NATIONAL BANK OF KAZAKHSTAN

BUILDING AND IMPLEMENTING DSGE MODELS IN THE FORECASTING AND POLICY ANALYSIS SYSTEM (FPAS) OF THE NATIONAL BANK OF THE REPUBLIC OF KAZAKHSTAN

Monetary Policy Department

Analytical Note No.2025-2

Alisher Tolepbergen

Economic studies and research notes of the National Bank of the Republic of Kazakhstan (“the NBK”) are meant to disseminate the outcomes of the NBK’s studies as well as of other academic research works of the NBK’s staff. Economic studies are disseminated in order to encourage discussions.

Working papers of the NBK’s staff reflect in-process studies as at the date of publication and are meant for discussion and receiving comments and remarks. Opinions and judgments presented in the paper are only personal opinions and judgments of authors and should not be regarded as those reflecting the view of the NBK and its top management.

Building and Implementing DSGE Models in the Forecasting and Policy Analysis System (FPAS) of the National Bank of the Republic of Kazakhstan

March 2025

NBRK – AN – 2025 – 2

Content

Alisher Tolepbergen[1]

On DSGE Models

DSGE models are popular among both academics and practitioners. Many central banks have come to rely on DSGE models to analyze policy and justify economic forecasts. The main feature of DSGE models is their microeconomic basis, which involves optimizing the behavior of economic agents such as households and firms. This feature of DSGE models makes them resistant to Lucas critique[2] which was addressed to non-structural models that are based on reduced-form equations. Accordingly, DSGE models allow policy analysis to be conducted in a clean laboratory setting, with a clear advantage due to a rigorous micro-framework, while traditional macroeconomic models are more suitable for industry analysis due to the broad coverage of the economy.

DSGE models are also used for forecasting, however, there is no consensus among practitioners about their effectiveness compared to other macroeconomic models. Although using the Bayesian estimation method helps significantly in fitting DSGE models to the data, there is also a problem of identification as the model size increases.

Currently, the medium-term forecasting and policy analysis in the NBK's Forecasting and Policy Analysis System are based on the Quarterly Projection Model (QPM)[3]. The QPM is a semi-structural model that includes three blocks where variables are represented in gaps. QPM models, being semi-structural, have a certain degree of flexibility, which allows them to be adapted relatively quickly and easily to different economic structures. On the other hand, the weaker microeconomic basis, compared to DSGE models, does not allow for a comprehensive policy analysis.

In practice, international organizations and central banks with extensive resources use a “set of models”, each of which is adapted to different purposes. Thus, the question of whether to develop and maintain an internal DSGE model ultimately comes down to how much it costs and whether the institution can afford it. Research has shown that it takes more than two years for, approximately, three full-time employees to create an internal DSGE model from scratch.[4]

This analytical note outlines the international experience of using DSGE models in central banks and the proposed structure of the DSGE model for the economy of Kazakhstan. It is worth noting that the note suggests the primary structure of the model, which will be further improved and expanded as the model is evaluated and the parameters are analyzed.

[1] Alisher Tolepbergen – Chief Specialist-Analyst of the Macroeconomic Research and Forecasting Division, Monetary Policy Department, National Bank of the Republic of Kazakhstan.
E-mail: alisher.tolepbergen@nationalbank.kz
[2] Lucas, R., E. 1976. Econometric policy evaluation: A critique. Carnegie-Rochester Conference Series on Public Policy (1), pp. 19-46.
[3] Chernyavskiy, D. 2017. Quarterly Projection model of the Republic of Kazakhstan and its Role in Decision-Making on Monetary Policy. NBRK Working Papers 2017(4).
[4] Norges Bank took 3 years and 3 employees, Bank of England – 2 years and 15 employees, Finland Ministry of Finance – 5 years (Hjelm et al., 2015; Saxegaard, 2017), and Swiss National bank – 2 years (Cuche-Curti et al., 2009).

Review of International Experience

According to a study by Yagihashi (2020)[5], about 40% of the surveyed government institutions (58 institutions[6]) have multiple DSGE models for different purposes and objectives. The majority of institutes (58.6%) have only one DSGE model, 16 institutes (27.6%) have two models, and the remaining 8 institutes (13.8%) have three or more DSGE models at their disposal. Furthermore, 30 institutions (51.7%) use other models along with DSGE models.

About 80% of DSGE models are developed by central banks, which shows that central banks are the main users of these models. Among the surveyed institutions, 37 central banks account for 55 DSGE models. Policy analysis is the most popular stated goal of DSGE models (29 cases or 43%). Next, 15 cases (22%) were reported for forecasting purposes using DSGE models.[7]

The overall study shows that DSGE models are popular among various institutions, primarily among central banks. Most institutions use DSGE models for policy analysis and as an additional forecasting tool. Next, let's look at individual examples of the forecasting and analysis systems of the world's leading central banks.

The two main forecasting models of the Fed are the optimization-based estimated dynamic model (EDO[8]) and the FRB/US[9] large-scale general equilibrium model. The EDO model is a medium-scale DSGE model and has been used since 2006. Along with EDO, the Fed's forecasts are based on the FRB/US large-scale model, which has been used since 1996. The FRB/US concept echoes the approach of the DSGE model, according to which the actions of households and firms are based on behavior optimization, where expectations about future economic conditions play an important role. However, compared to DSGE models, the FRB/US is more flexible due to its semi-structural setup, which allows its equations to better reflect patterns in historical data and facilitates economic modeling with greater detail.

The ECB relies on various models, including time series models, DSGE model New Area-Wide Model II (NAWM II), and semi-structural ECB-BASE and ECB-MC models, for forecasting purposes. The main models for the Eurozone are NAWM II and ECB-BASE, while ECB-MC is used for multi-country analysis. Along with these models, the ECB develops and uses various satellite time series models and a variety DSGE models.[10]

The Reserve Bank of Australia (RBA) is also developing and using several models for forecasting and policy analysis. The multi-sectoral DSGE model (MSM) is a part of the RBA model range and complements other models. Within the RBA's internal models, the MSM is most often used to analyze various scenarios rather than

---

[5] Yagihashi T. 2020. DSGE Models Used by Policymakers: A Survey. Policy Research Institute, Ministry of Finance, Japan.

[6] Of these, 37 central banks, 16 government agencies, and 5 international organizations.

[7] Note: the same model can serve multiple purposes. Business cycle analysis is among the top three (8 cases or 12%).

[8] https://www.federalreserve.gov/econres/edo-models-about.htm

[9] https://www.federalreserve.gov/econres/us-models-about.htm

[10] Ciccarelli et al. 2024. ECB macroeconometric models for forecasting and policy analysis. Occasional Paper Series 344

forecasting, since the causal mechanisms of the model do not always reflect how, according to economic policy-makers, the country's economy works. In addition, the MSM structure is less detailed and does not take into account some aspects of the Australian economy that the RBA experts use for analysis. The main forecasting model in the RBA is the semi-structural macroeconomic model, Macroeconomic Relationships for Targeting Inflation (MARTIN). The MARTIN model is a large system of reduced-form equations that describes both the short–term and long-term dynamics of the Australian economy.[11]

The Central Bank of the Russian Federation (CBRF) develops and uses a set of models, including QPM and different variations of DSGE models[12] for medium-term forecasting and policy analysis. The main forecasting tool is the QPM, while DSGE models allow for additional estimates of forecast trajectories and take into account structural assumptions that are not reflected in the QPM.[13]

A review of international experience in forecasting and policy analysis shows, first, that some central banks have two or more DSGE models. Accordingly, these models are used for various purposes. Second, along with DSGE models, most central banks use semi-structural macroeconomic models for policy analysis and forecasting. Some central banks[14] use DSGE models only. However, since the development and implementation of DSGE models is an intensive and difficult process, it took some time for these institutions to switch to DSGE models. For example, the National Bank of the Czech Republic developed an internal DSGE (g3) model by the end of 2006 and fully switched to it for forecasting purposes only in July 2008. Since January 2007, the predictive capability of the g3 model has been tested for internal analysis.[15]

Small Open Economy DSGE Model Structure

Kazakhstan is a small open economy that exports raw materials to the world market. In particular, oil exports account for a significant share of the country's total exports.[16] The share of gross value added of the oil and gas sector in GDP, on average, is 21%.[17] Tax revenues from oil exports go to the National Fund of the Republic of Kazakhstan (NFRK), where they are accumulated for future generations. At the same time, guaranteed transfers to the republican budget are allocated from the NFRK to cover the budget deficit. Accordingly, when constructing the DSGE model for Kazakhstan, along with the generally accepted characteristics of the modern DSGE model (the presence of nominal and real rigidities, household heterogeneity, etc.), the abovementioned aspects inherent to the

[11] Ballantyne et al. 2019. MARTIN Has Its Place: A Macroeconometric Model of the Australian Economy. Research Discussion Paper – RDP 2019-07.
[12] The CBRF developed DSGE models for small open economy, with fiscal and banking sectors. Accordingly, each of the models is used to answer certain questions and serves certain purposes.
[13] Forecasting and Modelling in the CBRF: https://www.cbr.ru/dkp/system_p/
[14] Czech National Bank, The Central Bank of Chile, Narodowy Bank Polski, etc.
[15] Andrle et al. 2009. Implementing the New Structural Model of the Czech National Bank. Working Paper Series 2.
[16] On average, between 2005-2023 the share of oil exports in total exports amounted to 54-60%, and in some periods the share exceeded 2/3. Source: NBRK calculations based on data from the BNS ASPR RK.
[17] Data for 2010-2023. Source: https://stat.gov.kz/ru/industries/economy/national-accounts/dynamic-tables/

economy of Kazakhstan should also be taken into account. The general structure of the DSGE model for Kazakhstan is provided below.

Non-Oil Sector

The non-oil sector consists of three types of firms: domestic, importing and exporting firms. Domestic firms, in turn, consist of a labor packer, intermediate, and final goods producers. The introduction of the labor packer into the model allows for the differentiated supply of labor by households. Intermediate goods firms produce differentiated goods using physical capital and labor (the labor packer good) and operate in a monopolistic environment. A producer of final goods combines intermediate goods and produces a homogeneous product that is used for consumption and investment.

The presence of a labor packer and monopolistic firms allows for nominal rigidities in wages and prices, respectively. Intermediate goods firms face a random probability that they can set prices optimally. Otherwise, these firms index prices based on past inflation and the inflation target. The same mechanism works in the labor market for wages.

Importing firms purchase homogeneous goods in the world market, differentiate them, and sell them in the domestic market for consumption or investment. Exporting firms purchase homogeneous goods in the domestic market, differentiate them, and sell them in the foreign market. Importing and exporting producers have monopoly power and can set prices. The price-setting mechanism is identical to the process faced by producers of intermediate goods in the domestic market.

Oil Sector

In global oil production, Kazakhstan is a peripheral producer with a small market share. The average share of oil production in Kazakhstan in global production and consumption is about 1.87%.[18] The price of oil is determined, exogenously, in the world market. For convenience and simplification of the model, it is assumed that oil production is determined exogenously and is entirely exported.

Households

Households make consumption and supply differentiated labor. The economy consists of two types of households, Ricardian and non-Ricardian, which differ in the degree of access to various financial resources. Ricardian households are not liquidity-constrained and have access to financial markets to smooth consumption. Also, Ricardian household consumption is prone to habit formation and preference shocks. Non-Ricardian households, in turn, are liquidity-constrained and do not have access to financial markets. The constrained households consume all their income each period.

The consumer basket of households consists of goods produced domestically and imported goods. The total investment good is also given as a function of investment goods produced domestically and those imported from abroad.

[18] Data for 2010-2023. Source: https://www.eia.gov/

Fiscal Policy

Government revenues are generated from taxes, issuance of debt, and transfers from the NFRK. Government spending accounts for consumption, interest payments on debts, and transfers to households. In the model, the government debt to GDP is determined exogenously.

The dynamics of the NFRK assets are determined by the receipts of tax revenues from oil production, interest earnings from investment activities, and transfers to the budget.

Monetary Policy

The central bank conducts monetary policy using a nominal interest rate. Monetary policy is based on the Taylor rule and responds to inflation and the output gap.

Foreign Economy

The foreign economy is determined by the SVAR model. Variables of foreign inflation, GDP growth, and interest rates can be used to determine the foreign economy. The approximation of the foreign economy can be based either on one large economy (the USA) or on a weighted average of the trading partner countries.

Conclusion

This analytical note outlines the need to build an internal DSGE model for the purposes of policy analysis at the NBK. First, DSGE models are more suitable for policy analysis due to their strong microeconomic foundation. Second, the successful experience of leading central banks and international organizations in using DSGE models demonstrates their usefulness and importance in the analysis and forecasting system. In addition, this analytical note describes the preliminary structure of the DSGE model for a small open economy, which takes into account the specifics of the Kazakhstani economy along with the generally accepted characteristics of business cycles.

International experience also shows some challenges in building and implementing DSGE models for policy analysis and forecasting purposes. First, the time to build and operate the DSGE model depends on the resources of the organization. The sufficiency of human capital and its continuous development are important factors. Second, the vast majority of central banks use several models for forecasting and policy analysis purposes. Semi-structural models are still being developed and used due to the conceptual and empirical flexibility of these models, which makes it possible to introduce various alternative specifications and additional blocks, as well as provide industry-specific details. Thus, the planned introduction of DSGE into the NBK's model block will complement the existing methods of analysis and forecasting and will strengthen the analytical tools for conducting monetary policy.