Estimation, Solution and Analysis of Equilibrium Monetary Models
Assignment 6: Tutorial on Analysis of an Equilibrium Monetary Model

This is a tutorial that takes you through the estimation and analysis of the general equilibrium model in Altig, Christiano, Eichenbaum and Linde ('Firm-Specific Capital, Nominal Rigidities and the Business Cycle') (ACEL). The estimation strategy chooses model parameters so that the model impulse response functions match the VAR-based estimated impulse response functions as closely as possible. Assignment 2 reviewed the estimation of the VAR-based impulse response functions and this will be taken as a given here. The questions in this tutorial will take you through a limited range of experiments with the equilibrium model. As in assignment 2, this will be done by executing main.m with various different settings of the parameters at the start of that program. Once familiar with the experiments considered here, the interested reader can explore a wider range of experiments by changing the settings of the parameters in main.m in other ways. Of course, the more ambitious reader could expand the range of experiments even further by changing the computational code itself. In any case, you should peek inside solveandsimulate.m and notice how the various steps discussed in lecture are followed: (i) find the steady state, (ii) log-linearize about the steady state, (iii) solve the linearized system. Then, simulate.

Many of the experiments involve comparing the impulse response functions of the model to the impulse response functions from the VAR. In order for the latter to be available, it is necessary to start by estimating the VAR ($estvar = 1$) and storing its impulse response functions and the associated confidence intervals ($estvar = 1$, $ndraws = 200$ - a larger value of $ndraws$ would ensure a more reliable estimate of the sampling uncertainty in the impulse response functions, but would also take a lot of time). The program automatically stores the results of these calculations in a file, which passes the necessary information on to the program that analyzes the equilibrium model. These calculations need not be repeated, unless experiments are done which require impulse response functions from a different VAR.

1. Compute and graph the impulse response functions from the benchmark equilibrium model (set $mimp = 1$, the model parameters are stored in getparam.m.) This question explores how different features of the model contribute to the shape of the impulse response functions. In practice, this is done by changing the value of a model parameter. To see the effect of this change it is convenient to have, on the same graph, both the response in

the benchmark version of the model and the version of the model with the changed parameter value. This can be accomplished in main.m. To see this, note that the part of main.m which graphs the model impulse responses has two calls to solveandsimulate.m. The first call reads parameters from getparams.m and uses the setting of *taux* provided by the user. The second call uses the same parameter values, except for any that might be reset in the lines between the calls. So, to do an experiment simply introduce lines between the calls to solveandsimulate.m to set the parameter values you want to change.

a. For this part of the question, we explore the role of sticky prices and wages in determining the shape of the impulse response functions. Consider first eliminating sticky prices. In fact, ξ_p does not appear as a parameter in the model. It enters via γ in the reduced form inflation equation. So, how do we incorporate a low value of ξ_p? It turns out that whether we adopt the firm-specific or homogeneous capital versions of the model, γ is decreasing in ξ_p. So, we capture flexible prices by setting γ to a high number, say $\gamma = 10,000$. We capture flexible wages in the model by setting ξ_w to a low number, say 0.01. Note too, that in the benchmark version of the model, prices and wages (as well as consumption, investment and capital utilization) are set before the realization of the current period monetary policy shock. For prices and wages to be fully flexible, they should be set after the current realization of the monetary policy shock. Unfortunately, at the moment the software is not set up to easily implement this.

   (i) Consider the effect of making wages and prices flexible (i.e., set $\gamma = 10,000$, $\xi_w = 0.01$). Note that monetary policy shocks are now essentially neutral.

   (ii) Investigate the role of the monetary policy feedback rule when wages and prices are flexible. To do this, set $\gamma = 10,000$, $\xi_w = 0.01$ right before the first call to solveandsimulate.m, so that prices and wages are flexible in both calls. Shut down the monetary policy feedback rule before the second call to solveandsimulate.m. To do this, recall that the policy rule is:

$$\begin{aligned}\hat{x}_{M,t} &= \rho_M \hat{x}_{M,t-1} + \varepsilon_{M,t} \\ \hat{x}_{z,t} &= \rho_{xz} \hat{x}_{z,t-1} + c_z \varepsilon_{z,t} + c_z^p \varepsilon_{z,t-1} \\ \hat{x}_{\Upsilon,t} &= \rho_{x\Upsilon} \hat{x}_{\Upsilon,t-1} + c_\Upsilon \varepsilon_{\Upsilon,t} + c_\Upsilon^p \varepsilon_{\Upsilon,t-1}\end{aligned}$$

So, to shut down the endogenous part of the policy rule, set c_z=0, cp_z=0, c_ups=0, cp_ups=0. Do this between the two calls to solveandsimulate.m. Does the endogenous part of the monetary policy rule have any impact on the response of real quantities (e.g., consumption, employment, capital utilization, etc.) to shocks?

(iii) Return ξ_w and the monetary policy rule to its benchmark specification, but keep $\gamma = 1,000$. The only difference from the benchmark specification now is that prices are flexible (apart from the fact that they are set before the monetary policy shock). Compare the responses of real variables to shocks between the benchmark and flexible price specification. Do these responses look very different?

b. Note that inflation hardly falls after a positive, neutral technology shock. At the same time, money growth responds quite strongly.

(i) Investigate whether the response of money growth to the neutral response is responsible for the counterfactual inflation response. To do this, cut the link between monetary policy and the neutral technology shock, by setting $c\_z = cp\_z = 0$ in between the two calls to solveandsimulate.m. Can you see why the estimation program 'chose' to introduce a strong monetary policy response to a neutral technology shock (hint: look at the response of hours worked, investment and output)? Evidently, the advantages, in terms of model fit, produced by a strong monetary response outweigh the disadvantage of the counterfactual inflation response.

(ii) Setting $c\_z = cp\_z = 0$ only makes the price level fall a little in response to a neutral technology shock. It does not fall as much as it does in the VAR. Could it be the sticky prices and wages that prevent the fall in the price level? To find out, set $c\_z = cp\_z = 0$ and $\xi_w = 0.01$, $\gamma = 10,000$. Note that inflation now drops a little relative to the benchmark, but not much. We can conclude that the strong response of money growth to a neutral technology shock is part, but not all, of the reason for the model's counterfactual implication for the response of inflation to a neutral technology shock. This counterfactual implication draws attention to a weak point in the analysis. Perhaps there is a mispecification in the model. Perhaps in the VAR.

c. The conclusions of the ACEL analysis depend strongly on σ_a being a large number. To understand why the estimation strategy settles on a large value for this parameter, set it to a very small value (say, 0.00001) and evaluate the impact of this change on the impulse response functions. How does the change affect the response of investment to a neutral technology shock? Provide an economic interpretation.

d. The conclusions of the ACEL analysis depend strongly on λ_f being close to unity. However, there appears to be little information in the aggregate data about this parameter. To see this, set λ_f to a larger number (try $\lambda_f = 1.90$, a number far greater than any reasonable estimate in the literature) and verify the relatively small impact on impulse response functions.

e. It is of interest to use the program to explore the impact of adjustment costs in investment and habit persistence in consumption.

   (i) Consider investment adjustment costs nearly equal to zero, $S'' = 0.1$ (actually, S'' is κ, or *kappa*, in main.m). What does this change do to the response of investment to the three shocks? Does the change amplify the response of hours worked to shocks? Why?

   (ii) Consider habit persistence nearly zero, $b = 0.01$. How does this change affect the response of consumption to a monetary policy shock? Explain the economic reason for the new response. Does the change have much of an effect on the transmission of the two technology shocks?

2. In the ACEL analysis, the model is estimated without taking a stand on whether capital is firm-specific or homogeneous. After estimation, the value of ξ_p is inferred from the parameters. Under the homogeneous capital interpretation, only γ is needed to infer ξ_p. Under the firm-specific capital model, the other parameters of the model play a role, most especially λ_f and σ_a. Inference about ξ_p is in fact very sensitive to the value taken on by these parameters. Under the benchmark parameter values, with $\sigma_a = 2.0136$,

$\lambda_f = 1.01$, the assumption that capital is firm-specific implies $\xi_p = 0.36$, which implies a duration of $1/(1-\xi_p) = 1.6$ quarters. The assumption that capital is homogeneous implies $\xi_p = 0.83$ and a duration of 6 quarters. Thus, the implied duration is very sensitive to the assumption of firm-specificity of capital.

Determine what happens to ξ_p and duration when $\lambda_f = 1.10$ and 1.20. (To do this, set lambda_f right before the call to findksip.m). These are values of λ_f that have been defended in the literature. However, a recent paper by David Bowman (see the course web site) argues that very low levels of λ_f are quite plausible.

Next, return λ_f to its benchmark value and consider a much lower value of σ_a, say $\sigma_a = .01$.

Can you provide intuition for the fact that ξ_p becomes is relatively insensitive to the degree of firm-specificity of capital when λ_f is close to unity and/or σ_a is close to zero?

3. Program main.m can be used to reestimate the model under alternative settings for the parameters.

   a. One exercise that is worth doing is to reestimate the VAR using business sector labor productivity for labor productivity and business sector hours worked in the computation of per capita hours worked (set $product = 2$). Then, reestimate the model, allowing λ_f to be free. (To implement this, you must enter setup.m and set $II(26,1) = 1$. Read the information at the top of this program for an explanation. Then, run main.m with $estimatemodel = 1$, $estvar = 1$, $imp = 1$. This will take some time to recompute the VAR and the impulse response confidence intervals, as well as to reestimate the equilibrium model.) Does the econometrics still favor a low value of λ_f and high value of σ_a?

   b. Reestimate the equilibrium model setting the number of lags in the VAR to 6.