

Macroeconomic models for monetary policy: State of play and way forward

Key findings from a SUERF workshop in cooperation with the ECB, Bank of Finland & Banca d'Italia
Online Event, 3 February 2022

Conference Report

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Introduction

On 3 February 2022, over 250 experts gathered for an international workshop to discuss on “Macroeconomic models for monetary policy: State of play and way forward”. The workshop was designed by Matthieu Darracq Paries, ECB; Ernest Gnan, OeNB and SUERF; Juha Kilponen, Bank of Finland, and Alessandro Notarpietro, Banca d'Italia.

Ernest Gnan, SUERF Secretary General, emphasized that economic models play a central role in modern central banks' assessment of the state of the economy (nowcasting), the forecasting of macroeconomic developments and inflation over the relevant policy horizon (2-3 years), the calibration of the adequate monetary policy stance and instruments, the appraisal of costs, benefits and risks of alternative policy routes (e.g. scenario analysis), as well as the identification of long-term secular economic trends. The workshop took the release of the Eurosystem Report of the [Work Stream on Eurosystem Modelling \(2021\)](#), which was one of the results from the ECB's 2020-2021 Strategy Review and which has also been published as ECB Occasional Paper No 267 last September as an opportunity to bring together global experts in the field to discuss the state of play and the way forward. The three co-chairs of this workstream, Matthieu Darracq Paries, European Central Bank, Juha Kilponen, Bank of Finland, and Alessandro Notarpietro, Banca d'Italia presented key findings and conclusions from the Eurosystem Report. These findings were compared with related work in major non-EA central banks, including top researchers and model developers from the BIS, the Fed, the Swedish Riksbank, the Bank of Canada, the IMF, Norges Bank and from King's College.

The topic of central bank models and forecasts has gained urgency recently due to economists' difficulties in adequately forecasting the strength and the persistence in the rise of inflation across the world. Beyond these short-term challenges, there are also major long-term structural changes which challenge economists, model builders, forecasters and stress-testers: the possibility of de-globalization, ageing and climate change and the energy transition may exert price shocks and alter the medium to long-term trend of productivity growth, r^* and inflation, among other things.

The workshop translated the technical modelling work into a policy-oriented format accessible to economic policy makers, financial practitioners and economists active outside the narrow field of economic modelling and forecasting. The aim was to provide orientation over the multitude of evolving workstreams and approaches, to encourage benchmarking and cross-fertilization between institutions,

to link interested researchers. SUERF hopes that this workshop will only be the first such gathering and that it will open avenues for future cooperation and exchanges.

For the **workshop program**, including the **presentations**, see [here](#).

For the **workshop video replay**, including timestamps of individual interventions, see [here](#).

Session 1 - Evolving role of macroeconomic models in central banks' monetary policies: Key lessons from recent Strategy Reviews

Fiorella De Fiore, **BIS**, opened the session by summarizing the key results from three major central banks' (Fed, ECB, Bank of England) monetary policy strategy reviews over the past 18 months. The Fed switched to flexible average inflation targeting, the ECB adjusted its price stability target to around 2 percent, the Bank of England elaborated on its approach of flexible inflation targeting. Structural economic models, notably DSGE models, but also semi-structural models were used to study the optimal monetary policy aims, while models were employed less for other questions such as the assessment of the state of the labor market or of climate change. Three questions arise now: First, do these new frameworks and our existing modelling toolkit increase the risk that central banks may fall behind the curve in the current situation of increased inflation? Second, are the models that we have adequate to gauge the effects from climate change? Third, is our modelling toolbox up to new challenges from fintech and CBDC?

Alessandro Notarpietro, **Banca d'Italia**, offered an introduction into the new ECB report on Macroeconomic modelling strategies in the Eurosystem. The report focuses on macro models regularly used for forecasting and policy analysis. The models used are quite diverse, comprising structural, semi-structural and time-series models; regarding geographic scope, they extend to individual countries, the euro area or the world; they are used for projections, monetary policy simulations and/or other policy purposes. Projections are typically done using large country-specific semi-structural models, given their flexibility and their data-driven nature. Forecasting is done bottom up, with the models being standardized to some extent. Most of these models do not specifically cater for the zero lower bound. Scenario analysis is done using structural DSGE models, they complement the narrative of projections. They reflect the interaction between fiscal and monetary policy, and incorporate the effective lower bound on interest rates. Two prominent examples are the ECB projections (BMPE and MPE), where the model-based input is supplemented with expert judgement; and the assessment of monetary policy measures. While NCBs run their own models, there are important and regular co-operations, notably in the Working Group on Econometric Modelling. A good example is the jointly developed EAGLE model. The suite of models approach is also typically used in non-EA central banks. It offers a good balance between model diversity and specialization. The model toolkit has expanded very much since 2003. Projection models have become more resilient. Regarding climate change, we are still in the early stages of developing adequate modelling tools. There, the global dimension needs to be reflected particularly well, given the global nature of the challenges from climate change. In the area of DSGE models for monetary policy analysis, there have been notable advances in incorporating the financial and banking sector. Regarding agent-based and stock-flow models, they are being developed and used in euro area central banks, but are not used so far for monetary policy analysis.

Fabian Winkler, Federal Reserve Board, gave a presentation on Modeling Expectations for the [Fed's Framework Review](#). The Fed did not have a formal review and stock taking of their modeling approaches. There is a [series of 13 memos to the FOMC](#) which are publicly available. The Fed's suite of models includes the FRB/US model, integrated balances sheet models, Heterogeneous Agents New Keynesian (HANK) models, small scale New-Keynesian models etc. In the rest of the presentation, Winkler focused on [memo no 5](#), which covers modelling exercises to study the effects from "make-up strategies". In particular, these exercises study what happens if only part of the public understands average inflation targeting. The finding is that Average Inflation Targeting (AIT) is effective if financial markets understand its implications, even if other agents, such as households, do not understand or follow this as spending in FRB/US responds to long-term borrowing rates. Second, a commitment to overshoot the inflation target could lead to an increase in long-run inflation expectations. A question asked there was how unanchored long-run inflation expectations affect AIT. The finding is that rising inflation expectations necessitate faster tightening and increase the cost of AIT. Third, the transition between policy regimes was studied. Existing literature on the evaluation of makeup strategies either assumes perfectly rational expectations or permanent cognitive or behavioral frictions. What if agents learn, e.g. in case of a switch from inflation targeting to price level targeting? Policy makers cannot talk the talk, they need to walk the walk. An important result is that, while in the long-run you achieve lower volatility, the transition to price level targeting leads to higher volatility due to learning in the interim. If the switch to such a new policy regime occurs in a recession, costs dominate over benefits under the assumption of learning. This is because the effective lower bound (ELB) on interest rates slows down learning, as does the surge in inflation.

Ulf Söderström, Sveriges Riksbank, offered a Swedish perspective of how to model monetary policy. The Riksbank has not recently done a monetary policy strategy review. The Riksbank's inflation targeting strategy rests on model forecasts and simulations. The Executive Board's six members' individual accountability makes their different preferences and views transparent to the public. Sweden's nature as a small open economy, the high degree of policy transparency and the large holdings of assets in the Riksbank's balance sheet has important modelling implications. To reflect the international dimension, the Riksbank has made efforts into introducing global trends into the Riksbank's Dynamic Stochastic General Equilibrium (DSGE) model. A challenge is to get co-movement right in DSGE models. The need to include many shocks derived in some of the literature contrasts with empirical evidence of very few driving forces in other research. Regarding forward guidance, the Riksbank has published forecasts of policy rates since 2007. There is the challenge to achieve credible effects of shifting future policy rates in macro models ("forward guidance puzzle"). Despite continued efforts in the Riksbank, it remains a challenge to evaluate what monetary policy effects are reasonable. Regarding asset purchases, there is still not much consensus on how their transmission mechanism works. There are several channels, but which is most important? Are the effects time and state-dependent, and asymmetric? Probably or likely yes. The reasons for different findings across countries lies in institutional differences, e.g. fixed versus variable interest rates, the different scale and character of asset markets. The Riksbank approaches this challenge using a calibrated open-economy DSGE model. Limited resources in a small central bank can at times be a challenge.

Marc-Andre Gosselin, Bank of Canada (BoC), offered an overview of the role of models from the recent [Review of Canadian Monetary Policy Frameworks](#). The Bank of Canada conducts a review of the monetary policy framework every five years as part of the agreement with the government. The [most recent review was concluded in December 2021](#). The first challenge many central banks worldwide face is the higher risk of a binding effective lower bound, given the lower natural rate of interest. A second challenge relates to labor market uncertainties due to technological change, ageing

and globalization. Inflation has become less sensitive to economic changes. Which policy regime is more flexible to cope with such challenges? The BoC did a horse race between six alternative frameworks. Alternative frameworks embed more history dependence or put more emphasis on stability of real variables than flexible inflation targeting. The BoC used various models to conduct this horse race, including model simulations using ToTEM, an estimated large-scale DSGE model for the Canadian economy. They also used laboratory experiments. Flexible inflation targeting (FIT), average inflation targeting (AIT) and a dual mandate yield the best results across various model simulations. AIT is most helpful when the economy is at the ELB. But it can entail more volatility when the economy is not at the ELB. Lab experiments were conducted to understand people's understanding and ability to forecast inflation. Most agents prove to use backward looking expectations. FIT and a dual mandate prove most robust, followed by AIT. FIT outperforms when people pay greater attention to the near future. During ELB episodes, FIT coupled with a state-contingent forward guidance (FG) delivers comparable results as AIT. Public consultation showed that low and stable inflation is most important for Canadians. FIT is easier to understand than alternatives. Key lessons are thus: FIT, AIT and a dual mandate have broadly similar overall performance. Benefits of AIT accrue when the economy is at the ELB. FIT and forward guidance perform equally well at the ELB. A dual mandate improves employment stability only marginally. Where did the BoC end up in its agreement with the Government? A 2% inflation target within a range of 1 to 3%. They will use maximum flexibility within this range to support employment, while making sure that inflation expectations remain stable and well-anchored.

Session 2 - Model development needs – themes and priorities

Session 2 on Model development needs – themes and priorities was moderated by **Matthieu Darracq Paries, ECB**. **Juha Kilponen, Bank of Finland**, identified analytical gaps in the Eurosystem's monetary policy models. The ECB report in Section 4 identified analytical gaps and model development needs: long-term trends, monetary policy transmission, interactions with financial and fiscal policies, climate change, large shocks and uncertainty, and global factors. Derived from these gaps, the report provides recommendations and offers a prioritization, also taking account of the distance in our models from the academic frontier and feasibility considerations. Regarding semi-structural models, these models typically take long-term trends as exogenous or neglect them altogether. Improvements are required. On monetary policy transmission, either model-consistent expectations, VAR-expectations or a mix of both types is advisable. The transmission of non-conventional policy measures need to be modelled better. Semi-structural models should also be used to model sectoral effects e.g. of COVID-measures and NGEU, the interaction of fiscal and monetary policies. Regarding climate change, specific transmission channels at the business cycle frequency should be included; the sectoral dimension and transition policies should be incorporated. Regarding structural models, exogenous long-term trends need to be taken on board, including time variation, potential growth drivers and the natural rate. The monetary policy transmission of non-conventional measures needs to be modelled better, including complementarities between instruments, learning, imperfect knowledge, and side effects. Advanced computational methods should be used to account for non-linearities in the monetary policy transmission mechanism. As regards the development of new models, a focus should be put on household and labor market heterogeneities, including HANK models. Non-linearities of monetary transmission and interactions with macro-prudential policies should be modelled. This would facilitate the cost-benefit analysis of policy measures. Climate change will also require the development of new models, including a modelling of the energy sector, externalities, the global dimension and the role of mitigation policies. Kilponen concluded with some examples, e.g. the behaviour of endogenous total factor productivity in the long term: hysteresis is amplified if monetary policy operates at the zero lower bound.

Jesper Lindé, IMF, leads an IMF team which develops structural monetary models for the IMF's Article IV consultations. Focusing on DSGE models, he discussed four issues: the forward guidance puzzle, the Phillips curve and expectations formation, unconventional monetary policy tools and open economy issues. The FG puzzle needs to be urgently addressed, and a growing literature aims to do so. What are the policy implications of various alternative approaches? The balance between fixing the FG puzzle and the policy implications may be delicate. Compared to a pure rational expectations (RE) approach, if you include discounting in the demand bloc, the differences in outcomes is reduces between various inflation policy rules. If discounting is included in both the demand and pricing, the differences become even smaller. This also implies that the zero lower bound becomes all the less relevant if discounting is included. I.e. if you focus on the short term, then the differences across rules become irrelevant and the effect of the ZLB becomes negligible. Regarding the Phillips curve, it is difficult to reconcile a standard forward-looking flat Phillips curve with the recent surge in US core inflation. In the Smets and Wouters model, the recent surge in US inflation is driven by monetary policy, pricing and wage margins, while the role of fiscal policy is negligible. Regarding inflation expectations, in our models, they are generally well anchored around the central bank's target by autopilot (i.e. assuming the central bank is doing its job). While this is a nice feature, there is an issue if we want to embed it by autopilot in our models. Should a persistent energy price shock be able to move expectations persistently? Should we distinguish between household and market expectations? Recent work by the Linde also explores how non-linearities may help explain inflation dynamics. If non-linearized, the Smets and Wouters (2003) model implies a banana shaped Phillips curve, which may explain an inflation surge. Regarding the modeling of unconventional monetary policies in monetary models, one first needs to think about a benchmark framework for doing so. Models should be able to motivate why unconventional monetary policy (UMP) tools are needed (not for financial stability but for the economic recovery). Should we have a rule for short-term policy rates and large scale asset purchases as exogenous instruments or try to establish rules for all policy instruments? This would be useful for providing alternative scenarios in monetary policy reports. This also leads to the question of how to best model central bank behavior (simple rules versus loss-function based approaches). Finally, Lindé emphasized the importance of co-movement and open-economy spillovers (e.g. spillover of high US inflation to European countries; from advanced economies to emerging market economies). These spillovers can be very large and significant.

Yang Zhang, Bank of Canada, elaborated on model development needs – themes and priorities at the Bank of Canada. She started out with a history of using models to inform policy since the 1960s. The first version of the workhorse “ToTEM” model was introduced in 2005 and been further developed since then. By contrast, the “LENS” model, is closer to data but less detailed. Key challenges currently include: household heterogeneity (income and wealth distribution, uninsurable income risk and precautionary savings), realistic expectations formation in a low neutral rate setting (incorporate insights from lab and survey evidence, greater need to capture non-linearities – ELB and value at risk, understanding extrapolative expectations), thinking in networks (global value chains, global trade and geopolitical uncertainty, commodity price shocks – use multi-sector DSGE models with production networks; modeling the persistent impact of the pandemic on prices), long-term trends and climate change (suite of models approach – interaction between various models to cover various sectors, supply structures and regions, taking account of heterogeneous households and firms).

A general point raised in the discussion related to model uncertainties, which we will neither know nor solve any time soon.

Session 3 - How to improve the use of models for monetary policy?

Session 3 dealt with how to improve the use of models for monetary policy and was moderated by **Alessandro Notarpietro, Banca d'Italia**. **Matthieu Darracq Paries, ECB**, emphasized the need for cost-benefit analyses and prioritization. First, models must deliver in a relevant and meaningful way for the policy narrative. E.g. the ECB's New Area Wide Model II is used to decompose global and domestic shocks to inform monetary policy decision making. Second, economic models serve to share best practices for model based projections and for how expert judgement should be incorporated in the various steps of the forecasting process. A third important field is to allow for a model-based assessment of risk and the building of scenarios. The pandemic highlighted this need, but the point is relevant beyond the pandemic experience. The ECB's "BASIR" model allows to show uncertainty ranges (fan charts) for GDP growth and inflation. Finally, models are needed for monetary policy sensitivity analysis around an enhanced medium-term reference scenario; climate change is important in this context. Darracq concluded by highlighting the importance and usefulness of information and knowledge-sharing platforms among ESCB model developers and forecasters.

Eleonora Granziera, Norges Bank, offered thoughts on macroeconomic modelling at central banks. Models serve central banks' various core functions. An important choice is to use a core model with extensions versus a suite of models. Norges Bank conducted its latest [model evaluation process in 2019](#). This was done by an external committee, the reference were best practices at relevant other central banks and latest advances in academic research. Regarding model-based narratives, challenges may be the limited ability to interpret innovations in projection models in terms of structural macroeconomic shocks, and the disconnect between the main projection models and the ones used to interpret them. The Norges Bank approach differs from the ECB's. The central model is "NEMO" a New-Keynesian DSGE model used for policy analysis, medium-long-term forecasting, risk management and communication. It is used both for forecasting and policy analysis. Additional models are used besides. Regarding model-based projections, judgement is pervasive in projections. This way, other information flows into the forecast, while the influence of expert judgement is not documented transparently. Regardless of the starting value, ECB forecasts always tend to return to equilibrium values (strong mean reversion). By contrast, Granziera advocated judgement-free forecasts as crosschecks (Norges Bank developed the so-called "SMART platform" for this, which includes all forecasting models used to initialize NEMO). The idea is to bring together various available models and to aim for transparency of the forecasting process and its drivers as much as possible. Regarding model-based risk analysis, currently in the Eurosystem this includes probabilities from expert judgement. By contrast, Norges Bank stopped providing fan charts in 2010. Instead, they now use model-based density forecasts. Regarding model-based monetary policy evaluation, a challenge is that this may hinge strongly on the satellite models used. By contrast, Norges Bank uses a HANK model to understand the heterogeneous effect of monetary policy on households, including the impact on housing. Regarding an enhancement of a medium-term reference scenario, Granziera recommended a fully-fledged model-based medium-term extension of the euro area long-term baseline. A point not included in the ECB report is data-based analysis both in projections and in scenario analysis. New types of high-frequency and very granular data on various aspects of the economy have become very important during the pandemic. This is an important area to pursue. We need to study the usefulness for forecasting and policy analysis with respect to existing data. This includes payments and textual data.

Francesca Monti, UCLouvain and King's College London (and formerly Bank of England), discussed how to improve the use of models for monetary policy. Key challenges when preparing projections for monetary policy are constructing a forecast with a suite of models and judgement, and thinking about optimal policy around this judgemental forecast in a consistent way. Why a suite of models? Models are maps to help us think about the economy in a more structured way. Different models are used for different purposes. Structural models are typically used for policy analysis and scenarios. Time series models are used for short-term monitoring and nowcasting, semi-structural models are used for forecasting, they allow judgement to be brought in more easily. The use of various models for different purposes is understandable but raises issues of consistency. Different central banks have different types of models as core and different compositions of their suite, but all face the same tradeoffs: theoretical consistency vs. flexibility in adjusting and adding judgement, what is incorporated in the core model versus in the suite, consistency and compatibility across models. Work and research go in all these areas. Is it possible to use a common framework for structural and scenario analysis and for monitoring macroeconomic conditions? In Monti's view, yes, e.g. by including high-frequency data into DSGE models (see e.g. [Giannone, Monti and Reichlin, 2016](#)). Judgement still remains a crucial part of forecasts. Judgement enters in various stages of the forecasting process (assumptions, short-term outlook propagation, scenarios...). Between rounds of forecasting, ensuring consistency of judgement may be tricky. It is important to evaluate the value of judgement for improving forecasts. Optimal policy projections are a good starting point for evaluating policy around the (judgement based) forecasts. It is crucial to incorporate risk assessments in the forecast. Methods like entropic tilting can bring insights from judgemental forecasts for all moments, density forecasts and use of mixed frequency BVARs can be useful to gauge the impact of new incoming data on the forecast. In Monti's view, a suite of model is preferable over an overly complex core model. Beware of model creep! Last but not least, models also need sufficient staff resources.

Annex – Video replay – Workshop program, speakers and video replay time stamps

Opening and welcome

[00:00:13](#) Ernest Gnan, OeNB and SUERF

Session 1: Evolving role of macroeconomic models in central banks' monetary policies: Key lessons from recent Strategy Reviews

[00:05:52](#) Fiorella De Fiore, BIS: Introduction

[00:17:45](#) Alessandro Notarpietro, Banca d'Italia: Macroeconomic modelling strategies in the Eurosystem

[00:38:33](#) Fabian Winkler, Federal Reserve Board: Modeling Expectations for the Fed's Framework Review

[00:59:49](#) Ulf Söderström, Sveriges Riksbank: Modelling monetary policy – A Swedish perspective

[01:15:40](#) Marc-Andre Gosselin, Bank of Canada: A Review of Canadian Monetary Policy Frameworks – Model Insights and Beyond

Session 2: Model development needs – themes and priorities

[01:31:06](#) Matthieu Darracq Paries, ECB: Introduction

[01:31:33](#) Juha Kilponen, Bank of Finland: Eurosystem model development needs – themes and priorities

- [01:51:14](#) Jesper Lindé, IMF: Model development needs – themes and priorities
[02:12:19](#) Yang Zhang, Bank of Canada: Model development needs – themes and priorities at the Bank of Canada

Session 3: How to improve the use of models for monetary policy?

- [02:32:42](#) Alessandro Notarpietro, Banca d'Italia: Moderation
[02:32:57](#) Matthieu Darracq Paries, ECB: How to improve the use of models for monetary policy?
[02:45:32](#) Eleonora Granziera, Norges Bank:
[03:05:27](#) Francesca Monti, King's College London:
[03:30:35](#) Closing

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