Chapter 3

1. The rational expectations equilibrium of the real business cycle model is characterized by the solution to a difference equation. We first explain how to solve for the unique rational expectations equilibrium: then we proceed to explain how to generate the Euler equation errors.

1.a In our example the following equation characterizes equilibrium:

(1.a-1) $$\begin{bmatrix} c_t \\ k_t \end{bmatrix} = A \begin{bmatrix} c_{t+1} \\ k_{t+1} \end{bmatrix} + B \begin{bmatrix} u^c_{t+1} \\ e_{t+1} \end{bmatrix}.$$

To solve for the rational expectations equilibrium, diagonalize A as $A = Q\Lambda Q^{-1}$, and pre-multiply equation (1.a-1) by Q^{-1} to obtain:

(1.a-2) $$Z_t = \Lambda Z_{t+1} + V_{t+1},$$

where the terms X, Z and V are defined as follows

$$X \equiv \begin{bmatrix} c \\ k \end{bmatrix}, \qquad Z \equiv Q^{-1}X \qquad \text{and,} \qquad \equiv Q^{-1}BW\text{, with} \quad = \begin{bmatrix} u^c \\ e \end{bmatrix}.$$

Now, let λ_1 be the eigenvalue of Λ which falls between zero and one. Then iterate the first equation in (1.a-2):

(1.a-3) $$z^1_t = \lim_{N\to\infty} \lambda^N_1 z^1_{t+N} + \sum_{j=1}^{\infty} \lambda^{j-1} v^1_{t+j} = \sum_{j=1}^{\infty} \lambda^{j-1} v^1_{t+j}.$$

Taking expectations in (1.a-3), conditional upon period t information, we obtain

(1.a-4) $$z^1_t = 0.$$

To obtain the expectational errors $\{u^c_t\}$ notice that, from (1.a-2),

(1.a-5) $$z^1_t = \lambda_1 z^1_{t+1} + v^1_{t+1},$$

which in conjunction with (1.a-4) implies that

(1.a-6) $$v^1_{t+1} = 0 \ \forall t$$

From the definition of v^1_t, it follows that

(1.a-7) $$v_{t+1}^{1} = q^{11}u_{t+1}^{c} + q^{12}e_{t+1} = 0 \quad \Rightarrow \quad u_{t+1}^{c} = -\frac{q^{12}}{q^{11}}e_{t+1},$$

where, q^{11} and q^{12} are the elements of the first row of the matrix $Q^{-1}B$. In other words, the Euler equation errors, $\{u_t^c\}_{t=1}^{\infty}$, are exact functions of the fundamental errors $\{e_t\}_{t=1}^{\infty}$.

2. The demand for money is given by:

$$\frac{M_t^D}{P_t} = k\left\{E_t\left[\frac{P_t}{P_{t+1}}\right]\right\}^c$$

and the money supply rule by:

$$M_t^S = M_{t-1}^S + g_t P_t .$$

2.a Using the definitions $\Pi_t = \frac{P_t}{P_{t-1}}$, $m_t = \frac{M_t}{P_t}$, we can rewrite demand and supply as follows:

(2.a-1) $$m_t^D = k\left\{E_t\left(\frac{1}{\Pi_{t+1}}\right)\right\}^c,$$

(2.a-2) $$m_t^S = \frac{m_{t-1}^S}{\Pi_t} + g_t$$

which implies that

(2.a-3) $$\frac{1}{\Pi_{t+1}} = \frac{m_{t+1}^S - g_{t+1}}{m_t^S}.$$

Substituting (2.a-2) into (2.a-1) and imposing market clearing, $m_t^S = m_t^D \equiv m_t$ gives:

(2.a-4) $$m_t = k\left\{E_t\left(\frac{m_{t+1} - g_{t+1}}{m_t}\right)\right\}^c,$$

or

(2.a-5) $$m_t^{1+c} = k\left\{E_t\left(m_{t+1} - g_{t+1}\right)\right\}^c.$$

Any bounded sequence that satisfies this equation is a rational expectations equilibrium.

2.b Let $c = 1$, $g_t = \bar{g}$. Then the non-stochastic steady states are given by:

(2.b-1) $$\bar{m}^2 = k(\bar{m} - \bar{g}) \Rightarrow \bar{m}^2 - k\bar{m} + k\bar{g} = 0.$$

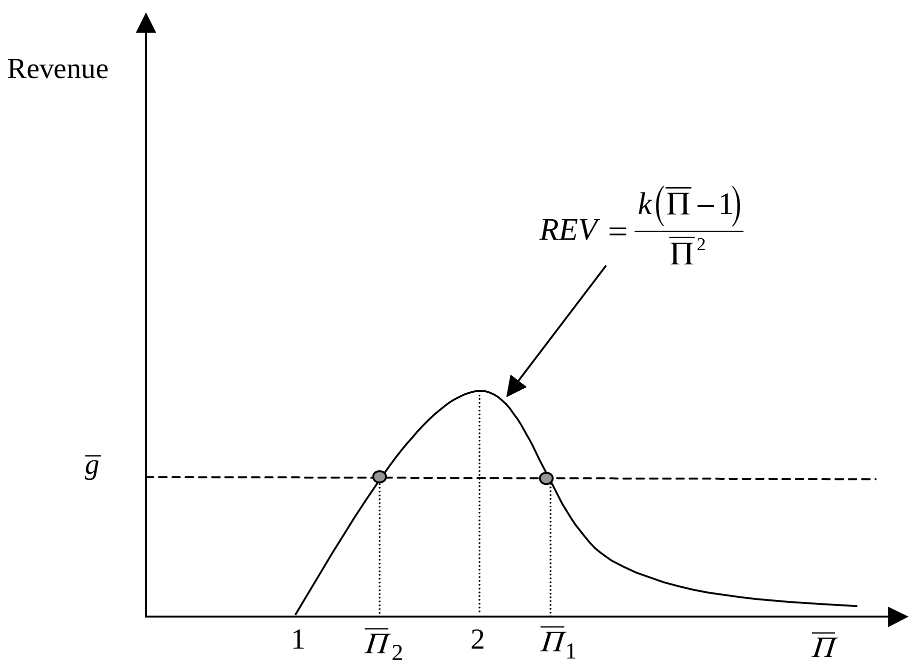
Using the formula for the roots of a quadratic equation gives:

(2.b-2) $$m_1 = \frac{k - \sqrt{k(k - 4\bar{g})}}{2}, \quad m_2 = \frac{k + \sqrt{k(k - 4\bar{g})}}{2}.$$

2.c From equation (2.a-1) evaluated in the steady state it follows that

(2.c-1) $$\Pi_1 = \frac{k}{m_1} = \frac{2k}{k - \sqrt{k(k - 4\bar{g})}},$$
$$\Pi_2 = \frac{k}{m_2} = \frac{2k}{k + \sqrt{k(k - 4\bar{g})}}.$$

2.d In the steady state, the revenue from the inflation tax is exactly equal to the expenditure by government on goods an services, $\bar{g}$. It follows that:



<u>Figure 3.1</u>

(2.d-1) $$\text{Revenue} = \bar{g} = \frac{\bar{m}\left(k - \bar{m}\right)}{k}.$$

But from (2.a-1), $\bar{m} = k / \bar{\Pi}$, hence:

(2.d-2) $$\text{Revenue} = \bar{g} = \frac{k\left(\bar{\Pi} - 1\right)}{\bar{\Pi}^2}.$$

This is the graph depicted in figure 3.1.

2.e Define the vector

(2.e-1) $$y_t = \begin{bmatrix} \log(m_t) - \log(m_2) \\ \log(\Pi_{t+1}) - \log(\Pi_2) \end{bmatrix}.$$

Linearize the money demand equation, (2.a-1) to give:

$$m_t = kE_t\left[\frac{1}{\Pi_{t+1}}\right],$$

$$\left(m_t - m_2\right) = kE_t\left[\frac{-1}{{\Pi_2}^2}\left(\Pi_{t+1} - \Pi_2\right)\right],$$

$$\frac{m_t - m_2}{m_2} = \frac{-k}{m_2\Pi_2} E_t\left[\left(\frac{\Pi_{t+1} - \Pi_2}{\Pi_2}\right)\right].$$

Now let

$$\tilde{m}_t = \frac{\left(m_t - m_2\right)}{m_2} \cong \log(m_t) - \log(m_2),$$
$$\tilde{\Pi}_t = \frac{\left(\Pi_t - \Pi_2\right)}{\Pi_2} \cong \log(\Pi_t) - \log(\Pi_2).$$

Since, from part (c) we know that $k = \bar{m}\,\bar{\Pi}$ it follows that:

(2.e-2) $$\tilde{m}_t = -E_t\left(\tilde{\Pi}_{t+1}\right).$$

Now linearize the money supply equation, (2.a-2):

$$m_t = \frac{m_{t-1}}{\Pi_t} + g_t$$

$$(m_t - m_2) = \left[\frac{1}{\Pi_2}\right](m_{t-1} - m_2) - \left[\frac{m_2}{\Pi_2^{\ 2}}\right](\Pi_t - \Pi_2) + (g_t - \bar{g})$$

$$\left(\frac{m_t - m_2}{m_2}\right) = \left[\frac{1}{\overline{\Pi}_2}\right]\left(\frac{m_{t-1} - m_2}{m_2}\right) - \left[\frac{1}{\Pi_2}\right]\left(\frac{\Pi_t - \Pi_2}{\Pi_2}\right) + \frac{\bar{g}}{m_2}\left(\frac{g_t - \bar{g}}{\bar{g}}\right)$$

hence:

(2.e-3) $$\tilde{m}_t = \left[\frac{1}{\Pi_2}\right]\tilde{m}_{t-1} - \left[\frac{1}{\Pi_2}\right]\tilde{\Pi}_t + \frac{\bar{g}}{m_2}\tilde{g}_t$$

where $\tilde{g}_t = \left(\frac{g_t - \bar{g}}{\bar{g}}\right)$.

Now define $w_{t+1} = -\left[E_t\left(\tilde{\Pi}_{t+1}\right) - \tilde{\Pi}_{t+1}\right]$. Using this definition we can write equations (2.e-2) and (2.e-3) as:

(2.e-4)
$$\tilde{m}_t + \tilde{\Pi}_{t+1} = w_{t+1},$$
$$\tilde{m}_t - \tilde{\Pi}_{t+1} = \Pi_2\tilde{m}_{t+1} - \left(\frac{\bar{g}\Pi_2}{m_2}\right)\tilde{g}_{t+1}.$$

In matrix form:

(2.e-5) $$\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix}\begin{bmatrix}\tilde{m}_t\\ \tilde{\Pi}_{t+1}\end{bmatrix} = \begin{bmatrix}0 & 0\\ \Pi_2 & 0\end{bmatrix}\begin{bmatrix}\tilde{m}_{t+1}\\ \tilde{\Pi}_{t+2}\end{bmatrix} + \begin{bmatrix}1 & 0\\ 0 & -\bar{g}\Pi_2/m_2\end{bmatrix}\begin{bmatrix}w_{t+1}\\ \tilde{g}_{t+1}\end{bmatrix}$$

or since

$$\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix}^{-1} = \frac{-1}{2}\begin{bmatrix}-1 & -1\\ -1 & 1\end{bmatrix} = \begin{bmatrix}1/2 & 1/2\\ 1/2 & -1/2\end{bmatrix}$$

(2.e-6) $$\underbrace{\begin{bmatrix}\tilde{m}_t\\ \tilde{\Pi}_{t+1}\end{bmatrix}}_{y_t} = \underbrace{\begin{bmatrix}\Pi_2/2 & 0\\ -\Pi_2/2 & 0\end{bmatrix}}_{A}\underbrace{\begin{bmatrix}\tilde{m}_{t+1}\\ \tilde{\Pi}_{t+2}\end{bmatrix}}_{y_{t+1}} + \underbrace{\begin{bmatrix}1/2 & -\bar{g}\Pi_2/2m_2\\ 1/2 & +\bar{g}\Pi_2/2m_2\end{bmatrix}}_{B}\underbrace{\begin{bmatrix}w_{t+1}\\ \tilde{g}_{t+1}\end{bmatrix}}_{e_{t+1}}.$$

The elements of e_{t+1} are w_{t+1} and $\tilde{g}_{t+1}$.

2.f The elements of A and B are given by:

$$A = \begin{bmatrix} \Pi_2/2 & 0 \\ -\Pi_2/2 & 0 \end{bmatrix} \text{ and } B = \begin{bmatrix} 1/2 & -\bar{g}\Pi_2/2m_2 \\ 1/2 & +\bar{g}\Pi_2/2m_2 \end{bmatrix}.$$

2.g The roots of A are given by

$$\left| \begin{bmatrix} \frac{\Pi_2}{2} & 0 \\ \frac{-\Pi_2}{2} & 0 \end{bmatrix} - \lambda I \right| = 0, \quad \begin{vmatrix} \frac{\Pi_2}{2} - \lambda & 0 \\ \frac{-\Pi_2}{2} & 0 - \lambda \end{vmatrix} = 0,$$

$$\left(\frac{\Pi_2}{2} - \lambda \right)(-\lambda) = 0$$

$$\Rightarrow \ \lambda_1 = 0, \ \lambda_2 = \left(\frac{\Pi_2}{2} \right)$$

and its eigenvectors are given by

$$\begin{bmatrix} 0 \\ 1 \end{bmatrix}, \ \textit{and} \ \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

hence the diagonalization of A is given by:

$$A = \begin{bmatrix} 0 & -1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & \Pi_2/2 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ -1 & 0 \end{bmatrix}$$

$$A = \quad Q \quad \Lambda \quad Q^{-1}$$

Now let

$$z_t = Q^{-1} y_t$$

then

$$z_t = \Lambda z_{t+1} + Q^{-1} B e_{t+1}\,.$$

Note: the equation with a zero eigenvalue expresses a purely static relationship. Iterating the second equation forwards leads to the restriction:

$$z_t^2 = 0\,,$$

where z_2 is defined from the matrix equation:

$$\begin{bmatrix} z_t^1 \\ z_t^2 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -1 & 0 \end{bmatrix} \begin{bmatrix} \tilde{m}_t \\ \tilde{\Pi}_{t+1} \end{bmatrix}.$$
$$z_t \quad = \quad Q^{-1} \quad y_t$$

It follows that in the rational expectations equilibrium:

$$z_t^2 = -\tilde{m}_t + 0\tilde{\Pi}_{\tau+1} = 0, \quad \Rightarrow \tilde{m}_t = 0.$$

In this rational expectations equilibrium m_t is always equal to m_2. If there is a fundamental shock to g_t, the price always responds one for one to keep real balances exactly at the determinate steady state. The equilibrium is locally unique.

2.h An econometrician might exploit the result in g) to run a regression of P_t on M_t. Over a period in which the rule for generating g_t was stable, this regression would uncover a stable relationship between prices and money. But if the rule for generating g_t, and hence M_t, were to change, the equilibrium would change and the estimated regression parameter would no longer be valid. This is the main idea behind the Lucas critique.

3. This problem involves the linearization of a model with positive government spending.

3.a The first order conditions for the choice of labor supply L_t and next period's capital stock K_{t+1}, are:

(3.a-1) $$L_t: \quad (1-\alpha)\frac{1}{C_t}A_t K_t^{\alpha} L_t^{-\alpha} - L_t^{\gamma} = 0,$$

(3.a-2) $$K_{t+1}: \quad -\frac{1}{C_t} + \left(\frac{1}{1+\rho}\right) E_t\left\{\frac{1}{C_{t+1}}\left(1-\delta+\alpha\frac{Y_{t+1}}{K_{t+1}}\right)\right\} = 0.$$

3.b To compute the steady state we begin by characterizing equilibrium as a solution to the following equations:

(3.b-1) $$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha},$$

(3.b-2) $$K_{t+1} = (1-\delta)K_t + Y_t - C_t - G_t,$$

(3.b-3) $$(1-\alpha)\frac{1}{C_t}\frac{Y_t}{L_t} = L_t^{\gamma},$$

(3.b-4) $$\frac{1}{C_t} = \left(\frac{1}{1+\rho}\right)E_t\left\{\frac{1}{C_{t+1}}\left(1-\delta+\alpha\frac{Y_{t+1}}{K_{t+1}}\right)\right\},$$

(3.b-5) $$A_{t+1} = A_t^{\lambda}u_t$$

(3.b-6) $$G_{t+1} = BG_t^{\theta}\varepsilon_{t+1}.$$

Now we search for a non-stochastic steady state solution to these equations. First set $\ln u$ and $\ln\varepsilon$ equal to their expected values of zero (so that, u = ε= 1). Hence A_t = 1, and $G_{t+1} = BG_t^{\theta}$. Let bars over variables denote their steady state values. Then, the steady states solve the set of equations (3.b-7) through (3.b-11):

(3.b-7) $$\overline{Y} = \overline{K}^{\alpha}\overline{L}^{1-\alpha},$$

(3.b-8) $$\delta\overline{K} = \overline{Y} - \overline{C} - \overline{G},$$

(3.b-9) $$(1-\alpha)\frac{1}{\overline{C}}\frac{\overline{Y}}{\overline{L}} = \overline{L}^{\gamma},$$

(3.b-10) $$1+\rho = 1-\delta+\alpha\frac{\overline{Y}}{\overline{K}},$$

(3.b-11) $$\overline{G} = B\overline{G}^{\theta}.$$

From (3.b-11),

(3.b-12) $$\overline{G} = B^{1/(1-\theta)}.$$

From (3.b-10),

(3.b-13) $$\frac{\overline{Y}}{\overline{K}} = \frac{\rho+\delta}{\alpha}.$$

From (3.b-7) and (3.b-13),

(3.b-14)
$$\frac{\overline{Y}}{\overline{K}} = \left(\frac{\overline{L}}{\overline{K}}\right)^{1-\alpha}$$
$$\Rightarrow \frac{\overline{L}}{\overline{K}} = \left(\frac{\rho+\delta}{\alpha}\right)^{1/(1-\alpha)}.$$

From (3.b-7), (3.b-9) and (3.b-14),

(3.b-15)
$$(1-\alpha)\frac{1}{\overline{C}}\overline{K}^{\alpha} = \overline{L}^{\alpha+\gamma} = \left(\frac{\rho+\delta}{\alpha}\right)^{(\alpha+\gamma)/(1-\alpha)}\overline{K}^{\alpha+\gamma}$$
$$\Rightarrow (1-\alpha)\overline{K}^{-\gamma} = \left(\frac{\rho+\delta}{\alpha}\right)^{(\alpha+\gamma)/(1-\alpha)}\overline{C}.$$

From (3.b-13), (3.b-8) and (3.b-12)

(3.b-16)
$$\left(\frac{\rho+\delta-\alpha\delta}{\alpha}\right)\overline{K} = \overline{C} + B^{1/(1-\theta)},$$

which using (3.b-15) gives:

(3.b-17)
$$(1-\alpha)\overline{K}^{-\gamma} = \left(\frac{\rho+\delta}{\alpha}\right)^{(\alpha+\gamma)/(1-\alpha)}\left[\left(\frac{\rho+\delta-\alpha\delta}{\alpha}\right)\overline{K} - B^{1/(1-\theta)}\right],$$

which has a unique real positive solution in $\overline{K}$. Now solve for $\overline{C}$ from (3.b-16), for $\overline{L}$ from (3.b-14) and for $\overline{Y}$ from (3.b-13).

3.c The linearized system, ignoring constant terms, comprises equations (3.c-1) through (3.c-6)

(3.c-1) $y_t = a_t + \alpha k_t + (1-\alpha)l_t$ {linearizes the production function (3.b-1)}

(3.c-2) $k_{t+1} = b_1 k_t + b_2 y_t + b_3 c_t + b_4 g_t$, {linearizes the resource constraint (3.b-2)}

where, $b_1 = 1-\delta,\quad b_2 = \overline{Y}/\overline{K},\quad b_3 = -\overline{C}/\overline{K},\quad b_4 = -\overline{G}/\overline{K}.$

(3.c-3) $-c_t + y_t = (1+\gamma)l_t$. {linearizes the F.O.C. for labor (3.b-3)}

(3.c-4) $c_t = c_{t+1} + ry_{t+1} - rk_{t+1} + w_{t+1}$, {linearizes the Euler equation (3.b-4)}

where,

$$w_{t+1} \equiv E_t\left[c_{t+1} + ry_{t+1} - rk_{t+1}\right] - \left[c_{t+1} + ry_{t+1} - rk_{t+1}\right]$$

is the expectational error with conditional mean zero, and the constant r is defined as

$r = \left(\alpha\bar{Y} / \bar{K}\right) / (1+\rho)$.

(3.c-5) $a_{t+1} = \lambda a_t + \ln u_t$, {linearizes the law of motion for a_t (3.b-5)}

(3.c-6) $g_{t+1} = \theta g_t + \ln \varepsilon_{t+1}$. {linearizes the law of motion for g_t (3.b-6)}

4. This exercise uses the results from the previous one. As a starting point, write the linearized system (3.c-1) through (3.c-6) in matrix form as follows:

(4-1) $A_1 x_t + A_2 z_t = 0$

(4-2) $A_3 x_t + A_4 z_t + A_5 x_{t+1} + A_6 z_{t+1} + A_7 e_{t+1} = 0$

See the GAUSS code for the definition of the matrices. In the program the system is reformulated as

(4-3) $x_t = J_1 x_{t+1} + J_2 e_{t+1}$, where

(4-4) $J_1 = -(A_3 - A_4 A_2^{-1} A_1)^{-1}(A_5 - A_6 A_2^{-1} A_1)$,

(4-5) $J_2 = -(A_3 - A_4 A_2^{-1} A_1)^{-1} A_7$.

The following GAUSS code is designed to answer any of the three questions in this exercise. Note the comments on the program included within /* and */ and also within @ and @.

```
/**********************************************************
                      Problem  3.4
              Simulation of an RBC economy
       thomas hintermaier, bauersknecht, march 1999
***********************************************************/

new;

/* !!!! specify question a., b., or c. of problem 3.4  !!!!*/
question=3; @1=a., 2=b., any other number=c.@

/* number of periods for the simulation */
periods=40;

/* specification of parameters */
rho=0.0163;
gam=0;
```

```
alpha=0.4;
lam=0.98;
varu=0.07;
theta=0.9;
ub=0.9957;
vare=0.01;
delta=0.0272;

/* solve for steady state values */
gss=ub^(1/(1-theta));
m1=((rho+delta)/alpha)^((alpha+gam)/(1-alpha)); @defined to reduce
                                                  the mess in the
                                                  computation of ss@
m2=(rho+delta-alpha*delta)/alpha;

eqsolveset;                       @ solve for steady state capital @
fn f(k)=(1-alpha)*k^(-gam)-(m1*(m2*k-gss));
__output=0;
{ kss,s }=eqsolve(&f,gss);

css=m2*kss-gss;
lss=((rho+delta)/alpha)^(1/(1-alpha))*kss;
yss=((rho+delta)/alpha)*kss;

/* define the matrices of the linearized system */
a1=zeros(2,4);
a1[1,2]=alpha;
a1[1,3]=1;
a1[2,1]=-1;
a2=zeros(2,2);
a2[1,1]=-1;
a2[1,2]=1-alpha;
a2[2,1]=1;
a2[2,2]=-(1+gam);

b1=1-delta;       @some coefficients needed in the following matrices@
b2=yss/kss;
b3=-css/kss;
b4=-gss/kss;
r=alpha/(1+rho)*yss/kss;

a3=zeros(4,4);
a3[1,1]=b3;
a3[1,2]=b1;
a3[1,4]=b4;
a3[2,1]=1;
a3[3,3]=lam;
a3[4,4]=theta;
a4=zeros(4,2);
a4[1,1]=b2;
a5=zeros(4,4);
a5[1,2]=-1;
a5[2,1]=-1;
a5[2,2]=-r;
a5[3,3]=-1;
a5[4,4]=-1;
a6=zeros(4,2);
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```
a6[2,1]=r;
a7=zeros(4,3);
a7[2,3]=1;
a7[3,1]=1;
a7[4,2]=1;

/* matrices in  the system of stochastic difference equations for the
state variables */
j1=-inv(a3-a4*inv(a2)*a1)*(a5-a6*inv(a2)*a1);
j2=-inv(a3-a4*inv(a2)*a1)*a7;

/* diagonalize the system */
{ evalu,evecu }=eigv(j1);   @find the eigenvalues and eigenvectors@

modev=abs(evalu);                             @and order them@
temp=sortc(modev~evalu~evecu',1);
eval=temp[.,2];
evec=(temp[.,3:cols(temp)])';

/* decide on existence and uniqueness of equilibrium */
count=0;
ind=1;
DO WHILE ind<=rows(eval);
      IF abs(eval[ind])<1;
         count=count+1;
      ENDIF;
      ind=ind+1;
ENDO;

/* terminate program in case of no solution or multiple equilibria */
IF count<1;
    print "No eigenvalue inside unit circle: multiple equilibria ";
    waitc;
    end;
ELSEIF count>1;
    print "More than one eigenvalue inside unit circle: no solution ";
    waitc;
    end;
ENDIF;

/* generate the sequences of shocks as specified in questions a., b.,
and c., respectively */
shocks=zeros(2,periods);
IF  question==1;
   shocks[1,1]=sqrt(varu);
ELSEIF question==2;
   shocks[2,1]=sqrt(vare);
ELSE;
   seed=151271;           @nota bene: this is NOT MY birthdate@
   rndseed seed;
   omega=varu~0|0~vare;
   shocks=chol(omega)*rndn(cols(shocks),rows(shocks))';
ENDIF;

/* initializing a matrix to store the sequences of relative deviations
    from ss
    for c, k, a, g, y, l (this ordering) */
```

```
devstore=zeros(6,periods+1);

/**** simulating the economy for the specified number of periods ****/
z=zeros(4,periods+1); @initializes matrix of obsvervations for the
                                                   diagonalized system@
@!!!! z[1,.]=0, that is, the first row of z is zero for all periods,
    since it corresponds to the eigenvalue inside the unit circle !!!!@

combi=real(inv(evec)*j2);   @by this matrix a linear combination of the
                              fundamental and the expectational errors
                              is added to each element of the
                              diagonalized system@
˝

rela=combi[1,.];   @since, for all t, z[1,.] is zero,
                     this row of the matrix
                     tells us how the expectational error is a function
                     of the fundamental errors, ...@
˝
w=zeros(1,periods);
˝
t=1;
DO WHILE t<=periods;      @...which is used here to ...@
    w[t]=-1/rela[3]*rela[1]*shocks[1,t]-1/rela[3]*rela[2]*shocks[2,t];
                    @ ...generate the sequence of expectational errors@
     t=t+1;
ENDO;
errors=shocks|w; @concatenation of all error sequences into one matrix@

/* generating the sequences for the observations in the diagonalized
system */
k=2;
DO WHILE k<=4;
    t=1;
    DO WHILE t<=periods;
        z[k,t+1]=1/eval[k]*z[k,t]-1/eval[k]*combi[k,.]*errors[.,t];
        t=t+1;
    ENDO;
   k=k+1;
ENDO;

/* recovering the proportional deviations of the state variables from
the diagonalized system */
j=1;
DO WHILE j<=periods+1;
   devstore[1:4,j]=evec*z[.,j];
    j=j+1;
ENDO;

/* get the proportional deviations of the other variables from their
   contemporaneous relationship with the state variables */
j=1;
DO WHILE j<=periods+1;
   devstore[5:6,j]=-inv(a2)*a1*devstore[1:4,j];
    j=j+1;
ENDO;
```

```
/* convert relative deviations from ss to levels of variables
   by multiplying by the steady state values and
   adding the steady state values */
cstore=devstore[1,.]*css+css;
kstore=devstore[2,.]*kss+kss;
astore=devstore[3,.]+1;
gstore=devstore[4,.]*gss+gss;
ystore=devstore[5,.]*yss+yss;
lstore=devstore[6,.]*lss+lss;

/* the last section generates the graphical output */
library pgraph;
graphset;
_ptitlht=0.5;
xax=seqa(1,1,cols(devstore));@an additive sequence defining the x-axis@
begwind;
window(2,3,0);
setwind(1);
  _pcolor=1;
  title("Consumption");
  xy(xax,cstore');
nextwind;
  _pcolor=2;
  title("Capital");
  xy(xax,kstore');
nextwind;
  _pcolor=3;
  title("Prod. disturb.");
  xy(xax,astore');
nextwind;
  _pcolor=4;
  title("Government");
   xy(xax,gstore');
nextwind;
  _pcolor=5;
  title("Output");
  xy(xax,ystore');
nextwind;
  _pcolor=6;
  title("Labour");
  xy(xax,lstore');
endwind;

end;
```