Intro 3b — New Classical model

Description

In this example, we solve a New Classical model similar to the one in King and Rebelo (1999). We also demonstrate how to compare a model's theoretical predictions under different parameter values using IRFs.

Remarks and examples

Remarks are presented under the following headings:

The model

In this model, output, consumption, investment, employment, and other variables are driven by state variables linked to production and demand. The model is similar to the one in King and Rebelo (1999) and is referred to as a real business cycle model.

The nonlinear form of the model is

$$\frac{1}{C_t} = \beta E_t \left\{ \frac{1}{C_{t+1}} (1 + R_{t+1} - \delta) \right\} \tag{1}$$

$$H_t^\eta = \frac{W_t}{C_t} \tag{2}$$

$$Y_t = C_t + X_t + G_t \tag{3}$$

$$Y_t = K_t^\alpha (Z_t H_t)^{1-\alpha} \tag{4}$$

$$W_t = (1-\alpha)\frac{Y_t}{H_t} \tag{5}$$

$$R_t = \alpha \frac{Y_t}{K_t} \tag{6}$$

$$K_{t+1} = (1-\delta)K_t + X_t \tag{7}$$

Equation (1) specifies consumption C_t as a function of expected future consumption and the expected future interest rate $E_t(R_{t+1})$. Equation (2) specifies labor hours H_t as a function of the wage W_t and consumption; it is a labor supply equation. Equation (3) is the national income accounting identity for a closed economy, specifying output Y_t as the sum of consumption, investment X_t, and government spending G_t. Equation (4) is a production function that specifies output as a function of labor input H_t, capital input K_t, and productivity Z_t. Equations (5) and (6) specify labor demand and capital demand, respectively. Equation (7) specifies the equation for capital accumulation. The model is completed when we add state transition equations for Z_t and G_t. These state transition equations are conventionally specified after the model has been linearized.

The linearized form of the model is

$$\begin{aligned}
c_t &= E_t(c_{t+1}) - (1 - \beta + \beta\delta)E_t(r_{t+1}) \\
\eta h_t &= w_t - c_t \\
\phi_1 x_t &= y_t - \phi_2 c_t - g_t \\
y_t &= (1 - \alpha)(z_t + h_t) + \alpha k_t \\
w_t &= y_t - h_t \\
r_t &= y_t - k_t \\
k_{t+1} &= \delta x_t + (1 - \delta)k_t \\
z_{t+1} &= \rho_z z_t + \epsilon_{t+1} \\
g_{t+1} &= \rho_g g_t + \xi_{t+1}
\end{aligned}$$

The model has six control variables and three state variables. Two of the state variables, z_{t+1} and g_{t+1}, are modeled as first-order autoregressive processes. The state equation for k_{t+1} depends on the current value of a control variable, namely, x_t.

Solving the model

The `solve` option of `dsge` places the model in state-space form without estimating parameters; it is similar to `iterate(0)` but is faster because it does not calculate standard errors. Using `solve` for different parameter values of your model is a useful way to explore the model's theoretical properties.

The parameter values used here are similar to those used in King and Rebelo (1999). Each has an interpretation. (1 − `alpha`) is labor's share of national income. `delta` is the depreciation rate of capital. `eta` is the slope of the labor supply curve. `phi1` and `phi2` are share parameters related to investment's share of national income and consumption's share of national income, respectively. `rhoz` and `rhog` are autoregressive parameters on the state variables.

```
. use https://www.stata-press.com/data/r16/usmacro2
(Federal Reserve Economic Data - St. Louis Fed, 2017-01-15)

. dsge (c = F.c - (1-{beta}+{beta}*{delta})*F.r, unobserved)
>       ({eta}*h = w - c, unobserved)
>       ({phi1}*x = y - {phi2}*c - g, unobserved)
>       (y = (1-{alpha})*(z+h) + {alpha}*k)
>       (w = y - h, unobserved)
>       (r = y - k, unobserved)
>       (F.k = {delta}*x+ (1-{delta})*k, state noshock)
>       (F.z = {rhoz}*z, state)
>       (F.g = {rhog}*g, state),
>       from(beta=0.96 eta=1 alpha=0.3 delta=0.025 phi1=0.2 phi2=0.6 rhoz=0.8 rhog=0.3)
>       solve noidencheck

DSGE model

Sample: 1955q1 - 2015q4                         Number of obs     =        244
Log likelihood = -1957.0261

------------------------------------------------------------------------------
             |                 OIM
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
/structural  |
        beta |        .96          .        .       .            .           .
       delta |       .025          .        .       .            .           .
         eta |          1          .        .       .            .           .
        phi1 |         .2          .        .       .            .           .
        phi2 |         .6          .        .       .            .           .
       alpha |         .3          .        .       .            .           .
        rhoz |         .8          .        .       .            .           .
        rhog |         .3          .        .       .            .           .
-------------+----------------------------------------------------------------
      sd(e.z)|          1          .                                 .           .
      sd(e.g)|          1          .                                 .           .
------------------------------------------------------------------------------
Note: Skipped identification check.
Note: Model solved at specified parameters.
```

The `solve` option solves the model at the specified values in `from()`. We skip the identification check with `noidencheck`. Simply solving the model does not involve any reference to the data or any estimation. Still, we can explore what these parameters imply.

Policy and transition matrices

After solving, we can use many of the postestimation commands, though standard errors will be missing throughout.

The state transition matrix shows how the state vector in the next period is related to the state vector in the current period. Some state variables are specified as first-order autoregressive processes, and their transition equations will simply repeat information that is already available in the estimation table. However, if any state variable equation contains control variables, then that state variable's transition equation will depend on the other state variables.

```
. estat transition
Transition matrix of state variables
```

	Coef.	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
F.k						
k	.9256785	.	.	.	.	.
z	.1078282	.	.	.	.	.
g	-.1070547	.	.	.	.	.
F.z						
k	0	(omitted)				
z	.8	.	.	.	.	.
g	2.22e-16	.	.	.	.	.
F.g						
k	0	(omitted)				
z	0	(omitted)				
g	.3	.	.	.	.	.

```
Note: Standard errors reported as missing for constrained transition matrix
      values.
```

The value of the state variables `z` and `g` in the next period depends only on their value in the current period, but the value of the capital stock `k` in the next period depends on the current value of all three state variables. This feature means that, for example, a shock to the `z` state variable has two effects: it increases future values of `z`, because `z` is autoregressive, but it also increases future values of `k`. Interrelationships among the state variables can generate more interesting patterns in the IRFs than the AR(1) dynamics that we saw in [DSGE] **Intro 3a**.

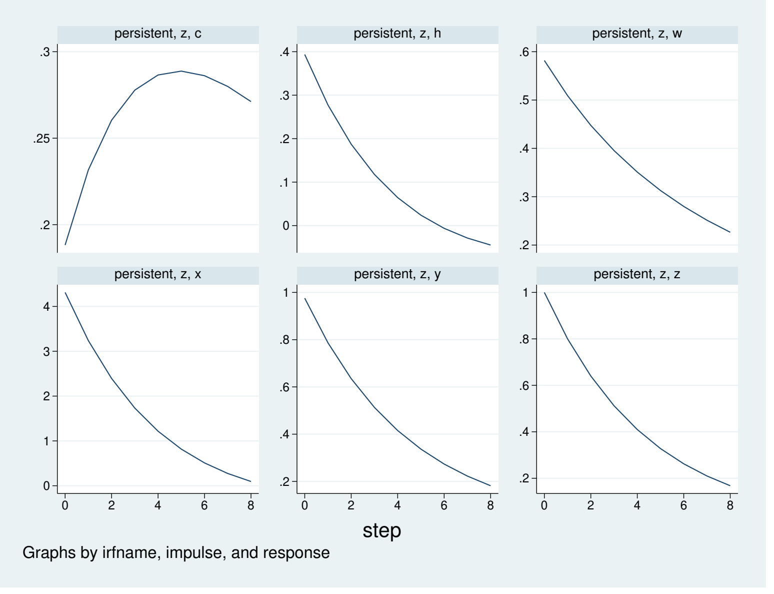
Impulse responses

One way to compare two parameter sets is to graph the impulse response of model variables to a shock under each parameter set. We first set the impulse–response file with `irf set` and then add impulse responses named `persistent` to the file with `irf create`.

```
. irf set rbcirf
(file rbcirf.irf created)
(file rbcirf.irf now active)

. irf create persistent
(file rbcirf.irf updated)
```

The response of model variables to a shock to z is graphed by typing

```
. irf graph irf, irf(persistent) impulse(z) response(y c x h w z) noci
> byopts(yrescale)
```



Each graph is labeled with the IRF name, the impulse variable, and the response variable. For instance, the top-left graph shows the response of consumption to a shock to the z_t state variable. The bottom-right graph shows the response of the state variable z_t itself. The state is persistent, which is not surprising: we set the autoregressive parameter in the z_t equation to 0.8.

In the top-left graph, we see that consumption c rises over time before returning to steady state. The time unit is quarters, so a value of about 0.27, 4 periods after the shock, indicates that consumption is 0.27% above its steady-state value one year after the shock. Hours worked h are shown in the top center graph and rise initially before falling below steady state. The real wage w, output y, and investment x all rise.

Sensitivity analysis

The responses of variables to a shock to z are persistent. Some variables, like consumption and the wage, show dynamics beyond the simple autoregressive behavior of z itself. To evaluate the role of persistence in z on the persistence of other model variables, we rerun the dsge command. This time, we set the persistence of z to a smaller value of 0.6.

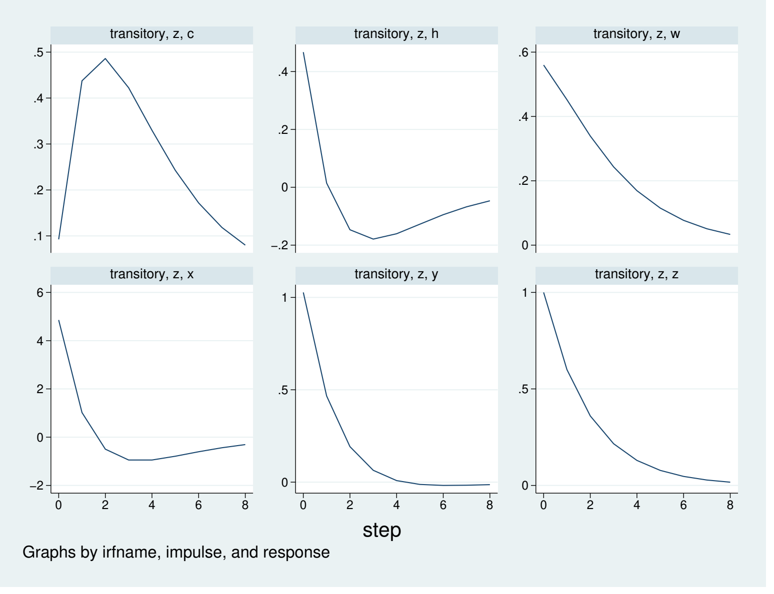
```
. dsge (c = F.c - F.r, unobserved)
>      ({eta}*h = w - c, unobserved)
>      ({phi1}*x = y - {phi2}*c - g, unobserved)
>      (y = (1-{alpha})*(z+h) + {alpha}*k)
>      (w = y - h, unobserved)
>      (r = y - k, unobserved)
>      (F.k = {delta}*x+ (1-{delta})*k, state noshock)
>      (F.z = {rhoz}*z, state)
>      (F.g = {rhog}*g, state),
>      from(eta=1 alpha=.3 delta=0.025 phi1=0.2 phi2=0.6 rhoz=0.6 rhog=0.3)
>      solve noidencheck
DSGE model

Sample: 1955q1 - 2015q4                         Number of obs     =        244
Log likelihood = -1447.5902
------------------------------------------------------------------------------
             |                 OIM
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
/structural  |
         eta |          1          .        .       .            .           .
        phi1 |         .2          .        .       .            .           .
        phi2 |         .6          .        .       .            .           .
       alpha |         .3          .        .       .            .           .
       delta |       .025          .        .       .            .           .
        rhoz |         .6          .        .       .            .           .
        rhog |         .3          .        .       .            .           .
-------------+----------------------------------------------------------------
      sd(e.z)|          1          .                             .           .
      sd(e.g)|          1          .                             .           .
------------------------------------------------------------------------------
Note: Skipped identification check.
Note: Model solved at specified parameters.
```

The only change in the parameter set is that `rhoz` has been set to 0.6 from its earlier setting of 0.8. We can add the impulse responses of this model to the `irf` file with the name `transitory`,

```
. irf create transitory, replace
irfname transitory not found in rbcirf.irf
(file rbcirf.irf updated)
```

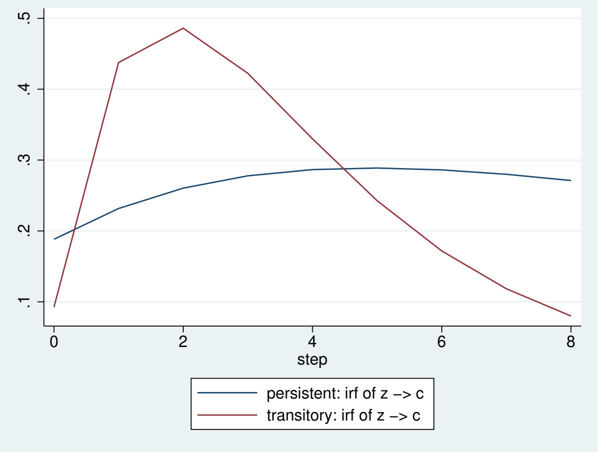
and graph them.

```
. irf graph irf, irf(transitory) impulse(z) response(y c x h w z) noci
> byopts(yrescale)
```



Model variables are much less persistent. We can use `irf ograph` to overlay the IRF for a variable under the two calibrations. This way we can view the differences across calibrations directly.

```
. irf ograph (persistent z c irf) (transitory z c irf)
```



When the shock itself is persistent, consumption responds persistently. When the shock is transitory, consumption returns to its steady-state value quickly.

Reference

King, R. G., and S. T. Rebelo. 1999. Resuscitating real business cycles. In *Handbook of Macroeconomics: Volume 1A*, ed. J. B. Taylor and M. Woodford, 927–1007. New York: Elsevier.

Also see

[DSGE] **Intro 1** — Introduction to DSGEs

[DSGE] **Intro 3a** — New Keynesian model

[DSGE] **Intro 3c** — Financial frictions model

[DSGE] **Intro 3e** — Nonlinear New Classical model

[DSGE] **dsge** — Linear dynamic stochastic general equilibrium models

[DSGE] **dsge postestimation** — Postestimation tools for dsge