Evaluating a monetary business cycle model for the euro area

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Goal of the paper

Which shocks and frictions shape the euro area business cycle?
1. Business-cycle facts

2. Estimation technique

3. Model

4. Model fit

5. Shocks and frictions

6. Alternative estimation technique
Euro area business-cycle facts
Euro Area Data from 1985:Q1 to 2006:Q1 expressed in log-deviations from sample average.
Spectral densities of euro area data
Output Growth

Consumption Growth

Investment Growth

90% confidence bands of US and EA data spectral densities
Estimation: Spectra matching (Wen 1998)

- focuses on auto-covariances, ignores cross-covariances
- greater weight on frequencies contributing most to variance
A New Keynesian model with unemployment
Standard features (CEE 2005, SW 2003)

- Quadratic price adjustment costs à la Rotemberg
- Hybrid NKPC through ad-hoc inflation indexation
- Habit, Investment adjustment cost & Variable capital utilization
- 7 shocks: Techno, Investment, Preference, Markup, Wage bargaining, Exogenous spending, Monetary
Search-and-matching frictions in labor market

- Income-pooling hypothesis (Merz 1995)
- No out-of-labor-force status
- Hours per worker constant
- Exogenous job destruction
- Wage inertia (Hall 2005) and Convex hiring costs (Yashiv 2006)
- Newly hired workers start producing immediately
Model fit
Yearly Output Growth

Yearly Consumption Growth

Yearly Investment Growth

Yearly Wage Growth

Vacancy / Unemployment

Yearly Inflation

Interest Rate

Data spectrum and model's 90% confidence bands.
Sources of business cycles in the euro area
Sources of business cycles in the euro area.
Sources of business cycles in the euro area.
Median impulse responses to a one-standard-deviation price markup shock and 90% bands.
Impulse responses to price-markup and wage-markup shocks (Solid line: median; Shaded area: 90% bands).
Key frictions for business cycles are nominal

1. Price-setting highly backward-looking ($\gamma_{\pi} = 0.95$)

2. Prices very sticky ($\phi_P = 285$)

$$\hat{\pi}_t = \beta \left[ \gamma_{\pi} \hat{\pi}_{t-1} + (1 - \gamma_{\pi}) E_t \hat{\pi}_{t+1} \right] + \left( \frac{\theta - 1}{\phi_P} \right) \hat{rmc}_t - \frac{1}{\phi_P} \hat{\theta}_t$$

1. and 2. $\implies$ inflation follows near-unit root process

3. Monetary policy very persistent ($\rho_R = 0.98$)

$$\hat{r}_t = \rho_R \hat{r}_{t-1} + \rho_{\pi} \hat{\pi}_t + \rho_y \left( \hat{y}_t - \hat{y}_t^N \right) + \varepsilon_{rt}$$

1., 2. and 3. $\implies$ real interest rate generates consumption cycles
Impulse responses to a price-markup shock under alternative calibrations

Baseline ($\phi_P^{SM} = 285, \gamma_\pi^{SM} = 0.95, \rho_R^{SM} = 0.98$)

$\rho_R = 0.7$

$\gamma_\pi = 0.4$

$\phi_P = 50$
Maximum likelihood estimation
Figure 21. Spectral densities of yearly output growth conditional on one shock at a time in the model estimated by (1) spectra matching (top panel), (2) maximum likelihood (bottom panel).
Conclusions

1. US and EA business cycles are different

2. Markup shocks: main source of business cycle in euro area

3. Key factors: (1) Inflation inertia, (2) Persistent monetary policy

4. DSGE misspecified $\Rightarrow$ spectra matching for Business Cycle Analysis
Improving model specification

1. Model fails to generate large variance of investment

2. Model fails to replicate trend in $\pi$ and $r$

3. Model unable to get hump-shaped $Coh(\Delta Y, V/U)$
Thank You!
Appendix
The *spectra-matching estimator* is given by

\[
\hat{\theta}_W = \arg \min_{\theta} [G_W(\theta)]
\]

\[
G_W(\theta) = \text{tr} \left[ \sum_{\omega_j \in (0, \pi)} W(\omega_j) \odot |F_m(\omega_j; \theta) - \hat{F}_d(\omega_j)| \right]
\]

\[
W(\omega_j) = \hat{F}_d(\omega_j) \odot \left[ \sum_j \hat{F}_d(\omega_j) \right]
\]
Household chooses $C_t, B_t, u_t, I_t,$ and $\overline{K}_t$ to max

$$E_t \sum_{s=0}^{\infty} \beta^s a_{t+s} \ln(C_{t+s} - hC_{t+s-1})$$

subject to

$$\overline{K}_t \leq (1 - \delta)\overline{K}_{t-1} + \mu_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right]I_t$$

$$P_t C_t + P_t I_t + B_t/r_t - B_{t-1} \leq W_t N_t + (1 - N_t)b_t + r^K u_t \overline{K}_{t-1} - P_t a(u_t) \overline{K}_{t-1} - T_t + D_t$$

where

$$K_t = u_t \overline{K}_{t-1}$$

$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \varepsilon_{at}$$

$$\ln(\mu_t) = \rho_\mu \ln(\mu_{t-1}) + \varepsilon_{\mu t}$$
Given $P_{i,t}$ and $P_t$, firm chooses $Y_{i,t}$ for all $i \in [0, 1]$ to max

$$P_tY_t - \int_0^1 P_{i,t}Y_{i,t} \, di$$

subject to

$$Y_t = \left[ \int_0^1 Y_{i,t}^{(\theta_t-1)/\theta_i} \, di \right]^{\theta_t/(\theta_t-1)}$$

where

$$\ln(\theta_t) = (1 - \rho_\theta) \ln(\theta) + \rho_\theta \ln(\theta_{t-1}) + \varepsilon_{\theta t}$$
Intermediate goods-producing firm

Firm \( i \) chooses \( K_{i,t}, N_{i,t}, V_{i,t}, Y_{i,t} \) and \( P_{i,t} \) to max

\[
E_t \sum_{s=0}^{\infty} \beta^s \Lambda_{t+s} \left( \frac{D_{i,t+s}}{P_{t+s}} \right)
\]

where

\[
D_{i,t} = P_{i,t} Y_{i,t} - W_{i,t} N_{i,t} - r^K_t K_{i,t} - \left[ \frac{\phi_N}{2} \left( \frac{q_t V_{i,t}}{N_{i,t}} \right)^2 + \frac{\phi_P}{2} \left( \frac{P_{i,t}}{\pi P_{i,t-1}} - 1 \right)^2 \right] P_t Y_t
\]

subject to

\[
Y_{i,t} = \left( \frac{P_{i,t}}{P_t} \right)^{-\theta_t} Y_t
\]

\[
Y_{i,t} \leq K_{i,t}^\alpha (A_t N_{i,t})^{1-\alpha}, \quad \ln(A_t) = \ln(A_{t-1}) + \ln(z) + \varepsilon_{zt}
\]

\[
N_{i,t} = \chi N_{i,t-1} + q_t V_{i,t}
\]

\[
q_t = \frac{m_t}{V_t}, \quad m_t = \zeta S_t^\sigma V_t^{1-\sigma}, \quad S_t = 1 - \chi N_{t-1}
\]
Empirical inflation equation

- Log-linearized *microfunded* inflation equation (NKPC)

$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \kappa m c_t + \theta_t$$

- Log-linearized *empirical* inflation equation (Hybrid NKPC)

$$\hat{\pi}_t = \beta [\gamma_\pi \hat{\pi}_{t-1} + (1 - \gamma_\pi) E_t \hat{\pi}_{t+1}] + \kappa m c_t + \theta_t$$
Wage setting

\( W_t^{NB} \) Nash bargaining wage

\[
W_t^{NB} = \arg \max_{W_t} (S_t^W) \eta_t (S_t^F)^{1-\eta_t}
\]

where

\[
\ln \eta_t = (1 - \rho_\eta) \ln \eta + \rho_\eta \ln \eta_{t-1} + \varepsilon_{\eta_t}
\]

\[
S_t^W = W_t - b_t + \beta \chi E_t \left[ \frac{\Lambda_{t+1}}{\Lambda_t} \frac{P_t}{P_{t+1}} (1 - s_{t+1}) S_{t+1}^W \right], \quad b_t = \tau W \exp(zt)
\]

\[
S_t^F = P_t \left( \frac{\Xi_t}{\Lambda_t} \right) \left[ (1 - \alpha) \frac{Y_t}{N_t} \right] - W_t + P_t \left( \frac{\phi_N Y_t x_t^2}{N_t} \right) + \beta \chi E_t \left( \frac{\Lambda_{t+1} P_t}{\Lambda_t P_{t+1}} S_{t+1}^F \right)
\]
Empirical wage equation

- **Microfunded** real wage equation

\[
W_{t}^{NB} = \eta_t \left\{ \left( \frac{\Xi_t}{\Lambda_t} \right)(1 - \alpha) \frac{Y_t}{N_t} + \frac{\phi_{NY_t}}{N_t} x_t^2 + \beta \chi E_t \left( \frac{\Lambda_{t+1}}{\Lambda_t} \frac{\phi_{NY_{t+1}}}{N_{t+1}} \right) s_{t+1} x_{t+1} \right\} + (1 - \eta_t) \bar{b}_t
\]

- **Empirical** log-linearized real wage equation

\[
\hat{W}_t = \gamma_w \hat{W}_{t-1} + (1 - \gamma_w) \hat{W}_t^{NB}
\]
Fiscal Policy

The government’s budget constraint is

\[ P_t G_t + (1 - N_t) b_t = (B_t/r_t - B_{t-1}) + T_t \]

Government spending \( G_t \) is a time-varying fraction of GDP

\[ G_t = \left(1 - \frac{1}{g_t}\right) Y_t \]

with

\[ \ln g_t = (1 - \rho_g) \ln g + \rho_g \ln g_{t-1} + \varepsilon_{gt} \]
Monetary Policy

Central bank adjusts $r_t$ following a Taylor rule

$$\ln\left(\frac{r_t}{r}\right) = \rho_r \ln\left(\frac{r_{t-1}}{r}\right) + \rho_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \rho_y \ln\left(\frac{Y_t}{Y_t^N}\right) + \varepsilon_{rt}$$

$Y_t^N$ : “flex price - flex wage level of output” $(\phi_P = 0, \gamma_w = 0)$

in absence of price markup and wage bargaining shocks $(\hat{\theta}_t = 0, \hat{\eta}_t = 0)$