Academia Sinica Mini-Course II

“Fluctuating Macro Policies and the Fiscal Theory” w/ T. Davig

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MONETARY AND FISCAL POLICY INTERACTIONS

- Standard reasoning about macro policy
  - active monetary policy necessary for stability
  - Taylor principle delivers good economic performance in many models
  - high and variable inflation due to indeterminacy
  - active monetary/passive fiscal policies insulate economy from demand shocks (e.g., fiscal)

- Reasoning rests on convenient assumptions
  - passive fiscal behavior
  - fixed policy regimes
  - local $\rightarrow$ global
Regime Change

Regime change is different realizations of parameters in

$$R_t = \alpha_0(S_t) + \alpha_\pi(S_t)\pi_t + \alpha_x(S_t)x_t + \sigma(S_t)\epsilon_t$$

$S_t$ evolves stochastically by a known process.

Many researchers have estimated policy rules to find parameters changed over time.

- Taylor, Clarida-Galí-Gertler, Auerbach, Lubik-Schorfheide, Sala, Favero-Monacelli

Fixed-regime theory: problematic interpretation

- ex-ante agents put probability 0 on change
- ex-post agents put probability 1 on new regime
- Cooley-LeRoy-Raymon: this is logically inconsistent
Bring together empirical and theoretical work
Estimate Markov-switching rules for U.S. monetary and fiscal policies
Embed estimated joint policy process in DSGE model with rigidities
WHAT WE FIND

- Policies fluctuate between active & passive
  - some active/active; some passive/passive
- Fit is good; connects to narrative accounts
- Post-war U.S. data can be modeled as a single, locally unique equilibrium
- Fiscal theory of price level always operative
  - taxes matter even with active MP/passive FP
- Fiscal theory mechanism quantitatively important
  - $1 transitory tax cut \(\Rightarrow\) PV output rises \(\approx\) $1
  - reconciles DSGE models with fiscal evidence
- Common practice: break samples into distinct regimes and embed rules in fixed-regime DSGE can produce misleading inferences
CASH-LESS, ENDOWMENT ECONOMY, FIXED REAL RATE

FISHER RELATION & GOVT BUDGET CONSTRAINT \((g = 0)\)

\[
R_t^{-1} = \beta E_t \frac{1}{P_t^{t+1}/P_t}
\]

\[
B_t = R_{t-1} \frac{B_{t-1}}{P_t}
\]

MONETARY & (LUMP-SUM) TAX RULES

\[
R_t^{-1} = \alpha_0 + \alpha \frac{P_{t-1}}{P_t} + \nu_t
\]

\[
T_t = \gamma_0 + \gamma \frac{B_{t-1}}{P_{t-1}} + \varepsilon_t
\]

Shocks are exogenous, possibly serially correlated
Obtain bivariate system in \( \{ P_{t-1}/P_t, B_t/P_t \} \)

\[
\frac{P_t}{P_{t+1}} = \beta^{-1} \alpha_0 + \beta^{-1} \alpha \frac{P_{t-1}}{P_t} + \beta^{-1} \nu_t + \eta_{t+1}^P
\]

\[
\eta_{t+1}^P = \frac{P_t}{P_{t+1}} - E_t \frac{P_t}{P_{t+1}}
\]

\[
\frac{B_t}{P_t} = (\beta^{-1} - \gamma) \frac{B_{t-1}}{P_{t-1}} - (\gamma_0 + E_{t-1} \varepsilon_t) + \eta_t^b
\]

\[
\eta_t^b = \frac{B_t}{P_t} - E_{t-1} \frac{B_t}{P_t}
\]
Categorize regions of the \((\alpha, \gamma)\) parameter space

**Active monetary policy:** \(|\alpha/\beta| > 1\)

**Passive monetary policy:** \(|\alpha/\beta| < 1\)

**Active fiscal policy:** \(|\beta^{-1} - \gamma| > 1\)

**Passive fiscal policy:** \(|\beta^{-1} - \gamma| < 1\)

A determinate bounded equilibrium requires:

**One active and one passive policy**

- Both passive: indeterminacy
- Both active: no equilibrium or no bounded equilibrium
MONETARY-FISCAL INTERACTIONS

- Active monetary/passive fiscal policy
  - The usual assumption (e.g., Taylor rule)
  - Inflation entirely a monetary phenomenon
  - Ricardian equivalence holds
- Active fiscal/passive monetary policy
  - The fiscal theory of the price level
  - Price level determined by fiscal policy
  - Ricardian equivalence fails
- Example: $\alpha = \gamma = 0$

\[
P_t = \frac{R_{t-1} B_{t-1}}{E_t \left[ \sum_{s=1}^{\infty} \beta^s (\gamma_0 + \varepsilon_{t+s}) \right]} \beta E_t \frac{P_t}{P_{t+1}} = \alpha_0 + \nu_t = R_t^{-1}
\]
Policy Rule Estimates

- Hidden Markov chain, as in Hamilton and Kim-Nelson
- Off-the-shelf policy rules; no dynamics
- Independent switching of M & F regimes

\[ r_t = \alpha_0(S_t^M) + \alpha_\pi(S_t^M)\pi_t + \alpha_x(S_t^M)x_t + \sigma_R(S_t^M)\varepsilon_t \]

4 states, \( \alpha \)'s have 2 sets of values, \( P^M \) transition matrix

\[ \tau_t = \gamma_0(S_t^F) + \gamma_b(S_t^F)b_{t-1} + \gamma_x(S_t^F)x_t + \gamma_g(S_t^F)g_t + \sigma_\tau(S_t^F)\varepsilon_t \]

2 states, \( P^F \) transition matrix

- \( S_t = (S_t^M, S_t^F) \). Joint distribution \( P = P^M \otimes P^F \), 8 states
Policy Rule Estimates

- U.S. data, 1948:2-2004:1
  - $r$: 3-month Treasury bill
  - $\pi$: log difference of GDP deflator
  - $x$: log output gap using CBO potential
  - $\tau$: federal receipts net transfers as share of GDP
  - $b$: market value of federal debt held by public as share of GDP
  - $g$: federal government consumption plus investment expenditures as a share of GDP
Four checks on plausibility of estimates

1. Are the estimates reasonable on *a priori* grounds?
2. Do the estimates fit the data?
3. Do the estimates accord with narrative and other evidence on active/passive periods?
4. Does the estimated policy process make sense in a standard DSGE model?

Yes!
# Monetary Policy Estimates

<table>
<thead>
<tr>
<th>State</th>
<th>$S_t^M = 1$</th>
<th>$S_t^M = 2$</th>
<th>$S_t^M = 3$</th>
<th>$S_t^M = 4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_{\pi}$</td>
<td>1.3079 (0.0527)</td>
<td>1.3079 (0.0527)</td>
<td>0.5220 (0.0175)</td>
<td>0.5220 (0.0175)</td>
</tr>
<tr>
<td>$\alpha_y$</td>
<td>0.0232 (0.0116)</td>
<td>0.0232 (0.0116)</td>
<td>0.0462 (0.0043)</td>
<td>0.0462 (0.0043)</td>
</tr>
<tr>
<td>$\sigma_r^2$</td>
<td>1.266e-5 (8.670e-6)</td>
<td>9.184e-7 (1.960e-6)</td>
<td>2.713e-5 (5.423e-6)</td>
<td>5.434e-7 (1.512e-6)</td>
</tr>
</tbody>
</table>

**Table:** Log likelihood value $= -1014.737$
## Tax Policy Estimates

<table>
<thead>
<tr>
<th>State</th>
<th>$S^F_t = 1$</th>
<th>$S^F_t = 2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_0$</td>
<td>0.0497</td>
<td>0.0385</td>
</tr>
<tr>
<td></td>
<td>(0.0021)</td>
<td>(0.0032)</td>
</tr>
<tr>
<td>$\gamma_b$</td>
<td>0.0136</td>
<td>-0.0094</td>
</tr>
<tr>
<td></td>
<td>(0.0012)</td>
<td>(0.0013)</td>
</tr>
<tr>
<td>$\gamma_y$</td>
<td>0.4596</td>
<td>0.2754</td>
</tr>
<tr>
<td></td>
<td>(0.0326)</td>
<td>(0.0330)</td>
</tr>
<tr>
<td>$\gamma_g$</td>
<td>0.2671</td>
<td>0.6563</td>
</tr>
<tr>
<td></td>
<td>(0.0174)</td>
<td>(0.0230)</td>
</tr>
<tr>
<td>$\sigma^2_\tau$</td>
<td>4.049e-5</td>
<td>5.752e-5</td>
</tr>
<tr>
<td></td>
<td>(6.909e-6)</td>
<td>(8.472e-6)</td>
</tr>
</tbody>
</table>

**Table**: Log likelihood value $= -765.279$
INTEREST RATE: ACTUAL & PREDICTED
INTRODUCTION
SOME BACKGROUND THEORY
ESTIMATION
THEORETICAL MODEL
SOLUTION
WRAP UP

MONETARY REGIME PROBABILITIES

Monetary Regime Probabilities
Active, High σ

Active, Low σ

Passive, High σ

Passive, Low σ

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Fiscal Regime Probabilities

Fiscal Regime Probabilities

Passive

Active
JOINT POLICY REGIME PROBABILITIES
A Model with Nominal Rigidities

- Conventional: monopolistic competition, Calvo pricing, elastic labor, lump-sum taxes, nominal debt

- Households

\[
E_t \sum_{i=0}^{\infty} \beta^i \left[ \frac{C_{t+i}^{1-\sigma}}{1-\sigma} - \chi \frac{N_{t+i}^{1+\eta}}{1+\eta} + \delta \frac{(M_{t+i}/P_{t+i})^{1-\kappa}}{1-\kappa} \right]
\]

\[
C_t = \left[ \int_0^1 c_{jt}^{\theta-1} \, dj \right]^{\frac{\theta}{\theta-1}}, \theta > 1
\]

\[
C_t + \frac{M_t}{P_t} + E_t \left( Q_{t,t+1} \frac{B_{t+1}}{P_{t+1}} \right) + \tau_t \leq \left( \frac{W_t}{P_t} \right) N_t + \frac{M_{t-1}}{P_t} + \frac{B_{t-1}}{P_t} + \Pi_t
\]

\[
E_t \left[ Q_{t,t+1} \right]^{-1} = 1 + r_t
\]
A Model with Nominal Rigidities

- Firms

\[ E_t \sum_{i=0}^{\infty} \varphi^i q_{t+i} \left[ \left( \frac{p_t^*}{P_{t+i}} \right)^{1-\theta} - \Psi_{t+i} \left( \frac{p_t^*}{P_{t+i}} \right)^{-\theta} \right] Y_{t+i} \]

\[ \frac{p_t^*}{P_t} = \left( \frac{\theta}{\theta-1} \right) \frac{K_{1t}}{K_{2t}} \]

\[ K_{1t} = (Y_t - G_t)^{-\sigma} \Psi_t Y_t + \varphi \beta E_t K_{1t+1} \left( \frac{P_{t+1}}{P_t} \right)^{\theta} \]

\[ K_{2t} = (Y_t - G_t)^{-\sigma} Y_t + \varphi \beta E_t K_{2t+1} \left( \frac{P_{t+1}}{P_t} \right)^{\theta-1} \]

\[ \pi_t^{\theta-1} = \frac{1}{\varphi} - \frac{1-\varphi}{\varphi} \left( \mu \frac{K_{1t}}{K_{2t}} \right)^{1-\theta} \]

- Relative price dispersion

\[ \Delta_t = (1 - \varphi) \left( \frac{p_t^*}{P_t} \right)^{-\theta} + \varphi \pi_t^{\theta} \Delta_{t-1} \]
A Model with Nominal Rigidities

- Policy follows estimated rules and satisfies

\[ G_t = \tau_t + \frac{M_t - M_{t-1}}{P_t} + E_t \left( Q_{t,t+1} \frac{B_t}{P_t} \right) - \frac{B_{t-1}}{P_t} \]

- Two information assumptions:
  - standard: \( \Omega_t = \{ \varepsilon_{t-j}^r, \varepsilon_{t-j}^\tau, S_{t-j}^M, S_{t-j}^F, j \geq 0 \} \)
  - foreknowledge: \( \Omega^*_t = \Omega_t \cup \{ \varepsilon_{t+1}^\tau \} \)

- Focus on stationary equilibria
  - \( b/y \to \infty \) feasible with lump-sum taxes
  - U.S. \( b/y \) appears stationary

- Use monotone map method to solve non-linear model
  - finds functions mapping state to decisions
  - state: \( \Theta_t = \{ b_{t-1}, w_{t-1}, \Delta_{t-1}, \varepsilon_t^r, \varepsilon_t^\tau, S_t \} \)
The Fiscal Theory Mechanism

- A (present value) equilibrium condition
  \[
  \frac{M_{t-1} + B_{t-1}}{P_t} = \sum_{T=t}^{\infty} E_t \left[ q_{t,T} \left( \tau_T - G_T + \frac{r_T}{1+r_T} \frac{M_T}{P_T} \right) \right]
  \]

- Three sources of financing: net-of-interest surpluses; seigniorage; revaluations induced by jumps in \( P_t \)

- Cut \( \tau_t \) with exogenous \( \tau - G \) and pegged \( r \)
  - at initial prices, feel wealthier
  - increase demand for current goods
  - raises output relative to potential
  - money stock expands passively
  - must also raise inflation & lower real rates

- With positive probability of active FP, the mechanism is always operating
Characteristics of Equilibrium

- Numerical analysis of uniqueness and stationarity
- Numerical checks
  - randomly perturb decision rules at points in state space: converge back?
  - how monotone map behaves when properties known
    - indeterminacy (non-convergence)
    - non-existence (converges but solutions explode)
  - zero expected present value of debt?
  - histograms
Three regimes are stationary

- AM/PF, PM/PF, PM/AF
- AM/AF exhibits slowly growing debt

A surprise tax cut of 2% of GDP, conditional on each stationary regime

1. condition on remaining in prevailing regime
2. average across future regimes

Compute tax multipliers

condition on initial regime
NON-LINEAR IMPULSE RESPONSES

- Draw from regime after initial shock

![Graphs showing non-linear impulse responses](image-url)
Tax Multipliers

- Defined as
  \[
  PV_n(\Delta y) / \Delta \tau_0 = \frac{1}{\Delta \tau_0} \sum_{s=0}^{n} q_{0,s} (y_s - \bar{y})
  \]

  \[n = 5, 10, 20, \infty\]

- Size depends on conditioning regime
  - always non-trivial
  - potentially large (\(> 1\))

- Similar impacts from unanticipated and anticipated changes

- With draws from future regimes
  - size depends on initial regime
  - range can be very wide
## Output Multipliers

<table>
<thead>
<tr>
<th>Init Regime</th>
<th>5 quarters</th>
<th>( \frac{PV(\Delta y)}{\Delta \tau} ) after 10 quarters</th>
<th>( \frac{PV(\Delta y)}{\Delta \tau} ) after 25 quarters</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM/PF</td>
<td>[−.126, −.400]</td>
<td>[−.213, −.754]</td>
<td>[−.430, −.922]</td>
</tr>
<tr>
<td>PM/PF</td>
<td>[−.215, −.401]</td>
<td>[−.271, −.623]</td>
<td>[−.414, −.764]</td>
</tr>
<tr>
<td>PM/AF</td>
<td>[−.365, −.568]</td>
<td>[−.537, −.928]</td>
<td>[−.993, −1.363]</td>
</tr>
</tbody>
</table>

**Table**: 80th percentile bands based on 10,000 draws
### Price Level Effects

<table>
<thead>
<tr>
<th>Regime</th>
<th>5 quarters</th>
<th>10 quarters</th>
<th>25 quarters</th>
<th>∞</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM/PF</td>
<td>0.324</td>
<td>0.641</td>
<td>1.513</td>
<td>6.704</td>
</tr>
<tr>
<td>PM/PF</td>
<td>0.770</td>
<td>1.077</td>
<td>1.232</td>
<td>1.237</td>
</tr>
<tr>
<td>PM/AF</td>
<td>0.949</td>
<td>1.369</td>
<td>1.620</td>
<td>1.633</td>
</tr>
</tbody>
</table>

**Table:** Cumulative effect on price level of an *i.i.d.* unanticipated tax cut of 2 percent of output
Fiscal Theory Robust

- Percentage of time in AM/PF regime
Some Empirical Implications

- Observed time series produced by switching DSGE
- Correctly identified VAR, but fixed regime
- Policy rules and pattern matrix:

\[
\begin{align*}
 r_t &= \alpha_0 + \alpha_{\pi}\pi_t + \alpha_x x_t + \varepsilon_t^r \\
 \tau_t &= \gamma_0 + \gamma_x x_t + \gamma_b b_{t-1} + \varepsilon_t^\tau
\end{align*}
\]

\[
\begin{array}{ccccccc}
 x & \times & \times & \times & \otimes & \otimes \\
 \pi & \times & \times & \times & \\
 b & \times & \\
 r & \times & \times & \times & \times \\
 \tau & \times & \times & \times & \times
\end{array}
\]

\times : freely estimated; \otimes : imposed
**Some Empirical Implications**

- Two assumptions about econometrician’s information
  1. Full sample from single regime (draws from shocks & regime)
  2. Extra-sample information to identify regime (draws only from shocks)
- Econometrician interprets results with fixed-regime DSGE
- Accurate quantitative estimates $\hat{\alpha}_\pi$, $\hat{\gamma}_b$

<table>
<thead>
<tr>
<th></th>
<th>All Regimes</th>
<th>AM/PF</th>
<th>PM/PF</th>
<th>PM/AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\alpha}_\pi$</td>
<td>0.723</td>
<td>1.308</td>
<td>0.595</td>
<td>0.528</td>
</tr>
<tr>
<td>$\hat{\gamma}_b$</td>
<td>0.002</td>
<td>0.016</td>
<td>0.018</td>
<td>$-0.003$</td>
</tr>
</tbody>
</table>

- Inaccurate qualitative inferences
Some Empirical Implications

Fiscal Policy

Monetary Policy

Graphs showing the impact of fiscal and monetary policy on various economic indicators over time.
“All regimes” implies PM/AF: fiscal theory equilibrium
  - correct inference about policy impacts
Conditioning on regime gives incorrect inferences
  - AM/PF: Taylor principle & Ricardian
  - PM/PF: Indeterminacy & sunspots
Most accuracy from full sample and averaging across regimes
  - quantitative predictions close
  - qualitative inferences correct
Fiscal theory can break down Ricardian equivalence
  - may be quantitatively important in U.S.
  - likely still more important in other countries
If fiscal theory important, need to modify models
Misleading to study MP (or FP) in isolation
  - models must be consistent with evidence on both MP & FP
Need a serious integration of MP & FP
  - tax distortions
  - other sources of non-neutrality
  - GBC met non-trivially
Much To Do

- Empirical complications
  - identification: disentagling monetary and fiscal impacts
  - unobserved fiscal state: foreknowledge of fiscal policy
- Understanding source of regime change
  - optimal policy response?
- Holy Grail
  - joint estimation of policy and private parameters in DSGE with switching