Title

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Intro 3a — New Keynesian model

Description Remarks and examples Reference Also see

Description

This introduction estimates and interprets the parameters of a simple New Keynesian model. In this entry, we demonstrate how to constrain parameters in the model and how to interpret structural parameters, policy matrix parameters, and state transition matrix parameters. We also predict values of both observed control variables and unobserved states. For Bayesian analysis of this model, see [DSGE] **Intro 9a**.

Remarks and examples

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Remarks are presented under the following headings:

The model

Equations (1)–(5) specify a canonical New Keynesian model of inflation p_t, the output gap x_t, and the interest rate r_t. These are the linearized equations; the model's nonlinear equations are similar to those in *Writing down nonlinear DSGEs* in [DSGE] **Intro 1**.

$$p_t = \beta E_t(p_{t+1}) + \kappa x_t \tag{1}$$
$$x_t = E_t(x_{t+1}) - \{r_t - E_t(p_{t+1}) - g_t\} \tag{2}$$
$$r_t = \psi p_t + u_t \tag{3}$$
$$u_{t+1} = \rho_u u_t + \epsilon_{t+1} \tag{4}$$
$$g_{t+1} = \rho_g g_t + \xi_{t+1} \tag{5}$$

Equation (1) specifies inflation as a linear combination of expected future inflation and the output gap. Equation (2) specifies the output gap as a linear combination of the expected future output gap, the real interest rate, and a state variable g_t. Equation (3) specifies the interest rate as a linear combination of inflation and a state variable u_t. The state variables are modeled as first-order autoregressive processes. The state variable u_t is the deviation of r_t from its equilibrium value of ψp_t. The state variable g_t is also the deviation of x_t from its equilibrium value.

Three of the parameters have structural interpretation. The parameter κ is known as the slope of the Phillips curve and is predicted to be positive. The parameter β is the discount factor that represents the degree to which agents discount the future relative to the current period. The parameter ψ measures the degree to which interest rates react to movements in inflation.

Parameter estimation

Not all model parameters are identified. We constrain β to be 0.96, a common value in the literature. The remaining parameters are identified.

```
. use https://www.stata-press.com/data/r18/usmacro2
(Federal Reserve Economic Data - St. Louis Fed, 2017-01-15)

. constraint 1 _b[beta]=0.96

. dsge (p = {beta}*F.p + {kappa}*x)
>      (x = F.x - (r - F.p - g), unobserved)
>      (r = {psi}*p + u)
>      (F.u = {rhou}*u, state)
>      (F.g = {rhog}*g, state),
>     from(psi=1.5)  constraint(1)
(setting technique to bfgs)
Iteration 0:  Log likelihood = -5736.4646
Iteration 1:  Log likelihood = -1190.0604  (backed up)
Iteration 2:  Log likelihood = -960.00953  (backed up)
Iteration 3:  Log likelihood = -928.79225  (backed up)
Iteration 4:  Log likelihood = -842.40806  (backed up)
(switching technique to nr)
Iteration 5:  Log likelihood = -810.92149  (backed up)
Iteration 6:  Log likelihood = -765.73779  (not concave)
Iteration 7:  Log likelihood = -759.67265
Iteration 8:  Log likelihood = -754.17723
Iteration 9:  Log likelihood = -753.59661
Iteration 10: Log likelihood = -753.57155
Iteration 11: Log likelihood = -753.57131
Iteration 12: Log likelihood = -753.57131

DSGE model

Sample: 1955q1 thru 2015q4                           Number of obs = 244
Log likelihood = -753.57131
 ( 1)  [/structural]beta = .96
```

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
/structural						
beta	.96	(constrained)				
kappa	.0849631	.0287693	2.95	0.003	.0285763	.14135
psi	1.943004	.2957869	6.57	0.000	1.363272	2.522735
rhou	.7005483	.0452604	15.48	0.000	.6118397	.789257
rhog	.9545257	.0186424	51.20	0.000	.9179873	.9910641
sd(e.u)	2.318204	.3047434			1.720918	2.91549
sd(e.g)	.5689891	.0982975			.3763296	.7616486

The slope of the Phillips curve, kappa, is estimated to be positive. The coefficient on inflation in the interest rate equation is estimated to be almost 1.94, meaning that interest rates are expected to rise almost two for one with increases in inflation.

Policy and transition matrices

Elements of the policy matrix represent the response of a control variable to a one-unit increase in a state variable.

```
. estat policy
Policy matrix
```

		Coefficient	Delta-method std. err.	z	P>|z|	[95% conf.	interval]
p							
	u	-.4172521	.0393609	-10.60	0.000	-.494398	-.3401061
	g	.9678177	.2777452	3.48	0.000	.4234472	1.512188
x							
	u	-1.608216	.405054	-3.97	0.000	-2.402107	-.8143245
	g	.9529203	.4813931	1.98	0.048	.0094071	1.896433
r							
	u	.1892776	.059166	3.20	0.001	.0733143	.3052409
	g	1.880474	.2616	7.19	0.000	1.367747	2.3932

An increase in u decreases the extent to which the inflation is above its short-run equilibrium value. This change decreases the output gap and increases interest rate.

An increase in g increases the extent to which the inflation is above its short-run equilibrium value. This change also increases output gap and interest rates.

Because the states are uncorrelated with each other in this example, the elements of the state transition matrix are just the persistence parameters in the model.

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

		Coefficient	Delta-method std. err.	z	P>|z|	[95% conf.	interval]
F.u							
	u	.7005483	.0452604	15.48	0.000	.6118397	.789257
	g	3.33e-16	.	.	.	.	.
F.g							
	u	0	(omitted)				
	g	.9545257	.0186424	51.20	0.000	.9179873	.9910641

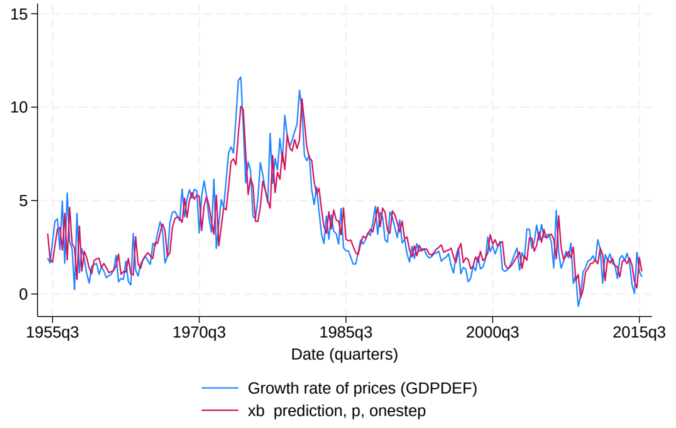
```
Note: Standard errors reported as missing for constrained transition matrix
      values.
```

See [DSGE] **Intro 4g** for an example in which the state variables depend on each other. The states can also depend on each other when a state variable is specified to depend on control variables, as in [DSGE] **Intro 3b**, or when the state vector includes lagged control variables, as in [DSGE] **Intro 4a**.

One-step-ahead predictions

Predictions after `dsge` depend on the estimated state-space parameters. Below, we obtain one-step-ahead predictions for each of the two observed control variables in the model, and we graph the actual and predicted inflation rates.

```
. predict dep*
(option xb assumed; fitted values)
. tsline p dep1, legend(col(1))
```



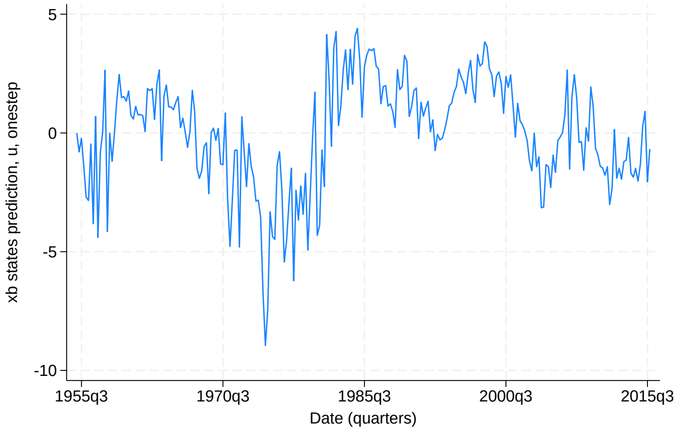
The graph shows that the one-step-ahead predictions closely follow realized inflation.

Estimating an unobserved state

The observed control variables are driven by two unobserved state variables. We can use `predict` with the `state` option to estimate the state variables.

Here we estimate the unobserved state u and plot it.

```
. predict state1, state
. tsline state1
```



The loose monetary policy in the mid-1970s, where predicted values of u_t are negative, and the subsequent Volcker contraction are apparent in this plot.

Reference

Schenck, D. 2017. Estimating the parameters of DSGE models. *The Stata Blog: Not Elsewhere Classified.* https://blog.stata.com/2017/07/11/estimating-the-parameters-of-dsge-models/.

Also see

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

[DSGE] **Intro 3b** — New Classical model

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

[DSGE] **Intro 3d** — Nonlinear New Keynesian model

[DSGE] **Intro 9a** — Bayesian estimation of a New Keynesian model

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

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