ECON 4325 – Monetary Policy and Business Fluctuations

Tommy Sveen

Norges Bank

January 18, 2009

15/1: Introduction and empirical evidence (Sveen)
Readings: Galí, ch. 1, Christiano, Eichenbaum and Evans (2005)

22/1: A simple RBC model, log-linearization (Sveen)
Readings: Galí, ch. 2

29/1: The basic new Keynesian model (Haugland)
Readings: Galí, ch. 3

5/2: The basic new Keynesian model (Haugland)

12/2: Interest rate rules (Sveen)
Readings: Galí, ch. 4

19/2: The credit channel of monetary policy (Alstadheim)
Readings: Walsh, ch. 7

26/2: Monetary policy and financial crises (Alstadheim)
Readings: To be announced

12/3: Time-inconsistency (Røisland)
Readings: Lecture notes

19/3: Optimal policy in the New Keynesian model (Røisland)
Readings: Galí, ch. 5.

26/3: Monetary policy in Norway (Røisland)
Readings: Holmsen, Qvigstad, Røisland and Solberg-Johansen (2008), Faust and Henderson (2004), Woodford (2005)

2/4: Welfare costs of business fluctuations (Holden)
Readings: Gali, Gertler, López-Salido

23/4: Monetary policy, unemployment and wages (Holden)
Readings: To be announced

30/4: Summary and some loose ends (Holden)
Readings: To be announced

Monetary Economics (ME) analyzes the relationship between real variables – such as real GDP, real interest rates, employment or unemployment, and real exchange rate – and nominal variables – such as rate of inflation, nominal interest rates, nominal exchange rate, and money supply:

- Relationship between different nominal variables.
- Relationship between different real variables – in monetary models.

- IS-LM and AD-AS models (60-70’s):
  - Ad hoc static models. Completely fixed prices.
  - AD-AS – adding a supply side: focus still on price level.
  - ME concerned with inflation.
  - Central bank controls money supply.

- Flexible-price models:
  - RBC-models: new-classical models with flexible prices and wages, microfounded, productivity shocks important.
  - Monetary models: Lucas' supply curve, LPC-models, MIU-models. Generally small effects from monetary disturbances.
- New-Keynesian models: Most models have classical long-run properties, microfoundation, monopolistic competition in product and factor markets, nominal rigidities.

- Correlation between the growth rate of money supply and inflation is almost 1 (varying between 0.92-0.96).
  - If money growth exogenous – evidence that money growth causes inflation (one-for-one).
  - The reverse causality equally consistent with high correlation – the CB adjusts money growth to the rate of inflation.
  - Theoretical models should be consistent with this finding.
- No correlation between inflation and GDP growth, but this result is less robust:
  - Slightly positive correlation at low levels of inflation.
  - Negative correlation for high levels of inflation.

Table 1

Business Cycles in 10 Developed Countries*

1970–mid-1990

	Volatility								Persistence:	Comovement: Correlation With Output					
	Standard Deviation		Ratio of Standard Deviation to That of Output						Auto-correlation of Output						
Country	Output	Net Exports	Consumption	Investment	Government Purchases	Employment	Productivity Shock			Consumption	Investment	Government Purchases	Net Exports	Employment	Productivity Shock
Australia	1.45%	1.23%	.66	2.78	1.28	.34	1.00		.60	.46	.68	.15	−.01	.12	.98
Austria	1.28	1.15	1.14	2.92	.36	1.23	.84		.57	.65	.75	−.24	−.46	.58	.65
Canada	1.50	.78	.85	2.80	.77	.86	.74		.79	.83	.52	−.23	−.26	.69	.84
France	.90	.82	.99	2.96	.71	.55	.76		.78	.61	.79	.25	−.30	.77	.96
Germany	1.51	.79	.90	2.93	.81	.61	.83		.65	.66	.84	.26	−.11	.59	.93
Italy	1.69	1.33	.78	1.95	.42	.44	.92		.85	.82	.86	.01	−.68	.42	.96
Japan	1.35	.93	1.09	2.41	.79	.36	.88		.80	.80	.90	−.02	−.22	.60	.98
Switzerland	1.92	1.32	.74	2.30	.53	.71	.67		.90	.81	.82	.27	−.68	.84	.93
United Kingdom	1.61	1.19	1.15	2.29	.69	.68	.88		.63	.74	.59	.05	−.19	.47	.90
United States	1.92	.52	.75	3.27	.75	.61	.68		.86	.82	.94	.12	−.37	.88	.96
Europe	1.01%	.50%	.83	2.09	.47	.85	.98		.75	.81	.89	.10	−.25	.32	.85

*All data are quarterly and have been detrended with the Hodrick-Prescott filter. All but net exports have also been logged. The specific variables included are real output; real consumption; real fixed investment; real government purchases; the ratio of net exports to output, both measured in current prices; civilian employment; and a productivity shock, which is the Solow residual, as defined in equations (1) and (2).

Sources of basic data: OECD and IMF

Common features

- Standard deviation of output 1.5-1.9 (except FRA).
- Consumption smoother than output (not in UK and A), while investments are 2-3 times as volatile as output.
- Employment smoother than output, but some differences across countries.
- Persistence fluctuations in output.
- Employment, consumption and investment are pro-cyclical.

- Have monetary policy disturbances played a role in economic fluctuations?
- Are the predictions from theoretical models consistent with empirical evidence?

Friedman and Schwartz

- Faster money growth tends to be followed by increases in output above trend – slower money growth by declines in output.
- Variations in money growth cause – with long and variable lags – variations in real activity.

- Proposed by Christopher Sims in 1970s, 1980s (see, e.g., “Macroeconomics and Reality”, *Econometrica* 48, 1-48.).
- Useful way to organize data.
- We want to answer the following question: "How does the economy respond to a particular shock?"
    - The answer can be very useful for discriminating between models, and for estimating the parameters of a given model.
    - VARs can not actually address such a question! We need Structural VARs.

The Basic Set-Up

- Let Y_t be a $N \times 1$ vector of macroeconomic variables. A Vector Autoregression is:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + ... + B_p Y_{t-p} + u_t,$$

where the $B's$ are parameters and u_t is a vector of shocks. Moreover we have $Eu_t u_t' = \Sigma_u$.

- It is easy to get estimates for the $B's$, the $u's$, and Σ_u, but we are interested in impulse response functions to *fundamental* shocks:

$$\begin{aligned} u_t &= Ce_t, \\ Ee_t e_t' &= \Sigma_e = I, \\ CC' &= \Sigma_u. \end{aligned}$$

- The structural VAR:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + ... + B_p Y_{t-p} + Ce_t.$$

- The impulse response to the i^{th} shock:

$$\begin{aligned} Y_t - E_{t-1} Y_t &= C_i e_{i,t}, \\ E_t Y_{t+1} - E_{t-1} Y_{t+1} &= B_1 C_i e_{i,t}, \\ &\ldots \end{aligned}$$

- To compute impulse responses we need $B_1, ..., B_p$, and C.

Identification

- There are n^2 different terms in C, while there are only $n(n+1)/2$ independent equations in $CC' = \Sigma_u$.
- Identification problem: not enough restrictions to pin down all the parameters in C.
- We need additional $n(n-1)/2$ identifying restrictions.

Example

- Consider a bivariate VAR in x_t and π_t with two lags:

$$
\begin{aligned}
x_t &= B^1_{xx} x_{t-1} + B^1_{x\pi} \pi_{t-1} + B^2_{xx} x_{t-2} + B^2_{x\pi} \pi_{t-2} + u_{x,t}, \\
\pi_t &= B^1_{\pi x} x_{t-1} + B^1_{\pi\pi} \pi_{t-1} + B^2_{\pi x} x_{t-2} + B^2_{\pi\pi} \pi_{t-2} + u_{\pi,t},
\end{aligned}
$$

and it is assumed that

$$
\begin{aligned}
u_{x,t} &= C_{xx} e_{x,t} + C_{x\pi} e_{\pi,t}, \\
u_{\pi,t} &= C_{\pi x} e_{x,t} + C_{\pi\pi} e_{\pi,t},
\end{aligned}
$$

- From the OLS estimation we get

$$
\Sigma_u = \begin{bmatrix} \sigma^2_{u_x} & \sigma_{u_x,u_\pi} \\ \sigma_{u_x,u_\pi} & \sigma^2_{u_\pi} \end{bmatrix}.
$$

- We need one additional restriction.

Identification

- Three basic approaches to solve the identification problem:

(i) Contemporaneous restrictions:
  - No short-run effects from policy shocks to some variable(s).
    - E.g. monetary policy shocks do not affect output within the same period.
  - No short-run effect from shocks to the policy instrument.
    - Monetary policy does not react – within the period – to certain shocks or variables.

Identification

(ii) Long-run restrictions:

- Monetary neutrality.
  - Monetary policy disturbances have no long-run effect on real variables (output, unemployment, real exchange rate, etc).
  - Demand shocks no long-run effects on output and unemployment.

(iii) Sign restrictions:

- Positive demand shocks increase inflation, while positive supply shocks decrease inflation.

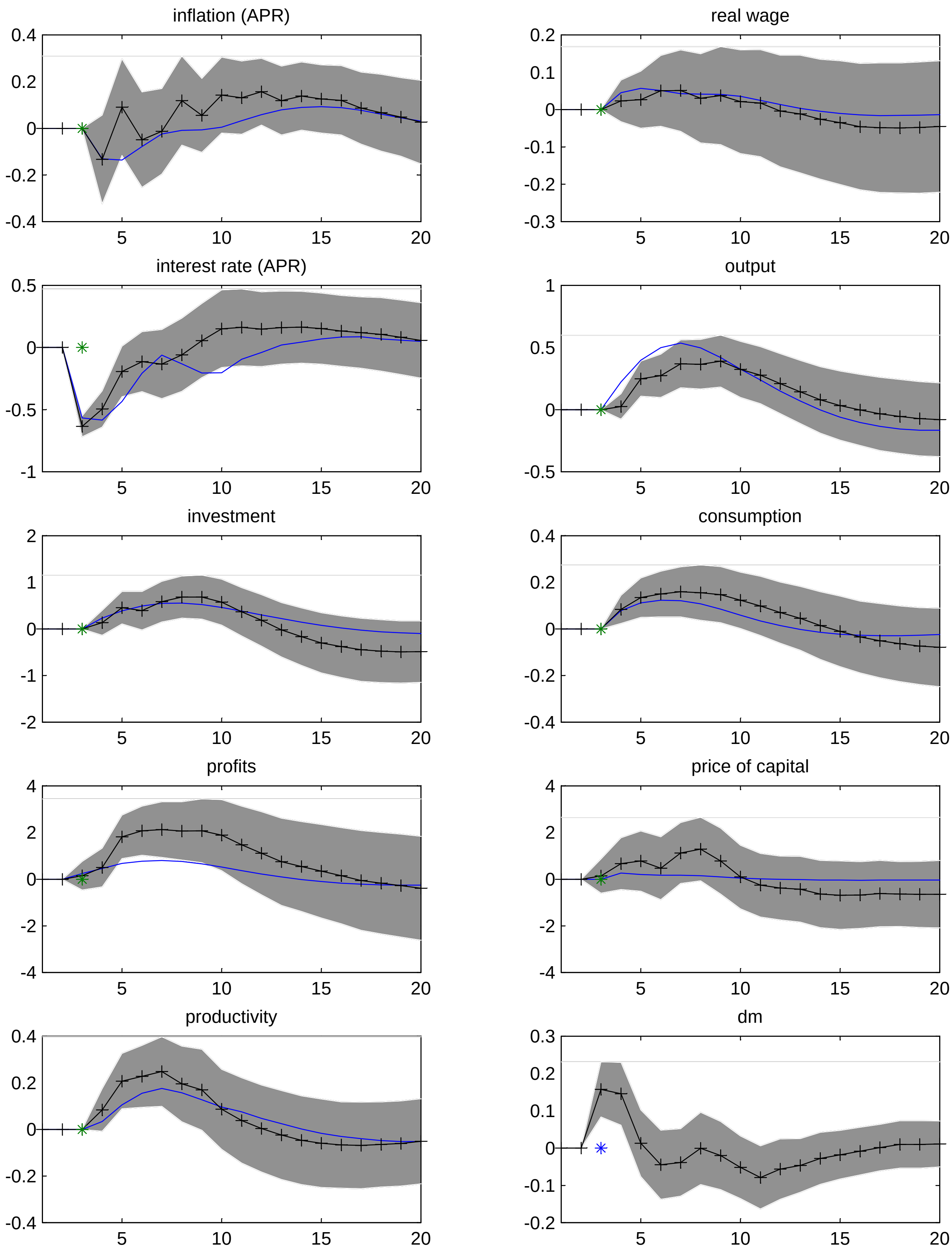
Christiano, Eichenbaum and Evans (2005)

- Use short-run restrictions to identify a monetary policy rule and the corresponding shock to policy:

  $$R_t = f(\Omega_t) + \epsilon_t,$$

  where R_t is the federal funds rate, f is a linear function of the information set Ω_t, and ϵ_t is the monetary policy shock.
- Let the vector of variables be $Y_t = [Y_{1,t}, R_t, Y_{2,t}]'$.
  - Variables in $Y_{1,t}$ (GDP, consumption, GDP deflator, investments, real wage, labor productivity) do not react to monetary policy shocks.
  - Variables in $Y_{2,t}$ (real profits and growth in M2) do not belong to Ω_t.

Figure 1: Model and Data Impulse Responses



Main Results

- Persistent effects on real variables.
- Inflation is slow to react.
- Hump-shaped responses of real variables.
- Walsh (2003): "We cannot design policy without a theory of how money – or monetary policy in general – affects the economy".

Log-Linearizing

- Useful method to approximate and solve dynamic models.
- Let x_t denote the log-deviation of variable X_t around it's steady state X:

$$x_t = \log\left(\frac{X_t}{X^{ss}}\right).$$

- Hence, we look at percentage deviations of the variable around it's steady state value:

$$x_t \approx \frac{X_t - X}{X}.$$

- If $X_t = F\left(Y_t, Z_t\right)$, how do we find the log-linear approximation of X_t?

Log-Linearizing

- Rewrite the equation as:

$$\log\left(e^{\log X_t}\right) = \log\left(F\left(e^{\log Y_t}, e^{\log Z_t}\right)\right).$$

- Take a first-order Taylor approximation around the (log of) steady state on both sides:
  - LHS:

$$\log X + \frac{e^{\log X}}{e^{\log X}}\left(\log X_t - \log X\right)$$

  - RHS;

$$\log F\left(Y, Z\right) + \frac{F_Y\left(Y, Z\right) e^{\log Y}\left(\log Y_t - \log Y\right)}{F\left(Y, Z\right)} + \frac{F_Z\left(Y, Z\right) e^{\log Z}\left(\log Z_t - \log Z\right)}{F\left(Y, Z\right)}$$

- Therefore we have:

$$X x_t \simeq F_Y\left(Y, Z\right) Y y_t + F_Z\left(Y, Z\right) Z z_t$$

Log-Linearizing

A Simple Method

- In many (most) cases there is no need to explicitly differentiate the function F.
- Let us consider a simpler method:

$$X_t = X\left(\frac{X_t}{X}\right) = Xe^{\log(X_t/X)} = Xe^{x_t}$$

- Take a first-order Taylor approximation:

$$\begin{aligned} Xe^{x_t} &\simeq Xe^0 + Xe^0(x_t - 0) \\ &\simeq X(1 + x_t). \end{aligned}$$

- Consider an equation like $X_t = Y_t Z_t$:

$$\begin{aligned} Xe^{x_t} &= YZe^{y_t + z_t} \\ X(1 + x_t) &\simeq YZe^0 + YZe^0 y_t + YZe^{0_t} z_t \\ x_t &\simeq y_t + z_t. \end{aligned}$$

Log-Linearizing

A Useful Observation

- Consider again the function $X_t = F(Y_t, Z_t)$:

$$\begin{aligned} X_t &\simeq F(Y,Z) + F_Y(Y_t,Z_t)(Y_t - Y) + F_Z(Y_t,Z_t)(Z_t - Z) \\ &\simeq F(Y,Z) + F_Y(Y,Z)\,Y(Y_t/Y - 1) \\ &\quad + F_Z(Y,Z)\,Z(Z_t/Z - 1) \\ &\simeq F(Y,Z)\left[1 + \epsilon_{x,y} y_t + \epsilon_{x,z} z_t\right], \end{aligned}$$

where $\epsilon_{x,y} = \frac{\partial F}{\partial Y}\frac{Y}{X}$ is the steady state elasticity of X wrt Y.

- Cobb-Douglas production function: $Y_t = K_t^\alpha N_t^{1-\alpha}$. What is log-linearized output?

$$Y_t = A_t K_t^\alpha N_t^{1-\alpha},$$

where Y_t is output, A_t is the level of technology, K_t is the capital stock, and N_t is labor. Parameter α is the capital share in production.

- Rewriting gives:

$$e^{y_t} = e^{a_t + \alpha k_t + (1-\alpha) n_t},$$

where we have used the steady state relationship.

- Next, we take a first-order Taylor approximation:

$$y_t = a_t + \alpha k_t + (1-\alpha)\, n_t.$$

- The aggregate resource constraint:

$$Y_t = C_t + I_t,$$

where C_t is consumption and I_t is investment.

- Rewriting:

$$1 = \frac{C_t}{Y_t} + \frac{I_t}{Y_t}.$$

- Taking a first-order Taylor approximation of the different terms gives:

$$\begin{aligned} 1 &\simeq \frac{C}{Y}\left(1 + c_t - y_t\right) + \frac{I}{Y}\left(i_t - y_t\right) \\ y_t &= \frac{C}{Y}c_t + \frac{I}{Y}i_t. \end{aligned}$$