

Applied macroeconomic analysis using DYNARE

Macro theory class presentation

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Abstract

This lecture provides a brief introduction to Dynamic Stochastic General Equilibrium (DSGE) modeling using DYNARE. The objective is to build on the student's previous understanding of DSGE modeling and present a simple tool for solving and simulating dynamic optimizing models using DYNARE (built into MATLAB). Topics covered include: installing DYNARE in MATLAB, setting up the .mod file, deterministic simulations and stochastic simulations for linear dynamic models.

Outline

- what is DYNARE and some features
- a simple model
- DYNARE syntax file
- solution of deterministic models
- solution of stochastic models
- summary

References: Clarida et al (1999), Cho and Moreno (forthcoming JMCB), Sims (2002) and Klein (2000)

What is DYNARE?

- DYNARE: A suite of programs for the simulation and estimation of rational expectation models
- Developed by a group of leading applied DSGE researchers headed by Michel Juillard since 1994
- Platforms: **MATLAB**, Scilab and Gauss
- Collection of over 200 functions (MATLAB)
- Widely used by central banks, IMF, academics research and in teaching graduate students
- More information: <http://www.cepremap.cnrs.fr/dynare/>
- Online help/discussion forum available

Features

- Computes the steady state of the D(S)GE model
- Computes the solution of deterministic models
- Computes the first and second order approximation of linear/non-linear stochastic models
- Estimates the parameters of DSGE models using MLE or Bayesian methods
- Computes optimal policy for LQ economies
- Simple regression tool
- Useful checking tool
- No or little programming skills required (That maybe a lie)

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A simple close economy NK model - Households

- The optimization problem:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \{U(C_t) - V(N_t)\} \quad (1)$$

$$U(C_t) = \frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} \quad \text{and} \quad V(N_t) = \frac{N_t^{1+\varphi}}{1+\varphi}$$

$$\text{s.t.} \int_0^1 P_t(i)C_t(i)di + E_t\{Q_{t,t+1}D_{t+1}\} \leq D_t + W_tN_t \quad (2)$$

- FOCS:

$$(C_t - hC_{t-1})^{-\sigma} \frac{W_t}{P_t} = N_t^\varphi \quad (3)$$

$$\beta R_t E_t \left\{ \frac{P_t}{P_{t+1}} \left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}} \right)^{-\sigma} \right\} = 1 \quad (4)$$

A simple model: Cho and Moreno (JMCB)

- IS: Euler equation with habit, Fuhrer (2000)

$$y_t = \mu E_t y_{t+1} + (1 - \mu)y_{t-1} - \phi(r_t - E_t \pi_{t+1}) + \varepsilon_{IS,t}$$

- Phillips Curve: Sticky price, Calvo (1983)

$$\pi_t = \delta E_t \pi_{t+1} + (1 - \delta)\pi_{t-1} + \lambda y_t + \varepsilon_{AS,t}$$

- Taylor rule: Clarida, Gali and Gertler (2000)

$$r_t = \rho r_{t-1} + (1 - \rho)[\beta E_t \pi_{t+1} + \gamma y_t] + \varepsilon_{MP,t}$$

- Matrix form: $AX_t = BE_t X_{t+1} + CX_{t-1} + \varepsilon_t$, $\varepsilon_t \sim (0, \Omega)$

*.mod VS *.m VS *.mat

- *.mod are DYNARE instruction (Syntax) file containing:
 - variables and parameters declarations
 - model declaration
 - shocks, initial and terminal conditions
 - tasks to be performed, eg: steady, check, forecast, simul, stoch_simul, estimation, olr
 - To run in MATLAB, type:
`dynare filename.mod`
- *.m are MATLAB program (function) files:

`function [output]=fcn_name(input)`

DYNARE has a collection of over 200 m-files
- *.mat are matrices produced by MATLAB

.mod file syntax: basic

```
// # declaration of endogenous variables
var inf, y, r;
// # declaration of exogenous variables
varexo eas, eis, emp;
// # declaration of parameters
parameters del, lam, mu, phi, roe, bet, gam, sigas, sigis, sigmp;

//parameter values
del=.5586; lam=.0011; mu=.4859; phi=.0045; roe=.8458; bet=1.6409;
gam=.6038; sigas=.4585; sigis=.3734; sigmp=.7327;

// # specification of the model equations
model(linear);
inf-del*inf(+1)-(1-del)*inf(-1)-lam*y-eas;
y-mu*y(+1)-(1-mu)*y(-1)+phi*(r-inf(+1))-eis;
r-roe*r(-1)-(1-roe)*(bet*inf(+1)+gam*y)-emp;
end;
```

.mod file syntax: simulations

```
// # initial and terminal conditions
initval; y=2; r=0; inf=0; end;

endval; y=0; r=0; inf=0; end;

// # specification of shocks
shocks;
var eas= sigas^2; var eis=sigis^2; var emp=sigmp^2; end;

// # Tasks
check;
simul[(periods=INTERGER)];
// or
stoch_simul[(OPTIONS...)]
    inf y r;
```

Solution of deterministic models

- The model: $AX_t = BX_{t+1} + CX_{t-1}$
- perfect foresight, use 'initval' and 'enval' to specify shocks
- approximation: impose return to terminal condition in finite time
- `simul(periods=30)`: computes the path of variables over a 30 period horizon by solving all the equations for every period
- Results:
 - eigenvalues of the system, no of eigenvalues ≥ 1 should be exactly the same as no of jump variables to ensure unique solution
 - the simulated variables are stored in `y_.mat`

Solution of linear stochastic models

- The linear model: $AX_t = BE_tX_{t+1} + CX_{t-1} + \varepsilon_t$, $\varepsilon_t \sim (0, \Omega)$
- agents decisions are subject to stochastic shocks but the process of the shocks are known
- agents has rational expectations
- DYNARE uses solution algorithms proposed by Klein (2000) and Sims (2002) - generalized Schur decomposition
- Rewrite model: $A_0E_tY_{t+1} = A_1Y_t + v_{t+1}$, where $Y_t = \begin{bmatrix} X_{t-1} \\ X_t \end{bmatrix}$

Idea of the algorithm (optional)

- perform the generalized Schur (QZ) decomposition of the system
- check for the BK condition
- transform the system into a triangular one and isolate the unstable block
- solve unstable (2nd) block forward
- using the solution of the 2nd block and solve the stable block (1st) backward
- the solution of the system can be written as an VAR(1):

$$Y_t = \Gamma_1 Y_{t-1} + \Gamma_2 v_t$$

Decision rule coefficients

- The economic model: $A_0 E_t Y_{t+1} = A_1 Y_t + v_{t+1}$
- Solution: $Y_t = Y^s + A Y_{t-1} + B v_t$
- Y_t and v_t are both in alphabetical order
 - Y^s : `dr_.ys` steady state values
 - A : `dr_.ghx` coef. on state variables
 - B : `dr_.ghu` coef. on exogenous variables
- compute moments, IRFs, forecast etc

DYNARE demonstration

- installing DYNARE in MATLAB
- setting up the .mod file
- initializing simulations
- perform simple deterministic simulation of Cho and Moreno model

What DYNARE can do

- specify a DSGE in linear or non-linear form, no need to write out state space matrices
- solves the model for its decision rule (with linear approximation)
- simulate (both deterministic and stochastic) the solution of the model to produce various statistics of interest: moments, IRF, forecasts, etc
- estimate the model's parameters using MLE or Bayesian methods
- compute optimal policies
- built in conditioning statements

What DYNARE CAN'T do

- write your thesis or get promoted
- solve all your problems without thinking about the problem
- relatively difficult to modify the DYNARE code to produce “non-standard” calculations
- the documentation is still relatively poor at this stage with little explanation on which routines does what
- relatively difficult to detect errors