Branching paths: the Czech National Bank's many modelling options

Three external reviews each recommended a different combination of models. The CNB now faces tough design choices, and must also decide how to upgrade its economic research

By **Daniel Hinge**
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In November, the Czech National Bank published the results of an external review of its modelling framework – the first in its history. More precisely, the central bank published three external reviews and one additional benchmarking report, as well as a report detailing the current modelling framework. Between them, the documents offer countless paths that the CNB could take as it works to fix the flaws in its economic modelling.

Each review made somewhat different recommendations on the route ahead. One, authored by **Roman Šustek**, proposed retaining and upgrading the existing model, a dynamic stochastic general equilibrium (DSGE) model known as g3+, supplemented with an expanded set of

satellite models. Another, by John Muellbauer, proposed scrapping g3+ and adopting a semi-structural model, potentially supported by an agent-based model. The third, by Karel Brůna and Martin Mandel, steered somewhere between the other two, recommending at least a temporary period where an updated version of g3+ operates alongside a new semi-structural model.

Speaking to *Central Banking* in November, shortly after the reviews were published, CNB governor Aleš Michl said the bank was still considering the results. But he emphasised the common ground between the three reviews: "The assessments recommend we reduce our reliance on a single model, explore alternatives to DSGE models and expand economic research within the bank."

The CNB now has the chance to enact major upgrades to a framework that – much like the Bank of England's DSGE-led approach – struggled to cope under the extraordinary conditions of the post-Covid inflation surge. But the reviews also highlight the complexity of such a decision. Not only are there myriad choices to make regarding what goes into the model, including the key issue of how to represent the financial sector, but also the

Aleš Michl

Photo: Roberto Torís

question of how the model fits into the policy-making and policy communication process. Then, there is the wider question of how the model operates through time, how it copes with shocks, and how it is upgraded – including how insights from academia and central bank research departments can be incorporated.

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Aleš Michl, Czech National Bank

Time to rethink

The review came about partly because it was overdue, partly due to large forecast errors and partly because g3+ produced a trajectory for interest rates in 2022 that implied the policy rate should rise to 11%. The board strongly disagreed, ultimately raising rates to a peak of 7%, which proved sufficient to curb inflation. These factors all added to a growing dissatisfaction among policy-makers with the CNB's reliance on a single model type, the lack of transparency behind g3+ and the design of the model itself.

Muellbauer, a professor of economics at the University of Oxford, tells *Central Banking* there are many problems with g3+. He notes it makes the "extreme assumption" of Calvo pricing – a fixed portion of firms update prices each period – as well as assuming that uncovered interest parity holds. Both these features have been contradicted by empirical research. In another break with reality, households are assumed to own all the businesses and make investment decisions, and there are no banks or asset prices.

Muellbauer acknowledges the model was improved in 2019, when g3 became g3+. An important change was to add a portion of 'non-Ricardian' households, who immediately consume their income because they have no access to financial markets and therefore cannot smooth their consumption over time. The CNB also added an endogenous foreign sector based on the eurozone, which is a major influence on the Czech economy. Lastly, the bank curbed rational expectations by limiting agents' horizons to three years. Muellbauer says the changes were an "important step towards reality", but on their own were "not enough".
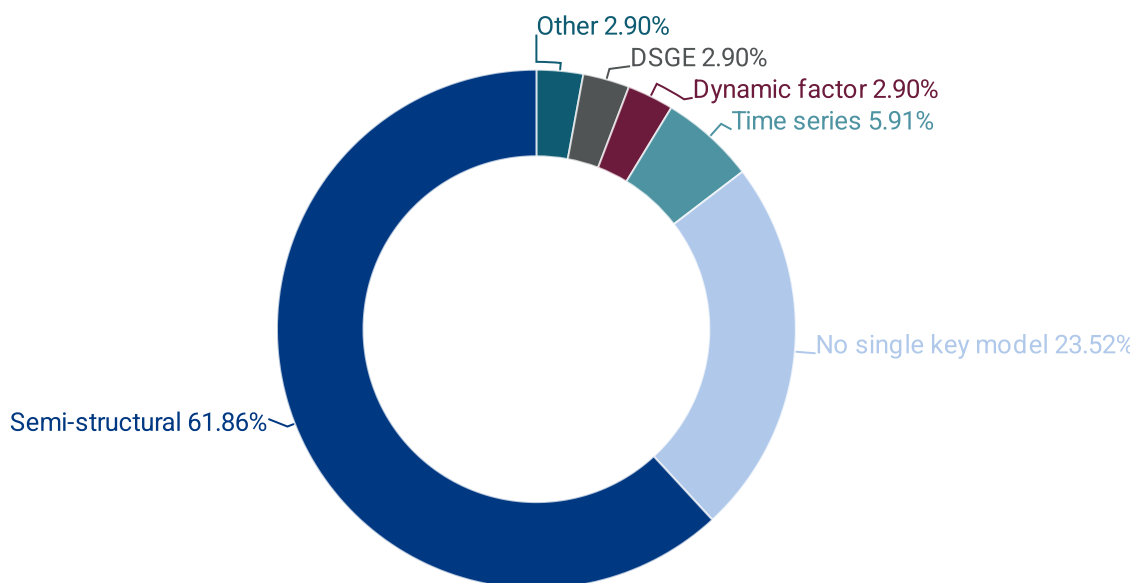
Structural questions

The CNB broadly has two options for its main model: DSGE or semi-structural. The latter model type traces its lineage to the US Federal Reserve's FRB/US model, a large model that is econometric but controlled by a few theoretical restrictions. Semi-structural models tend to be more adaptable than DSGE models and can produce a better fit to the data. However, their size can make it challenging to update them quickly in the event of complex shocks.

DSGE models are often considered more theoretically rigorous, but because they are solved as a system, their size is limited and adjusting the design once they have been built can be difficult. Partly due to this need for parsimony, DSGE models also typically ignore the financial sector, or model it in a relatively limited way, despite its important role in economic dynamics.

DSGE remains dominant in the academic literature. Šustek, a reader in economics at Queen Mary University of London, notes most journal editors are sceptical of economists who keep adding features to their models until they fit the data. DSGE forces an economist to choose a small set of key equations. By contrast, semi-structural models can be expanded until a good empirical fit is achieved – one reason why they are popular forecast tools among central banks. *Central Banking's* Economics Benchmarks 2024 show 62% of central banks use semi-structural models to produce their headline forecasts. Following this trend, in the wake of its recent forecasting review, the BoE has chosen to start developing a semi-structural model. Very few central banks rely as heavily on DSGE as the CNB.

Main forecast model types used by central banks

Other 2.90%
DSGE 2.90%
Dynamic factor 2.90%
Time series 5.91%
No single key model 23.52%
Semi-structural 61.86%

Source: Central Banking Benchmarking Service/Economics 2024

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The CNB could operate both main model types, as many central banks do. This has the advantage that the strengths of one model can offset the weaknesses of the other. But both types are large and complex to maintain, requiring many hours of input from skilled economists. *Central Banking's* model banks analysis shows it is typically large central banks in advanced economies that use multiple key models. These central banks also happen to have much larger economics teams, with more PhD-level staff, and higher rates of pay to attract top talent.

Brůna and Mandel, both economists at the Prague University of Economics and Business, recommend the CNB should develop a semi-structural model and run it alongside g3+ for a time. But, they tell *Central Banking* in emailed comments, this will likely have to be a temporary state of affairs. "At some point, in our view, the CNB will be forced to opt for one of the models as the main forecasting model, with

the other model operating in the background and playing more of a control role," they say. Running two "full-fledged forecasting models" at once "would probably be very demanding and also very confusing for the public", they add.

Though they avoid expressing a strong view on which model the CNB should choose, they highlight the benefits of the semi-structural approach. "The obvious advantage of the semi-structural model is that it can capture the financial sector in a much more comprehensive and detailed way and, at the same time, with much less effort than the existing DSGE model," they say.

Šustek's review ultimately leans towards retaining g3+, partly because it is well understood at the CNB, and partly because DSGE models remain the expected model type in academia, which provides a pipeline of useful development work. He also argues state-of-the-art DSGE models and semi-structural models have many similarities. "On balance, the advantages and disadvantages of the alternative approach do not seem to justify such a major change in the forecasting and analytical system," he writes.
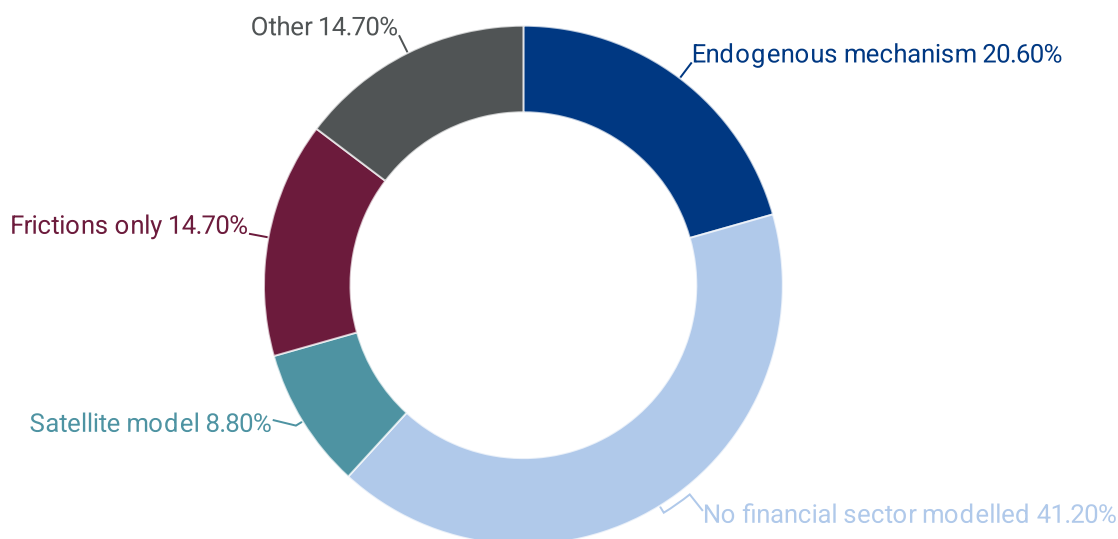
But he acknowledges the pros and cons of both main model types and says the CNB should rely less heavily on one key model, drawing more guidance from an updated array of satellite models. He suggests producing purely statistical forecasts with simple time series models, which can then be used to debate the reasons for any discrepancies with g3+.

Financial features

The reviewers offer many more specific recommendations for elements that could be added to the modelling framework. Muellbauer, Brůna and Mandel all urge the CNB to develop the financial side of the model, which would tend to imply that a semi-structural model is necessary. Brůna and Mandel say implementing their proposed financial elements would be "quite challenging" in a DSGE framework.

Ways financial sector is incorporated in main forecasting models

Other 14.70%

Endogenous mechanism 20.60%

Frictions only 14.70%

Satellite model 8.80%

No financial sector modelled 41.20%

Benchmarking briefing: Just over 20% of respondents include an endogenous financial mechanism in their main macroeconomic model. However, 41.2% of central banks do not model the financial sector at all in this key forecast model.

Source: Central Banking Benchmarking Service/Economics 2024

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Four of Brůna and Mandel's recommendations cover financial elements. In one, they propose a new kind of non-Ricardian household, one that builds precautionary savings and cuts borrowing when risks are perceived to be rising. Muellbauer supports something similar – he points to the work of Angus Deaton, who during the 1990s explored how people facing income risk and liquidity constraints build buffers to protect their consumption, a result left out of the standard New Keynesian framework.

Brůna and Mandel add to their wish list a government bond market and whole yield curve, rather than just short-term rates, as well as a banking system, which can then be influenced by macro-prudential policies. They also propose replacing the short-term interest rate in koruna with an

equation for uncovered interest parity that captures the influence of eurozone monetary policy on the Czech economy.

Similarly, Muellbauer says international issues are "going to be very important" in any model redesign. He points out that a large share of Czech companies are foreign-owned and much of the country's debt is denominated in euros. More broadly, he emphasises how critical it is to understand the financial side of the economy – credit constraints and liquidity – in driving behaviour.

He suggests this might be a reason why g3+ produced such unhelpful recommendations for interest rates during the post-Covid inflation shock. As an example, he outlines a scenario in which inflation and inflation expectations both rise but the nominal interest rate remains constant. In the DSGE model, the lower real interest rate causes an increase in consumption due to intertemporal substitution, which in turn leads the model to suggest a sharp increase in the policy rate is needed.

Muellbauer argues "real world transmission" is likely to be different. The inflation shock makes liquid assets less valuable in real terms, while the value of illiquid assets also falls due to expectations of higher interest rates, creating a negative balance-sheet effect. Because wages are sticky, real incomes fall. Households are sensitive to the near term and therefore are likely to cut their consumption in aggregate, even if a few with ready access to credit can take advantage of intertemporal substitution. With weaker aggregate demand, a much smaller increase in rates is necessary.

A new model type?

Besides the semi-structural model, Muellbauer suggests the CNB could develop an agent-based model (ABM). This would take it into relatively new territory for central banks, though at least one – the Bank of Canada – already uses an ABM for monetary policy-making, and many others, including the BoE, use them for research and macro-prudential policy analysis.

"It's something that's on its way. I think the CNB would be wise to invest," Muellbauer says.

If the situation at the CNB does not improve, in 10 years the bank will find itself being stuck in an institutional groupthink and intellectual isolation from its peers

Roman Šustek

ABMs model the economy as a complex system, simulating what happens when different groups of agents interact. Muellbauer says such a design is helpful for capturing structural shifts, because flows between firms are modelled explicitly. "So, when you have a supply-chain disruption you can put that into the model," he says. The model can reveal how firms react when parts of the economy are shut down. Another possible use is to see the effect of macro-prudential policy – what would be the effect of a tighter loan-to-value ratio cap? In DSGE models of the g3 or g3+ type, "there is no way of doing that", he says.

ABMs rely on highly granular data to allow the creation of a detailed model at a sector level. Muellbauer says such data is available to the CNB, in part through its banking supervision work. He argues the forecasting performance of ABMs "compares well" with DSGE and vector autoregressions.

Avoiding 'intellectual isolation'

Šustek tells *Central Banking* that more important than any single modelling choice is to "come up with a process that is going to be sufficiently robust and sustainable" for operating and developing the central model and any satellites in the long term. The other reviewers make similar recommendations. The model needs to be adaptable enough to cope with shocks and to incorporate new research insights. The CNB's economists also need to be adaptable enough.

This speaks to wider organisation and resourcing issues. Šustek says he believes the central bank has a well-resourced modelling team, but an under-resourced research team, which has impaired the process of model upgrades. "If the situation at the CNB does not improve, in 10 years the

bank will find itself being stuck in an institutional groupthink and intellectual isolation from its peers," he writes.

According to figures Šustek compiled, research staff make up only 0.67% of the CNB's total employees, even when researchers in both the monetary and financial stability departments are counted together. That compares with 1% at the Reserve Bank of Australia, 2.1% at the National Bank of Denmark, 3.1% at the Bank of Finland, 2.2% at the Bank of Lithuania, 1.3% at the Netherlands Bank, 1.2% at Norges Bank, and 3.1% at Sveriges Riksbank.

Central Banking's benchmarking data echoes Šustek's findings. The CNB's peers among advanced economy central banks on average employ research economists equivalent to 3% of total central bank staff, with a range from 0.7% to 4.9%, putting the CNB at the low end. Among emerging market economies the average is 1.4%, ranging from 0% to 4.2%.

The need for stronger research at the Czech central bank was therefore clear and, indeed, the CNB announced in December it was forming a new **research and statistics department**. The new unit merges parts of the monetary policy and financial stability departments, and will be led by Simona Malovaná, previously head of the financial research division. An important task for the new department will be to develop an "alternative macroeconomic model", the CNB said in a statement.
A spokesperson for the bank confirms that the model under development is semi-structural, and will be designed so that it "better incorporates financial factors, enhances flexibility for policy-makers and aligns closely with observed economic data". The new model will take time to develop and test, and will eventually "serve as either an alternative or a complementary framework". The CNB also plans to diversify its modelling tools, "leveraging additional data-driven models and methods, and utilising the granular data we have in-house", the spokesperson adds.

Muellbauer says for the research pipeline to be effective, researchers need to be incentivised to produce research relevant to the CNB's modelling capabilities. That could be a problem if the bank chooses to retain the

semi-structural model, since publishing research based on DSGE modelling in academic journals is much easier. "Career ladders need to be adjusted to reward quality research that enhances the policy-relevant modelling and forecasting capacity of the bank," Muellbauer writes. He tells *Central Banking* that it would be helpful if a journal took a more "positive attitude" to semi-structural modelling. An obvious candidate, he notes, is the *International Journal of Central Banking*, which is run by central banks.

The reviews include various other recommendations the CNB could consider: more opportunity for challenge and debate in the forecasting round; more scenario analysis; a greater willingness to update parameters in the face of shocks; more systematic analysis of forecast errors; and more investment in data. All reflect examples of best practice that are being adopted at other central banks, and all will need to be balanced against limited budgetary resources.

During the interview, Michl kept his cards close to his chest, while making it clear the CNB was preparing for major upgrades to its economics function. "We will start to develop some new models that can challenge the universal DSGE model and will establish a dedicated research team – one that thrives on challenges like this – to elevate our knowledge and capabilities at the CNB to the next level. That will be a priority."

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