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# **TROLL and DYNARE Basics for Solving GIMF**

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## TROLL and DYNARE Basics for Solving GIMF

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## Introduction

GIMF can be solved under two different platforms:

1. TROLL (with FAME).
2. DYNARE in MatLab.

## The TROLL Platform

Strengths of the TROLL platform:

1. Easy user interface.
2. Links easily with powerful database software such as FAME.
3. Excellent for deterministic simulations of models.

## The TROLL Platform (cont'd)

More strengths of the platform:

1. Flexible coding of the model – implicit functions can be used for equations.
  - endogenous variables can be declared in the equations, or as a separate list.
  - removes the need to understand the ordering of the model as it is coded.
  - the only requirement (usually) is that number of equations and endogenous variables are equal.

## The TROLL Platform (cont'd)

2. Can easily simulate forward-looking models – a variety of techniques and mathematical algorithms are available.

⇒ No need to explicitly linearize the model.

3. Large tool box available (from the modelling group of the IMF and TROLL) of TROLL macros for calibrating and simulating larger, more complex, macroeconomic DSGE models, such as GIMF (and others such as the GEM).

## *TROLL and GIMF*

Under the TROLL platform, we can easily, and efficiently, change in GIMF:

1. number of regions;
2. number of sectors;
3. calibration of the economy;
4. parameters of the economy.



## Structure of a Model Run

All contained in *driver.inp*:

1. Create the model, and an initial, functional, steady state.
2. Calibrate the model.
3. Simulate the model, using user-specified shocks.

## Create the Model

- Model code = a TROLL macro, *gimf1.src*
  - Written so that you can specify which sectors you want included in (or excluded from) the resulting model.
  - Flexible number of regions, with names of the user's choosing.
  - each dynamic model equation is paired with an equivalent representation for the steady-state model.
- Once model code is generated, for specific sectors and regions, we simulate an initial "vanilla" steady state, with a symmetric (and simplified) calibration of all the exogenous variables and parameters.

## Calibrate the Model

Calibrate parameters in the model:

1. to replicate national accounts and balance of payments.
2. to match other "great ratios" related to capital, labor, fiscal policy.
3. to match assumptions on the behaviour consumption, wealth, labour demand and supply, investment demand and supply, the financial accelerator.

## *Techniques for Calibration*

1. Calibration and simulation versions of the model differ. Some ratios are taken as exogenous, while related parameters are endogenous.
  - Automated by the TROLL macro *&flipmod*, or simple TROLL commands – both forms appear in the *driver* file.

## *Techniques for Calibration (cont'd)*

- Example – we can state a specific value for the steady-state import-to-GDP ratio.
  - we do not have a value for the parameter that governs the bias of the home country towards imported goods.
  - by endogenizing the bias parameter, we find the value consistent with the exogenized import-to-GDP ratio.
  - Throughout the calibration process, we are increasing the number of parameters “flipped” with endogenous variables.

## *More Techniques for Calibration*

2. It is hard to simulate the model with a new value for the parameter. We need to gradually move the parameter from its old value to a new value.
  - Example – The intertemporal elasticity of substitution of consumption is 0.2; we want a value of 0.5. The model will not simulate at the new value.
    - But, it will simulate at 0.25 easily.

## *More Techniques for Calibration (cont'd)*

- Calibrating the intertemporal elasticity of substitution of consumption.
  - Solution? - Simulate the model at 0.25, save the answer; simulate again at 0.30; save the answer; simulate repeatedly at 0.05 increments until the intertemporal elasticity of substitution of consumption is at 0.5.
- This process is called the DAC (divide-and-conquer) algorithm. This process is automated by the TROLL macro *&dac*, which is used throughout the *driver* file.

## Simulate the Model

Based on code found in the TROLL macro *&runshocks*.

1. Specify the shock in the file that generates *&runshocks*.
  - Not just restricted to single impulse responses. Can do a combination of shocks, both temporary and permanent.
2. Some minimal format requirements in *&runshocks* ensure that the shock can be simulated using one of the methods contained in the TROLL macro *&simshock*.



## *Simulation Methods*

- Three different simulation routines contained in the TROLL macro *&simshocks*.
- User should be aware of them, but the macro does not require any user intervention.

## *Non-linear Simulation*

- Based on the native TROLL simulation methods using a Newton-Raphson algorithm, and stacked time.
- Can be improved using the DAC (divide-and-conquer) algorithm - run the shock in increments.
  - after each increment, save the simulation results, and use then as the starting point for the next increment.

## *Linear Simulation*

Two methods:

1. Numeric linearization around a local steady state - good for temporary and permanent shocks.
  - The non-linear model is simulated. However, the shocks to be simulated are divided by a numeric factor to linearize the model.
  - The model solution (relative to the steady-state) is then multiplied up by the same factor, and shown stacked on the steady-state solution.

## *Linear Simulation (cont'd)*

2. First-order Taylor expansion of the model around a steady-state - good for temporary shocks.
  - Same linearization technique as in DYNARE. Has been tested with the GEM, not yet with GIMF.

## *Simulation Output*

Postscript files, generated by FAME:

- *reportss.ps* – Reports of the steady-state model simulation.
- Graphs of all the output of the dynamic model simulation.
  - all together – *fullpack.ps*, for each country.
  - sets of numbered graphs (18 per country).

## The DYNARE Platform

Free add-in for MatLab – many canned routines and capabilities. It is especially good for:

1. estimation (maximum likelihood, Bayesian).
2. stochastic simulation and impulse responses.
3. monetary policy work - determine optimal simple rules; optimal rules; Taylor frontiers.
4. welfare analysis.

## More on the DYNARE Platform

1. Easy to use – comprehensive instruction manual.
2. Can integrate easily with MatLab capabilities – such as making good graphics of simulation results.
3. Can use non-linear models.
4. Provides checking of model stability – ensures that Blanchard-Kahn conditions hold.

## DYNARE and Model Simulation

- DYNARE can linearize or log-linearize nonlinear models around a steady-state.
  - either as a first-order or second-order Taylor approximation.
- can use a prespecified numeric steady-state, or it can use the nonlinear model to determine the numeric steady state.
- there is also code, compatible with DYNARE, in development, that allows for the easy coding of symmetric multi-region models.



## A Typical DYNARE File

DYNARE files are self-contained, with sections describing, in order:

1. the list of endogenous variables (*VAR*).
2. the lists of exogenous variables (*VAREXO*), and parameters (*PARAMETERS*).
  - followed by their values – sometimes this section is placed after the model code.

## A Typical DYNARE File (cont'd)

3. *MODEL*: model code.

- can be written in fully nonlinear form, including implicit functions.

4. *INITVAL*: initial values for the model – can be a complete steady state, or just starting values.

## *Model-Use Commands*

Commands that use / simulate the model include (roughly in order of execution):

1. *STEADY*: computes the numeric steady state.
2. *CHECK*: linearizes the model around the steady state, and checks the Blanchard Kahn conditions for stability.

### *Model-Use Commands (cont'd)*

3. Any other task you wish to do - estimation, stochastic simulation (for impulse responses), optimal rules, taylor frontiers, etc.
  - Usually consists of set-up (i.e. standard errors of shocks; distributions of parameters to be estimated; priors), followed by the main command (*ESTIMATE*, *STOC\_SIMUL*, *OSR*).

## Using Advanced Modelling Files in DYNARE

DYNARE can be used to code up complex models – i.e. multi-region, not fully calibrated, as in the *driver* file for TROLL.

- Uses the work of Sébastien Villemot of the Banque de France.
- An example is GIMF.

## GIMF as an Advanced DYNARE file

1. Model code can be written, exploiting the MatLab programming language, in terms of equations for a single region.
  - Using looping structures, similar to those in TROLL, the code can be replicated for as many regions as desired.
2. Parameters can be recalibrated using the DAC algorithm during the *STEADY* command, with the *HOMOTOPY* option.

## Further Reading, Listening and Learning

There are a number of resources for TROLL and DYNARE available online:

1. *douglaslaxton.org* - especially the TROLL online training, which explains Newton methods, and how they are exploited for the divide and conquer (DAC) strategy and algorithm.
  2. *www.dynare.org* – download (portal to downloading versions of DYNARE); documentation (includes the excellent user's guide; the DYNARE manual).
- more material will follow as a result of this workshop, over the next month.