# MAKRO – The Next Generation of Models Designed for Supporting Projections and Policy Analysis at the MoF

Denmark has a long history of developing econometric models. For example, the ADAM modeling project was started in the 1970s and managed by Statistics Denmark. The ADAM team has done an excellent job in organizing data for macroeconomic projections and policy analysis. MAKRO represents the next generation of macro models that incorporate forward-looking and optimizing behaviour. It has been designed specifically by the DREAM Model Development Team (DMDT) to support projections and policy analysis by economists at the MoF.

The External Evaluation Team (EET) was very impressed that the DMDT has successfully developed a state-of-the-art Overlapping Generations Model. The MAKRO modeling framework can be used to study longer-term demographic issues (e.g. ageing-related issues such as pension reforms and fiscal sustainability) as well as to support annual projections and policy analysis, which also needs to obviously focus on the short term and medium term.

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## INTENDED USES OF MAKRO

- Medium and long-term macroeconomic projections and analysis of public finances (fiscal sustainability).
- Impact assessment of policy measures and exogenous shocks (e.g. COVID-19 and the GFC).
- Framework for helping to impose macroeconomic consistency in both near-term projections and longer-term projections. But it is important to understand that MAKRO is not intended as a tool to generate near-term forecasts.
- The existing version of MAKRO is also not intended to study the effects of different policy measures on labor supply and structural unemployment, but given estimates of such measures on these variables, MAKRO can be used to study their macroeconomic and fiscal implications.

## DESCRIPTION OF MAKRO:

- MAKRO is a true-blue overlapping generations (OLG) model, meaning that it has a detailed demographic structure of the age composition of the population (and labor force), which changes slowly over time. It features 100 different age cohorts, and each cohort consists of two types of households: hand-to-mouth households that consume based on their disposable income; and forward-looking unconstrained households whose consumption depends on financial wealth as well as their current and future income.
- The firms in the model are also forward-looking and optimizing.
- International trade is modelled via an Armington trade system where it is assumed that Denmark and the rest of the world are trading goods that are imperfect substitutes.
- Income, prices and the interest rate in the rest of the world are exogenous.
- The exchange rate is set exogenously, reflecting the fact that Denmark maintains a fixed exchange rate to the euro. Conceptually, this would be consistent with the view that interest rates in Denmark are determined based on the world interest rate plus a country risk premium (assumed to be zero in the baseline).
- A search-and-matching framework is used to model the labour market.
- The model is specified at annual frequency and has a very detailed description of the public sector and of public finances.
- For obvious tractability reasons, the model does not incorporate many real-world features, including uncertainty and the implications of uncertainty on precautionary-saving behaviour - such as what has been experienced in many countries in response to COVID-related shocks. These types of effects in MAKRO and other standard models must be treated as shifts in the consumption function. This provides a good example of where users may have to use judgment in designing scenarios with MAKRO.

## TWO BASIC QUESTIONS FOR THE EXTERNAL EVALUATION TEAM (EET)

Do the theoretical modeling and empirical strategy live up to international standards considering the model's intended areas of application?

Are the qualitative and quantitative properties of the model response to shocks theoretically and empirically sensible?

## EET'S CONCLUSIONS

The short answer is yes to both questions above. In fact, the EET would like to applaud the great collaborative effort of the DREAM Model Development Team (DMDT) from academia and the team at the Ministry of Finance (MoFT). Not only will this framework provide benefits to the MoF in Denmark, but it will hopefully also provide an important source of inspiration to MoFs in other countries and stand as an important example of the benefits of collaboration between researchers in academia and economists in policymaking institutions.

The EET was very impressed that the DMDT was able to develop such a sophisticated overlapping generations model. As modeling experts, each of the EET members naturally have a long list of things on their model-improvement wish list, but they all agree entirely on one thing. It is time to take the model and start using it to help study real-world issues. The model has been designed to study many important questions, including longer-term issues related to ageing (e.g., measures to increase labor supply, pension reforms and fiscal sustainability). The Ministry of Finance Team (MoFT) is also interested in using MAKRO to help impose macro consistency on their evolving near-term and medium-term projections. This will involve using MAKRO to help think through the macroeconomic and fiscal implications of relevant shocks driving the Danish economy.

At the request of the EET, the MoFT has already mapped out a basic strategy for how they plan to use MAKRO to study the implications of very large shocks (COVID and the GFC). The EET strongly encourages this type of work and at the same time want to emphasize the importance of not trying to rely exclusively on one model for all issues. Indeed, for future development priorities, the EET would recommend a suite-of-models approach that would build on the human capital that has been developed thus far on the DMDT and MoFT.

## THE SUITE-OF-MODELS APPROACH

The MoF is quite familiar with this approach. If MAKRO were to become the core annual projection model MoFT will need to revise its internal processes to make sure all the tools have been designed and are being used effectively in this new environment. Box 1 provides an illustrative example of the role of different types of models in an advanced policy environment as well as references to examples of how these models have been applied in practice.

In the Box, MAKRO is labeled as a true-blue OLG model, as it models and keeps track of 100 age-dependent cohorts and how their population (and labor force) size evolves gradually over time. For many issues it is possible to construct simpler representations of the economy than MAKRO. These are models that assume, for example, fixed population shares. In the DSGE tradition, these models are linearized around a steady-state solution to exploit powerful system-estimation methods as well as to dramatically increase the speed of solving the model. The latter can be very important for bringing large and complicated models like MAKRO to demanding production-oriented environments where simulation speed is important for both understanding model results and for meeting tight deadlines.

For some analysis (such as studying fiscal sustainability) it is clearly inappropriate to linearize as the key issues are intimately linked to the nonlinearities in the model. A good example would be using MAKRO to examine fiscal sustainability issues where uncertainty about the global real interest rate has important implications for the costs associated with delaying necessary adjustments in the primary fiscal balance to keep government debt at prudent levels. Hence, the EET applauds both the DMDT and the MoFT for developing such an ambitious model, but for some projects it will be useful to work with simpler representations of the Danish economy.

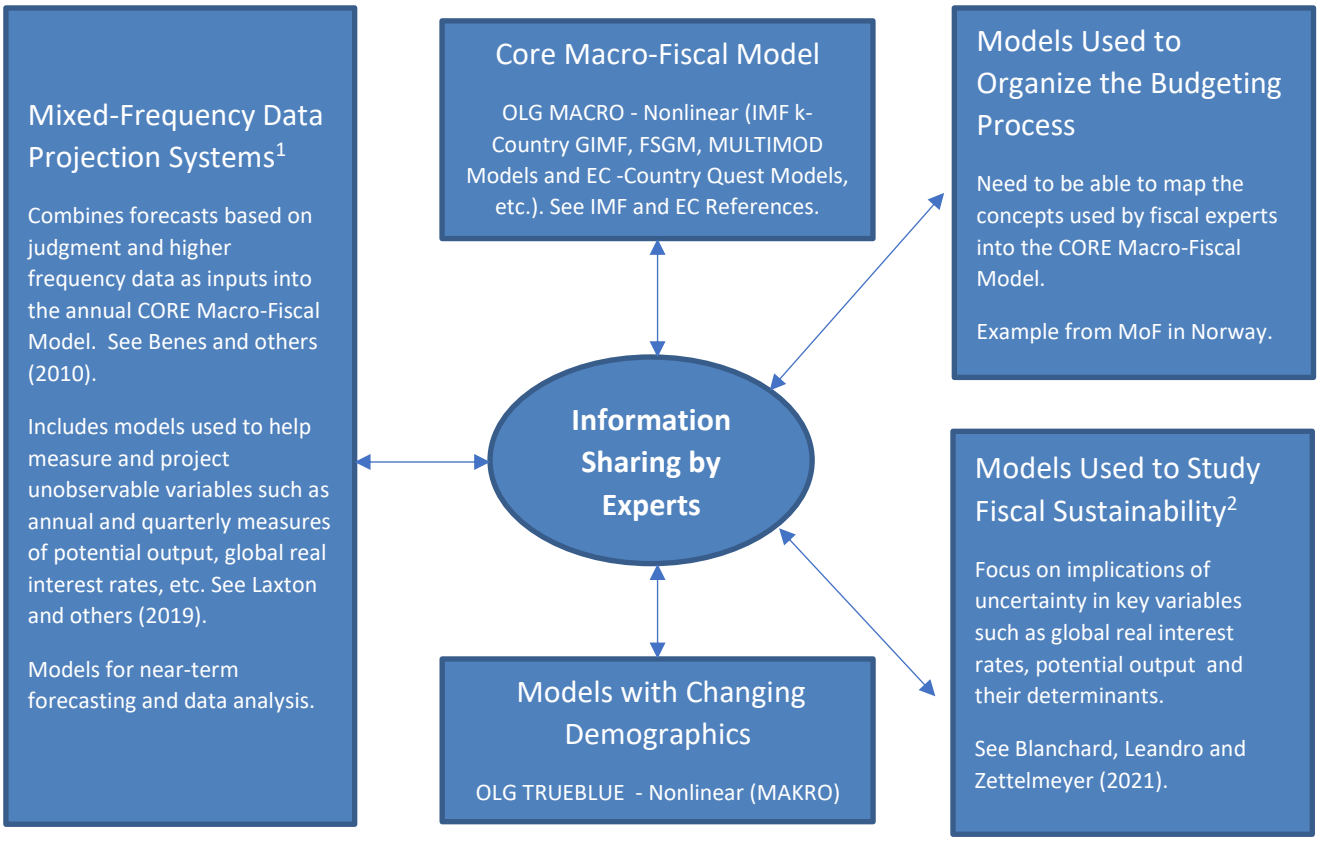
One important advantage of linearization is that it is then possible to employ system-estimation methods for both model estimation and validation. For example, Laxton (2008) lists several advantages of employing Bayesian methods and Benes and others (2010) have provided examples of how these methods have been applied on some of real-world mixed-frequency examples that are relevant for the DMDT and MoFT. Indeed, Laxton and others (2019) provide an example of the U.S. economy that could be used as a good starting point for a modeling framework to help analyze and measure the US equilibrium real interest rate. This would provide a useful starting point for thinking about relevant future foreign interest rate paths that are important assumptions for doing near-term and medium-term projections for the Danish economy.

Another advantage of simpler representations of the economy is that they can be used to help understand key short-run, medium-term and long-term results from the model. In addition, simpler representations of OLG theory (as developed in IMF and EC modeling projects) could also be developed to study specific issues such as the implications of policies that affect labor supply and housing as well as how they interact with other key sectors of the Danish economy.

In summary, the DMDT have done a very impressive job calibrating such a large model using standard techniques and solution methods for dealing with such large nonlinear models. The methodology employed involves trying to match the impulse response functions of MAKRO with an SVAR. One of the advantages

of employing a suite-of-models approach is that it will allow the DMDT and MoFT to use other standard tools for model solution, estimation, and validation.

**Box 1. Example of a Suite of Models to Support Forward-Looking Macro-Fiscal Frameworks**




Box Notes:

1) (a) MAKRO is an annual model and abstracts from higher-frequency daily, monthly, and quarterly data. Benes and others (2010) show how to blend forecasts of quarterly series (GDP etc.) based on higher frequency data with the forecasts of a quarterly semi-structural model. The same ideas can be applied to an annual semi-structural model like MAKRO. (b) Be very careful about deploying purely data-driven times-series models without thinking about the issues---see Kostanyan and Laxton (2021) for an example of using Dynamic factor models to nowcast EU GDP. (c) Laxton and others (2020) provide a model about how to think about the U.S. real interest rate, which will be a very important input for a small open economy like Denmark.

2) Fiscal Sustainability: It is very important to study the implications of uncertainty in global interest rates. Need models to assess the implications of the bubble bursting in bond markets and what the implications will be of a large jump in global interest rates.

## GENERAL COMMENTS ON THE MODELING CHOICES

The model's intended uses are wide ranging. First, the model should be suited for medium and long-run projections and fiscal sustainability analyses. This requires a model that can take demographic changes into account. The model should also be able to handle permanent shocks to technology and labour supply. It also requires a high level of detail to match the level of detail of public finances in the assessment of fiscal sustainability. Second, the model should be suited for analysis of structural fiscal policy measures. This requires a model which has some measure of forward looking and optimizing households and firms, to capture how changes in policy affect agents' behavior. For the model to capture the effects as the economy transitions to new long run levels, the model needs to also include the frictions that affect economic behavior in the short run, for example price and wage rigidities as well as rigidities in household consumption. Finally, the supply block, including the labour market, must be specified such that the model is consistent with stylized growth facts. As a result of these ambitions, the model becomes very rich but also very complex.

## HOUSEHOLDS

The model features two types of households: unconstrained households and hand-to-mouth households. The unconstrained households are forward looking and choose their consumption of non-durable consumption and of housing given their financial wealth as well as their current and future income. They can borrow from banks, including mortgages with housing as collateral, and save in a portfolio of bank deposits, bonds, and domestic and foreign equities. The unconstrained households get utility from bequests. The hand-to-mouth households are assumed to have limited access to financial markets. In particular, it is assumed that they consume all of their disposable income after paying the interest on their mortgages.

In MAKRO, the households are also divided into cohorts by age. Each cohort consists of both hand-to-mouth households and unconstrained households. Age-profiles of income, assets, liabilities etc. are then calibrated to match administrative data.

It is a stylized fact that private consumption generally responds more to temporary income changes than the pure life-cycle model predicts. One driving force is that some households are credit constrained, and therefore consume more of their current income. Introducing hand-to-mouth households in the model is a simplified way of introducing credit constrained households. This is common practice in macroeconomic models and contributes to generate a marginal propensity of consume in the model that is in line with empirical estimates. The specification of the household utility functions also includes habit formation, which means that consumption is valued in relation to a reference level. Habit formation is a standard feature of macroeconomic models and is motivated by the empirical observation that consumption reacts sluggishly to shocks. Overall, the modeling of households is detailed and lives up to international standards.

## LABOUR MARKET

The labour market is modelled according to the search-and-matching framework. This framework is well established for analysis of the labour market, and not uncommon in macroeconomic models in policy institutions. The modeling choice has advantages since the search-and-matching framework explicitly models the matching of firms and workers and the flows in and out of employment. However, in most

applications of the search-and-matching framework it is assumed that all workers are participating in the labour market. This implies that the decision of how intensely to search for a job is modelled, but not the decision of whether to enter the labour market or not. Therefore, the labour market participation of workers is not modelled in MAKRO. Instead, given the level of employment, the labour force and thereby the unemployment rate (defined as unemployed as a share of the labour force) is determined outside of the model. This modeling choice is reasonable given the substantial increase in complexity that would result if the labor market participation decision was included in the model. However, it implies that policy changes that directly affect the decision of whether to participate in the labour market must be analyzed outside of the model.

It is assumed that there is no wealth effect in the wage decisions to facilitate aggregation across cohorts. Standard steady state properties with wages growing with labour productivity is achieved via the wage rule in the bargaining framework which links the real wage to productivity. Perfect labour mobility across sectors is assumed (there is common wage). This is a theoretically consistent assumption and often used in models with a tradable and non-tradable sector. It might nevertheless be interesting to see whether this assumption is consistent with sufficiently high co-movement of wages over the business cycle.

## ASSUMPTIONS FOR THE REST OF THE WORLD

The foreign economy, the so-called rest of the world, is not structurally modeled. The advantage is that it reduces the complexity of the model. The disadvantage can arise when one wants to analyze the effects on the Danish economy of foreign shocks. It is more difficult to assess if changes in Danish export demand originate from supply or demand shocks and if these shocks are global, how they should affect Danish firms and consumers. Current practice seems to be to distinguish between supply and demand shocks by adjusting foreign GDP and prices in an ad hoc fashion.

## SCALE EFFECT

MAKRO assumes so-called scale effects in exports from Denmark to the rest of the world. The scale effect is modelled such that a measure of the structural labour supply (in the private sector) is included in the demand equation for Danish exports. It implies that if the structural labour supply increases, foreign demand for Danish exports increases with a time lag. The inclusion of the structural labour supply in the export demand equation is motivated by a number of empirical studies which stress that exports are driven by an intensive margin (existing goods) and an extensive margin (product innovations). This effect is also shown for Danish exports. On theoretical grounds, the scale effect is motivated by the following argument: an increase in the labour force leads to entry of new firms which produce new varieties of goods. These new varieties will be demanded by foreign consumers, which leads exports to increase.

According to the modeling team an important reason for the scale effect is to eliminate permanent real exchange rate variations in case of permanent supply shocks. In standard models a real depreciation usually occurs when the positive supply shock affects all sectors of the economy, while a real appreciation can occur with a positive supply shock in the tradable sector (together with high labour mobility across sectors). Since MAKRO has a sectoral dimension, the model can generate a range of real exchange rate effects, depending on the sectoral origin of the supply shock. Such a diversity of the exchange rate response is

economically plausible and should be regarded as a plus of the model which allows to look at scenarios under which certain real exchange rate responses can occur.

The modeling of the scale effect is not standard in open economy models. It is well motivated by the observation that product innovations associated with permanent labour supply and productivity shocks can have an additional effect on exports. However, the current specification lacks micro foundations and is too automatic. Hence, the scale effect needs to be used with care. Since the link between employment and productivity shocks are not dependent on specific circumstances in the model (e. g. low skilled vs high skilled employment shock), automatic adjustment of exports cannot be recommended. If, for example, an increase in the structural labour supply results in an increase in high skilled workers employed in the R&D intensive pharmaceutical industry, it is reasonable that it would lead to development of new products and consequently to an increase in Danish exports of pharmaceuticals. In that case, the modeling of the scale effect captures that phenomenon. However, if the increase in structural labour supply results in an increase in employment of low skilled workers or workers employed in the domestic service industry, it is less likely that it would result in new varieties of goods or services demanded by other countries. If that is the case, the scale effect in the export demand function should be switched off in order not to overestimate the foreign demand. Therefore, it is important that the scale effect is used with care. In addition, the supply effect should ideally be relative, i.e., it is the increase in varieties produced in Denmark relative to the increase in varieties produced in other countries which determines the demand for Danish exports. Since the modeling of the foreign economy is not structural, this feature is difficult to capture in MAKRO.

There are also some technical modeling issues to be considered. If one justifies the shift in exports with increased variety (consistent with the Armington framework) then it appears insufficient to implement this by only shifting the export equation. Increased variety by Danish producers affects the utility function of domestic and foreign households and therefore also affects the demand for domestic goods as well as the demand for Danish imports. It also affects the (ideal) CES consumer price deflator for Denmark (not in the rest of the world because of small country assumption). The specification chosen in MAKRO is strictly speaking consistent with the view that a shift in employment and productivity in Denmark only affects variety in export markets.

## FISCAL POLICY

The high level of detail makes the model very well suited for assessments of fiscal sustainability. The cohort structure allows for modeling age-specific transfers. In the model, public investment increases output in the public sector but it does not affect productivity in the private sector as often found in empirical studies (see Bom and Ligthart (2009)). We are aware that productivity effects of public spending shocks can always be added in an ad hoc fashion. Adding public capital, with an explicit output elasticity would nevertheless increase transparency and facilitate the comparison of results on fiscal policy measures to results obtained in the literature. In addition, the model has the typical set of instruments for taxation, including income tax, VAT, corporate income tax etc.

## EMPIRICAL STRATEGY

The complexity of the model implies that it is very difficult to employ local approximation techniques commonly used in system estimation of DSGE models. Instead, the model is calibrated using different strategies for different subsets of parameters.

## BEHAVIORAL PARAMETERS

The so-called behavioral parameters are divided into two categories: the first category is parameters that are estimated separately, either based on own estimations or external literature. The parameter values are motivated by rigorous empirical analysis that has been undertaken for many parameters. The second category are matched parameters. These parameters are calibrated so that the model responses to chosen chocks matches the responses estimated in SVAR-models. This is a method commonly used in the DSGE literature.

Smaller estimated models are often used to decompose a forecast into its main driving shocks or to study how important certain shocks have been in specific historic situations and analyze the stabilizing properties of policy measures during those episodes. Given the size of MAKRO such shock decomposition exercises are difficult to implement. Therefore, there are advantages with developing a smaller, less disaggregated model for such purposes which otherwise shares the same properties with MAKRO, se our recommendations below.

## LEVEL PARAMETERS

The so-called level parameters are calibrated to match historical data. The parameters are then held constant or projected based on time series models, typically ARIMA models. The process for generating projections is automated. Calibrating the parameters to match the data for a base year or historical period is a common procedure for this type of models.

## QUALITATIVE AND QUANTITATIVE PROPERTIES

## RESPONSE TO A FOREIGN SHOCK

Overall, the model response to a foreign demand shock is sensible. However, there is too little co-movement between consumption and investment and there is too little international co-movement. MAKRO shares these two features with many open economy DSGE models. Standard DSGE models and semi-structural models typically have extremely simple assumptions for banking (either no banks or based on loanable-funds theory) and as a result it is very difficult to match the co-movement between consumption and investment (see Benes, Kumhof and Laxton 2014) even for simple and reasonably well-defined shocks such as foreign demand shocks. In the real world, banks provide financing to both households and firms during good times and models that capture these features obviously are designed, among other reasons, to explain the high correlation between consumption and investment. The co-movement between investment and consumption is a well-known problem in standard DSGE models (without banks or banks based on loanable funds theory) and one way of dealing with it in these simple DSGE models is to introduce a so-called flight-to-quality shock (see Fisher, 2015), which implies adding a (linear) preference term for holding risk free assets to the utility function. Therefore, we suggest using a combination of shocks to capture the effects of

temporary changes in foreign demand. This suggestion is in line with one interpretation of co-movement between the domestic and the foreign economy, namely that co-movement is largely due to common shocks. Justiniano and Preston (2010), Chen and Crucini (2016) and Alpanda and Aysun (2014) look at raw material price shocks, financial panics, and technology diffusion as sources for correlated shocks and find that taking these into account, considerably improves international co-movement. Burgert et al. (2020), provide some further evidence on international shock correlations.

There is also a literature which explores ways to increase the transmission mechanism of supply shocks originating abroad. Drozd et al., (2021) explore modifications of the standard model such as (1) imposing more financial autarky, (2) Greenwood-Hercowitz-Huffman preferences, and (3) dynamic trade elasticities (low in short run and high in long run). They find that especially the latter modification increases the international transmission of technology shocks. Bergholt and Sveen (2014) find that allowing for intermediate trade increases the transmission of technology shocks. MAKRO allows for intermediate trade, we would therefore expect that the model disposes of an important mechanism for generating international co-movement of GDP of supply shocks which originate in the rest of the world.

## RESPONSE TO A LABOUR SUPPLY SHOCK

The impulse responses of GDP, the individual demand responses, real wages, and the real ex-change rate are as expected given the structure of the model, the fiscal assumptions (no increase in government consumption and therefore a decline in the tax rate) and the scale assumption made on exports. This is an important quality check given that the model will used to study the consequences of permanent supply shocks.

The MAKRO team provided additional permanent productivity and population shocks which allow to check more precisely the (constant) returns to scale property and the homogeneity constraints in the labour market. This has been done by simultaneously increasing productivity in Denmark and in the rest of the world and to increase government consumption at the same rate. In this case one would expect a long run increase of Danish GDP (and components) identical to the productivity shock and constant employment. The results show that this is nearly exactly the case. A similar exercise has been done with a permanent population shock with similar results. The deviations are small enough for the MAKRO to pass this consistency check.

## LONG-RUN MONEY NEUTRALITY

Long-run money neutrality (e.g., a change in the price level affects only nominal variables) is implied by optimizing behavior. Super neutrality is not generally implied by optimizing behavior. Super neutrality can especially be absent if money demand plays an important role in portfolio decisions. In standard models used for policy one would nevertheless like to have a super neutrality property such that for example, a change in the inflation target does not have real effects in the long run.

The neutrality results presented for MAKRO are close enough such that one can assume that homogeneity restrictions hold in the model. Super neutrality exercises are not standard among model practitioners. Even though a model may have the super neutrality property standard solution techniques will nevertheless run into problems solving models with continuously rising deviations of nominal variables from the baseline.

The MAKRO team has assured that a simple analytical version of MAKRO have the super neutrality property but this cannot be confirmed for MAKRO because of the technical problems mentioned above. This is yet another example where it is useful to have a smaller model in place to check desirable analytical properties.

## SUMMARY OF OTHER SHOCKS

Apart from the three shocks discussed above, on which we have concentrated because of their importance for a small open economy and their relevance for checking model consistency, several temporary shocks on government spending, the interest rate and oil prices have also been presented. The impulse responses are lying within the plausibility range and are also close to the SVAR results.

## TRANSPARENCY

The MAKRO model is a large and complex model, compared to most models used in policy making organizations. The model is a combination of conditions derived from optimization by households and firms and conditions that are determined exogenously or within the model by the model user. This setup brings advantages in terms of flexibility and implies that the model can capture different trends. However, the scale and complexity of the model implies that transparency regarding the driving forces of the model results becomes very important.

## OVERALL ASSESSMENT

The MAKRO modeling project is very ambitious. The basic philosophy seems consistent with the approach taken by modelers at the EU, the IMF and other policy making institutions. We conclude that the theoretical modeling and empirical strategy of MAKRO live up to international standards considering the model's intended areas of application. Overall, the qualitative and quantitative properties of the model response to shocks are theoretically and empirically sensible. We would like to applaud the great collaborative efforts of people in academia and the Ministry of Finance.

## SOME IDEAS FOR FURTHER DEVELOPMENT

- The DREAM Model Development Team (DMDT) has clearly demonstrated their skills in developing complicated nonlinear OLG models. There are important reasons why it would also be useful to build simplified representations of MAKRO. First, it would be easy to do given the skills of the DMDT and work of others in this area. Second, for many business-cycle issues it is simply not necessary to include the effects of the evolving structure of the population and labor force. A simplified version of the model, which should have a well-defined steady state, could be solved extremely quickly with standard techniques that approximate the model's dynamics around the steady state. This open and transparent methodology would allow more users to work with the model and help them develop their intuition to understand the more complex results generated by MAKRO. Having a state-analogue model of any model (MAKRO or simplified versions) helps to facilitate analysis of the long-run effects of exogenous shocks, as well as to study the effects of permanent policy changes. Most importantly, linearizing

around the steady state opens the possibility of using system-estimation methods. We recommend that DMDT first work on a smaller model to develop some experience using these methods and then at some point explore if these techniques would be useful for their more complicated OLG models.

- The scale effect in exports is well motivated by the observation that product innovations associated with permanent labour supply and productivity shocks can have an additional effect on exports. However, the current specification lacks micro foundations and is too automatic and must therefore be used with care. We suggest borrowing from product variety models to more precisely account for all implications of product innovations/increased variety on model equations.
- Currently, the rest of the world is modelled in reduced form. In the future, two alternatives could be considered. First, a structural VAR could be estimated which distinguishes between supply and demand shocks and second, to estimate a small DSGE model for GDP, inflation and the real interest rate (demand equation, Phillips curve, potential output trend and a Taylor rule).
- Since Denmark is a small open economy with considerable trade openness (export/import share of more than 50%) and is highly integrated into international financial markets it is strongly exposed to foreign demand, technology, and financial shocks. A model of the Danish economy should therefore be able to capture the transmission of these shocks. Currently, the model is able to generate the observed international co-movement by assuming that common shocks are important. Co-movement of shocks could itself be the result of, in particular, financial market linkages which are less developed in MAKRO. Together with a more structural specification of the rest of the world, international financial linkages could be further explored.
- The rich demographic structure of MAKRO allows for tracing the consequences of specific fiscal measures (e. g. pension reforms) on consumption and savings of different age cohorts. With standard utility functions one would also expect direct cohort specific effects on labour force participation and wage behavior (via wealth effects). We recognize that adding wealth effects on labour supply in a search-and-matching framework is ambitious but nevertheless we see cohort specific labour supply responses to fiscal measures as a useful avenue for further model development.

## REFERENCES

QUEST Model Documentation: https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/economic-research/macroeconomic-models_en

Alpanda, S., and Aysun, U. (2014), "International Transmission of Financial Shocks in an Estimated DSGE Model," Journal of International Money and Finance 47: 21-55.

Andrle, M., P. Blagrave, P. Espaillat, K. Honjo, B. Hunt, M. Kortelainen, R. Lalonde, D. Laxton, E. Mavroeidi, D. Muir, S. Mursula, S. Snudden, 2015, "The Flexible System of Global Models – FSGM," IMF Working Paper No. 15/64.

Benes, J., K. Clinton, M. Johnson, D. Laxton and T. Matheson, "Structural Models in Real Time," IMF Working Paper 10/56 (March 2010).

Benes, J., M. Kumhof, and D. Laxton, 2014, "Financial Crises in DSGE Models: Selected Applications of MAPMOD," IMF Working Paper 14/156.

Bergholt, D., and Sveen, T. (2014), "Sectoral Interdependence and Business Cycle Synchronization in Small Open Economies," Norges Bank Working Paper, No. 2014/04.

Blanchard O., A. Leandro and J. Zettelmeyer, 2021. "Redesigning EU fiscal rules: From rules to standards," Working Paper Series WP21-1, Peterson Institute for International Economics.

Burgert, M., W. Roeger, J. Varga, J. in 't Veld and L. Vogel (2020), "A Global Economy Version of QUEST: Simulation Properties," ECFIN Discussion Paper 126.

Bom, P. R. D and J. E. Ligthart, (2009). How Productive is Public Capital? A Meta-Regression Analysis," International Center for Public Policy Working Paper Series.

Chen, K., and Crucini, M. (2016), "Trends and Cycles in Small Open Economies: Making the Case for a General Equilibrium Approach," Journal of Economic Dynamics and Control 72: 159–168.

Drozd, L. A., S. Kolbin, and J. B. Nosal (2021), "The Trade-Comovement Puzzle," American Economic Journal: Macroeconomics 2021, 13(2): 78–120.

Fisher, J., 2015. "On the Structural Interpretation of the Smets-Wouters "Risk Premium" Shock." Journal of Money, Credit and Banking, 47(2-3), 511-516.

Justiniano, A., and Preston, B., 2010, "Can Structural Small Open-Economy Models Account for the Influence of Foreign Disturbances?" Journal of International Economics 81: 61-74.

Kumhof, M., D. Laxton, D. Muir and S. Mursula, 2010, "The Global Integrated Monetary Fiscal Model (GIMF)---Theoretical Structure," IMF Working Paper 10/34 (February 2010)

Laxton, D., 2008, "Getting to Know the Global Economy Model and Its Philosophy," IMF Staff Papers, Vol. 55, No. 2, pp. 213–42.

Laxton D., A. Kostanyan, A. Liqokeli, G. Minasyan, A. Nurbekyan and T. Sopromadze, 2019, "Mind the Gaps! Financial-Cycle Output Gaps and Monetary-Policy-Relevant Output Gaps," London School of Economics and Political Science.