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Workshop Summary
"Central Bank Models: The Next Generation"[1]

Introduction

In November 2016, the Bank organized a workshop on "Central Bank Models: The Next Generation" to stimulate the Bank's thinking towards developing the next generation of policy models. In this workshop, Bank staff discussed three important subjects with academics and practitioners: (i) new directions for model development, (ii) desired features of the modeling toolbox, and (iii) the role of models in the policy process. In this note, we summarize the main conclusions for each of these subjects.

1 New Directions for Model Development

The economic data since the Great Recession has demonstrated the overall disconnect between observed economic behaviors and the way these behaviors are modeled in policy models. Moreover, it has highlighted the importance of exploring heterogeneity and financial frictions to account for substantial aggregate fluctuations and acceleration mechanisms. Workshop participants provided a number of new directions for model development that could improve the characterization of economic behavior and our understanding of important economic phenomena. We group these directions in five main takeaways.

Takeaway 1: There is a need to replace some of the key assumptions that influence the characterization of the decision making process of economic agents.

Some of the key assumptions in models pertain to the decision problem of economic agents. There was a consensus that at least three of these assumptions need to be replaced to better describe economic behavior: i) full information rational expectations, ii) complete markets, and iii) household and firm

[1] We thank workshop participants for sharing their views on central bank policy models. We are especially grateful to workshop presenters: Craig Burnside, Jeffrey Campbell, Xavier Gabaix, Itay Goldstein, Paul Hiebert, Peter Howitt, Andrew Levin, Rhys Mendes, James Nason, José Víctor Ríos Rull, John Taylor, and Rafael Wouters. The views expressed here are solely those of the authors and intend to reflect and summarize the views expressed by workshop participants; no responsibility for them should be attributed to the Bank. All errors or inaccuracies are ours.

homogeneity. Important implications of replacing these assumptions for policy analysis were also discussed.

Full information rational expectations has been seen in the profession as imposing discipline in the analysis. However, Craig Burnside (Duke University) and Rhys Mendes (Bank of Canada) argued that it should be possible to maintain discipline while departing from full rational expectations in favor of alternative expectation formation mechanisms such as ambiguity aversion, overconfidence, social dynamics, learning, adaptive expectations, partial myopia, rational inattention, and imperfect and heterogeneous information.

Xavier Gabaix (Harvard) showed how partial myopia would work in a New Keynesian (NK) model. In this variant of the NK model, the agent (household, firm or both) is partially myopic to unusual events and does not anticipate the future perfectly. The degree of myopia is a parameter in the model and can be estimated. A nice property of the model is that it nests the full information rational expectations model. Gabaix also showed important consequences of this modeling approach for policy analysis. First, fiscal policy is more powerful than in the traditional model, given that the agent is not fully Ricardian because she does not anticipate future taxes well. Second, forward guidance is less powerful than in the traditional model because of the agents' myopia about the future.

Complete markets and household homogeneity are critical to derive the standard Euler equation for consumption, which plays a key role in the transmission of monetary policy in current DSGE models. Participants agreed that replacing these assumptions is important to account for critical aspects of household decision making that matter for the response of consumption to changes in the policy rate. For instance, McKay et al. (2016) show that when agents face uninsurable idiosyncratic income risk and borrowing constraints in the standard NK model with full information rational expectations, a precautionary savings effect arises and moderates the response of households' consumption to changes in expected future interest rates.

Takeaway 2: Heterogeneity plays an important role in explaining economic phenomena.

The Great Recession has highlighted the importance of accounting for heterogeneity of economic agents in macroeconomic models. Most of the discussion focused on the important role of household heterogeneity. For instance, Victor Rios-Rull (University of Pennsylvania) explained that wealth and income inequality is a key ingredient for demonstrating formally how the recent financial crisis caused a large drop in consumption in the U.S.[2] Incorporating this source of heterogeneity is particularly important because it allows models to capture the following key facts that are relevant for consumption dynamics: i) recessions affect the consumption of more vulnerable households proportionally more; ii) poor households have higher marginal propensity to consume out of disposable income than rich ones;

[2] Rios-Rull also noted that other important ingredients that provide amplification should complement household heterogeneity to account for the substantial decline in consumption in the U.S. during the Great Recession. These are: i) large fluctuations in house prices; ii) reallocation of resources is costly, which makes it more difficult to rebuild the lost wealth; iii) sufficient feedback from expenditures to productivity such that a recession is accompanied by a reduction in productivity and iv) some form of wage rigidity.

iii) poor households have no wealth while middle-class households are very leveraged; and iv) for most homeowners, the home is their primary or only source of wealth.

Bringing household heterogeneity into policy models is also important for assessing the effects of policies that are not uniform across people. For example, households' experience of the employment-inflation trade-off may be different by income, age, and education groups. Moreover, incorporating heterogeneity of firms and financial institutions could be beneficial for policy analysis, especially for macro-prudential policy which is, in part, concerned with outcomes for the most vulnerable firms, banks and households. Overall, there was consensus that there are many dimensions in which incorporating heterogeneity should be beneficial for central banks' analysis. Regarding the costs, they can be significant but are increasingly manageable with newly developed numerical methods and increased computational power.

Takeaway 3: Accounting for financial cycles has important implications for understanding business cycles.

Standard macroeconomic models fail to account for the observed dynamics of financial cycle variables such as credit and asset prices. In particular, the challenge that these models face is to generate propagation mechanisms that yield more persistence and volatility of financial cycle variables. Paul Hiebert (IMF) argued that theoretical mechanisms based on the interaction of financial frictions with time-varying risk aversion could help account for the characteristics of financial cycles. Moreover, he showed that explaining these features could have important implications for the response of output to technology shocks.

Takeaway 4: It is worth exploring Agent-Based Models (ABMs).

Exploration of new directions for model development can go even further and use alternative paradigms. Given the advent of big data and increasing computing power, ABMs are currently used to examine how the interaction of individual agents' decisions influences macroeconomic outcomes without imposing a specific equilibrium.

Peter Howitt (Brown University) discussed a few examples in economics where ABMs have been used. For instance, he noted that the heterogeneity in agents' leverage constraints captured in an ABM was important to explain the boom and bust in the U.S. housing market. Geanakoplos et al. (2012) use the ABM approach to illustrate the relative importance of interest rates and leverage by simulating the model by freezing either interest rates or leverage, and use this to show that the boom and bust pattern is almost entirely attenuated when holding leverage constant, suggesting that this was the dominant driver of the observed pattern of house prices.

Takeaway 5: The modeling process should be supported by the use of micro-data.

There was consensus about the importance of employing micro-data in the modeling process. First, surveys of consumers' and firms' expectations can help to discipline the modeling of expectations. Second, the parameterization of our models should be based on micro data, given the existence of weak

identification of structural parameters and over-fitting. However, participants acknowledged that it can sometimes be challenging to establish a clear link between the available micro data and what a parameter means in the model. Finally, micro-data can help to distinguish between competing models that have very similar implications in the relationships between aggregate variables.

2 Desired Features of the Modeling Toolbox

All models are false. Consequently, as James Nason (North Carolina State University) clarified, the approach to the modeling toolbox should recognize the trade-off between (i) obtaining useful policy analysis from falsifiable models, and (ii) keeping internal mechanisms clear and coherent, thus allowing policymakers to easily communicate policy decisions to the public. Moreover, he acknowledged that there is a need for different classes of models in macroeconomics because there is no unified theory that can handle all research and policy questions.

The lack of a unified theory of the economy calls for different classes of models to be used by central banks: "Core" models (complex DSGE models with general equilibrium effects) and "Periphery" models (smaller models with features developed from first principles to cover specific sectors or policy issues). Itay Goldstein (Wharton) pointed out that there is a key trade-off between these two classes of models. The first type provides quantitative answers to important policy questions but misses some economic phenomena that require first principles to be understood. The second type deepens our understanding of economic phenomena with qualitative answers but lacks quantitative implications that are usually needed by policy makers.

In turn, Rafael Wouters (National Bank of Belgium) supported the "one for all" approach. In his view, there should be one main central bank projection model that should deliver i) a structural interpretation of the state of the economy; ii) competitive statistical forecasts; iii) counterfactual policy simulations; and iv) integration of real and financial linkages.

Three main takeaways emerged from the discussion of the desired features of the modeling toolbox.

Takeaway 6: Core DSGE models should remain in the toolbox.

DSGE models have been heavily criticized for not being able to account for key features of the Great Recession. Some economists have even suggested abandoning these models and exploring alternative paradigms. However, in the workshop there was consensus that DSGE models should not be dismissed from the modeling toolbox. Several factors supported this consensus. First, in contrast to reduced form and statistical models, DSGE models are based on micro-foundations that are crucial to conduct policy analysis and to analyze and take into account structural change.[3] Second, DSGE models are well suited for providing quantitative answers and for informing the narrative for policy scenarios, given that these

[3] For instance, Jeffrey Campbell (Chicago Fed) mentioned that during the process of forecasting, the structural parameters in the Chicago Fed model have been adjusted with judgement to account for the structural change.

models are internally consistent and comprehensive in terms of sectoral coverage. Third, DSGE models are useful for addressing different questions and are sufficiently adaptable to include new features. Fourth, with the increase in technical and computing resources, DSGE models can be enlarged easily to add key sectors or markets when the latter are critical for studying policy transmission.

Takeaway 7: No clear consensus about how large core policy models should be.

When a core policy model cannot address a policy question, the modellers always evaluate whether to enlarge the policy model or use an alternative approach to answer this question (for instance, building a small model with the relevant feature to address the question). The first approach implies that the size of the core model will tend to grow over time. This led naturally to the following question during the workshop: how large should the core model be? Arguments both in favor and against large policy models were provided by different participants in the workshop.

Jeffrey Campbell (Chicago Fed) and Rafael Wouters (National Bank of Belgium) argued in favour of focusing on one large and comprehensive core policy model. Both of them agreed that if it matters for policy it should be in the model – efforts should always be made to add key sectors or markets that are critical for policy analysis. Before integrating these new sectors or elements in the core model though, simple models should first be developed to better understand the issue. Moreover, they pointed to three reasons for preferring the comprehensive model approach. First, the core model is well suited to provide quantitative answers and is more comprehensive in terms of sectoral coverage. Second, central banks have a resource constraint, so it is better to focus the resources on one model. Third, it is easier to communicate the narrative of policy scenarios based on the results of one model. Finally, model sprawl could be addressed by using factor analysis (Jeffrey Campbell) or sparse programming (Xavier Gabaix) to distil the important factors driving model outcomes.

There were also arguments cautioning against large policy models. First, Andrew Levin (Dartmouth College) mentioned that large models can become "black boxes" associated with difficulty in estimating the parameters or identifying the assumptions that lead to inaccurate or erroneous predictions. In his view, small models are preferable because their internal mechanisms are always clear and coherent, which is extremely important to understand the results and communicate them. Second, Itay Goldstein (Wharton) warned that there are fundamental issues that strongly require relying on first principles and cannot be studied in large models, such as bank runs and panics.

Takeaway 8: It is desirable to explore and broaden the spectrum of periphery models.

Core DSGE models are useful but sometimes limited in incorporating many important phenomena such as crises, speculative bubbles, liquidity runs, etc. For this reason, the profession should develop small micro-founded periphery models with features developed from first principles to focus on specific mechanisms or policy issues. These models can cover sector-specific phenomena or provide qualitative answers to questions of interest. Periphery models are especially important for evaluating risks in the financial system, since few core models do that explicitly.

Expanding the set of the periphery models, unlike expanding the scope of the core models, allows for a much broader coverage of unexplored issues that can be relevant for sound policy. A richer modeling toolbox, therefore, will allow central bankers to address the heightened uncertainty associated with the effects of policy actions on the economy after the last crisis. How can central bankers exploit this richness?

James Nason answered that robust control provides a formal way of drawing policy recommendations from multiple models. In addition, multiple models help to understand, for a given interest rate path, the role of structural shocks in out-of-sample forecasts, which is akin to an evaluation of the cross-equation restrictions of a DSGE model.

Itay Goldstein noted that perhaps the main drawback of models of the periphery is that they do not provide quantitative conclusions, which are so desired by policymakers. He proposed to use the sufficient statistic approach, developed and used mainly in public finance, to obtain quantitative policy implications for specific questions. The idea is that it is sometimes sufficient to estimate endogenous high-level variables instead of the deep "primitive" parameters to arrive at quantitative predictions.

3 The Role of Models in the Policy Process

Modeling tools and the policy process are inherently intertwined. So what can modelers do to make their models useful for policy? And what impact does the policy process have on the design of the models in central bankers' toolbox? Workshop participants emphasized two important aspects of the role of models in the policy process that are summarized in the following two takeaways.

Takeaway 9: Models are useful for evaluating risks and formulating contingency plans to mitigate them.

Andrew Levin (Dartmouth College) proposed using smaller models for identifying material risks and formulating contingency plans for mitigating such risks, i.e., "stress tests for monetary policy." His argument was that this approach allows the formulation of transparent and systematic policy strategies that are robust to model uncertainty, and, in turn, can help achieve coordination and assign responsibilities among different policy institutions.

Rafael Wouters noted that a similar approach to the one proposed by Andrew Levin could be used to design "stress tests for macroprudential policy." Given that macro-prudential policy is usually more interested in outcomes for the most vulnerable banks, firms and households, smaller models analyzing heterogeneity and vulnerabilities within sectors can provide valuable insights for policymakers to evaluate risks associated with macroprudential policies.

John Taylor (Stanford University) argued that the goal of central bank research should be to get back from "path-space" to a "rule-space" policy framework, and that models are designed for the purpose of evaluating policy rules. Taylor cautioned that while specific rules may work well in the model they are

designed for, their performance is mixed in other models, and therefore modelers need to thoroughly check new policy rules or interventions for robustness.

Other participants emphasized that the notion of policy rules does not have a mechanical definition (which would imply zero tolerance for uncertainty) but rather provides a useful benchmark in the context of a risk-management decision framework.

Takeaway 10: Models should be a device of central bank communication.

John Taylor noted that it is very important to have a communication strategy that provides a very transparent connection between policy analysis and policy decisions. Given that models are key tools for policy analysis, it is natural to use them when communicating policy decisions. Taylor acknowledged that there were practical problems to deal with when setting the communication strategy, including uncertainty about the output gap, effective lower bound on the interest rate, or changes in the equilibrium real rate. In Taylor's view, these problems are easier to deal with in a policy rules-based environment.

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