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Directorate General Economics

ECB macro-modelling strategy:
Suite of model approach

Workshop on Forecasting and Policy Analysis with Semi-Structural Models
Paris, September 25 2019

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The financial and sovereign debt crises have posed challenges to the economics profession and macro modelling in particular, with the ECB being no exception.

All central banks have been affected by the near absence of financial markets in aggregate models of the economy and the neglect of macro-financial linkages.

Over recent years, there have been substantial modelling efforts at the ECB to adapt or develop models by incorporating:

- a variety of financial channels and frictions
- more granularity in terms of sectors and agents
- strengthen the multi-country dimension
- model unconventional monetary policy tools
One or many models?

- Resonance or dissonance between academic research and modelling at policy institutions?

<table>
<thead>
<tr>
<th>Academic research</th>
<th>Policy modelling</th>
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<tbody>
<tr>
<td>Simple and stylised</td>
<td>Realistic and granular</td>
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<tr>
<td>Deep theoretical foundations</td>
<td>Robust to structural uncertainty</td>
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<tr>
<td>Original and strong policy prescriptions</td>
<td>Continuity and consistency with policy paradigm</td>
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- No aspiration to build a model that includes everything

- Need for continuity in the assessment while keeping changing and including new channels and frictions

- **ECB approach**: develop and maintain a suite of macro-econometric models
ECB macro-modelling portfolio for monetary policy preparation

- **MAIN** euro area models
  - **DSGE**
    - NAWM I/II
  - Macro-financial
  - Fiscal/labour market/structural
  - Global economy

- **SATELLITE** models
  - **Semi-structural**
    - NMCM
    - ECB-BASE
    - ECB-MC
  - Sectoral modules
  - NL/TVP EA model

- **Time-series**
  - EA structural DFM
  - EA/multi-country BVARs
  - Short-term forecasting
  - Quantitative risk metrics
## ECB macro-modelling portfolio: guiding principles

| Ensure robustness across modelling approaches | • The range of models portfolio aims at exploiting the trade-off between strong **structural** features and **empirical** performance |
| Aggregate and multi-country modelling of the monetary union | • Capturing the country heterogeneity has become even more important after the financial crisis |
| Interactions between MAIN and SATELLITE models | • Create a common institutional language though MAIN models: only few of them and with appropriate scope  
• But articulate them with specialised SATELLITE models |
| Evolutionary process | • Balance the need to learn from on-going research creativity while maintaining consistency in the model-based input to the policy process |
ECB staff rationale for investing in semi-structural models

- Need to account for country dimension:
  • Managing a multi-country/sector dimension is relatively easier (e.g. in terms of specification and estimation) than in a structural model

- Need to include rich and flexible financial sector with multiple transmission channels:
  • Complementary to DSGE models also under different or hybrid expectations formation, and in combination with satellite financial models

- Need to introduce empirical flexibility in a changing world for timely analyses:
  • Exploit a greater data flexibility and sectoral granularity within a consistent theoretical and accounting framework

- Need to introduce institutional flexibility amenable to the policy process:
  • Forecasting with judgment, incorporating sectoral and/or country-specific expert views
ECB-BASE Model-based projections with different residual rules

Real GDP – Euro area
(y-o-y growth rates, in %)

Private consumption deflator – Euro area
(y-o-y growth rates, in %)

Source: ECB staff calculations based on ECB-BASE. The forecast is produced conditioning on financial, foreign, inventories and fiscal blocks variables. All conditioning assumptions are assumed to be deterministic. The shaded areas represent the 95% (light grey) and the 75% (dark grey) of a forecast density based on drawing residuals from a Bayesian Unobserved Component Model (BUCM) fitted to residuals. The bounds therefore represent the residual uncertainty of endogenous variables, while the uncertainty of the conditioning variables is not taken into account.
ECB-BASE Long term target inflation expectations

- Short term inflation expectations (PC curve) depend on long term attractor ($EHIC_t$):

$$EHIC_t = \rho EHIC_{t-1} + (1-\rho)[\omega^*\text{Inflation Target} + (1-\omega)^*\text{GDP def}_{t-1}]$$

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<thead>
<tr>
<th>Scenario \ parameter</th>
<th>$\rho$</th>
<th>$\omega$</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>0.75</td>
<td>0.6</td>
</tr>
<tr>
<td>Complete anchoring</td>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>De-anchoring</td>
<td>0.75</td>
<td>0</td>
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</tbody>
</table>
ECB-BASE Anchoring and de-anchoring long term inflation expectations

**Private consumption deflator – Euro area**
(y-o-y growth rates, in %)

**Long term inflation expectations target**
(y-o-y growth rates, in %)

Source: ECB projections database and ECB staff calculations based on ECB-BASE. The forecast is produced conditioning on financial, foreign, inventories and fiscal blocks variables. All conditioning assumptions are assumed to be deterministic. The shaded areas represent the 95% (light grey) and the 75% (dark grey) of a forecast density based on drawing residuals from a Bayesian Unobserved Component Model (BUCM) fitted to residuals. The bounds therefore represent the residual uncertainty of endogenous variables, while the uncertainty of the conditioning variables is not taken into account.
ECB-BASE Model-based risk sensitivity: Financial risk events

Real GDP – Euro area
(y-o-y growth rates, in %)

Private consumption deflator – Euro area
(y-o-y growth rates, in %)

Source: ECB projections database and ECB staff calculations based on ECB-BASE. The forecast is centered on the September 2019 MPE. This scenario, Financial set-back, reflects the higher paths for the short- and the long-term interest rates by around 20 and 100 basis points, respectively. The scenario is run under the assumption that only foreign variables are deterministic. The shaded areas represent the 95% (light grey) and the 75% (dark grey) of a forecast density based on a non-parametric bootstrap of historical residuals. The conditioning set to produce the bounds (financial, foreign, inventories and fiscal blocks) is assumed to be deterministic.
EBC-BASE Model-based risk sensitivity: Subdued international environment

Real GDP – Euro area
(y-o-y growth rates, in %)

Private consumption deflator – Euro area
(y-o-y growth rates, in %)

Source: ECB projections database and ECB staff calculations based on ECB-BASE. The forecast is centered on the September 2019 MPE.

This scenario, Subdued international environment reflects lower world demand (by 2 percent at the peak) and losses in external competitiveness akin to a Brexit type of event.

The shaded areas represent the 95% (light grey) and the 75% (dark grey) of a forecast density based on a non-parametric bootstrap of historical residuals. The conditioning set to produce the bounds (financial, foreign, inventories and fiscal blocks) is assumed to be deterministic.
Supplementary material
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<tr>
<th>Economic projections</th>
<th>Risk analysis</th>
<th>Policy analysis</th>
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<tr>
<td>Contribute to the elaboration of the projection baseline for the largest euro area countries</td>
<td>Benchmarking with model-based projections</td>
<td>Impact study of monetary policy options</td>
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<td>Forecasting with judgment and model-based projection narratives</td>
<td>Strategic issues related to Monetary-fiscal-financial policy mix in the euro area</td>
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<td>Statistical Risk metrics</td>
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<td>Scenario analysis of relevant macroeconomic contingencies</td>
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<td>Combining predictive densities: NAWM, ECB-MC/EA, DFM/BVAR, NL/TV modelling approaches</td>
<td>NAWM, ECB-MC/EA, satellite DSGEs</td>
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<tr>
<td>NMCM/ECB-MC</td>
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<tr>
<td>EA: NAWM, ECB-BASE, DFM/BVAR</td>
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<td>BIG 5: NMCM, ECB-MC, BVARs</td>
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Time-series
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- Short-term forecasting
- Quantitative risk assessment

MAIN euro area models

SATELLITE models

Under development
ECB-BASE Model expectations

Simulating de-anchoring

• ECB-MC expectation formation: VAR based or MC
• Allows to simulate change in the long term expectations/end points/perceived steady state

VAR expectation formation

• Long term properties of the VAR are anchored by long term expectations.
• Base VAR variables converge to long term expectations:
  - Inflation: Long term Inflation expectation (Consensus forecast)
  - Interest rate: Long term Interest rate expectations (IR swaps)
  - Output gap: 0
ECB-BASE policy applications: stochastic simulations at the ELB

- Stochastic simulations of the model around the balanced growth path (steady state) allow to assess how often the ELB constrained is binding on average.
- The structure of the Taylor rule and assumptions on the parameters such as the natural rate of interest influence the frequency of the ELB constraint.
- The ECB-BASE simulations are based on bootstrapped residuals and impose an ELB constraint as well as a countercyclical fiscal policy, that is activated only if the output gap is above/below 10 percent.

<table>
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<tr>
<th>flexible Taylor rule (unconstrained)</th>
<th>flexible Taylor rule with ZLB</th>
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<tbody>
<tr>
<td>ELB frequency in %</td>
<td>na</td>
</tr>
<tr>
<td>real interest rate in %</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean output gap in %</td>
<td>0</td>
</tr>
<tr>
<td>Mean inflation rate in %</td>
<td>2.1</td>
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<tr>
<td>Standard deviation output gap</td>
<td>2.1</td>
</tr>
<tr>
<td>Standard deviation inflation rate</td>
<td>1.6</td>
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[Preliminary numbers, to be revisited and to be extended with other policy rules]
Predictive densities around the September 2019 MPE Baseline

2020 Real GDP – Euro area
(annual growth rate, in %)

2021 Real GDP – Euro area
(annual growth rate, in %)

Source: ECB projections database and ECB staff calculations based on: NAWM II, ECB-BASE, BVAR skewed (density forecast from a combination of seven 3-variables BVAR models, with weights obtained by optimizing the combined predictive likelihoods), (QRA (quantitative risk assessment of the September 2019 MPE baseline).
Model-based projections

- NAWM II points to the risk of pervasive economic weakness through 2020
- Time-series models indicate more persistence of past-forecast errors on medium-term inflation projections

Source: ECB projections database and ECB staff calculations based on BVARs and NAWM II.
Update incorporates the new data, new assumptions and the short-term projections up to 2019Q4, conditioned on the short-term outlook.
Model-based risk sensitivity (NAWM II)

Real GDP – Euro area
(y-o-y growth rates, in %)

HICP – Euro area
(y-o-y growth rates, in %)

Source: ECB projections database and ECB staff calculations based on NAWM II. The shaded areas represent the 50% (dark grey) and the 90% (light grey) of a forecast density obtained from a combination of seven 3-variables BVAR models with optimal weights, tilted so that the mean and the skewness match those of the QRA.

Financial set-back: higher short- and long-term interest rates.
Subdued international environment: lower world demand and weaker external competitiveness consistent with a Brexit-type risk event.
Stronger financial easing: lower long-term interest rates.
Supportive fiscal policy: increase in government consumption.