (as mentioned above).



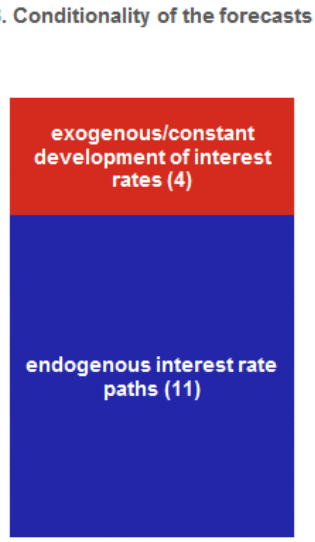
Preparation of the model forecasts and their accuracy

Model-based forecasts are most often prepared by a single team when multiple models are used, with only 3 CBs having independent teams for their models. In most CBs, the preparation of forecasts involves the same input data assumptions as well as the same initial conditions,[1] such as a shared perspective on supply and demand pressures on inflation.

The accuracy of the forecasts is most often assessed internally, with 8 CBs conducting internal assessments and 6 CBs also publishing these assessments. Only one CB does not assess the accuracy of its forecasts. More than half of the CBs (8) assess forecast accuracy based solely on statistical criteria, 2 CBs assess it based only on the evolution of the individual exogenous factors using counter-factual simulations, and 3 CBs use both approaches.

Conditionality of interest rate forecasts

From the perspective of forecast conditionality, CBs using two or more models mostly use endogenous interest rate paths (a total of 11 CBs). However, 4 CBs take a different approach in this regard, using either exogenous or constant interest rate paths. Two CBs fix the interest rate for the entire forecast horizon.



[1] The question distinguished between "same input data assumptions" and "same initial conditions" with the following explanation: Same input data assumptions = same information set and deduction of input data as of a certain date. Same initial conditions = same input data assumptions + consensus on the interpretation of the data based on which the unobserved model variables are set at the start of the forecast horizon (e.g. broad consensus on the assessment of inflation pressures as demand- or supply-driven).