Econ 413R: Computational Economics
Spring Term 2013
Solving DSGE Models using DYNARE

1 Preliminaries

1.1 Readings and Videos

Look over this chapter as well as the homework so you know what to pay specific attention to during the lecture. I will be going in depth in the advanced topics during that time.

Watch the following Dynare Videos (you can play them in fast mode if you prefer):

i. Dynare 1 by Bryan Perry on YouTube

   http://www.youtube.com/watch?v=ZH-BRQaAaBU

ii. Dynare 2 by Bryan Perry on YouTube

   http://www.youtube.com/watch?v=P9VYrKMAYrE

Consider reading through last year's notes on "Bayesian Inference and Computation", which can be downloaded from the 2013 BYUMCL Bootcamp repository where you got these notes.

1.2   Introduction

Dynare is a software platform which runs on top of MATLAB and Octave. It is used to model economic models which include DSGE and OLG models. Dynare is able to handle various expectations hypotheses including rational expectations, perfect anticipation, and limited rationality (incorporating learning processes). Models are also free to incorporate different types of agents such as consumer behavior, productive firms, governments, monetary authorities, investors and financial intermediaries. Several public and private institutions both national and international use Dynare for policy analysis; it is also employed by professors and researchers in postgraduate macroeconomics courses.

1.3   Installation

Steps to installation and use of Dynare on top of MATLAB:

  i. Download Dynare from www.dynare.org/download

 ii. Select the correct file according to computer

iii. Run execution file

 iv. Set path in MATLAB

  (a) Set Path

  (b) Add Folder

  (c) Select dynare "Matlab" folder (for example: C:\dynare\4.3.3\matlab

  (d) Save

2 Using DYNARE

2.1 The Model File

Dynare model files should be saved as .mod files. The command to run a model file in MATLAB (after having set the correct path) is: dynare filename. The output corresponds to three main structures as well as output in the command window. These structures include `M_` which contains various information about your model, `options_` which contains values of the various options used by Dynare during the computation, and `oo_` which contains the various results of the computations (this is the most interesting and important structure of the three).

A model file contains a list of command and blocks. Each command and each element of a block is terminated by a semicolon. Each block is terminated by the command end; on a separate line. Double backslash `//` comments out a line of code, `/**/` is able to comment out several lines of code when these symbols figure as bookends to those comments.

The main blocks of a model file are the following:

i. Preamble

ii. Model Block

iii. Stead State and/or Initial Value

iv. Shocks Block

v. Computation

Figure below shows a basic template for a model file that has been set up for a stochastic simulation.

2.2 Output

Output includes: steady state results, Blanchard Khan conditions, model summary, matrix of covariance of exogenous shocks, policy and transition functions coefficients, moments of simulated variables, correlation of simulated variables, autocorrelation of simulated variables, and impulse response functions of the variables to each of the shocks.

3 Advanced Topics

3.1 Modeling Tips

3.1.1 Habit Persistence

Let utility in period t be:

$$U_t = \frac{1}{1-\sigma} \left(\frac{C_t}{Z_t^\gamma} \right)^{1-\sigma} \tag{3.1}$$

where C_t is consumption in period t and Z_t is the habit formation "reference" level of consumption.

Z_t evolves according to:

$$Z_t = \rho Z_{t-1} + (1-\rho)C_{t-1} \tag{3.2}$$

Utility is no longer time-separable; the consumption choice today influ-

ences the future habit reference level in next periods and all future periods utility. γ indexes the importance of habit formation in the utility function. If $\gamma = 0$, then the standard model applies; $\gamma = 1$ implies that only consumption relative to previous consumption matters (hence the parameter is between 0 and 1). An increase in current consumption lowers the marginal utility of consumption in the current period and increases it in the next period (the more you eat today, the hungrier you are tomorrow). The parameter indexes the persistence or memory in the habit formation reference level. If $\rho = 0$, then only last periods consumption matters, for $0 \leq \rho \leq 1$, the larger it is the further back in time is the reference level determined.

Using (**??**) and (**??**) we can derive the overall utility function as a function of present and discounted future utility. We get the following expression of the derivative of total utility with respect to consumption in period t.

$$\frac{\partial U}{\partial C_t} = \frac{1 - \sigma}{C_t} U_t - \gamma(1 - \sigma)(1 - \rho) \sum_{i=1}^{\infty} \frac{\beta^i \rho^{i-1} U_{t+i}}{Z_{t+i}} \qquad (3.3)$$

Note that marginal utility today depends on an infinite sum of future utiliies. This makes construction an Euler equation that is a function of the state variables problematic. One possible solution is to create an additional state variable S_t that is this infinite foreward-looking sum. S_t will have a recursive form which makes in much easier to deal with.

To derive the Euler equation, the optimal path of consumption should reflect the fact that an arbitrarily small shift in consumption from one period to the next produces no change in utility. The decline in utility in period t must be equal to the discounted increase in utility in period t+1 with the addition that real interest has accrued on the income saved until the next

period.

3.1.2 Budget Constraints

A period-by-period budget constraint Campbell and Mankiw (1989) of a consumer who invests his wealth in a single asset is:

$$Y_{t+1} = (1 + r_{t+1})(Y_t - C_t) \tag{3.4}$$

Solving forward with infinite horizon and imposing transversality condition, we get the following:

$$Y_t = C_t + \sum_{i=1}^{\infty} \frac{C_{t+i}}{\prod_{j=1}^{i}(1 + r_{t+j})} \tag{3.5}$$

hence todays wealth equals the discounted value of all future consumption.

As above this can also represented as $Y_t = C_t + D_t$, where D_t can be represented in a recursive form.

3.2 Bayesian Estimation

Presented in Class.

A good source for a Bayesian Estimation Tutorial is Dynare 3 by Bryan Perry on YouTube (despite it being an hour long, it is very instructive). http://www.youtube.com/watch?v=RtGW-ZogMqg.

Also, look through last year's notes on "Bayesian Inference and Computation", which can be downloaded from the 2013 BYUMCL Bootcamp repository where you got these notes.

Exercises

Homework 1

Using the methods discussed in section 3.1.1, write a recursive form of the infinite sum, S_t.

Derive the Euler equation.

Homework 2

Using the methods discussed in section 3.1.2, write a recursive form of the infinite sum, D_t.

Homework 3

Using the same setup as Problem 14 from the Week 3 DSGE homework, let's tweak the utility function a little bit by including a preference shock to consumption Lester, Pries, and Sims (2013).

$$u(c_t, \ell_t) = \nu_t \frac{c_t^{1-\gamma}}{1-\gamma} + a \frac{(1-\ell_t)^{1-\gamma}}{1-\gamma}$$

where $\nu_t = (1 - \rho_\nu) + \rho_\nu \nu_{t-1} + \varepsilon_t^\nu$; with $\varepsilon_t^\nu \sim$ i.i.d.$(0, \sigma_\nu^2)$ and $\sigma_\nu = .02$.

nu_t is a multiplicative shock to utility from consumption and will therefore shock marginal utility of consumption as well. It is like a demand shock. Note that the coefficient of relative risk aversion and the elasticity of substitution are independent of this shock.

Also assume $\varepsilon_t^z \sim$ i.i.d.$(0, \sigma_z^2)$ and $\sigma_z = .01$.

Rewrite the two characterizing equations as they should now appear with this preference shock to consumption.

Write the Dynare code to perform a stochastic simulation of this model for 2100 periods, use the second-order Taylor-series approximation, and generate IRFs of all the variables to each shock for 100 periods. Provide the output, graphs and code as part of your homework submission. Comment on the IRF graphs; intuitively describe the responses of output and consumption each of the shocks.

Homework 4

Modify the Dynare code used above, eliminating the stochastic simulation, and gearing it toward a Bayesian estimation of the following parameters: $\gamma, a, \beta, \rho_z, \rho_\nu, \sigma^z$ and σ_ν. You will need to include new variables in your model that are more suited toward Bayesian estimation:

$$dc = c_t - c_{t-1}$$

$$dy = y_t - y_{t-1}$$

These will be the variables you will be observing in the code. I will provide the data file for you. Start your estimation according to the table below.[1]

Do this estimation for 20000 replications, 3 Metropolis Hastings blocks, drop the first 15% of the replications (burn in of 15%), start `mh_jscale` at 0.5 and ADJUST the `mh_jscale` as you monitor the acceptance rate so that you get an acceptance rate as close to 25% as possible once the replications within

---

[1]Prior distributions inspired by the in class example and Del Negro, Schorfheide, Smets and Wouters, 2005

Table 1: Bayesian Estimation Setup

Parameter	Prior Distribution	Prior Mean	Prior St. Dev.
γ	Gamma	2.5	0.05
a	Beta	0.5	0.01
β	Beta	0.98	0.002
ρ_z	Beta	0.90	0.05
ρ_ν	Beta	0.95	0.05
σ_z	Inverse Gamma	0.01	∞
σ_ν	Inverse Gamma	0.02	∞
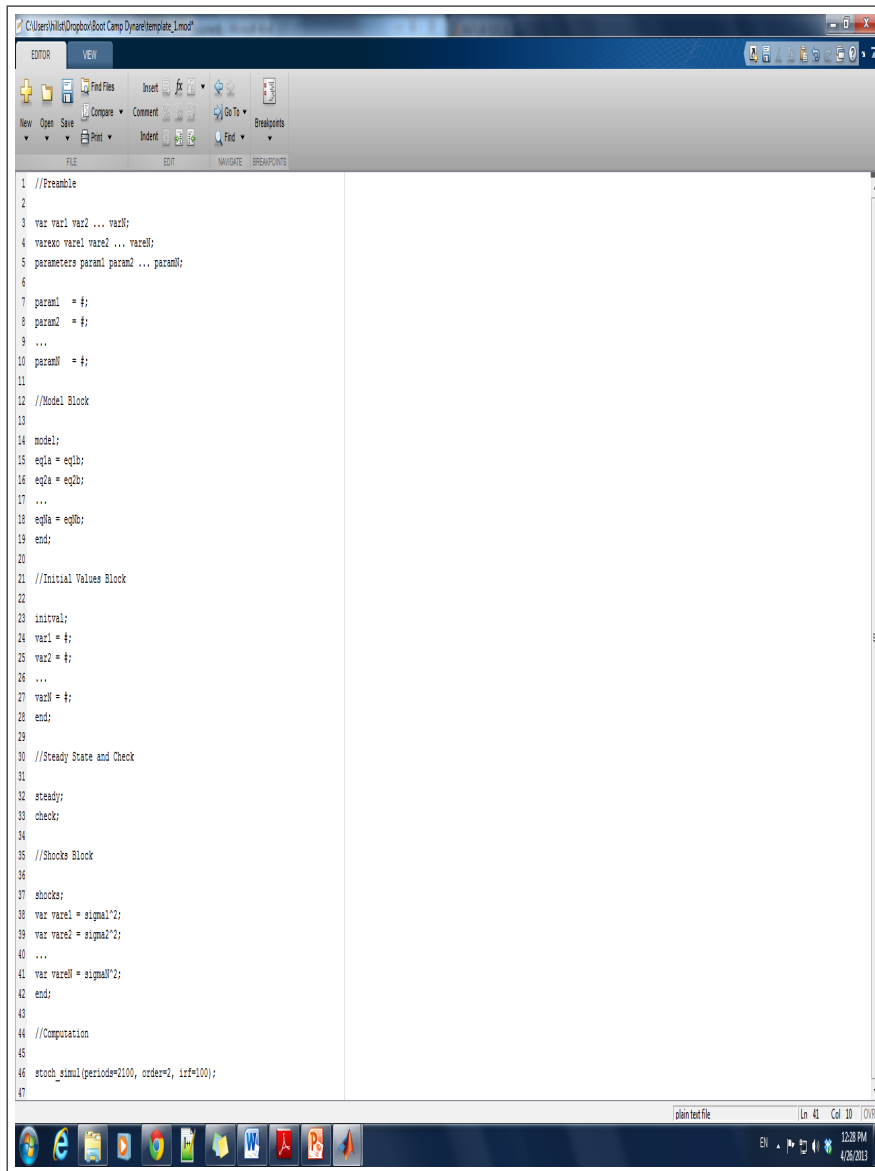
the block seem to stabilize around a particular rate. Report the posterior mode for each of the parameters. This is the most important information. Also report the posterior mean and confidence intervals for each parameter from the provided output. Provide the graphs from the output.

If you were to redo the Bayesian estimation, for which parameters would you re-specify the prior distribution or how would you modify the replication procedure? Use the graphs as support for your answer. If you feel the priors were reasonably specified, provide support (again from the graphs) toward the legitimacy of the priors specified.

References

ADJEMIAN, S., H. BASTANI, M. JUILLARD, F. KARAME, F. MIHOUBI, G. PERENDIA, J. PFEIFER, M. RATTO, AND S. VILLEMOT (2011): "Dynare: Reference Manual, Version 4," Dynare Working Papers, 1, CEPREMAP.

CAMPBELL, J. Y., AND N. G. MANKIW (1989): "Consumption, Income and Interest Rates: Reinterpreting the Time Series Evidence," in *NBER Macroeconomics Annual 1989, Volume 4*, NBER Chapters, pp. 185–246. National Bureau of Economic Research, Inc.

CARLIN, B. P., AND T. A. LOUIS (2009): *Bayesian Methods for Data Analysis, 3rd Ed.* Chapman and Hall/CRC.

DEL NEGRO, M., F. SCHORFHEIDE, F. SMETS, AND R. WOUTERS (2005): "On the Fit and Forecasting Performance of New Keynesian Models," CEPR Discussion Papers 4848, C.E.P.R. Discussion Papers.

FUHRER, J. C. (2000): "Habit Formation in Consumption and Its Implications for Monetary-Policy Models," *American Economic Review*, 90(3), 367–390.

HAAN, W. J. D. (2011): "Dynare and Bayesian Estimation," London School of Economics.

LESTER, R., M. PRIES, AND E. SIMS (2013): "Volatility and Welfare," .

Figure 1: Sample Dynare Model File