EABCN Training School: Monetary-Fiscal Policy Interactions

Lecture 4. Generalizing Policy Interactions (B)

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THE MESSAGES

- Draws heavily from "Fluctuating Macro Policies and the Fiscal Theory" with Troy Davig (*NBER Macroeconomics Annual*, 2006) and "Monetary and Fiscal Policy Switching" with Hess Chung and Troy Davig (*JMCB*, June 2007)
- Difficult to obtain general analytical results with both monetary and fiscal switching
- Will examine some special cases and then turn to numerical results
- Allowing recurring regime change in both MP & FP can dramatically change nature of equilibria we study
- Raises the possibility for FP to play a role in our interpretations of business cycles

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 $\Longrightarrow$ global

Regime Change

- Regime change: realizations of params in policy rule

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

  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

What We Do

- 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 $\Longrightarrow$ PV output rises $\approx$ \$1
- Common practice: break samples into distinct regimes and embed rules in fixed-regime DSGE can produce misleading inferences

An Analytical Example

- Canzoneri, Cumby, Diba: Ricardian equilibria more general than non-Ricardian
  - if responses of taxes to liabilities is positive infinitely often—however small and infrequent—then eqm exhibits Ricardian equiv
  - because fiscal response does not stabilize debt, these are potentially equilibria with unbounded debt-output ratios
- Our example satisfies CCD's assumptions, but delivers a unique eqm in set with bounded debt-output ratios
  - this eqm is non-Ricardian
  - important conclusions hinge on unboundedness ass'n of CCD

THE MODEL

- MIUF, constant endowment, log prefs, constant g
- Fisher equation

$$\frac{1}{R_t} = \beta E_t \frac{1}{\pi_{t+1}}$$

- Money demand

$$m_t = \left[\frac{R_t - 1}{R_t}\right]^{-1} c$$

- Monetary policy

$$R_t = exp\left(\alpha_0 + \alpha(S_t)\hat{\pi}_t + \theta_t\right)$$

- Tax policy

$$\tau_t = \gamma_0 + \gamma(S_t)(b_{t-1} + m_{t-1}) + \psi_t$$

(θ_t, ψ_t) exogenous policy shocks; $\hat{\pi} = \ln \pi$

The Model

- S_t an N-state Markov chain with transition probs $P[S_t = j | S_{t-1} = i] = p_{ij}$
- Define expectation error (and use Fisher equation)

$$\eta_{t+1} \equiv \frac{1/\pi_{t+1}}{E_t[1/\pi_{t+1}]} = \beta \frac{R_t}{\pi_{t+1}}$$

- Then the inflation process is given by

$$\hat{\pi}_{t+1} = \alpha(S_t)\hat{\pi}_t + \alpha_0 + \theta_t - \hat{\eta}_{t+1} + \ln\beta$$

- Let $l_t = b_t + m_t$, real govt liabilities
- Use tax rule & money demand in govt budget constraint

$$l_t = \left[\frac{R_{t-1}}{\pi_t} - \gamma(S_t)\right] l_{t-1} - \frac{R_{t-1}}{\pi_t} c + D - \psi_t$$

$D = g - \gamma_0$

SOLUTION

- Assume that
  I $E_t[\gamma_{t+1}] = \gamma$
  II γ satisfies $|1/\beta - \gamma| > 1$
  III inflation process is stable in expectation (i.e., there exists a $0 < \xi < \infty$ such that $|E_t \pi_{t+k}| < \xi$ for all k
  - (I)-(II): on average FP active; (III): on average MP passive
- Iterate on l equation and take E_{t-1} and law of iterated expectations

$$E_{t-1}[l_{t+k}] = (1/\beta - \gamma)^{k+1}\left[l_{t-1} - c\left(\frac{1/\beta - D/c}{1/\beta - \gamma - 1}\right)\right] + c\left(\frac{1/\beta - D/c}{1/\beta - \gamma - 1}\right)$$

Stability requires that $l_{t-1} = c\left(\frac{1/\beta - D/c}{1/\beta - \gamma - 1}\right)$, which is positive if $D/c < 1/\beta$

Solution

- The value of η_t is obtained from the budget constraint after substituting in the value of l:

$$
\begin{aligned}
\eta_t &= \beta \frac{(1+\gamma(S_t))\,(1/\beta - D/c) - (D/c)\,(1/\beta - \gamma - 1)}{1+\gamma - D/c} \\
&\quad + \frac{\beta}{c}\left(\frac{1/\beta - \gamma - 1}{1+\gamma - D/c}\right)\psi_t
\end{aligned}
$$

- The unique eqm mapping from ψ_t and $\gamma(S_t)$ to forecast error in inflation
- η and π_t process yields unique solution for inflation

Concrete Example

- Two regimes, $N = 2$, and policy parameters take on the values

$$\alpha(S_t) = \begin{cases} \alpha(1) \text{ for } S_t = 1 \\ \alpha(2) \text{ for } S_t = 2 \end{cases} \qquad \gamma(S_t) = \begin{cases} \gamma(1) \text{ for } S_t = 1 \\ \gamma(2) \text{ for } S_t = 2 \end{cases}$$

- Suppose $\alpha(1)$ and $\alpha(2)$ are sufficiently small such that the inflation process is stable in expectation

$$E[\gamma_{t+j} \,|S_t = 1, \Omega_t] = \gamma(1)p_{11} + \gamma(2)p_{12}$$
$$= E[\gamma_{t+j} \,|S_t = 2, \Omega_t] = \gamma(1)p_{21} + \gamma(2)p_{22} \equiv \gamma$$

- If either $\gamma(1)$ or $\gamma(2)$ is positive, then the model satisfies CCD's premise that taxes adjust to debt infinitely often
- But negative tax shocks generate wealth effects that raise inflation
- The only eqm with *bounded* debt is one in which Ricardian equiv breaks down: counterexample to CCD

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

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

4 states, α's have 2 sets of values, P^M transition matrix

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

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
  - π : log difference of GDP deflator
  - x : log output gap using CBO potential
  - τ : 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

Policy Rule Estimates

- 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

	Active		Passive	
State	$S_t^M = 1$	$S_t^M = 2$	$S_t^M = 3$	$S_t^M = 4$
α_π	1.3079	1.3079	.5220	.5220
	(.0527)	(.0527)	(.0175)	(.0175)
α_y	.0232	.0232	.0462	.0462
	(.0116)	(.0116)	(.0043)	(.0043)
σ_r^2	1.266e-5	9.184e-7	2.713e-5	5.434e-7
	(8.670e-6)	(1.960e-6)	(5.423e-6)	(1.512e-6)

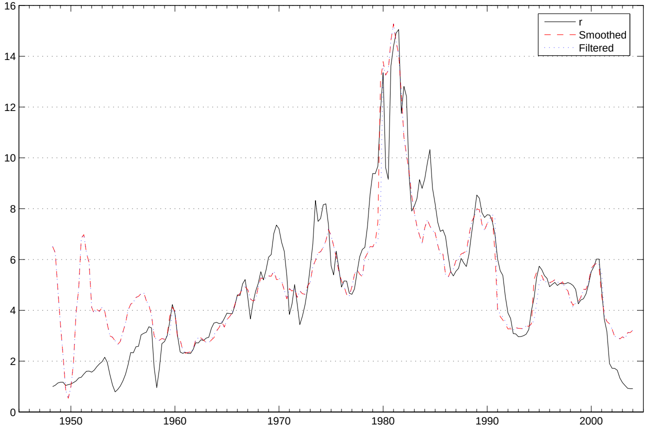
TABLE 1: Log likelihood value $= -1014.737$

Tax Policy Estimates

State	$S_t^F = 1$	$S_t^F = 2$
γ_0	.0497	.0385
	(.0021)	(.0032)
γ_b	.0136	-.0094
	(.0012)	(.0013)
γ_y	.4596	.2754
	(.0326)	(.0330)
γ_g	.2671	.6563
	(.0174)	(.0230)
σ_τ^2	4.049e-5	5.752e-5
	(6.909e-6)	(8.472e-6)

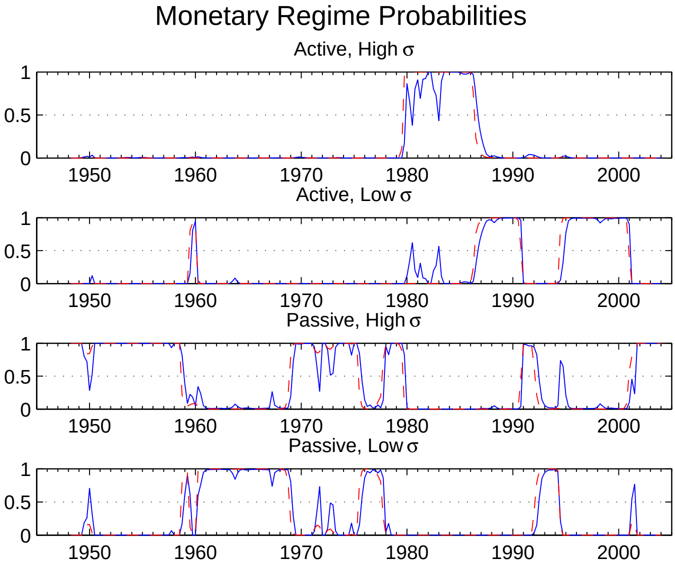
Table 2: Log likelihood value $= -765.279$

Interest Rate: Actual & Predicted

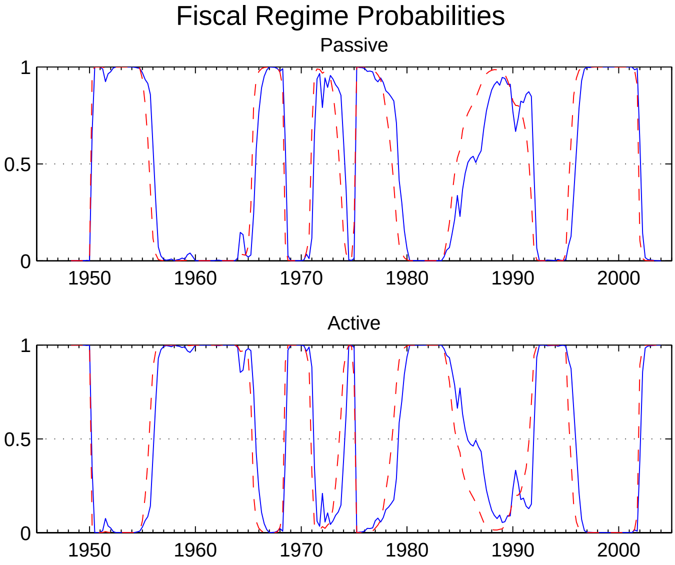


TAXES: ACTUAL & PREDICTED

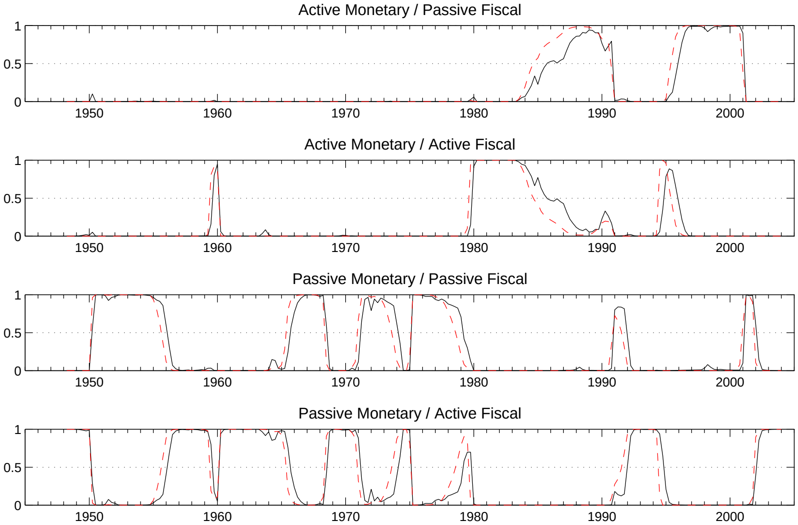
MONETARY REGIME PROBABILITIES



Fiscal Regime Probabilities



JOINT POLICY REGIME PROBABILITIES



A Model with Nominal Rigidities

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

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

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

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

$$E_t [Q_{t,t+1}]^{-1} = 1 + r_t$$

A Model with Nominal Rigidities

- Firms

$$E_t \sum_{i=0}^{\infty} \varphi^i q_{t,t+i} \left[\left(\frac{p_t^*}{P_{t+i}} \right)^{1-\theta} - \Psi_{t+i} \left(\frac{p_t^*}{P_{t+i}} \right)^{-\theta} \right] Y_{t+i} \, \frac{p_t^*}{P_t} = \left(\frac{\theta}{\theta-1} \right) \frac{K_{1t}}{K_{2t}}$$

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

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

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

- 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: $\Omega_t = \{\varepsilon^r_{t-j}, \varepsilon^\tau_{t-j}, S^M_{t-j}, S^F_{t-j}, j \geq 0\}$
  - foreknowledge: $\Omega^*_t = \Omega_t \cup \{\varepsilon^\tau_{t+1}\}$
- 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: $\Theta_t = \{b_{t-1}, w_{t-1}, \Delta_{t-1}, \varepsilon^r_t, \varepsilon^\tau_t, S_t\}$

THE FISCAL THEORY MECHANISM

- The **ubiquitous 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 τ_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

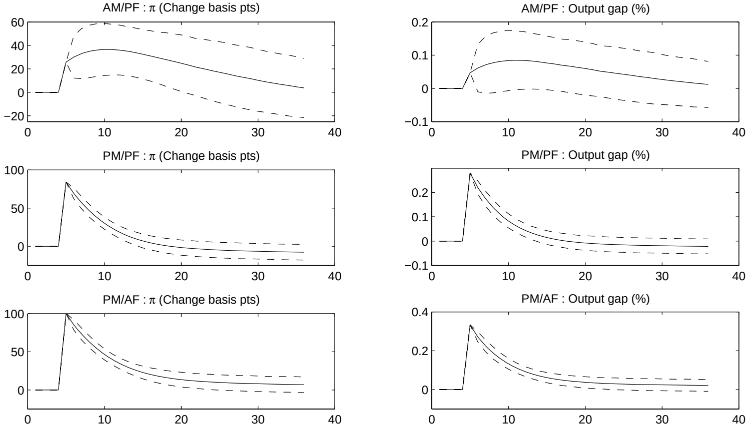
- Numerical analysis of uniqueness and stationarity
- Numerical checks
  - randomly perturb decision rules at points in state space: converge back?
  - how monotone map behaves when properties known
    - indeterminacy (non-convergence)
    - non-existence (converges but solutions explode)
  - zero expected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

Quantifying the Fiscal Theory

- 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



TAX MULTIPLIERS

- Defined as

$$PV_n(\Delta y)/\Delta\tau_0 = \frac{1}{\Delta\tau_0}\sum_{s=0}^{n} q_{0,s}(y_s - \overline{y})$$

  $n = 5, 10, 20, \infty$

- 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

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

TABLE 3: 80th percentile bands based on 10,000 draws

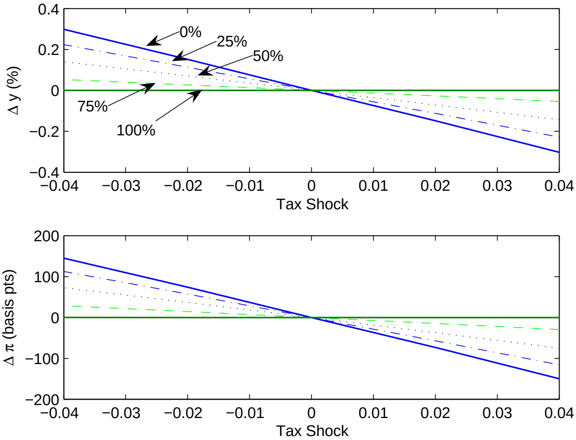
Price Level Effects

	$\%\Delta P$ after			
Regime	5 quarters	10 quarters	25 quarters	∞
AM/PF	0.324	0.641	1.513	6.704
PM/PF	0.770	1.077	1.232	1.237
PM/AF	0.949	1.369	1.620	1.633

Table 4: Cumulative effect on price level of an $i.i.d.$ unanticipated tax cut of 2 percent of output, conditional on regime

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:

$$r_t = \alpha_0 + \alpha_\pi \pi_t + \alpha_x x_t + \varepsilon_t^r$$
$$\tau_t = \gamma_0 + \gamma_x x_t + \gamma_b b_{t-1} + \varepsilon_t^\tau$$

	x	π	b	MP	FP
x	$\times$	$\times$	$\times$	$\otimes$	$\otimes$
π		$\times$	$\times$	$\times$	
b			$\times$		
r	$\times$	$\times$	$\times$	$\times$	
τ	$\times$	$\times$	$\times$		$\times$

$\times$: freely estimated; $\otimes$: imposed

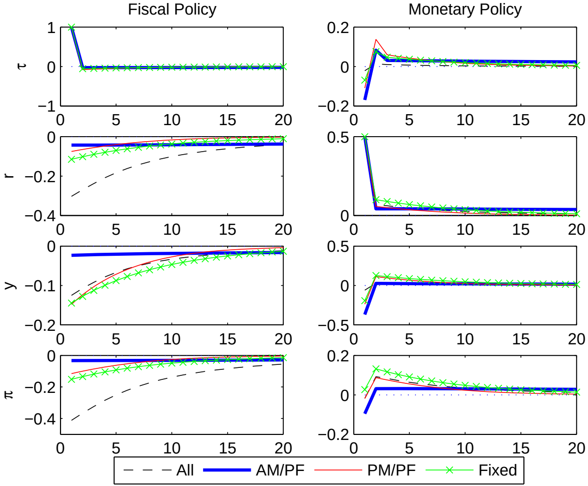
Some Empirical Implications

- 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 $\hat{\alpha}_\pi, \hat{\gamma}_b$

	All Regimes	AM/PF	PM/PF	PM/AF
$\hat{\alpha}_\pi$	0.723	1.308	0.595	0.528
$\hat{\gamma}_b$	0.002	0.016	0.018	-0.003

- Inaccurate qualitative inferences

Some Empirical Implications



"Fixed": All Regimes parameters in fixed-regime DSGE

Some Empirical Implications

- "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

WRAP UP

- 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

WRAP UP

- 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
  - some work with just MP switching (Zha et al.) and with everything switching (Svensson-Williams)
  - no work with MP & FP switching